F

APPENDIX F

Aquatic Ecology Letter

195 Rattray Street
PO Box 1023
Dunedin, 9054

30 March 2020

Telephone 03 477 2119
Mobile 027 437 7617

g.ryder@ryderenv.nz

Gavin Lee / Duncan Ross
OceanaGold (NZ) Ltd
Dunedin

Dear Sirs,

Response to ORC RFI on aquatic ecology

You have asked me to comment on several aspects of the ORF RFI relating to the Deepdell North consent application. I set out my comments below.

18. Provide all of the available nutrient data for Deepdell Creek and Shag River, and a detailed assessment of what suitable nutrient guidelines would be to control periphyton growth. As the Ecological Effects Assessment states that dual nutrient management will be considered, standards should be provided for both dissolved inorganic nitrogen and dissolved reactive phosphorus.

The nutrient data that I have been able to obtain for Deepdell Creek and Shag River are presented in Appendix A.

Water quality data from the Shag River (obtained from the LAWA database) was analysed for trends through time. Statistical trend analyses determine the magnitude of the trend and the confidence of the trend direction. These analyses are useful for determining whether water quality is improving or degrading across multiple sites and variables.

Water quality parameters are as follows: total phosphorus (TP), dissolved reactive phosphorus (DRP), ammoniacal nitrogen (NH_4-N), total oxidised nitrogen (TON[1]), and total nitrogen (TN). The Otago Regional Council (ORC) collected water quality data from Craig Road and Goodwood Pump about every other month from 2004 to 2020. Craig Road site is the more upstream site and is located approximately 15 km downstream from the mine. Goodwood Pump is located 10 km downstream from Craig Road and is approximately 26 km from the mine.

Trend analyses were performed for each nutrient and site for the full data period (2004-2020), and the most recent 8 years of data (2012-2020). Trend analyses were constrained quarterly (January – March, April – June, July-September, and October – December). Water quality trends (e.g., increasing, decreasing) were calculated using a method developed by the company Land Water People (LWP), performed in R statistical software, and were compared to results from the traditional NIWA TimeTrends (TT) approach (version 6.3. Jowett 2017), as described in Appendix B. Full details of the results of these analyses are presented in Appendix B and key points are summarised below.

[1] Total Oxidised Nitrogen or TON is a measure of two inorganic forms of nitrogen (nitrite-nitrogen and nitrate-nitrogen) found in a sample. Dissolved inorganic nitrogen, or DIN, comprises nitrite-nitrogen, nitrate nitrogen and ammoniacal-nitrogen. In New Zealand rivers, nitrite typically represents a very small, almost negligible, component of DIN, and ammoniacal-nitrogen typically comprises only a small component. At the Shag River Craig Road monitoring site, ammoniacal-nitrogen typically represents less than 5% of the total DIN concentration.

Trends over the last 8 years (2012 – 2020)

TP at Craig Rd had an insignificant increasing trend but TP at Goodwood was either possibly (TT) or extremely likely (LWP) to be decreasing by about 6 %. DRP at Craig Rd is insignificantly increasing but DRP at Goodwood was very (TT) to extremely (LWP) likely to be decreasing by 5 – 6 %. NH_4 trends at Craig Rd were inconclusive due to a high proportion of censored values. TON at Craig Rd is insignificantly increasing by 6 % and insignificantly decreasing by 2 % at Goodwood. TN is insignificantly increasing by 0.3 % at Craig Rd and insignificantly decreasing by 2 % at Goodwood.

Trend direction and confidence was largely inconclusive from the eight-year trend analyses. This result is likely due to the small sample size and therefore a larger proportion of uncensored values in the data.

Trends over the longer monitoring record (2004 – 2020)

TP is significantly decreasing at both sites, at a rate of 5 % at Craig and 2 % at Goodwood. DRP is significantly decreasing at both sites (see Figure 1 below for Craig Road), however less significantly at Goodwood (0.8 %) compared to Craig (-3 %). Due to the high proportion of censored data for NH_4, the LWP analysis produced indeterminant trends, however the data suggest NH_4 is likely decreasing at both sites. TON is significantly increasing at both sites, however the rate of change is higher at Craig (~ 8 %, see Figure 2) compared to Goodwood (~ 2 %). TN is also significantly increasing by about 2 % at both sites, but the trend is more probable for Craig than Goodwood.

Discussion

Due to inconclusive results from the recent 8-year period, this discussion focuses on the results from the longer 2004 – 2020 record. Overall, TP and DRP are decreasing over time, however both variables are decreasing at a higher rate at Craig compared to Goodwood. This may be due to the higher concentration of agricultural activity occurring between Craig and Goodwood and thus more constant inputs of P into the river. It is difficult to say whether the observed decreasing NH_4 trend is significant due to the high proportion of censored data. However, this does indicate that whether or not NH_4 is increasing or decreasing, the concentrations are very low. In contrast, the trend analysis suggests that TON and TN are both significantly increasing in the Shag River, and the rate of increase for TON (which encompasses nitrate-nitrite) is 4x greater at the monitoring site closest to the mine (Craig).

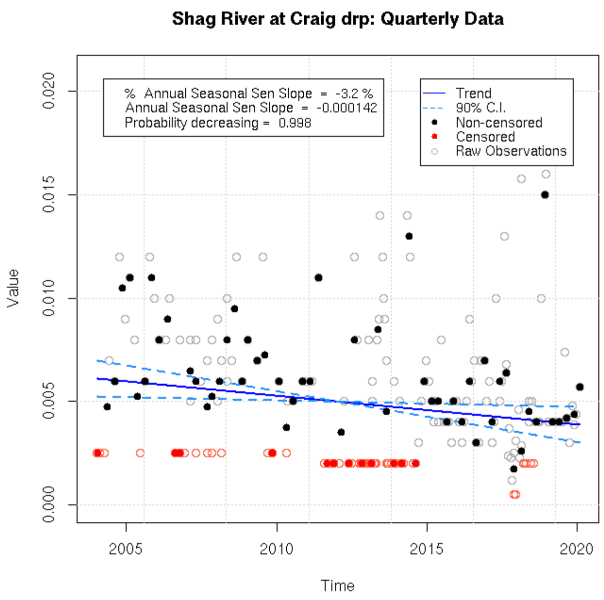


Figure 1. *DRP concentrations over time at the Shag River Craig Road monitoring site.*

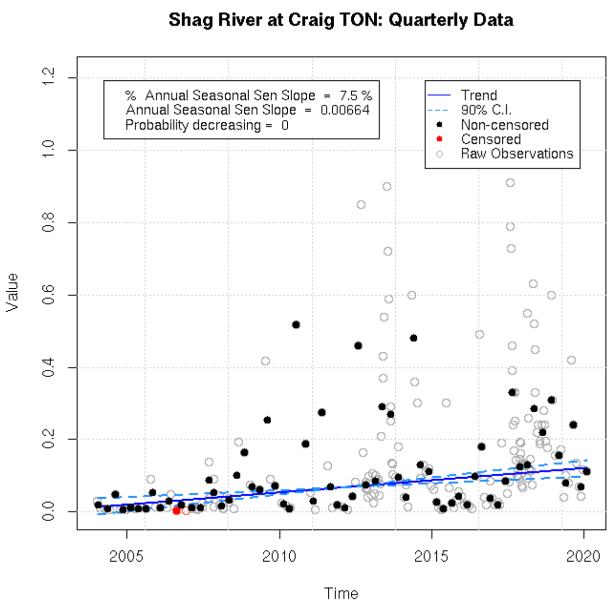


Figure 2. *Total Oxidized Nitrogen (TON) concentrations over time at the Shag River Craig Road monitoring site.*

As the EEA stated in section 5.3, "*Given a highly significant reduction in typical nitrate concentrations in the creek are unlikely, it is recommended that focus on managing phosphorus losses to water be given greater attention in the catchment. Both nitrate and dissolved phosphorus are necessary to stimulate algae and plant growth. The pathway for phosphorus to reach surface waters is primarily via overland flow (and direct through stock access to water), whereas nitrate can reach surface waters via subsurface seepage and groundwater.*

This is not to say that management of waste rock stacks at Macraes will be not required to avoid adverse effects on freshwater ecology, but rather dual nutrient management be considered".

The EEA also stated in section 5.3.4 that, "*Given a highly significant reduction in typical nitrate concentrations in the creek are unlikely, it is recommended that focus on managing phosphorus losses to water be given greater attention in the catchment.*". Thus, the EEA did not explicitly state that dual nutrient management will be considered. Having said that, understanding the relationship between both N and P is important for management purposes, which is why the trend analysis above was undertaken. While bioavailable concentrations of nitrogen are trending up in lower Deepdell Creek and the Shag River, they can still be regarded as being at acceptable levels, while DRP levels at least in the Shag River are low and there is no indication that they are trending up.

For context, the 2019 Draft National Policy Statement for Freshwater Management proposes the following attribute bands for DIN (Table 5 of the proposed 2019 NPS-FM) and DRP (Table 6 of the proposed 2019 NPS-FM).These attribute states are for the management of ecosystem health.

Table 5. Dissolved inorganic nitrogen (DIN) (2019 NPS-FM)

Value (and component)	Ecosystem health (water quality)	
Freshwater Body Type	Rivers	
Attribute Unit	DIN mg/L (milligrams per litre)	
Attribute band and description	**Numeric Attribute State**	
	Median	95th percentile
A Ecological communities and ecosystem processes are similar to those of natural reference conditions. No adverse effects attributable to DIN enrichment are expected.	≤ 0.24	≤ 0.56
B Ecological communities are slightly impacted by minor DIN elevation above natural reference conditions. If other conditions also favour eutrophication, sensitive ecosystems may experience additional algal and plant growth, loss of sensitive macroinvertebrate taxa, and higher respiration and decay rates.	> 0.24 and ≤0.50	> 0.56 and ≤01.10
C Ecological communities are impacted by moderate DIN elevation above natural reference conditions, but sensitive species are not experiencing nitrate toxicity. If other conditions also favour eutrophication, DIN enrichment may cause increased algal and plant growth, loss of sensitive macroinvertebrate & fish taxa, and high rates of respiration and decay.	> 0.5 and ≤ 1.0	> 1.10 and ≤ 2.05
National Bottom Line	**1.0**	**2.05**
D Ecological communities impacted by substantial DIN elevation above natural reference conditions. In combination with other conditions favouring eutrophication, DIN enrichment drives excessive primary production and significant changes in macroinvertebrate and fish communities, as taxa sensitive to hypoxia and nitrate toxicity are lost.	>1.0	>2.05
Groundwater concentrations also need to be managed to ensure resurgence via springs and seepage does not degrade rivers through DIN enrichment. Numeric attribute state must be derived from the rolling median of monthly monitoring over five years.		

Table 6. Dissolved reactive phosphorus (DRP) (2019 NPS-FM)

Value (and component)	Ecosystem health (water quality)	
Freshwater Body Type	Rivers	
Attribute Unit	DRP mg/L (milligrams per litre)	
Attribute band and description	**Numeric Attribute State**	
	Median	95th percentile
A Ecological communities and ecosystem processes are similar to those of natural reference conditions. No adverse effects attributable to DRP enrichment are expected.	≤ 0.006	≤ 0.021
B Ecological communities are slightly impacted by minor DRP elevation above natural reference conditions. If other conditions also favour eutrophication, sensitive ecosystems may experience additional algal and plant growth, loss of sensitive macroinvertebrate taxa, and higher respiration and decay rates.	> 0.006 and ≤0.010	> 0.021 and ≤0.030
C Ecological communities are impacted by moderate DRP elevation above natural reference conditions. If other conditions also favour eutrophication, DRP enrichment may cause increased algal and plant growth, loss of sensitive macro-invertebrate & fish taxa, and high rates of respiration and decay.	> 0.010 and ≤ 0.018	> 0.030 and ≤ 0.054
National Bottom Line	**0.018**	**0.054**
D Ecological communities impacted by substantial DRP elevation above natural reference conditions. In combination with other conditions favouring eutrophication, DRP enrichment drives excessive primary production and significant changes in macroinvertebrate and fish communities, as taxa sensitive to hypoxia are lost.	>0.018	>0.054
Numeric attribute state must be derived from the rolling median of monthly monitoring over five years.		

Applying the criteria for calculating numeric attribute states for DRP and DIN in the NPS-FM (the median concentration is derived from the rolling median of monthly monitoring over five years) for Craig Road and Goodwood monitoring sites on the Shag River, the following statistics are derived:

2015-2020 DRP and DIN NPS-FM attribute statistics for Shag River monitoring sites

Nutrient	Craig Road	Goodwood
DRP (mg/L) (median)	0.0040 (A band)	0.0050 (A band)
DRP (mg/L) (95th percentile)	0.0135 (A band)	0.0140 (A band)
DIN (mg/L) (median)	0.1300 (A band)	0.2025 (A band)
DIN (mg/L) (95th percentile)	0.6160 (B band)	0.7225 (B band)

The table above indicates that DRP and DIN median concentrations at both monitoring sites would be placed in the highest NPS-FM band (A band). The DRP 95th percentile concentration would be placed in the A band for both sites, while the DIN 95th percentile concentration would be placed in the B band for both sites The NPS-FM A band descriptions for DRP and DIN are as follows:

> "*Ecological communities and ecosystem processes are similar to those of natural reference conditions. No adverse effects attributable to DIN enrichment are expected.*"

> "*Ecological communities and ecosystem processes are similar to those of natural reference conditions. No adverse effects attributable to DRP enrichment are expected.*"

The NPS-FM B band descriptions for DRP and DIN are as follows:

> "*Ecological communities are slightly impacted by minor DIN elevation above natural reference conditions. If other conditions also favour eutrophication, sensitive ecosystems may experience additional algal and plant growth, loss of sensitive macroinvertebrate taxa, and higher respiration and decay rates.*"

> "*Ecological communities are slightly impacted by minor DRP elevation above natural reference conditions. If other conditions also favour eutrophication, sensitive ecosystems may experience additional algal and plant growth, loss of sensitive macroinvertebrate taxa, and higher respiration and decay rates.*"

I would recommend that DRP in the Shag River be managed for the A band attribute state and that DIN be managed for the B band attribute state for ecosystem health. Nitrate could be used as a substitute for DIN given it is by far the dominant dissolved form of nitrogen in these rivers. As discussed further below, DRP concentrations will need to remain at their current low levels (Figure 3), if further increases in DIN concentrations are anticipated.

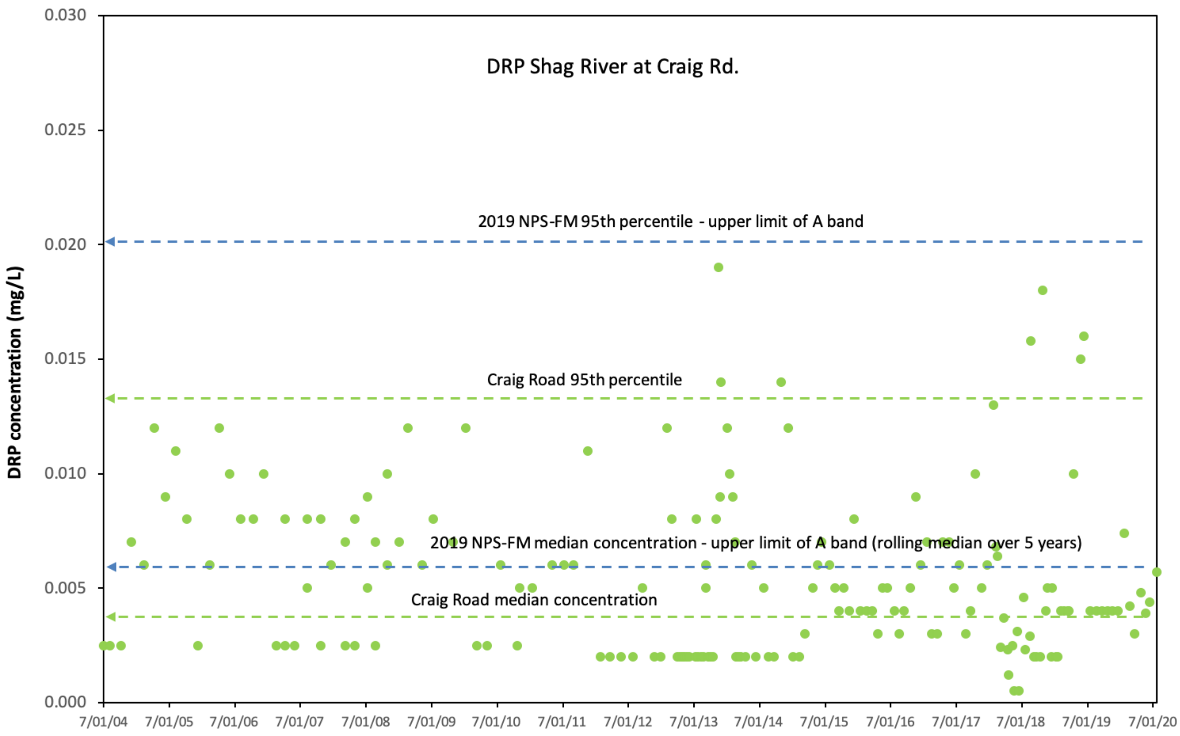


Figure 3. *DRP concentrations over time at the Shag River Craig Road monitoring site relative to proposed NPS-FM A band attribute state.*

Historically, there has been no monitoring of DRP at OceanaGold Deepdell Creek monitoring sites. DIN monitoring at seven OceanaGold monitoring sites is being undertaken, although not at monthly intervals (as required for assessing against NPS-FM attribute states). However, for the purposes of addressing this information request, the DIN data that has been monitored by OceanaGold has been assessed in terms of median and 95th percentile concentrations for data that has been collected from 2015 onwards. Statistics generated by this analysis are presented below:

2015-2020 DIN NPS-FM attribute statistics for Deepdell Creek monitoring sites

Nutrient	DC01	DC02	DC03	DC04	DC05	DC06	DC07
DIN (mg/L) (median)	0.0110 (A band)	0.0210 (A band)	0.0055 (A band)	0.1210 (A band)	0.0750 (A band)	0.0450 (A band)	0.0885 (A band)
DIN (mg.L) (95th percentile)	2.4510 (D band)	2.4070 (D band)	1.5810 (C band)	1.5790 (C band)	1.7220 (C band)	1.8100 (C band)	1.7370 (C band)
DIN (mg.L) (95th percentile) (with 15-Oct-15 results removed)	0.6170 (B band)	0.5905 (B band)	0.6300 (B band)	0.6635 (B band)	0.6535 (B band)	0.6675 (B band)	0.6680 (B band)

The analyses above indicate that median DIN concentrations in Deepdell Creek over the past five years of monitoring place all monitoring sites in the 2019 NPS-FM A band. 95th percentile concentrations place two Deepdell Creek monitoring sites upstream of the mine's influence in the D band and the five other monitoring sites in the C band. However, these results are strongly influenced by samples collected on 15 October 2015, when all sites including those upstream of the mine had very high nitrate concentrations (6.7 mg/L at DC01, 6.6 at DC02, 3.8 at DC03, 3.7 at DC04, 4.2 at DC05, 4.4 at DC06 and 3.7 at DC07). Removing the data from this date significantly reduces the 95th percentile concentrations puts all Deepdell monitoring sites in the B band (as shown above).

For the Highlay Creek HC01 monitoring site, monitoring data for DIN places it in the A band for both median and 95th percentile concentrations (although based on a limited dataset between May 2018 and February 2020).

2015-2020 DIN NPS-FM attribute statistics for Highlay Creek

Nutrient	HC01
DIN (mg/L) (median)	0.0880 (A band)
DIN (mg/L) (95th percentile)	0.4120 (A band)

As noted earlier, maintaining DRP levels at their current low state in the Shag River is necessary in order to restrict the influence of N on producing nuisance plant and algae growths. The same rationale applies to Deepdell Creek. This can be assessed by examining the ratio of N to P. The N:P ratio is known as the Redfield ratio and is often used as a guide for determining which nutrient is potentially limiting algae growth in lakes and rivers. Typically, ratios of the bioavailable forms of these nutrients (dissolved inorganic nitrogen – DIN and dissolved reactive phosphorus – DRP) are assessed in rivers and streams. On a mass basis (mg/L), the Redfield N: P ratio is 7:1.

DIN:DRP ratios were determined from Shag River Craig Road monitoring data to predict P-limitation (>15:1), N-limitation (<7:1) or co-limitation (between 7:1 and 15:1) as used by (McDowell, 2009). These ratios have also been used by MfE (2007). These data are presented in Appendix C.

An examination of the N:P ratios in the Shag River at the Craig Road monitoring site indicates that, since about mid-2008, the river is usually P limited, and has always been P limited since about mid-2017 (Appendix B and Figure 4).

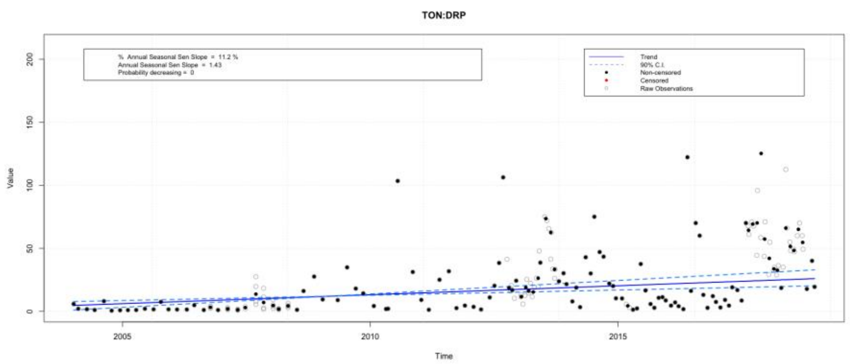


Figure 4. *N:P ratio and trend over time at the Shag River Craig Road monitoring site.*

It is likely that this is because nitrate has been increasing over this period while DRP has not been increasing either very slowly or not at all. To confirm this assumption, a trend analysis of the data over time for the N:P ratio was undertaken, with the results presented in Figure 4 and in the table below. The ratio is trending upwards with time and this reflects the fact that nitrate concentrations have been increasing while DRP concentrations have remained stable and low over the same period.

Site	Source	Seasonal	Sample	Non-detect	P	Sen Slope	% Change	Prob. of trend	Trend
Craig	LWP	TRUE	60	n/a	0.000000068	1.4	10.8	0.725	Increasing trend exceptionally likely

The N:P relationship for the Craig Road site suggests that N is not the issue with respect to managing nuisance algae and plant growths, and the analysis strongly suggests that P is the nutrient limiting nuisance growths in the Shag. This conclusion only applies if P levels are sufficiently low in them themselves to limit growth. The DRP data presented in Figure 3 indicates that DRP are sufficiently low to control nuisance algae and plant growths although flow variability will also have an influence on the accrual of algae and plant biomass. The same rationale applies to Deepdell Creek.

One comment on the relationship between nitrate levels and cyanobacteria growths; this is an emerging field of research and relationships are yet to be clearly established. One preliminary conclusion reached by McAllister[2] was that there was no significance difference in cyanobacteria biomass for nitrate concentrations of between 0.03 and 0.40 mg/L/, however, wider research in New Zealand notes that, from a management perspective, mitigation options may need to be river or site-specific[3].

20 Provide the likely contaminant concentrations in both Highlay Creek and its Western Tributary (location shown in appendix 1) and proposed water quality standards for these creeks that can be applied in consent conditions. For nutrients, these standards should be set to control plant growth rather than toxicity.

Nitrate concentrations monitored at the Highlay Creek HC01 site are presented in Appendix A.

The Western Tributary is highly degraded and has been subject to stock access over time, resulting in damage to banks and the channel, and directs inputs of nutrients and organic matter (Figure 5). The Figure 1 map/aerial supplied with the 92 letter clearly shows that the vast majority of this tributary is not affected by the mine expansion, and only about 315 metres of the lower section of the tributary would be affected by discharges from the new waste rock stack. While there is no water quality monitoring data for this tributary, I do not consider it appropriate to apply a high level of water quality protection to it and recommend that proposed NPS-FM C bands for DIN and DRP are sufficient to protect existing ecosystem health, based on monitoring in lower Highlay Creek (at HC02). The bulk of Western Tributary will not be affected by the expansion of mining under DDN Stage III as it is largely upstream of where treated discharges will enter the stream from a silt pond.

[2] McAllister. T.G. *Phormidium* accrual cycles in Canterbury rivers: the relative effects of flow and nutrients.

[3] McAllister, T.G., Wood, S.A., Atalah, J., & Hawes, I. 2018. *Spatiotemporal dynamics of Phormidium cover and anatoxin concentrations in eight New Zealand rivers with contrasting nutrient and flow regimes. Science of The Total Environment, 612, 71–80.*

Figure 5a. *Western Tributary being joining by a tributary that drains the proposed waste rock stack (bottom left of photo).*

Figure 5b. *Western Tributary (far right of photo) and the tributary joining it that drains the proposed waste rock stack.*

The Highlay Creek HC01 monitoring site is currently in the A band for DIN and is likely to be A or B band for DRP. I would suggest that managing Highlay Creek for B band DIN and DRP concentrations would not compromise the existing freshwater biota of this creek.

21. Provide an assessment of the effects of culverting the "Highlay Tributary" (location shown in appendix 1), particularly around construction effects.

It is my understanding that the proposed culvert in the Highlay Tributary mentioned in the s92 letter is to be located in the section of tributary shown above in Figure 5b, at a point approximately in the mid-left of the photo. I also understand that the area of watercourse disturbed would be approximately 51 metres long.

From my experience, OceanaGold and its associated contractors are very experienced at undertaking the types of works associated with culvert construction. I understand that construction will be undertaken under 'off-line' conditions. This would most likely involve establishing a coffer dam and, if necessary, pumping water around the construction area. It is worth noting that the tributary identified in Figure 5b has a very small catchment and probably has intermittent flow, and as such its surface flow is typically very small, if at all. It can be seen in Figure 5b (photo taken in September 2019) that the wetted channel has a soft bed, is dominated by grasses, and the flow is sluggish and shallow at best.

The habitat within the tributary is marginal at best for fish and benthic invertebrate communities that are typically associated with perennial flowing streams. There are no records for the presence of fish upstream of the proposed culvert. I do not consider the loss of the watercourse channel associated with the establishment of a culvert can be regarded as being anything more than minor with respect to loss of stream ecosystem habitat.

The greatest risk of the culvert construction on freshwater ecosystems is during construction, and that is related to the effects of sediment mobilisation on stream habitat further downstream. However, the practices described above (working off-line and pumping water around the construction site if necessary) will reduce the risk of meaningful levels of sediment discharging to lower sections of Highlay Creek.

In summary, there will be no loss of fish habitat and the loss of open watercourse habitat is of marginal quality. Risk to perennial downstream habitat through sediment runoff during construction can be managed through construction methodologies such as those described above.

22. Provide an assessment of the effects of the expected increase in nitrate concentration (see figures 10, 11, 17 and 18 of Appendix E in the application) on periphyton growth in Deepdell Creek and Shag River based on existing water quality and ecological data. The Ecological Effects Assessment does not do this to an appropriate standard.

The issue has been largely addressed under item 18. Ensuring DRP concentrations are kept low, or reduced even further, is important and will enable some further increase in DIN over time to occur without compromising ecosystem health. Current attribute states for DRP and DIN are relatively high for the Shag River.

I think it is important to note that elevated periphyton cover has been a feature of lower Deepdell Creek monitoring sites since regular monitoring commenced in the early 1990s. For example, the summer 1993 report states that some sites had 80-95+% algae cover, dominated by stalked diatoms (*Gomphonema*) and filamentous green algae (*Ulothrix*). This level of cover is greater than that reported in the most recent report (e.g., February 2018, 60% filamentous algae cover at DC07) and greater than that for February 2019 (39%) and for March 2020 (12% filamentous algae cover) at DC07. There is no indication that increasing nitrate levels observed at lower Deepdell Creek monitoring sites in recent years have resulted in increases in periphyton and macrophyte cover.

23. Provide an assessment of the cumulative loss of habitat since the mine was started and compare this to the mitigation already undertaken to offset habitat loss.

This is a very broad request and I would suggest almost impossible to provide with useful accuracy. Firstly, to my knowledge, detailed mapping of the stream network was never undertaken prior to the commencement of modern mining. While the pre-mining stream network can be inferred from older topographical maps, this approach would be unreliable for distinguishing between sections of ephemeral, intermittent and perennial sections. I was involved in ground surveys of streams in the Macraes area with Fish & Game staff prior to the commencement of modern mining (i.e., in the mid-late 1980s) and still have hard copies of the reports produced from the surveys. Very little information was gathered on the stream network with respect to its physical extent. The primary focus was on benchmarking existing stream communities of Deepdell Creek, some of its tributaries, and tributaries of the upper North Branch of the Waikouaiti River.

Secondly, I do not consider it is possible to reasonably compare stream habitat loss in the Macraes area with mitigation already undertaken to offset habitat loss. This is because some of the past mitigation is offset mitigation in the truest meaning of the term and as such one is not comparing apples with apples. Examples include:

Avoidance

- 2.00km of consented streambed as part of Coronation North Extension

Mitigation

- Translocation of Taieri Flathead galaxiid and Koura from impacted stream beds for Coronation North development.
- Fish baffles in the recently re-installed Deepdell Culvert.

Compensation – Length of stream bed within ecological covenants

- Coronation North – 7.09km (Island Block and Highlay Hill Covenant)
- Coronation – 2.15km (Cranky Jims Wetland Covenant)
- Macraes Phase III – 3.38km (Cranky Jims Shrubland, Deepdell Tussock and Highlay Creek Covenants).

OceanaGold has produced a plan that calculates the loss of watercourses due to mining within the Deepdell Creek catchment (Appendix D). Some of the creek disturbance has been inferred from previous topographic data as accurate surveys for all areas do not exist. The data used for the map in Appendix D included the LINZ data from 2004. These were used to derived the waterways and from that 'Disturbed Waterways' (coloured red) measurements were estimated. The 'Inferred Disturbance' was hand drawn on to the map (coloured yellow) based on the Nespair aerial imagery from 1988. The following estimates of stream lengths were produced:

Total Deepdell Creek length	176,900 m	
Total mine disturbed length	14,449 m	8.17% of total creek
Total proposed additional disturbance for DDN III	500 m	0.28% of total creek

Potentially, it may be possible to roughly estimate the loss of potential flathead galaxias habitat due to modern mining at Macraes and compare this with the known distribution with the species throughout Otago, using the above approach, however this would require the need to make several assumptions about the local population in the past and populations (and their threats) at other locations throughout the region. The number of assumptions required would probably render the assessment rather futile. It is worth remembering that the disturbance of watercourses associated with DDN stage III do not appear to support fish populations.

24. Water quality impacts are to be mitigated via water releases from the to be constructed Camp Creek dam.

- ***Provide detail regarding how the effectiveness of this mitigation will be monitored.***

OceanaGold propose to construct a freshwater dam in the Camp Creek catchment (operating by January 2022) to provide a base flow to Deepdell Creek to manage and effectively mitigate sulphate concentrations in Deepdell Creek and in the Shag River as far as the confluence with McCormicks Creek (GHD 2019). It is anticipated that this will also act to mitigate nitrate concentrations. It is recommended that this dam also be assessed for potential to provide periodic flushing flows down Deepdell Creek to remove nuisance algae and plant biomass that may accrue over summer stable low flow periods. Additional stream shading may also reduce the need to reduce instream nitrogen.

Regular monitoring of fish and invertebrate populations in Deepdell Creek (existing monitoring sites) and Highlay Creek (HC02) should continue as a check against potential effects on freshwater biota due to potential changes in water quality. Regular nitrate and phosphorus monitoring should commence in Highlay Creek and at the existing Deepdell Creek monitoring sites if it hasn't already done so.

Investigating the potential to provide effective flushing flows from the Camp Creek dam is recommended. Water releases from a dam in the Camp Creek catchment have been proposed as a means of mitigating downstream water quality in particular to reduce concentrations of sulphate. The ability to monitor water quality by setting up a monitoring programme that involves the collection of water samples from strategic locations would seem a relatively straight forward exercise. Samples can be collected from the dam, immediately upstream of the Camp Creek confluence with Deepdell Creek, approximately 50-100 metres downstream of the Camp Creek confluence (or after reasonable mixing has occurred) and at existing water quality monitoring sites down Deepdell Creek (list). The rate of discharge from the dam should be monitored continuously together with the flow of Deepdell Creek at the existing flow recorder site. Information on flows and concentration will enable the calculation of the relative contribution of water quality contaminants from the dam versus that upstream and downstream in Deepdell Creek, as well as the effectiveness of the dam in diluting contaminant concentrations.

If flushing flows were planned to mitigate the likes of nuisance algal and macrophyte growths, pre- and post-flushing flow release surveillances of Deepdell Creek could be undertaken to determine the effectiveness of flushing. Surveillance could be undertaken in a quantitative fashion (e.g., percent cover of filamentous algae) to provide greater (measurable) information on outcomes.

Obviously, in the medium (seasonal) to long (years) term the regular surface water monitoring programme will be capable of detecting trends in water quality and ecosystem health.

- ***The dam must be designed to release flows of sufficient size to scour algal and macrophytes, and have the water capacity to do this through the summer. Provide an assessment that addresses these issues and investigates the overall feasibility of the dam to be able to provide flushing flows.***

Consent No. RM10.351.38 permits the discharge of water from a reservoir in Camp Creek to Camp Creek downstream of the reservoir for the purpose of operating the Camp Creek Reservoir and supplementing flows in the Deepdell Creek catchment. Condition 7 of this consent states the following:

A flushing flow of at least 58 litres per second with a duration of three hours shall be released from the Camp Creek Reservoir downstream into Camp Creek between the months of January and April inclusive. This shall occur:

i) *At least three times per year for the first two years following completion of the construction of the Camp Creek dam embankment: and*

ii) *At least two times per year from three to eight years following the completion of the construction of the Camp Creek Dam embankment.*

Deepdell Creek (at DC04) has a median flow of 30 L/sec and a 7-day mean annual low flow of 4 L/sec (GHD 2019[4]). Flows necessary to scour nuisance periphyton growth are typically considered to be around three times the median flow (FRE3), although this can vary greatly between rivers. This theoretical relationship assumes that flows of this magnitude are capable of moving bed material and in doing so help scour attached periphyton. In reality, studies in Canterbury have shown that the range of flows required to ‘effectively’ remove periphyton in this manner can range anywhere between 1.5 and 10 times the median flow (Kilroy *et al*. 2017[5]). The exact flow required for Deepdell Creek is unknown. Further, Deepdell Creek contains section of bedrock as well as gravel, and substrate type will influence the ability of higher flows to scour periphyton. Given the very low flows that are experienced in Deepdell Creek under certain dry weather conditions, it may be that a lower flow than the FRE3 is capable of removing nuisance periphyton growths.

I recommend that the design of the Camp Creek dam include provision to enable an instantaneous flow release greater than the minimum 58 L/s stated in consent conditions (I note that Condition 7 states that the flushing flow should be ‘at least’ 58 L/sec).

- ***It is also proposed that dam flushing flows can be used to manage algal and macrophyte build up in Deepdell Creek if the increase in nitrates promotes excessive plant and algal growth. Provide the proposed trigger levels for algae and macrophyte growth that will result in flushing to be required. and how these levels are to be monitored .***

I suggest that an appropriate trigger for nuisance algae growth for Deepdell Creek is when filamentous algae >2cm long exceeds 30% of cover of the creek bed at at least two of the existing Deepdell Creek monitoring sites downstream of the Camp Creek confluence. Assessments of periphyton cover can be undertaken quickly and I would suggest that such assessments for flow release purposes are undertaken over the summer months of the year (December to March) when a FRE3 flow has not occurred for more than 30 days and repeated every 30 days unless a FRE3 event occurs prior to the next 30 days. Note that periphyton and macrophyte cover assessments already occur in February as a part of existing consent monitoring conditions. With this approach, the earliest need to provide a flushing flow would be the end of December, with the maximum number of flushing flows being four, should no

[4] Deepdell North Stage III Project Receiving Water Quality Analysis. Prepared by GHD for Oceana Gold NZ Ltd.

[5] Kilroy, C., Wech, J., Kelly, D., and Clarke, G. 2017. Analysis of a three-year dataset of periphyton biomass and cover in Canterbury Rivers. Prepared for Environment Canterbury by NIWA.

FRE3 events occur between the start of December and the end of March.

Triggers for flow releases in relation to macrophyte cover are less easy to recommend as there are no widely recognised guidelines for managing macrophytes in New Zealand streams and rivers. Those that do exist have been derived to protect trout fishery-angling values (Matheson *et al*. 2016[6]). Past monitoring in Deepdell Creek indicates that nuisance macrophyte cover is a relatively insignificant issue and I suspect that the flow flushing trigger based on filamentous algae cover alone will be sufficient.

25. Provide details of the frequency of the existing monitoring of flora and fauna and the water quality sampling regime are required.

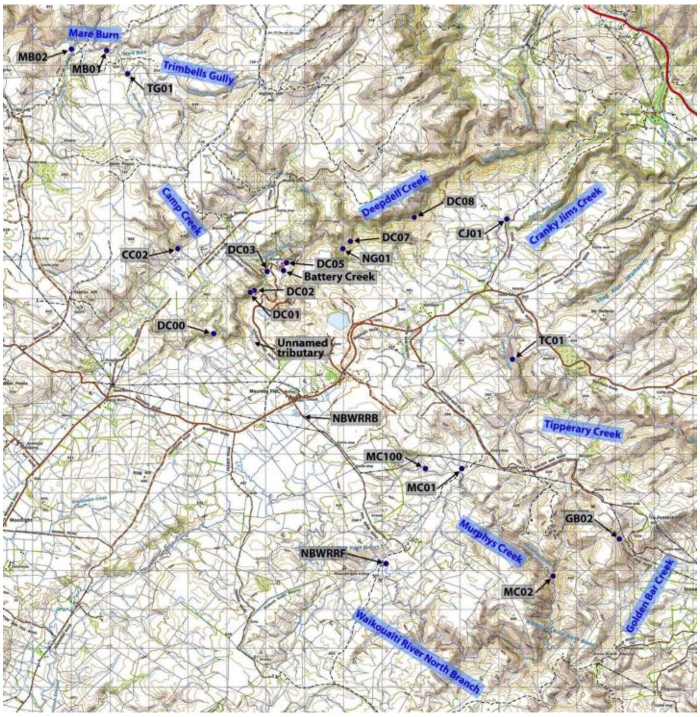
Aquatic monitoring in the Deepdell Creek catchment is currently undertaken at the following sites:

Site	Monitoring commenced	Control/ Impact	Macroinvertebrates		Macrophytes & periphyton	Fish
			Qualitative (Kicknet)	Quantitative (Surber)		
Deepdell Creek catchment						
DC00	May 2012	Control	-	✓	✓	✓
DC01	1989/1990	Control	-	✓	✓	✓
DC02	1989/1990	Control	-	✓	✓	✓
DC03	1989/1990	Impact	-	✓	✓	✓
DC05	May 2012	Impact	-	✓	✓	✓
DC07	1989/1990	Impact	-	✓	✓	✓
DC08	May 2012	Impact	-	✓	✓	✓
Battery Creek	1989/1990	Impact	✓	-	-	-
NG01	1989/1990	Impact	✓	-	-	-
Unnamed tributary*	1989/1990	Impact	✓*	-	-	-
CC02	August 2014	Impact	-	✓	✓	✓

* 'Unnamed tributary' has not been monitored for a number of years due to a lack of flow.

These are displayed on the map below.

[6] Matheson, F., Quinn, J., and Unwin, M. 2016. Instream plant and nutrient guidelines: Review and development of an extended decision-making framework Phase 3. Prepared by NIWA Prepared for Ministry of Business, Innovation and Employment Envirolink Fund.



Water quality monitoring for nutrient management should be undertaken at monthly intervals in order to be consistent with NPS-FM attribute state assessments.

26. Provide an assessment of the cumulative effects of stream loss.

Stream loss in the Macraes area will have resulted in loss of habitat for stream fauna and flora communities. Benthic invertebrate monitoring in the area since the late 1980s has found that the stream invertebrate communities in the area are not unique in any way and generally reflect communities typical of those found in gravel and soft-sediment creeks throughout inland Otago that are set within catchments subject to extensive farming practices. Such streams are often mildly enriched, have historically had little or no riparian protection and are subject to very low flows for extended periods of time, particular in summer/autumn period. Under such circumstances, water in these creeks becomes very warm and slow flowing. The combination of these characteristics provide ideal conditions for the development of periphyton and macrophyte nuisance growths, as has been observed in creeks associated with the Macraes Goldmine surface water monitoring programme for decades.

As such, these creeks have never, since regular monitoring commenced, exhibited characteristics that one could describe as being indicative of good water quality or habitat.

I regard the most significant ecological loss associated with streams and creeks in the Macraes area is that associated with the habitats of the flathead galaxias and koura. Some eel and brown trout habitat would have been lost as well, however these two species have never been found in significant numbers and creeks are always dominated by flatheads and koura.

Under question 23, the creek length lost since modern mining commenced at Macraes was estimated at approximately 8% with another 0.28% associated with DDN III. Assuming, very conservatively, that all of that stream length supported flathead and koura populations, then the losses to the local Macraes populations would equate to 8.28%. However this is likely to be over-estimate given most of the stream channel lost are small headwaters of which some will be ephemeral or intermittent and thus unlikely to support fish populations. Further, larger creeks, such as Deepdell Creek and Highlay Creek support larger populations than appears to be the case for smaller tributaries.

Please let us know if you require any further information.

Yours sincerely,

Greg Ryder
Environmental Scientist
Ryder Environmental Limited

References

McDowell, R.W. *et al*. 2009. *Nitrogen and phosphorus in New Zealand streams and rivers: control and impact of eutrophication and the influence of land management*. NZ Journal of marine and freshwater Research, 2009, Vo.43 985-995

MfE (Ministry for the Environment). 2007. *Lake Water Quality in New Zealand: Status in 2006 and Recent Trends 1990–2006*. Ministry for the Environment, Wellington, New Zealand.

Appendix A

Nutrient data for Deepdell Creek, Highlay Creek and Shag River

Date	DRP Shag R. at Craig Rd. (mg/L)	Date	DRP Shag R. at Goodwood (mg/L)	Date	TP Shag R. at Craig Rd. (mg/L)	Date	TP Shag R. at Goodwood (mg/L)
7/01/04	<0.005	7/01/04	<0.005	7/01/04	<0.005	7/01/04	<0.005
10/02/04	<0.005	10/02/04	<0.005	10/02/04	0.005	10/02/04	0.024
14/04/04	<0.005	14/04/04	<0.005	14/04/04	<0.005	14/04/04	<0.005
10/06/04	0.007	10/06/04	0.007	10/06/04	0.007	10/06/04	0.012
17/08/04	0.006	17/08/04	0.007	17/08/04	0.013	17/08/04	0.012
13/10/04	0.012	13/10/04	0.008	13/10/04	0.018	13/10/04	0.013
14/12/04	0.009	14/12/04	0.006	14/12/04	0.019	14/12/04	0.012
10/02/05	0.011	10/02/05	0.006	10/02/05	0.026	10/02/05	0.017
12/04/05	0.008	12/04/05	<0.005	12/04/05	0.013	12/04/05	0.012
15/06/05	<0.005	15/06/05	<0.005	15/06/05	0.007	15/06/05	<0.005
18/08/05	0.006	18/08/05	0.006	18/08/05	0.008	18/08/05	0.007
11/10/05	0.012	11/10/05	0.006	11/10/05	0.03	11/10/05	0.022
6/12/05	0.01	6/12/05	0.005	6/12/05	0.021	6/12/05	0.017
7/02/06	0.008	7/02/06	0.005	7/02/06	0.014	7/02/06	0.016
20/04/06	0.008	20/04/06	0.006	20/04/06	0.019	20/04/06	0.024
14/06/06	0.01	14/06/06	0.005	14/06/06	0.012	14/06/06	0.012
23/08/06	<0.005	23/08/06	<0.005	23/08/06	<0.05	23/08/06	<0.05
23/08/06		23/08/06		23/08/06		23/08/06	
11/10/06	<0.005	11/10/06	<0.005	11/10/06	0.014	11/10/06	0.013
11/10/06	0.008	11/10/06		11/10/06	0.016	11/10/06	
6/12/06	<0.005	6/12/06	0.006	6/12/06	0.008	6/12/06	0.013
6/12/06		6/12/06		6/12/06	0.033	6/12/06	
15/02/07	0.008	15/02/07	0.008	15/02/07	0.01	15/02/07	0.011
15/02/07	0.005	15/02/07		15/02/07	0.008	15/02/07	
30/04/07	<0.005	30/04/07	0.006	30/04/07	0.015	30/04/07	0.015
30/04/07	0.008	30/04/07		30/04/07	0.008	30/04/07	

Date	DRP Shag R. at Craig Rd. (mg/L)	Date	DRP Shag R. at Goodwood (mg/L)	Date	TP Shag R. at Craig Rd. (mg/L)	Date	TP Shag R. at Goodwood (mg/L)
25/06/07	0.006	25/06/07		25/06/07	<0.005	25/06/07	
25/06/07		25/06/07		25/06/07		25/06/07	
11/09/07	<0.005	11/09/07	<0.005	11/09/07	0.011	11/09/07	0.009
11/09/07	0.007	11/09/07		11/09/07	0.007	11/09/07	
7/11/07	<0.005	7/11/07	0.005	7/11/07	0.013	7/11/07	0.012
7/11/07	0.008	7/11/07		7/11/07		7/11/07	
16/01/08	0.009	16/01/08	0.008	16/01/08	0.018	16/01/08	0.018
16/01/08	0.005	16/01/08		16/01/08	0.017	16/01/08	
26/02/08	0.007	26/02/08	0.006	26/02/08	0.016	26/02/08	0.016
26/02/08	<0.005	26/02/08		26/02/08	0.009	26/02/08	
5/05/08	0.01	5/05/08	0.009	5/05/08	0.012	5/05/08	0.015
5/05/08	0.006	5/05/08	0.006	5/05/08	0.014	5/05/08	0.017
10/07/08	0.007	10/07/08	0.014	10/07/08	0.009	10/07/08	0.039
27/08/08	0.012	27/08/08		27/08/08	0.038	27/08/08	0.023
13/11/08	0.006	13/11/08	0.009	13/11/08	0.013	13/11/08	
15/01/09	0.008	15/01/09	0.013	15/01/09	0.011	15/01/09	0.015
12/03/09		12/03/09	0.01	12/03/09		12/03/09	0.017
6/05/09	0.007	6/05/09		6/05/09	0.009	6/05/09	
14/07/09	0.012	14/07/09	0.013	14/07/09	0.018	14/07/09	0.022
16/09/09	<0.005	16/09/09	0.005	16/09/09	0.008	16/09/09	0.011
10/11/09	<0.005	10/11/09	0.008	10/11/09	0.01	10/11/09	0.016
27/01/10	0.006	27/01/10	0.007	27/01/10	0.012	27/01/10	0.013
24/03/10		24/03/10		24/03/10		24/03/10	
27/04/10	<0.005	27/04/10		27/04/10		27/04/10	
12/05/10	0.005	12/05/10	0.009	12/05/10	0.006	12/05/10	0.009
22/07/10	0.005	22/07/10	0.007	22/07/10	0.008	22/07/10	0.009
10/11/10	0.006	10/11/10	0.007	10/11/10	0.01	10/11/10	0.016
12/01/11	0.006	12/01/11	0.008	12/01/11	0.013	12/01/11	0.019
8/03/11	0.006	8/03/11	0.012	8/03/11	0.01	8/03/11	0.014
26/05/11	0.011	26/05/11	0.014	26/05/11	0.013	26/05/11	0.018

Date	DRP Shag R. at Craig Rd. (mg/L)	Date	DRP Shag R. at Goodwood (mg/L)	Date	TP Shag R. at Craig Rd. (mg/L)	Date	TP Shag R. at Goodwood (mg/L)
3/08/11	<0.004	3/08/11	<0.004	3/08/11	0.004	3/08/11	0.004
28/09/11	<0.004	28/09/11	<0.004	28/09/11	<0.004	28/09/11	<0.004
29/11/11	<0.004	29/11/11	<0.004	29/11/11	0.015	29/11/11	0.009
1/02/12	<0.004	1/02/12	0.004	1/02/12	0.007	1/02/12	0.01
27/03/12	0.005	27/03/12	<0.004	27/03/12	0.006	27/03/12	0.009
30/05/12	<0.004	30/05/12	0.006	30/05/12	<0.004	30/05/12	0.006
4/07/12	<0.004	4/07/12	<0.004	4/07/12	<0.004	4/07/12	0.006
7/08/12	0.012	7/08/12	0.013	7/08/12	0.028	7/08/12	0.022
6/09/12	0.008	6/09/12	0.011	6/09/12	0.013	6/09/12	0.018
4/10/12	<0.004	4/10/12	<0.004	4/10/12	0.01	4/10/12	0.011
8/10/12		8/10/12	0.011	8/10/12		8/10/12	0.031
19/10/12	<0.004	19/10/12	<0.004	19/10/12	0.018	19/10/12	0.011
31/10/12	<0.004	31/10/12	0.005	31/10/12	0.012	31/10/12	0.014
6/11/12	<0.004	6/11/12	<0.004	6/11/12	<0.004	6/11/12	0.005
12/11/12	<0.004	12/11/12	0.008	12/11/12	0.033	12/11/12	0.025
28/11/12	<0.004	28/11/12	<0.004	28/11/12	<0.004	28/11/12	0.006
6/12/12		6/12/12	0.005	6/12/12		6/12/12	0.016
11/12/12	<0.004	11/12/12	<0.004	11/12/12	0.01	11/12/12	0.016
14/01/13	<0.004	14/01/13	0.006	14/01/13	0.006	14/01/13	0.013
18/01/13	0.008	18/01/13	0.006	18/01/13	0.04	18/01/13	0.039
30/01/13	<0.004	30/01/13	<0.004	30/01/13	0.005	30/01/13	0.014
13/02/13	<0.004	13/02/13	<0.004	13/02/13	0.007	13/02/13	0.012
13/02/13		13/02/13	0.007	13/02/13		13/02/13	0.012
27/02/13	<0.004	27/02/13	0.006	27/02/13	0.026	27/02/13	0.016
12/03/13	0.005	12/03/13	<0.004	12/03/13	0.006	12/03/13	0.012
13/03/13	0.006	13/03/13	0.008	13/03/13	0.006	13/03/13	0.012
26/03/13	<0.004	26/03/13	0.009	26/03/13	0.006	26/03/13	0.01
8/04/13	<0.004	8/04/13	0.009	8/04/13	<0.004	8/04/13	0.012
17/04/13		17/04/13	0.012	17/04/13		17/04/13	0.012
23/04/13	<0.004	23/04/13	<0.004	23/04/13	0.01	23/04/13	0.01
9/05/13	0.008	9/05/13	0.009	9/05/13	0.011	9/05/13	0.017

Date	DRP Shag R. at Craig Rd. (mg/L)	Date	DRP Shag R. at Goodwood (mg/L)	Date	TP Shag R. at Craig Rd. (mg/L)	Date	TP Shag R. at Goodwood (mg/L)
22/05/13	0.019	22/05/13	0.016	22/05/13	0.048	22/05/13	0.033
30/05/13	0.009	30/05/13	0.01	30/05/13	0.007	30/05/13	0.017
7/06/13	0.014	7/06/13	0.015	7/06/13	0.025	7/06/13	0.022
10/07/13	0.012	10/07/13	0.013	10/07/13	0.021	10/07/13	0.017
25/07/13	0.01	25/07/13	0.012	25/07/13	0.013	25/07/13	0.01
8/08/13	0.009	8/08/13	0.009	8/08/13	0.009	8/08/13	0.013
23/08/13	0.007	23/08/13	0.008	23/08/13	0.013	23/08/13	0.022
28/08/13	<0.004	28/08/13	0.005	28/08/13	0.006	28/08/13	0.014
5/09/13	<0.004	5/09/13	0.006	5/09/13	<0.004	5/09/13	0.015
20/09/13	<0.004	20/09/13	0.004	20/09/13	<0.004	20/09/13	<0.004
24/09/13	<0.004	24/09/13	<0.004	24/09/13	0.005	24/09/13	0.011
22/10/13	<0.004	22/10/13	0.006	22/10/13	0.005	22/10/13	0.01
25/11/13	0.006	25/11/13	0.012	25/11/13	0.008	25/11/13	0.017
17/12/13	<0.004	17/12/13	0.009	17/12/13	<0.004	17/12/13	0.01
29/01/14	0.005	29/01/14	0.012	29/01/14	0.006	29/01/14	0.016
27/02/14	<0.004	27/02/14	0.011	27/02/14	0.009	27/02/14	0.018
27/03/14	<0.004	27/03/14	0.007	27/03/14	0.004	27/03/14	0.007
7/05/14	0.014	7/05/14	0.013	7/05/14	0.021	7/05/14	0.018
13/06/14	0.012	13/06/14	0.013	13/06/14	0.019	13/06/14	0.021
10/07/14	<0.004	10/07/14	0.004	10/07/14	<0.004	10/07/14	0.005
18/08/14	0.002	18/08/14	0.005	18/08/14	0.005	18/08/14	0.008
16/09/14	0.003	16/09/14	0.006	16/09/14	0.011	16/09/14	0.013
28/10/14	0.005	28/10/14	0.009	28/10/14	0.01	28/10/14	0.013
25/11/14	0.006	25/11/14	0.01	25/11/14	0.013	25/11/14	0.02
16/12/14	0.007	16/12/14	0.007	16/12/14	0.014	16/12/14	0.02
30/01/15	0.006	30/01/15	0.011	30/01/15	0.009	30/01/15	0.016
2/03/15	0.005	2/03/15	0.004	2/03/15	0.008	2/03/15	0.013
25/03/15	0.004	25/03/15	0.005	25/03/15	0.006	25/03/15	0.01
21/04/15	0.005	21/04/15	0.006	21/04/15	0.009	21/04/15	0.013
20/05/15	0.004	20/05/15	0.007	20/05/15	<0.004	20/05/15	0.007
17/06/15	0.008	17/06/15	0.01	17/06/15	0.006	17/06/15	0.01
22/07/15	0.004	22/07/15	0.005	22/07/15	0.004	22/07/15	0.006
28/08/15	0.004	28/08/15	0.006	28/08/15	0.004	28/08/15	0.006

Date	DRP Shag R. at Craig Rd. (mg/L)	Date	DRP Shag R. at Goodwood (mg/L)	Date	TP Shag R. at Craig Rd. (mg/L)	Date	TP Shag R. at Goodwood (mg/L)
25/09/15	0.004	25/09/15	0.004	25/09/15	0.005	25/09/15	0.008
27/10/15	0.003	27/10/15	0.005	27/10/15	0.004	27/10/15	0.012
24/11/15	0.005	24/11/15	0.006	24/11/15	0.008	24/11/15	0.011
18/12/15	0.005	18/12/15	0.005	18/12/15	0.008	18/12/15	0.013
26/01/16	0.004	26/01/16	0.005	26/01/16	0.013	26/01/16	0.038
25/02/16	0.003	25/02/16	0.005	25/02/16	0.006	25/02/16	0.019
22/03/16	0.004	22/03/16	0.007	22/03/16	0.008	22/03/16	0.017
26/04/16	0.005	26/04/16	0.011	26/04/16	0.006	26/04/16	0.01
26/05/16	0.009	26/05/16	0.008	26/05/16	0.022	26/05/16	0.022
21/06/16	0.006	21/06/16	0.008	21/06/16	0.008	21/06/16	0.01
26/07/16	0.007	26/07/16	0.007	26/07/16	0.017	26/07/16	0.015
24/08/16	0.003	24/08/16	0.004	24/08/16	0.008	24/08/16	0.007
20/09/16	0.003	20/09/16	0.004	20/09/16	0.008	20/09/16	0.008
21/10/16	0.007	21/10/16	0.006	21/10/16	0.042	21/10/16	0.012
29/11/16	0.007	29/11/16	0.007	29/11/16	0.027	29/11/16	0.016
22/12/16	0.005	22/12/16	0.007	22/12/16	0.014	22/12/16	0.018
24/01/17	0.006	24/01/17	0.008	24/01/17	0.014	24/01/17	0.017
27/02/17	0.003	27/02/17	0.005	27/02/17	0.007	27/02/17	0.009
28/03/17	0.004	28/03/17	0.005	28/03/17	0.007	28/03/17	0.013
21/04/17	0.01	21/04/17	0.011	21/04/17	0.018	21/04/17	0.015
29/05/17	0.005	29/05/17	0.007	29/05/17	0.008	29/05/17	0.011
29/06/17	0.006	29/06/17	0.005	29/06/17	0.007	29/06/17	0.008
19/07/17		19/07/17		19/07/17		19/07/17	
31/07/17	0.013	31/07/17	0.014	31/07/17	0.028	31/07/17	0.026
2/08/17		2/08/17		2/08/17		2/08/17	
8/08/17		8/08/17		8/08/17		8/08/17	
16/08/17	0.0068	16/08/17		16/08/17	0.012	16/08/17	
22/08/17	0.0064	22/08/17	0.0051	22/08/17	0.011	22/08/17	0.009
30/08/17		30/08/17		30/08/17		30/08/17	
4/09/17		4/09/17		4/09/17		4/09/17	
12/09/17	0.0024	12/09/17		12/09/17	<0.004	12/09/17	
20/09/17		20/09/17		20/09/17		20/09/17	0.009
26/09/17	0.0037	26/09/17	0.0029	26/09/17	0.008	26/09/17	0.005

Date	DRP Shag R. at Craig Rd. (mg/L)	Date	DRP Shag R. at Goodwood (mg/L)	Date	TP Shag R. at Craig Rd. (mg/L)	Date	TP Shag R. at Goodwood (mg/L)
11/10/17		11/10/17		11/10/17		11/10/17	
19/10/17	0.0023	19/10/17		19/10/17	<0.004	19/10/17	0.007
24/10/17	0.0012	24/10/17	0.0013	24/10/17	0.008	24/10/17	
31/10/17		31/10/17		31/10/17		31/10/17	
9/11/17		9/11/17		9/11/17		9/11/17	
17/11/17	0.0025	17/11/17		17/11/17	0.005	17/11/17	
23/11/17	<0.001	23/11/17	0.0025	23/11/17	0.005	23/11/17	0.008
27/11/17		27/11/17		27/11/17		27/11/17	
4/12/17		4/12/17		4/12/17		4/12/17	
13/12/17	0.0031	13/12/17		13/12/17	0.009	13/12/17	
19/12/17	<0.001	19/12/17	0.0013	19/12/17	<0.004	19/12/17	0.01
21/12/17		21/12/17		21/12/17		21/12/17	
4/01/18		4/01/18		4/01/18		4/01/18	
11/01/18		11/01/18		11/01/18		11/01/18	
15/01/18	0.0046	15/01/18		15/01/18	0.007	15/01/18	
23/01/18	0.0023	23/01/18	<0.001	23/01/18	0.009	23/01/18	0.028
19/02/18	0.0029	19/02/18		19/02/18	<0.004	19/02/18	
26/02/18	0.0158	26/02/18	0.0149	26/02/18	0.035	26/02/18	0.007
5/03/18		5/03/18		5/03/18		5/03/18	
14/03/18	<0.004	14/03/18		14/03/18	0.007	14/03/18	
27/03/18	<0.004	27/03/18	<0.004	27/03/18	0.018	27/03/18	0.098
14/03/18		14/03/18		14/03/18		14/03/18	
17/04/18	<0.004	17/04/18		17/04/18	0.008	17/04/18	
1/05/18	0.018	1/05/18	0.018	1/05/18	0.113	1/05/18	0.008
8/05/18		8/05/18		8/05/18		8/05/18	
21/05/18	0.004	21/05/18		21/05/18	0.01	21/05/18	
28/05/18	0.005	28/05/18	0.005	28/05/18	<0.004	28/05/18	0.01
20/06/18	<0.004	20/06/18		20/06/18	0.005	20/06/18	
26/06/18	0.005	26/06/18	<0.004	26/06/18	<0.004	26/06/18	0.007
17/07/18	<0.004	17/07/18		17/07/18	0.005	17/07/18	
23/07/18	<0.004	23/07/18	0.005	23/07/18	0.005	23/07/18	0.006
13/08/18	0.004	13/08/18		13/08/18	0.004	13/08/18	
30/08/18	0.004	30/08/18	0.004	30/08/18	0.006	30/08/18	0.064

Date	DRP Shag R. at Craig Rd. (mg/L)	Date	DRP Shag R. at Goodwood (mg/L)	Date	TP Shag R. at Craig Rd. (mg/L)	Date	TP Shag R. at Goodwood (mg/L)
19/09/18	0.004	19/09/18		19/09/18	0.009	19/09/18	
25/09/18	0.004	25/09/18	0.013	25/09/18	0.013	25/09/18	0.01
23/10/18	0.01	23/10/18	0.004	23/10/18	0.01	23/10/18	0.036
30/11/18	0.015	30/11/18	0.013	30/11/18	0.034	30/11/18	0.19
19/12/18	0.016	19/12/18	0.024	19/12/18	0.178	19/12/18	0.008
22/01/19	0.004	22/01/19	0.004	22/01/19	0.006	22/01/19	0.006
28/02/19	0.004	28/02/19	0.004	28/02/19	0.005	28/02/19	0.074
28/03/19	0.004	28/03/19	0.004	28/03/19	0.004	28/03/19	0.012
30/04/19	0.004	30/04/19	0.004	30/04/19	0.004	30/04/19	0.007
27/05/19	0.004	27/05/19	0.004	27/05/19	0.004	27/05/19	0.004
25/06/19	0.004	25/06/19	0.004	25/06/19	0.004	25/06/19	0.015
30/07/19	0.0074	30/07/19	0.0074	30/07/19	0.022	30/07/19	0.004
29/08/19	0.0042	29/08/19	0.005	29/08/19	0.004	29/08/19	0.006
24/09/19	0.003	24/09/19	0.0043	24/09/19	0.006	24/09/19	0.01
29/10/19	0.0048	29/10/19	0.0051	29/10/19	0.008	29/10/19	0.011
26/11/19	0.0039	26/11/19	0.0034	26/11/19	0.01	26/11/19	0.009
17/12/19	0.0044	17/12/19	0.0052	17/12/19	0.009	17/12/19	0.012
28/01/20	0.0057	28/01/20	0.0044	28/01/20	0.011	28/01/20	

Date	TON Shag R. at Craig Rd. (mg/L)	Date	TON Shag R. at Goodwood (mg/L)	Date	TN Shag R. at Craig Rd. (mg/L)	Date	TN Shag R. at Goodwood (mg/L)
7/01/04	0.029	7/01/04	0.021	7/01/04	0.18	7/01/04	0.2
10/02/04	0.01	10/02/04	0.268	10/02/04	0.13	10/02/04	0.55
14/04/04	0.008	14/04/04	0.087	14/04/04	0.09	14/04/04	0.22
10/06/04	0.007	10/06/04	0.196	10/06/04	0.11	10/06/04	0.32
17/08/04	0.048	17/08/04	0.321	17/08/04	0.23	17/08/04	0.51
13/10/04	0.006	13/10/04	0.132	13/10/04	0.15	13/10/04	0.31
14/12/04	0.007	14/12/04	0.03	14/12/04	0.94	14/12/04	0.2
10/02/05	0.01	10/02/05	0.018	10/02/05	0.24	10/02/05	0.13

Date	TON Shag R. at Craig Rd. (mg/L)	Date	TON Shag R. at Goodwood (mg/L)	Date	TN Shag R. at Craig Rd. (mg/L)	Date	TN Shag R. at Goodwood (mg/L)
12/04/05	0.008	12/04/05	0.035	12/04/05	0.15	12/04/05	0.2
15/06/05	0.01	15/06/05	0.124	15/06/05	0.07	15/06/05	0.23
18/08/05	0.009	18/08/05	0.087	18/08/05	0.12	18/08/05	0.21
11/10/05	0.089	11/10/05	0.057	11/10/05	0.47	11/10/05	0.39
6/12/05	0.015	6/12/05	0.035	6/12/05	0.17	6/12/05	0.18
7/02/06	0.011	7/02/06	<0.005	7/02/06	0.15	7/02/06	0.15
20/04/06	0.011	20/04/06	0.028	20/04/06	0.36	20/04/06	0.31
14/06/06	0.048	14/06/06	0.218	14/06/06	0.26	14/06/06	0.35
23/08/06	<0.005	23/08/06	<0.005	23/08/06	0.14	23/08/06	0.33
23/08/06		23/08/06		23/08/06		23/08/06	
11/10/06	0.02	11/10/06		11/10/06	<0.05	11/10/06	
11/10/06	0.019	11/10/06		11/10/06	0.2	11/10/06	
6/12/06	<0.005	6/12/06	0.098	6/12/06	0.18	6/12/06	0.26
6/12/06		6/12/06		6/12/06	0.19	6/12/06	
15/02/07	0.009	15/02/07	0.078	15/02/07	0.14	15/02/07	0.22
15/02/07	0.015	15/02/07		15/02/07	0.16	15/02/07	
30/04/07	0.006	30/04/07	0.154	30/04/07	0.17	30/04/07	0.26
30/04/07	0.008	30/04/07		30/04/07	0.09	30/04/07	0.32
25/06/07	0.023	25/06/07	0.228	25/06/07	0.08	25/06/07	0.58
25/06/07	0.012	25/06/07		25/06/07	0.09	25/06/07	
11/09/07	0.038	11/09/07	0.371	11/09/07	0.22	11/09/07	
11/09/07	0.137	11/09/07		11/09/07	0.33	11/09/07	
7/11/07	0.013	7/11/07	0.259	7/11/07	0.18	7/11/07	0.43
7/11/07	0.091	7/11/07		7/11/07	0.27	7/11/07	
16/01/08	0.046	16/01/08	0.302	16/01/08	0.26	16/01/08	0.45
16/01/08	0.02	16/01/08		16/01/08	0.17	16/01/08	
26/02/08	0.009	26/02/08	0.113	26/02/08	0.18	26/02/08	0.27
26/02/08	0.011	26/02/08		26/02/08	0.22	26/02/08	
5/05/08	0.038	5/05/08	0.237	5/05/08	0.2	5/05/08	0.38
5/05/08	0.028	5/05/08		5/05/08	0.22	5/05/08	

Date	TON Shag R. at Craig Rd. (mg/L)	Date	TON Shag R. at Goodwood (mg/L)	Date	TN Shag R. at Craig Rd. (mg/L)	Date	TN Shag R. at Goodwood (mg/L)
10/07/08	0.008	10/07/08	0.126	10/07/08	0.14	10/07/08	0.28
27/08/08	0.193	27/08/08	0.262	27/08/08	0.55	27/08/08	0.66
13/11/08	0.165	13/11/08	0.505	13/11/08	0.35	13/11/08	0.76
15/01/09	0.075	15/01/09	0.484	15/01/09	0.24	15/01/09	0.61
12/03/09	0.061	12/03/09	0.581	12/03/09	0.26	12/03/09	0.76
6/05/09	0.062	6/05/09	0.52	6/05/09	0.2	6/05/09	0.69
14/07/09	0.418	14/07/09	0.587	14/07/09	0.73	14/07/09	0.9
16/09/09	0.09	16/09/09	0.486	16/09/09	0.27	16/09/09	0.7
10/11/09	0.071	10/11/09	0.296	10/11/09	0.15	10/11/09	0.38
27/01/10	0.025	27/01/10	0.32	27/01/10	0.2	27/01/10	0.51
24/03/10	0.016	24/03/10	0.026	24/03/10	0.14	24/03/10	0.16
27/04/10	0.009	27/04/10		27/04/10		27/04/10	
12/05/10	0.01	12/05/10	0.9	12/05/10	0.13	12/05/10	1.03
22/07/10	0.517	22/07/10	1.02	22/07/10	0.74	22/07/10	1.28
10/11/10	0.187	10/11/10	0.496	10/11/10	0.36	10/11/10	0.69
12/01/11	0.054	12/01/11	0.236	12/01/11	0.27	12/01/11	0.47
8/03/11	0.007	8/03/11	0.067	8/03/11	0.19	8/03/11	0.25
26/05/11	0.275	26/05/11	0.368	26/05/11	0.53	26/05/11	0.66
3/08/11	0.127	3/08/11	0.154	3/08/11	0.32	3/08/11	0.33
28/09/11	0.01	28/09/11	0.088	28/09/11	0.24	28/09/11	0.34
29/11/11	0.018	29/11/11	0.105	29/11/11	0.24	29/11/11	0.34
1/02/12	0.014	1/02/12	0.145	1/02/12	0.23	1/02/12	0.35
27/03/12	0.007	27/03/12	0.083	27/03/12	0.18	27/03/12	0.29
30/05/12	0.044	30/05/12	0.26	30/05/12	0.14	30/05/12	0.35
4/07/12	0.081	4/07/12	0.28	4/07/12	0.2	4/07/12	0.38
7/08/12	0.46	7/08/12	0.58	7/08/12	0.72	7/08/12	0.84
6/09/12	0.85	6/09/12	1.27	6/09/12	1.08	6/09/12	1.56
4/10/12	0.165	4/10/12	0.52	4/10/12	0.43	4/10/12	0.72
8/10/12		8/10/12	0.52	8/10/12		8/10/12	0.69
19/10/12	0.074	19/10/12	0.26	19/10/12	0.3	19/10/12	0.48

Date	TON Shag R. at Craig Rd. (mg/L)	Date	TON Shag R. at Goodwood (mg/L)	Date	TN Shag R. at Craig Rd. (mg/L)	Date	TN Shag R. at Goodwood (mg/L)
31/10/12	0.064	31/10/12	0.33	31/10/12	0.32	31/10/12	0.56
6/11/12	0.082	6/11/12	0.33	6/11/12	0.25	6/11/12	0.5
12/11/12	0.067	12/11/12	0.31	12/11/12	0.47	12/11/12	0.68
28/11/12	0.041	28/11/12	0.22	28/11/12	0.26	28/11/12	0.4
6/12/12		6/12/12	0.29	6/12/12		6/12/12	0.48
11/12/12	0.097	11/12/12	0.29	11/12/12	0.34	11/12/12	0.46
14/01/13	0.046	14/01/13	0.22	14/01/13	0.25	14/01/13	0.44
18/01/13	0.105	18/01/13	0.185	18/01/13	0.55	18/01/13	0.63
30/01/13	0.023	30/01/13	0.148	30/01/13	0.19	30/01/13	0.3
13/02/13	0.05	13/02/13	0.22	13/02/13	0.15	13/02/13	0.34
13/02/13		13/02/13	0.23	13/02/13		13/02/13	0.33
27/02/13	0.101	27/02/13	0.22	27/02/13	0.23	27/02/13	0.28
12/03/13	0.081	12/03/13	0.21	12/03/13	0.15	12/03/13	0.31
13/03/13	0.087	13/03/13	0.26	13/03/13	0.23	13/03/13	0.42
26/03/13	0.089	26/03/13	0.22	26/03/13	0.36	26/03/13	0.52
8/04/13	0.046	8/04/13	0.27	8/04/13	0.19	8/04/13	0.39
17/04/13		17/04/13	0.2	17/04/13		17/04/13	0.37
23/04/13	0.076	23/04/13	0.34	23/04/13	0.22	23/04/13	0.54
9/05/13	0.21	9/05/13	0.29	9/05/13	0.43	9/05/13	0.5
22/05/13	0.37	22/05/13	0.48	22/05/13	0.74	22/05/13	0.82
30/05/13	0.43	30/05/13	0.66	30/05/13	0.61	30/05/13	0.88
7/06/13	0.54	7/06/13	0.66	7/06/13	0.92	7/06/13	0.93
10/07/13	0.9	10/07/13	1.21	10/07/13	1.29	10/07/13	1.66
25/07/13	0.72	25/07/13	1.11	25/07/13	0.96	25/07/13	1.38
8/08/13	0.59	8/08/13	1.08	8/08/13	0.84	8/08/13	1.27
23/08/13	0.29	23/08/13	0.68	23/08/13	0.49	23/08/13	0.88
28/08/13	0.25	28/08/13	0.7	28/08/13	0.39	28/08/13	0.85
5/09/13	0.134	5/09/13	0.44	5/09/13	0.31	5/09/13	0.66
20/09/13	0.104	20/09/13	0.5	20/09/13	0.28	20/09/13	0.65
24/09/13	0.133	24/09/13	0.54	24/09/13	0.32	24/09/13	0.75
22/10/13	0.095	22/10/13	0.37	22/10/13	0.3	22/10/13	0.6
25/11/13	0.181	25/11/13	0.46	25/11/13	0.38	25/11/13	0.64

Date	TON Shag R. at Craig Rd. (mg/L)	Date	TON Shag R. at Goodwood (mg/L)	Date	TN Shag R. at Craig Rd. (mg/L)	Date	TN Shag R. at Goodwood (mg/L)
17/12/13	0.086	17/12/13	0.35	17/12/13	0.19	17/12/13	0.48
29/01/14	0.039	29/01/14	0.177	29/01/14	0.2	29/01/14	0.33
27/02/14	0.075	27/02/14	0.28	27/02/14	0.19	27/02/14	0.41
27/03/14	0.013	27/03/14	0.059	27/03/14	0.12	27/03/14	0.16
7/05/14	0.6	7/05/14	0.76	7/05/14	0.9	7/05/14	1.07
13/06/14	0.36	13/06/14	0.52	13/06/14	0.62	13/06/14	0.75
10/07/14	0.3	10/07/14	0.48	10/07/14	0.49	10/07/14	0.68
18/08/14	0.094	18/08/14	0.24	18/08/14	0.23	18/08/14	0.35
16/09/14	0.13	16/09/14	0.31	16/09/14	0.37	16/09/14	0.49
28/10/14	0.11	28/10/14	0.26	28/10/14	0.29	28/10/14	0.37
25/11/14	0.12	25/11/14	0.2	25/11/14	0.27	25/11/14	0.39
16/12/14	0.072	16/12/14	0.13	16/12/14	0.17	16/12/14	0.25
30/01/15	0.061	30/01/15	0.018	30/01/15	0.18	30/01/15	0.15
2/03/15	0.028	2/03/15	0.034	2/03/15	0.17	2/03/15	0.27
25/03/15	0.012	25/03/15	0.043	25/03/15	0.15	25/03/15	0.2
21/04/15	0.0062	21/04/15	0.047	21/04/15	0.11	21/04/15	0.15
20/05/15	0.0089	20/05/15	0.064	20/05/15	0.069	20/05/15	0.13
17/06/15	0.3	17/06/15	0.3	17/06/15	0.44	17/06/15	0.59
22/07/15	0.066	22/07/15	0.17	22/07/15	0.22	22/07/15	0.31
28/08/15	0.023	28/08/15	0.13	28/08/15	0.16	28/08/15	0.27
25/09/15	0.011	25/09/15	0.029	25/09/15	0.12	25/09/15	0.13
27/10/15	0.032	27/10/15	0.049	27/10/15	0.15	27/10/15	0.16
24/11/15	0.056	24/11/15	0.018	24/11/15	0.11	24/11/15	0.084
18/12/15	0.043	18/12/15	<0.002	18/12/15	0.1	18/12/15	0.073
26/01/16	0.018	26/01/16	0.013	26/01/16	0.17	26/01/16	0.15
25/02/16	0.021	25/02/16	0.0033	25/02/16	0.028	25/02/16	0.046
22/03/16	0.016	22/03/16	0.01	22/03/16	0.12	22/03/16	0.14
26/04/16	0.0083	26/04/16	0.0067	26/04/16	0.098	26/04/16	0.11
26/05/16	1.1	26/05/16	1	26/05/16	1.5	26/05/16	1.3
21/06/16	0.097	21/06/16	0.25	21/06/16	0.23	21/06/16	0.36
26/07/16	0.49	26/07/16	0.44	26/07/16	0.87	26/07/16	0.78
24/08/16	0.18	24/08/16	0.34	24/08/16	0.43	24/08/16	0.6
20/09/16	0.039	20/09/16	0.14	20/09/16	0.28	20/09/16	0.36

Date	TON Shag R. at Craig Rd. (mg/L)	Date	TON Shag R. at Goodwood (mg/L)	Date	TN Shag R. at Craig Rd. (mg/L)	Date	TN Shag R. at Goodwood (mg/L)
21/10/16	0.019	21/10/16	0.079	21/10/16	0.39	21/10/16	0.3
29/11/16	0.084	29/11/16	0.21	29/11/16	0.31	29/11/16	0.42
22/12/16	0.037	22/12/16	0.11	22/12/16	0.22	22/12/16	0.27
24/01/17	0.018	24/01/17	0.043	24/01/17	0.26	24/01/17	0.27
27/02/17	0.027	27/02/17	0.0057	27/02/17	0.18	27/02/17	0.17
28/03/17	0.018	28/03/17	0.027	28/03/17	0.18	28/03/17	0.23
21/04/17	0.19	21/04/17	0.38	21/04/17	0.5	21/04/17	0.68
29/05/17	0.084	29/05/17	0.19	29/05/17	0.26	29/05/17	0.37
29/06/17	0.051	29/06/17	0.13	29/06/17	0.22	29/06/17	0.3
19/07/17	0.082	19/07/17		19/07/17		19/07/17	
31/07/17	0.91	31/07/17	1.2	31/07/17	1.2	31/07/17	1.4
2/08/17	0.79	2/08/17		2/08/17		2/08/17	
8/08/17	0.73	8/08/17		8/08/17		8/08/17	
16/08/17	0.46	16/08/17		16/08/17	0.71	16/08/17	
22/08/17	0.39	22/08/17	0.59	22/08/17	0.56	22/08/17	0.82
30/08/17	0.33	30/08/17		30/08/17	0.32	30/08/17	
4/09/17	0.24	4/09/17		4/09/17		4/09/17	
12/09/17	0.17	12/09/17		12/09/17		12/09/17	
20/09/17	0.33	20/09/17		20/09/17		20/09/17	
26/09/17	0.25	26/09/17	0.41	26/09/17	0.5	26/09/17	0.65
11/10/17	0.143	11/10/17		11/10/17		11/10/17	
19/10/17	0.102	19/10/17		19/10/17	0.29	19/10/17	
24/10/17	0.115	24/10/17	0.28	24/10/17	0.27	24/10/17	0.45
31/10/17	0.099	31/10/17		31/10/17		31/10/17	
9/11/17	0.092	9/11/17		9/11/17		9/11/17	
17/11/17	0.146	17/11/17		17/11/17	0.33	17/11/17	
23/11/17	0.192	23/11/17	0.36	23/11/17	0.39	23/11/17	0.55
27/11/17	0.191	27/11/17		27/11/17		27/11/17	
4/12/17	0.162	4/12/17		4/12/17		4/12/17	
13/12/17	0.135	13/12/17		13/12/17		13/12/17	0.25
19/12/17	0.071	19/12/17	0.29	19/12/17	0.24	19/12/17	0.46
21/12/17	0.066	21/12/17		21/12/17		21/12/17	
4/01/18	0.13	4/01/18		4/01/18		4/01/18	

Date	TON Shag R. at Craig Rd. (mg/L)	Date	TON Shag R. at Goodwood (mg/L)	Date	TN Shag R. at Craig Rd. (mg/L)	Date	TN Shag R. at Goodwood (mg/L)
11/01/18	0.127	11/01/18		11/01/18		11/01/18	
15/01/18	0.134	15/01/18		15/01/18	0.28	15/01/18	
23/01/18	0.126	23/01/18	0.188	23/01/18	0.27	23/01/18	0.35
19/02/18	0.094	19/02/18		19/02/18	0.23	19/02/18	
26/02/18	0.55	26/02/18	0.72	26/02/18	0.93	26/02/18	1.11
5/03/18	0.26	5/03/18		5/03/18		5/03/18	
14/03/18	0.115	14/03/18		14/03/18	0.36	14/03/18	
27/03/18	0.145	27/03/18	0.2	27/03/18	0.47	27/03/18	0.53
14/03/18	0.115	14/03/18		14/03/18		14/03/18	
17/04/18	0.074	17/04/18		17/04/18	0.29	17/04/18	
1/05/18	0.63	1/05/18	0.72	1/05/18	1.29	1/05/18	1.46
8/05/18	0.52	8/05/18		8/05/18		8/05/18	
21/05/18	0.45	21/05/18		21/05/18	0.7	21/05/18	
28/05/18	0.33	28/05/18	0.43	28/05/18	0.57	28/05/18	0.69
20/06/18	0.22	20/06/18		20/06/18	0.39	20/06/18	
26/06/18	0.24	26/06/18	0.39	26/06/18	0.4	26/06/18	0.57
17/07/18	0.197	17/07/18		17/07/18	0.32	17/07/18	
23/07/18	0.189	23/07/18	0.37	23/07/18	0.37	23/07/18	0.55
13/08/18	0.24	13/08/18		13/08/18	0.43	13/08/18	
30/08/18	0.28	30/08/18	0.44	30/08/18	0.48	30/08/18	0.65
19/09/18	0.24	19/09/18		19/09/18	0.45	19/09/18	
25/09/18	0.197	25/09/18	0.4	25/09/18	0.44	25/09/18	1
23/10/18	0.177	23/10/18	0.28	23/10/18	0.4	23/10/18	0.51
30/11/18	0.6	30/11/18	0.74	30/11/18	1.01	30/11/18	1.16
19/12/18	0.31	19/12/18	0.189	19/12/18	1.93	19/12/18	1.99
22/01/19	0.156	22/01/19	0.26	22/01/19	0.42	22/01/19	0.53
28/02/19	0.157	28/02/19	0.36	28/02/19	0.32	28/02/19	0.52
28/03/19	0.173	28/03/19	0.33	28/03/19	0.33	28/03/19	0.5
30/04/19	0.04	30/04/19	0.28	30/04/19	0.199	30/04/19	0.5
27/05/19	0.1	27/05/19	0.25	27/05/19	0.24	27/05/19	0.34
25/06/19	0.08	25/06/19	0.21	25/06/19	0.195	25/06/19	0.33
30/07/19	0.42	30/07/19	0.51	30/07/19	0.61	30/07/19	0.7
29/08/19	0.24	29/08/19	0.38	29/08/19	0.41	29/08/19	0.56

Date	TON Shag R. at Craig Rd. (mg/L)	Date	TON Shag R. at Goodwood (mg/L)	Date	TN Shag R. at Craig Rd. (mg/L)	Date	TN Shag R. at Goodwood (mg/L)
24/09/19	0.136	24/09/19	0.26	24/09/19	0.32	24/09/19	0.46
29/10/19	0.07	29/10/19	0.138	29/10/19	0.28	29/10/19	0.35
26/11/19	0.042	26/11/19	0.059	26/11/19	0.24	26/11/19	0.26
17/12/19	0.116	17/12/19	0.141	17/12/19	0.28	17/12/19	0.3
28/01/20	0.112	28/01/20	0.113	28/01/20	0.25	28/01/20	0.26

Date	NH4-N Shag R. at Craig Rd. (mg/L)	Date	NH4-NN Shag R. at Goodwood (mg/L)
7/01/04	0.01	7/01/04	0.02
10/02/04	0.02	10/02/04	0.02
14/04/04	<0.01	14/04/04	<0.01
10/06/04	<0.01	10/06/04	<0.01
17/08/04	<0.01	17/08/04	<0.01
13/10/04	0.01	13/10/04	0.02
14/12/04	<0.01	14/12/04	<0.01
10/02/05	0.01	10/02/05	0.01
12/04/05	<0.01	12/04/05	0.01
15/06/05	0.01	15/06/05	0.01
18/08/05	<0.01	18/08/05	0.01
11/10/05	<0.01	11/10/05	<0.01
6/12/05	<0.01	6/12/05	0.01
7/02/06	0.01	7/02/06	0.01
20/04/06	<0.01	20/04/06	<0.01
14/06/06	0.01	14/06/06	0.01
23/08/06	<0.01	23/08/06	<0.01
23/08/06	0.01	23/08/06	
11/10/06	0.02	11/10/06	0.01

Date	NH4-N Shag R. at Craig Rd. (mg/L)	Date	NH4-NN Shag R. at Goodwood (mg/L)
11/10/06	<0.01	11/10/06	
6/12/06	<0.01	6/12/06	0.01
6/12/06		6/12/06	
15/02/07	0.01	15/02/07	0.01
15/02/07	<0.01	15/02/07	
30/04/07	<0.01	30/04/07	<0.01
30/04/07		30/04/07	
25/06/07	<0.01	25/06/07	<0.01
25/06/07		25/06/07	
11/09/07	<0.01	11/09/07	<0.01
11/09/07		11/09/07	
7/11/07	<0.01	7/11/07	0.01
7/11/07		7/11/07	
16/01/08	<0.01	16/01/08	0.02
16/01/08	0.01	16/01/08	
26/02/08	<0.01	26/02/08	<0.01
26/02/08		26/02/08	
5/05/08	<0.01	5/05/08	<0.01
5/05/08		5/05/08	
10/07/08	0.01	10/07/08	0.01
27/08/08	<0.01	27/08/08	<0.01
13/11/08	0.006	13/11/08	0.03
15/01/09	<0.01	15/01/09	0.02
12/03/09	<0.01	12/03/09	<0.01
6/05/09	<0.01	6/05/09	<0.01
14/07/09	<0.01	14/07/09	<0.01
16/09/09	<0.01	16/09/09	0.01
10/11/09	<0.01	10/11/09	0.01
27/01/10	<0.01	27/01/10	<0.01
24/03/10	<0.01	24/03/10	<0.01

Date	NH4-N Shag R. at Craig Rd. (mg/L)	Date	NH4-NN Shag R. at Goodwood (mg/L)
27/04/10		27/04/10	
12/05/10	<0.01	12/05/10	<0.01
22/07/10	<0.01	22/07/10	<0.01
10/11/10	<0.01	10/11/10	0.01
12/01/11	<0.01	12/01/11	0.02
8/03/11	<0.01	8/03/11	<0.01
26/05/11	<0.01	26/05/11	<0.01
3/08/11	<0.01	3/08/11	<0.01
28/09/11	<0.01	28/09/11	<0.01
29/11/11	<0.01	29/11/11	<0.01
1/02/12	0.011	1/02/12	0.016
27/03/12	<0.01	27/03/12	<0.01
30/05/12	<0.01	30/05/12	<0.01
4/07/12	<0.01	4/07/12	<0.01
7/08/12	<0.01	7/08/12	<0.01
6/09/12	<0.01	6/09/12	<0.01
4/10/12	<0.01	4/10/12	<0.01
8/10/12		8/10/12	<0.01
19/10/12	<0.01	19/10/12	<0.01
31/10/12	<0.01	31/10/12	<0.01
6/11/12	<0.01	6/11/12	<0.01
12/11/12	<0.01	12/11/12	<0.01
28/11/12	<0.01	28/11/12	<0.01
6/12/12		6/12/12	<0.01
11/12/12	<0.01	11/12/12	<0.01
14/01/13	<0.01	14/01/13	<0.01
18/01/13	<0.01	18/01/13	0.019
30/01/13	<0.01	30/01/13	<0.01
13/02/13	<0.01	13/02/13	<0.01
13/02/13		13/02/13	<0.01

Date	NH4-N Shag R. at Craig Rd. (mg/L)	Date	NH4-NN Shag R. at Goodwood (mg/L)
27/02/13	<0.01	27/02/13	<0.01
12/03/13	<0.01	12/03/13	<0.01
13/03/13	<0.01	13/03/13	0.01
26/03/13	0.012	26/03/13	0.012
8/04/13	<0.01	8/04/13	0.011
17/04/13		17/04/13	<0.01
23/04/13	<0.01	23/04/13	<0.01
9/05/13	<0.01	9/05/13	<0.01
22/05/13	<0.01	22/05/13	<0.01
30/05/13	<0.01	30/05/13	<0.01
7/06/13	<0.01	7/06/13	<0.01
10/07/13	<0.01	10/07/13	0.013
25/07/13	<0.01	25/07/13	0.013
8/08/13	<0.01	8/08/13	<0.01
23/08/13	<0.01	23/08/13	<0.01
28/08/13	<0.01	28/08/13	<0.01
5/09/13	<0.01	5/09/13	<0.01
20/09/13	<0.01	20/09/13	0.014
24/09/13	<0.01	24/09/13	<0.01
22/10/13	<0.01	22/10/13	<0.01
25/11/13	<0.01	25/11/13	0.015
17/12/13	<0.01	17/12/13	<0.01
29/01/14	<0.01	29/01/14	<0.01
27/02/14	<0.01	27/02/14	<0.01
27/03/14	<0.01	27/03/14	<0.01
7/05/14	<0.01	7/05/14	<0.01
13/06/14	<0.01	13/06/14	<0.01
10/07/14	<0.01	10/07/14	<0.01
18/08/14	<0.005	18/08/14	0.007
16/09/14	0.018	16/09/14	0.013
28/10/14	0.021	28/10/14	0.015
25/11/14	0.007	25/11/14	0.018

Date	NH4-N Shag R. at Craig Rd. (mg/L)	Date	NH4-NN Shag R. at Goodwood (mg/L)
16/12/14	0.012	16/12/14	0.015
30/01/15	0.017	30/01/15	0.01
2/03/15	<0.005	2/03/15	<0.005
25/03/15	0.005	25/03/15	<0.005
21/04/15	<0.005	21/04/15	0.007
20/05/15	0.005	20/05/15	0.01
17/06/15	<0.005	17/06/15	0.029
22/07/15	<0.005	22/07/15	0.005
28/08/15	<0.005	28/08/15	0.006
25/09/15	<0.005	25/09/15	0.005
27/10/15	0.008	27/10/15	0.012
24/11/15	0.007	24/11/15	0.008
18/12/15	<0.005	18/12/15	<0.005
26/01/16	0.007	26/01/16	0.008
25/02/16	<0.005	25/02/16	<0.005
22/03/16	0.005	22/03/16	0.006
26/04/16	<0.005	26/04/16	<0.005
26/05/16	0.008	26/05/16	0.012
21/06/16	<0.005	21/06/16	0.011
26/07/16	<0.005	26/07/16	0.01
24/08/16	0.005	24/08/16	0.007
20/09/16	<0.005	20/09/16	<0.005
21/10/16	0.012	21/10/16	0.02
29/11/16	0.012	29/11/16	0.013
22/12/16	0.006	22/12/16	0.009
24/01/17	0.007	24/01/17	0.01
27/02/17	<0.005	27/02/17	<0.005
28/03/17	0.007	28/03/17	0.007
21/04/17	0.008	21/04/17	0.011
29/05/17	0.0055	29/05/17	0.007
29/06/17	0.006	29/06/17	0.006
19/07/17		19/07/17	
31/07/17	0.049	31/07/17	0.01

Date	NH4-N Shag R. at Craig Rd. (mg/L)	Date	NH4-NN Shag R. at Goodwood (mg/L)
2/08/17		2/08/17	
8/08/17		8/08/17	
16/08/17	<0.005	16/08/17	
22/08/17	<0.005	22/08/17	<0.005
30/08/17	<0.005	30/08/17	
4/09/17		4/09/17	
12/09/17		12/09/17	
20/09/17		20/09/17	
26/09/17	<0.005	26/09/17	<0.005
11/10/17		11/10/17	<0.005
19/10/17	<0.005	19/10/17	
24/10/17	<0.005	24/10/17	
31/10/17		31/10/17	
9/11/17		9/11/17	
17/11/17	<0.005	17/11/17	
23/11/17	<0.005	23/11/17	<0.005
27/11/17		27/11/17	
4/12/17		4/12/17	
13/12/17	<0.005	13/12/17	
19/12/17	<0.005	19/12/17	<0.005
21/12/17		21/12/17	
4/01/18		4/01/18	
11/01/18		11/01/18	
15/01/18	<0.005	15/01/18	
23/01/18	<0.005	23/01/18	<0.005
19/02/18	<0.005	19/02/18	
26/02/18	<0.005	26/02/18	<0.005
5/03/18		5/03/18	
14/03/18	<0.005	14/03/18	
27/03/18	<0.005	27/03/18	<0.005
14/03/18		14/03/18	
17/04/18	<0.005	17/04/18	
1/05/18	<0.005	1/05/18	<0.005

Date	NH4-N Shag R. at Craig Rd. (mg/L)	Date	NH4-NN Shag R. at Goodwood (mg/L)
8/05/18		8/05/18	
21/05/18	<0.005	21/05/18	
28/05/18	<0.005	28/05/18	<0.005
20/06/18	<0.005	20/06/18	
26/06/18	<0.005	26/06/18	<0.005
17/07/18	<0.005	17/07/18	
23/07/18	<0.005	23/07/18	<0.005
13/08/18	0.005	13/08/18	
30/08/18	0.005	30/08/18	0.005
19/09/18	0.005	19/09/18	
25/09/18	0.005	25/09/18	0.012
23/10/18	0.006	23/10/18	0.007
30/11/18	0.005	30/11/18	0.005
19/12/18	0.005	19/12/18	0.005
22/01/19	0.005	22/01/19	0.005
28/02/19	0.005	28/02/19	0.005
28/03/19	0.005	28/03/19	0.005
30/04/19	0.005	30/04/19	0.005
27/05/19	0.005	27/05/19	0.008
25/06/19	0.005	25/06/19	0.006
30/07/19	0.005	30/07/19	0.011
29/08/19	0.005	29/08/19	0.006
24/09/19	0.007	24/09/19	0.008
29/10/19	0.005	29/10/19	0.007
26/11/19	0.005	26/11/19	0.005
17/12/19	0.005	17/12/19	0.005
28/01/20	0.005	28/01/20	0.007

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
MAC-DC01	16-Aug-05	7.8	5.5						
	11-Sep-05	8.09	1.5						
	13-Feb-06	7.82	1.8						
	16-Aug-06	7.38	7.5						
	05-Oct-06	7.77	7	0.03			0.06	0.03	
	15-Nov-06	8.12	1.6						
	20-Feb-07	8.07	1.7						
	03-May-07	8.01	3.5	<0.01			<0.02	<0.01	
	09-Aug-07	7.37	10.5						
	07-Nov-07	8.43	3.7						
	21-Feb-08	8.47	3.1						
	14-May-08	7.7	9.5	<0.002		0.0021	<0.011	<0.01	
	27-Aug-08	7.5	11						
	20-Nov-08	7.4	4.1						
	11-Feb-09	8.2	1.3						
	28-May-09	7.2	9	0.21	0.21	0.0034		<0.01	0.22
	17-Aug-09	6.5	11						
	17-Nov-09	7.8	2.3						
	08-Feb-10	7.6	1.4						
	17-May-10	7.9	6					<0.01	0.022
	12-Aug-10	7.2	14.8						
	15-Nov-10	7.9	4.6						
	16-Feb-11	7.7	5.5						
	18-May-11	7.6	7.9					<0.01	0.044
	23-Aug-11	7.7	10.1						
	14-Nov-11	7.7	4.5						

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	16-Jan-12	7.8	9.6						
	23-Apr-12	7.8	5.2				<0.002	<0.01	0
	09-Jul-12	7.8	15.2						
	07-Nov-12	7.6	3.4						
	30-Jan-13	7.7	1.7						
	18-Apr-13	7.7	10					<0.01	0
	24-Jul-13	7.6	9.4						
	21-Oct-13	7.6	4.1						
	20-Jan-14	7.9	3						
	28-Apr-14	7.6	12						
	15-Jul-14	7.8	21						
	21-Oct-14	7.8	6.7						
	02-Feb-15	8	1.7						
	23-Apr-15	8	29		0.003			<0.01	<0.011
	07-Jul-15	7.5	18						
	15-Oct-15	8.1	20		6.7			<0.01	6.7
	01-Feb-16	8.2	13		0.003			<0.01	<0.011
	19-Apr-16	8	9		0.01			<0.01	<0.011
	25-Jul-16	7.4	19	0.6	0.61	0.004		<0.01	0.61
	26-Oct-16	7.7	5	0.003	0.004	<0.002		<0.01	<0.011
	24-Jan-17	7.9	28	<0.002	<0.002	<0.002		<0.01	<0.011
	11-Apr-17	8	116		0.29			<0.01	0.29
	31-Jul-17	7.4	23	0.62	0.62	0.003		<0.01	0.63
	30-Oct-17	8.1	86	0.24	0.25	0.003		<0.01	0.25
	29-Jan-18	7.9	71	0.033	0.035	0.003		<0.01	0.035
	01-Apr-18	7.9	27	<0.002	<0.002	<0.002		<0.01	<0.011

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	01-Jul-18	7.8	30	0.022	0.022	<0.002		<0.01	0.029
	31-Oct-18	7.7	18	<0.002	0.003	0.002		<0.01	<0.011
	17-Jan-19	7.8	43	0.58	0.58	0.003		<0.01	
	09-Apr-19	7.9	136	0.011	0.011	<0.002		<0.01	0.011
	25-Jul-19	7.7	71	0.25	0.25	<0.002		<0.01	
	08-Oct-19	7.7	40	0.2	0.2	<0.002		<0.01	
	22-Jan-20	8	54	0.029	0.034	0.004		0.037	
MAC-DC02	16-Aug-05	7.78	5.3						
	11-Sep-05	8.09	1.5						
	13-Feb-06	7.83	1.7						
	16-Aug-06	7.45	7.8						
	05-Oct-06	7.78	7	0.03			0.03		
	15-Nov-06	8.04	1.6						
	20-Feb-07	8.04	1.5						
	03-May-07	7.95	3.5	<0.01			<0.02	<0.01	
	09-Aug-07	7.84	10.5						
	07-Nov-07	8.35	3.7						
	14-May-08	7.7	9.5	<0.002		<0.002	<0.011	<0.01	
	27-Aug-08	7.6	11						
	20-Nov-08	7.8	4.2						
	11-Feb-09	8.2	1.5						
	28-May-09	7.3	8.9	0.21	0.22	<0.002		<0.01	0.22
	17-Aug-09	6.6	8.5						
	17-Nov-09	8	2.9						
	08-Feb-10	7.5	1.8						
	17-May-10	7.8	6.3					<0.01	0.025

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	12-Aug-10	7.2	14.6						
	15-Nov-10	7.8	4.4						
	16-Feb-11	7.7	5.6						
	18-May-11	7.6	7.8					<0.01	0.044
	23-Aug-11	7.2	10						
	14-Nov-11	7.7	4.6						
	16-Jan-12	7.7	9.5						
	23-Apr-12	7.8	5.2				0.003	<0.01	0
	09-Jul-12	7.8	15.2						
	07-Nov-12	7.6	3.4						
	30-Jan-13	7.7	1.7						
	18-Apr-13	3.1	11					<0.01	0
	24-Jul-13	7.5	9.3						
	21-Oct-13	7.6	4.1						
	20-Jan-14	7.9	2.3						
	28-May-14	7.5	12.1						
	15-Jul-14	7.8	21						
	21-Oct-14	7.8	7						
	02-Feb-15	8.1	2						
	23-Apr-15	8	29		0.003			<0.01	<0.011
	07-Jul-15	7.6	18						
	15-Oct-15	8.1	21		6.6			<0.01	6.6
	01-Feb-16	8.1	13		0.006			<0.01	<0.011
	19-Apr-16	7.9	9		0.016			<0.01	0.016
	25-Jul-16	7.4	19	0.6	0.61	0.005		<0.01	0.61
	26-Oct-16	7.7	6	0.003	0.004	<0.002		<0.01	<0.011

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	24-Jan-17	7.7	27	<0.002	<0.002	<0.002		<0.01	<0.011
	11-Apr-17	8	123		0.28			<0.01	0.28
	31-Jul-17	7.4	23	0.57	0.58	0.003		<0.01	0.58
	30-Oct-17	8.1	87	0.24	0.24	0.002		<0.01	0.25
	29-Jan-18	7.9	71	0.034	0.036	0.003		0.036	0.073
	01-Apr-18	7.8	26	<0.002	<0.002	<0.002		<0.01	<0.011
	01-Jul-18	7.7	30	0.016	0.017	<0.002		<0.01	0.021
	31-Oct-18	7.8	23	<0.002	0.003	<0.002		<0.01	<0.011
	17-Jan-19	7.8	42	0.004	0.005	<0.002		<0.01	
	09-Apr-19	7.9	138	0.027	0.027	<0.002		<0.01	0.027
	25-Jul-19	7.6	71	0.25	0.25	<0.002		<0.01	
	08-Oct-19	7.7	38	0.2	0.2	<0.002		<0.01	
	22-Jan-20	7.9	52	0.036	0.041	0.005		0.054	
MAC-DC03	16-Aug-05	7.86	5.3						
	11-Sep-05	8.2	1.9						
	13-Feb-06	7.87	1.6						
	16-Aug-06	7.62	7.7						
	05-Oct-06	7.77	7.1	0.07			0.08	0.01	
	14-Nov-06	8.06	2.2						
	20-Feb-07	8.43	1.9						
	03-May-07	8.17	3.5	0.02			0.04	0.02	
	09-Aug-07	7.73	10.4						
	07-Nov-07	7.98	3.9						
	20-Feb-08	7.85	3.4						
	08-May-08	7.7	7.6	0.013		<0.002	0.013	<0.01	
	27-Aug-08	7.6	11						

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	12-Nov-08	8.5	3.6						
	11-Feb-09	7.8	1.9						
	28-May-09	7.3	8.8	0.24	0.24	<0.002		<0.01	
	17-Aug-09	6.7	12						
	17-Nov-09	8.4	3.5						
	08-Feb-10	8.2	5.6						
	17-May-10	8.1	6.5					<0.01	0.0133
	12-Aug-10	7.2	14						
	15-Nov-10	7.9	5.2						
	16-Feb-11	7.7	10						
	18-May-11	7.6	8.7					<0.01	0.057
	23-Aug-11	7.2	9.1						
	14-Nov-11	7.7	4.6						
	16-Jan-12	7.7	9.4						
	23-Apr-12	7.8	5.4				<0.002	<0.01	0
	09-Jul-12	7.8	13.6						
	07-Nov-12	7.7	3.4						
	30-Jan-13	7.7	6.9						
	18-Apr-13	7.7	11					<0.01	0
	26-Jun-13	7.1	11						
	03-Jul-13	7.4	6.3						
	24-Jul-13	7.5	9.2						
	21-Oct-13	7.7	4.5						
	20-Jan-14	7.9	3.1						
	28-May-14	7.6	11						
	15-Jul-14	7.7	22						

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	21-Oct-14	7.8	6.8						
	19-Jan-15	8.3	4.9						
	23-Apr-15	8	28		0.002			<0.01	<0.011
	07-Jul-15	7.6	18						
	15-Oct-15	8.2	15		3.8			<0.01	3.8
	01-Feb-16	8	13		0.005			<0.01	<0.011
	19-Apr-16	8.1	7		0.006			<0.01	<0.011
	25-Jul-16	7.5	19	0.62	0.63	0.005		<0.01	0.63
	26-Oct-16	7.7	6	0.003	0.004	0.002		0.01	0.011
	24-Jan-17	7.9	27	<0.002	<0.002	<0.002		<0.01	<0.011
	11-Apr-17	8	119		0.23			<0.01	0.23
	31-Jul-17	7.4	23	0.61	0.62	0.003		0.01	0.63
	30-Oct-17	8.1	65	0.072	0.075	0.002		<0.01	0.075
	29-Jan-18	8.1	64	0.026	0.028	0.003		<0.01	0.028
	01-Apr-18	7.7	25	<0.002	<0.002	<0.002		<0.01	<0.011
	01-Jul-18	7.8	27	0.003	0.004	<0.002		<0.01	<0.011
	31-Oct-18	7.8	25	0.005	0.007	<0.002		<0.01	<0.011
	17-Jan-19	7.8	38	0.005	0.007	<0.002		<0.01	
	09-Apr-19	7.9	168	0.006	0.007	<0.002		<0.01	<0.011
	25-Jul-19	7.7	76	0.26	0.27	<0.002		<0.01	
	08-Oct-19	7.9	39	0.124	0.126	<0.002		<0.01	
	22-Jan-20	7.9	55	0.029	0.033	0.004		0.076	
MAC-DC04	16-Aug-05	7.79	6						
	11-Sep-05	7.74	4.4						
	13-Feb-06	7.74	3.4						
	16-Aug-06	7.64	8.2						

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	05-Oct-06	7.74	8.2	0.07			0.08	0.01	
	15-Nov-06	8.22	2.9						
	20-Feb-07	8.13	7.1						
	03-May-07	7.99	6.8	0.01			<0.02	<0.01	
	09-Aug-07	7.68	10.9						
	07-Nov-07	7.87	7.7						
	20-Feb-08	7.67	9.7						
	08-May-08	7.2	11	0.016		<0.002	0.02	<0.01	
	27-Aug-08	7.6	11						
	12-Nov-08	8.2	11						
	11-Feb-09	7.6	11						
	28-Jun-09	7.3	13	0.24	0.25	<0.002		<0.01	
	17-Sep-09	6.6	23						
	17-Nov-09	8.1	64						
	08-Feb-10	7.8	170						
	17-May-10	7.9	36					<0.01	0.082
	12-Aug-10	7.3	30						
	15-Nov-10	7.8	89						
	16-Feb-11	7.7	28						
	18-May-11	7.6	24					<0.01	0.139
	23-Aug-11	7.2	13.4						
	14-Nov-11	7.7	18.1						
	16-Jan-12	7.8	41						
	23-Apr-12	7.8	42				0.121	<0.01	0
	09-Jul-12	7.8	39						
	07-Nov-12	7.7	23						

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	30-Jan-13	7.7	41						
	18-Apr-13	7.7	74					<0.01	0
	24-Jul-13	7.7	55						
	21-Oct-13	7.8	45						
	20-Jan-14	7.9	52						
	28-May-14	7.6	14.7						
	15-Jul-14	7.8	59						
	21-Oct-14	7.9	67						
	19-Jan-15	8	320						
	23-Apr-15	8	59		0.132			<0.01	0.132
	07-Jul-15	7.6	31						
	15-Oct-15	8.1	26		3.7			<0.01	3.7
	01-Feb-16	8.1	38		0.061			<0.01	0.065
	19-Apr-16	8	35		0.013			<0.01	0.013
	25-Jul-16	7.5	26	0.66	0.66	0.005		<0.01	0.67
	26-Oct-16	7.7	13	0.023	0.023	0.002		0.01	0.023
	24-Jan-17	7.9	56	0.047	0.051	0.004		<0.01	0.051
	11-Apr-17	8	126		0.23			<0.01	0.23
	31-Jul-17	7.4	33	0.65	0.65	0.003		<0.01	0.66
	30-Oct-17	7.9	77	0.101	0.104	0.003		<0.01	0.104
	29-Jan-18	7.8	230	0.197	0.2	0.003		<0.01	0.2
	01-Apr-18	7.7	68	0.12	0.121	<0.002		<0.01	0.121
	01-Jul-18	7.8	55	0.128	0.129	<0.002		<0.01	0.129
	31-Oct-18	7.8	39	0.048	0.05	<0.002		<0.01	0.05
	17-Jan-19	7.9	101	0.131	0.133	<0.002		<0.01	
	09-Apr-19	7.9	210	0.102	0.103	<0.002		<0.01	0.103

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	25-Jul-19	7.8	153	0.53	0.53	0.002		<0.01	
	08-Oct-19	7.9	43	0.14	0.142	0.002		<0.01	
	23-Jan-20	8	94	0.041	0.045	0.004		<0.01	
MAC-DC05	16-Aug-05	7.91	9.5						
	11-Sep-05	7.89	11.3						
	13-Feb-06	7.72	11.1						
	16-Aug-06	7.61	13						
	05-Oct-06	7.68	11.5	0.08			0.09	0.01	
	14-Nov-06	7.83	46.9						
	20-Feb-07	7.82	63.3						
	03-May-07	7.85	42.4	<0.01			<0.02	<0.01	
	21-Aug-07	7.51	28.5						
	07-Nov-07	7.87	47.1						
	21-Feb-08	7.92	48.2						
	14-May-08	7.7	28	0.0082		<0.002	<0.011	<0.01	
	27-Aug-08	7.6	15						
	12-Nov-08	8.1	78						
	11-Feb-09	7.7	130						
	28-Jun-09	7.5	30	0.27	0.28	0.0023		<0.01	
	17-Aug-09	6.9	44						
	17-Nov-09	8.1	170						
	08-Feb-10	7.8	370						
	17-May-10	8	116					<0.01	<0.011
	12-Aug-10	7.4	47						
	15-Nov-10	7.9	210						
	16-Feb-11	7.6	56						

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	18-May-11	7.8	55					<0.01	0.154
	23-Aug-11	7.2	17.2						
	14-Nov-11	7.7	41						
	16-Jan-12	7.8	133						
	23-Apr-12	7.9	124				0.068	<0.01	0
	09-Jul-12	7.9	102						
	07-Nov-12	7.7	51						
	30-Jan-13	7.8	113						
	18-Apr-13	7.8	178					<0.01	0
	26-Jun-13	7.1	14						
	03-Jul-13	7.3	18.2						
	24-Jul-13	7.7	77						
	21-Oct-13	7.8	70						
	20-Jan-14	7.9	113						
	28-May-14	7.6	17.2						
	15-Jul-14	7.9	90						
	21-Oct-14	8	172						
	13-Jan-15	8	380						
	23-Apr-15	8	85		0.053			<0.01	0.053
	07-Jul-15	7.7	45						
	15-Oct-15	8.1	50		4.2			<0.01	4.2
	01-Feb-16	8	56		0.002			<0.01	<0.011
	19-Apr-16	8.1	210		<0.002			<0.01	<0.011
	25-Jul-16	7.4	31	0.66	0.66	0.005		<0.01	0.66
	26-Oct-16	7.8	25	0.01	0.011	0.002		0.01	0.011
	24-Jan-17	7.9	66	<0.002	0.004	0.003		<0.01	<0.011

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	11-Apr-17	8.1	132		0.171			<0.01	0.179
	31-Jul-17	7.5	41	0.63	0.64	0.003		0.011	0.65
	30-Oct-17	8	89	0.073	0.075	0.002		<0.01	0.075
	29-Jan-18	7.9	330	0.003	0.004	<0.002		<0.01	<0.011
	01-Apr-18	7.7	96	0.088	0.089	<0.002		<0.01	0.089
	01-Jul-18	7.8	71	0.125	0.125	<0.002		<0.01	0.125
	31-Oct-18	7.8	49	0.037	0.039	<0.002		<0.01	0.039
	17-Jan-19	7.9	88	0.044	0.046	0.002		<0.01	
	09-Apr-19	7.8	310	0.141	0.142	<0.002		<0.01	0.142
	25-Jul-19	7.6	102	0.31	0.31	<0.002		<0.01	
	08-Oct-19	7.8	74	0.163	0.165	<0.002		<0.01	
	22-Jan-20	8	220	0.003	0.004	<0.002		<0.01	
MAC-DC06	16-Aug-05	7.98	11.6						
	11-Sep-05	8.09	13.7						
	13-Feb-06	8.2	13.7						
	16-Aug-06	7.67	10.4						
	05-Oct-06	7.87	20.2	0.08			0.1	0.02	
	15-Nov-06	7.93	567						
	20-Feb-07	7.98	776						
	03-May-07	8.29	76.5	0.05			0.05	<0.01	0.05
	21-Aug-07	7.69	128						
	07-Nov-07	7.94	209						
	20-Feb-08	8.7	77.5						
	14-May-08	8	130	<0.002		<0.002	<0.011	<0.01	
	27-Aug-08	7.7	28						
	20-Nov-08	8.2	1,330						

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	11-Feb-09	7.4	420						
	28-Jun-09	7.4	47	0.25	0.26	0.0022		<0.01	
	17-Sep-09	7.6	56						
	17-Nov-09	8.2	300						
	08-Feb-10	8.1	980						
	17-May-10	8	141					<0.01	<0.011
	12-Aug-10	7.4	46						
	15-Nov-10	8	187						
	16-Feb-11	7.6	56						
	18-May-11	7.8	55					<0.01	0.147
	23-Aug-11	7.1	19						
	14-Nov-11	7.7	41						
	16-Jan-12	7.9	126						
	23-Apr-12	7.9	121				0.035	<0.01	0
	09-Jul-12	7.9	102						
	07-Nov-12	7.8	51						
	30-Jan-13	7.8	112						
	18-Apr-13	7.9	172					<0.01	0
	24-Jul-13	7.7	77						
	21-Oct-13	8	170						
	20-Jan-14	8	111						
	28-May-14	7.6	20						
	15-Jul-14	7.9	98						
	21-Oct-14	8	171						
	13-Jan-15	8.1	750						
	23-Apr-15	8.1	103		0.022			<0.01	0.022

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	07-Jul-15	7.7	55						
	15-Oct-15	8.1	68		4.4			<0.01	4.4
	01-Feb-16	8.3	79		<0.002			<0.01	<0.011
	19-Apr-16	8.1	196		0.002			<0.01	<0.011
	25-Jul-16	7.5	39	0.69	0.69	0.005		<0.01	0.7
	26-Oct-16	7.8	35	0.012	0.014	0.002		0.01	0.015
	24-Jan-17	8.1	99	<0.002	<0.002	<0.002		<0.01	<0.011
	11-Apr-17	8.1	140		0.134			<0.01	0.137
	31-Jul-17	7.6	52	0.64	0.65	0.003		<0.01	0.65
	30-Oct-17	8.2	111	0.043	0.045	0.002		<0.01	0.045
	29-Jan-18	8	300	<0.002	<0.002	<0.002		<0.01	<0.011
	01-Apr-18	7.8	116	0.076	0.078	<0.002		<0.01	0.078
	01-Jul-18	7.9	80	0.09	0.09	<0.002		<0.01	0.09
	31-Oct-18	7.9	49	0.027	0.028	<0.002		<0.01	0.028
	17-Jan-19	8	108	0.094	0.096	0.002		<0.01	
	09-Apr-19	8	360	0.064	0.065	<0.002		<0.01	0.065
	25-Jul-19	7.8	148	0.41	0.41	<0.002		<0.01	
	08-Oct-19	7.9	86	0.116	0.117	<0.002		<0.01	
	22-Jan-20	7.9	290	0.007	0.008	<0.002		<0.01	
MAC-DC07	02-May-00	8.78		0.026			0.03	<0.01	
	08-Aug-00	8.03		0.038			0.08	0.04	
	06-Nov-00	8.93		0.024			0.034	0.01	
	08-Feb-01	8.52	15	0.023			0.03	0.01	
	16-May-01	8.08	13.2	0.058			0.08	0.02	
	21-Aug-01	8.29	10	0.044			0.05	0.01	
	30-Aug-01	8.29	10	0.044			0.05	0.01	

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	21-Nov-01	8.57	5.2	0.042			0.042	<0.01	
	18-Feb-02	8.3	55	0.029			0.05	0.02	
	04-Jun-02	7.99	63.1	0.189			0.21	0.02	
	21-Aug-02	7.78	22.3	0.31			0.34	0.03	
	25-Nov-02	8.32	21.1	0.17			0.18	0.01	
	20-Feb-03	8.28	25.2	0.03			0.04	0.01	
	15-Apr-03	8.02	27.8	0.06			0.08	0.02	
	15-May-03	8.07	34.2	0.08			0.1	0.02	
	14-Aug-03	8.14	26.8	<0.06			<0.1	0.02	
	17-Nov-03	7.99	45.3	<0.04			<0.05	<0.01	
	19-Feb-04	8.46	49.5	<0.04			<0.06	0.02	
	13-May-04	8.07	22.2	0.03			0.05	0.02	
	05-Aug-04	8.27	19.9	0.01			0.01	0.01	
	30-Nov-04	8.28	7.6	0.17			0.23	0.06	
	10-Feb-05	9.05	13.1	0.05			0.07	0.02	
	09-May-05	8.36	13.1	0.04			0.05	0.01	
	16-Aug-05	7.9	11.9						
	11-Sep-05	8.81	14.7						
	13-Feb-06	8.54	67.1						
	16-Aug-06	7.7	9.9						
	05-Oct-06	7.82	22.3	0.16			0.17	0.01	
	23-Nov-06	8.36	1,020						
	18-Jan-07	8.4	189						
	18-Feb-07	8.4	189						
	20-Feb-07	8.46	552						
	03-May-07	8.4	82.2	0.26			0.26	<0.01	

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	09-Aug-07	7.75	56.3						
	07-Nov-07	8.04	180						
	20-Feb-08	7.93	51.5						
	14-May-08	8	120	0.0054		<0.002	<0.011	<0.01	
	27-Aug-08	7.7	23						
	12-Nov-08	8.3	170						
	26-Feb-09	7.9	29						
	28-Jun-09	7.6	53	0.38	0.39	0.0031		<0.01	
	17-Sep-09	7.7	56						
	17-Nov-09	8.4	280						
	08-Feb-10	8.1	500						
	17-May-10	8.2	151					<0.01	<0.011
	12-Aug-10	7.6	85						
	15-Nov-10	8.1	410						
	23-Feb-11	8	44						
	18-May-11	7.7	54					<0.01	0.25
	23-Aug-11	7	16.7						
	14-Nov-11	8	37						
	16-Jan-12	8	138						
	23-Apr-12	8.1	320				1.06	<0.01	1
	09-Jul-12	8	127						
	07-Nov-12	7.8	125						
	30-Jan-13	7.9	240						
	18-Apr-13	7.9	210					<0.01	0
	24-Jul-13	7.9	185						
	21-Oct-13	7.9	172						

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	20-Jan-14	8.1	320						
	28-May-14	7.6	20						
	15-Jul-14	8.1	210						
	21-Oct-14	8.2	350						
	21-Jan-15	8.4	780						
	23-Apr-15	8.1	125		0.072			<0.01	0.072
	07-Jul-15	7.8	70						
	15-Oct-15	8.4	174		3.7			<0.01	3.7
	01-Feb-16	8.3	82						
	19-Apr-16	8.1	250		0.002			<0.01	<0.011
	25-Jul-16	7.5	41	0.67	0.67	0.004		<0.01	0.68
	26-Oct-16	7.8	30	0.021	0.022	0.021		0.01	0.025
	24-Jan-17	8.3	132	0.103	0.105	0.002		<0.01	0.105
	11-Apr-17	8	122		0.025			<0.01	0.025
	31-Jul-17	7.6	57	0.65	0.66	0.002		<0.01	0.66
	30-Oct-17	8.2	175	0.147	0.149	<0.002		<0.01	0.149
	29-Jan-18	8	240	0.002	0.002	<0.002		<0.01	<0.011
	01-Apr-18	8.1	132	0.055	0.056	<0.002		<0.01	0.056
	01-Jul-18	8	157	0.39	0.39	<0.002		<0.01	0.39
	31-Oct-18	8	62	0.018	0.019	<0.002		<0.01	0.019
	17-Jan-19	7.9	109	0.139	0.14	<0.002		<0.01	
	09-Apr-19	8	360	0.17	0.171	<0.002		<0.01	0.171
	25-Jul-19	7.8	144	0.44	0.45	<0.002		<0.01	
	01-Jan-20	8.1	300	0.048	0.05	<0.002		<0.01	
MAC-HC01 (Highlay Creek at ford)	14-May-18	7.6	8	0.49	0.5	0.004		<0.01	0.5
	01-Jun-18	7.5	7	0.38	0.38	0.003		<0.01	0.39

Data Point	Date	pH (pH unit)	Sulphate (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Nitrite-N (g/m3)	Nitrogen-Total (g/m3)	Nitrogen-Total Ammoniacal (g/m3)	Total Inorganic Nitrogen (g/m3)
	01-Jul-18	7.7	<5	0.25	0.25	<0.002		<0.01	0.25
	01-Aug-18	7.7	9						
	06-Sep-18	7.7	8						
	15-Oct-18	7.7	<5	0.013	0.013	<0.002		<0.01	0.018
	01-Nov-18	7.5	<5	0.25	0.25	<0.002		<0.01	0.25
	18-Dec-18	6.7	5	0.15	0.153	0.003		<0.01	0.154
	17-Jan-19	7.6	<5	0.26	0.26	0.003		<0.01	0.26
	25-Feb-19	8.2	8	0.022	0.023	<0.002		<0.01	
	12-Mar-19	7.8	7	0.041	0.041	<0.002		<0.01	
	09-Apr-19	7.8	7.4	0.035	0.036	<0.002		<0.01	0.037
	08-May-19	7.8	<5	0.027	0.027	<0.002		<0.01	
	11-Jun-19	7.8	71	0.046	0.046	<0.002		<0.01	0.048
	25-Jul-19	7.5	10	0.104	0.105	<0.002		<0.01	0.109
	06-Aug-19	7.5	7	0.087	0.088	<0.002		<0.01	0.088
	03-Sep-19	7.7	8	0.016	0.016	<0.002		<0.01	0.017
	08-Oct-19	7.5	<5	0.025	0.026	<0.002		0.011	0.037
	13-Nov-19	7.7	7	0.012	0.013	<0.002		<0.01	0.017
	16-Dec-19	7.8	6	0.103	0.104	<0.002		<0.01	0.107
	22-Jan-20	7.9	<5	0.021	0.021	<0.002		<0.01	0.022
	01-Feb-20	7.9	<5	0.032	0.032	<0.002		<0.01	0.037
MDL									

** below detectable limit*
*** above detectable limit*

Appendix B

Water Quality Trend Analyses

Statistical trend analyses determine the magnitude of the trend and the confidence of the trend direction. These analyses are useful for determining whether water quality is improving or degrading across multiple sites and variables.

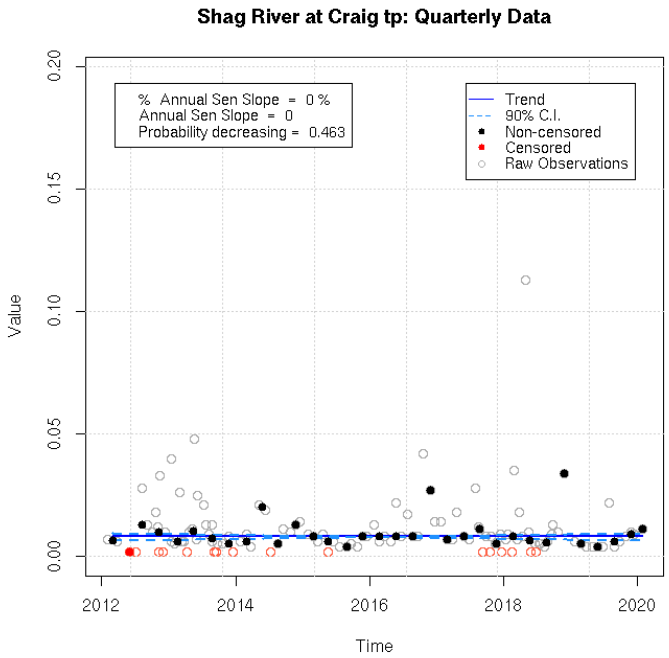
B.1 LWP-Trends Library

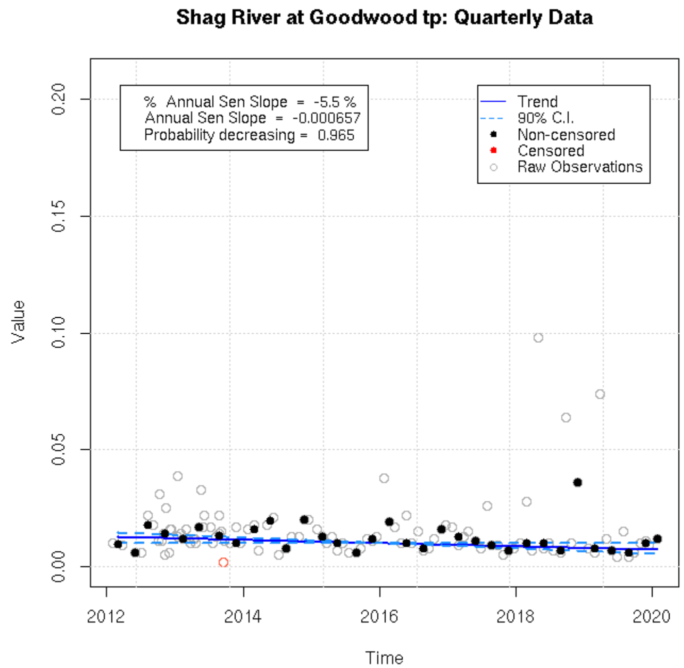
The primary difference between the LWP-trends and the NIWA TT approach is the treatment of censored data [e.g., above or below detection limit (DL)] and the validation of seasonal data. The LWP trend analysis (Snelder and Fraser 2018) interpolates unique values for censored data using 'regression on order statistics' (ROS) based on the distribution of uncensored values. The program then randomly distributes interpolated values throughout the data set to avoid inducing a trend. Furthermore, the LWP trend analysis data is tested for seasonality using a Kruskall Wallis non-parametric ANOVA ($p < 0.05$). A Mann Kendall test is applied for both non-seasonal and seasonal data, however a co-variable of seasonality is incorporated into the test for seasonal data. Trend magnitude was determined by a Sen-slope estimator (Hirsch et al. 2982), which is the slope parameter of a non-parametric regression and is calculated as the median of all possible inter-observation slopes. The seasonal version of the SSE was used when seasonality was significant. Trend confidence and direction (e.g. "likely increasing") was determined using the S-statistic and *p*-value derived from the Mann Kendall test. The approach used in LWP-Trends Library is a more reliable method because the trend magnitude and confidence is robust irrespective of the number of censored observations.

B.2 TimeTrends

NIWA TimeTrends handles censored data by assigning values below the DL as ½ the DL and values above the DL as 10 % above the DL. One issue with this method is that trends can be induced in the data if a large proportion of values are censored. Additionally, the NIWA protocol does not recommend running a statistical analysis to determine whether data is seasonal. Instead, all data is analysed with a Seasonal Kendall Trend Test. To calculate trend confidence, TT uses the Sen-slope and its confidence intervals as described by Larned *et al.* (2015). An issue with this approach is that it excludes sites with more than 15 % of observations as censored. As a result, results contain insignificant (i.e., fail to reject null hypothesis that there is no different) or insufficient data trends. These results can be interpreted as "no change" or "stable" when in reality there is likely a trend present, but there is not enough data to detect such a trend. The LWP-Trends method described in the above section handles censored data in a more robust way by classifying a trend as "indeterminant", or produces a warning, when too many censored values influence the calculated Sen-Slope.

Shag River: *2012 -2020* Water Quality Trends



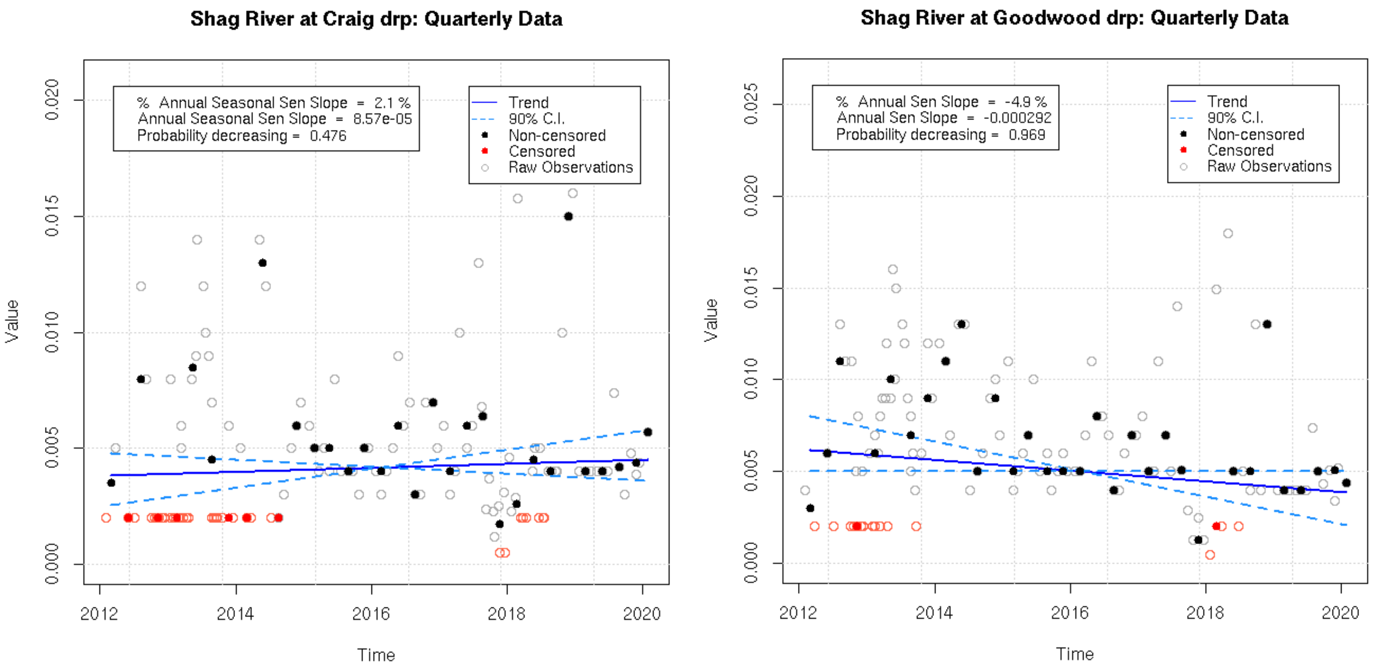


Total Phosphorous (TP) from Craig and Goodwood monitoring sites (2012 – 2020) (values are expressed as mg/m^3).

Results from the LWP and TT analysis for TP trends from 2012 – 2020.

Site	Source	Seasonal	Sample	Non-detect	P	Sen Slope	% Change	Prob. Of Trend	Trend
Craig	TT	FALSE	33	n/a	0.76	0	0.625	0.617	Trend Unlikely
Goodwood	TT	FALSE	33	n/a	0.135	-0.001	-6.192	0.947	Decreasing Trend Possible
Craig**	LWP	FALSE	33	16	0.92	0	0	0.5	Increasing trend as likely as not
Goodwood	LWP	FALSE	33	1	0.07	-0.0006	-5.47	0.96	Decreasing trend extremely likely

****Sen-slope calculation influenced by censored values, trend category indeterminant**

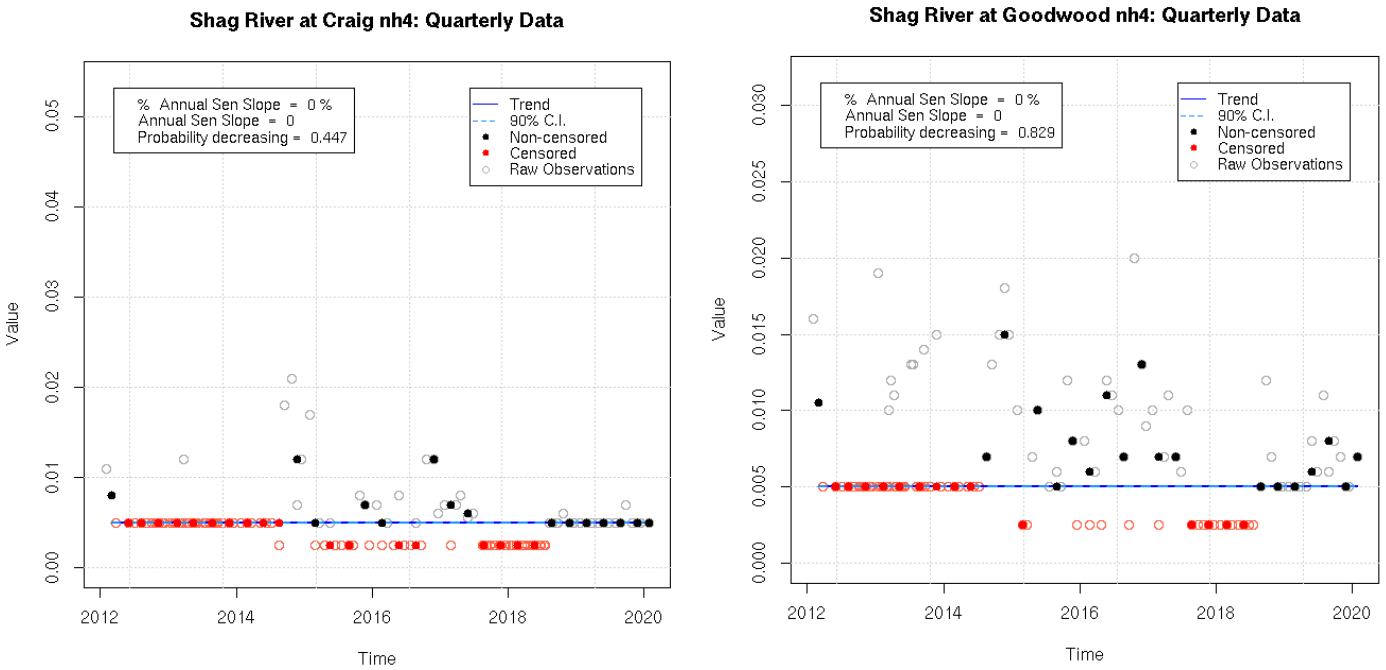


Dissolved Reactive Phosphorous (DRP) from Craig and Goodwood monitoring sites (2012 – 2020).

Results from the LWP and TT analysis for DRP trends from 2012 – 2020.

Site	Source	Seasonal	Sample	Non-detect	P	Sen Slope	% Change	Prob. Of trend	Trend
Craig	TT	TRUE	33	n/a	0.55	0	2.041	0.725	Increasing trend as likely as not
Goodwood	TT	FALSE	33	n/a	0.04	0	-6.207	0.985	Decreasing Trend very likely
Craig**	LWP	TRUE	33	34	0.96	0	2.14	0.5	Increasing trend as likely as not
Goodwood	LWP	FALSE	33	14	0.06	0	-4.86	0.96	Decreasing trend extremely likely

****Sen slope calculation influenced by censored values, trend category indeterminant**

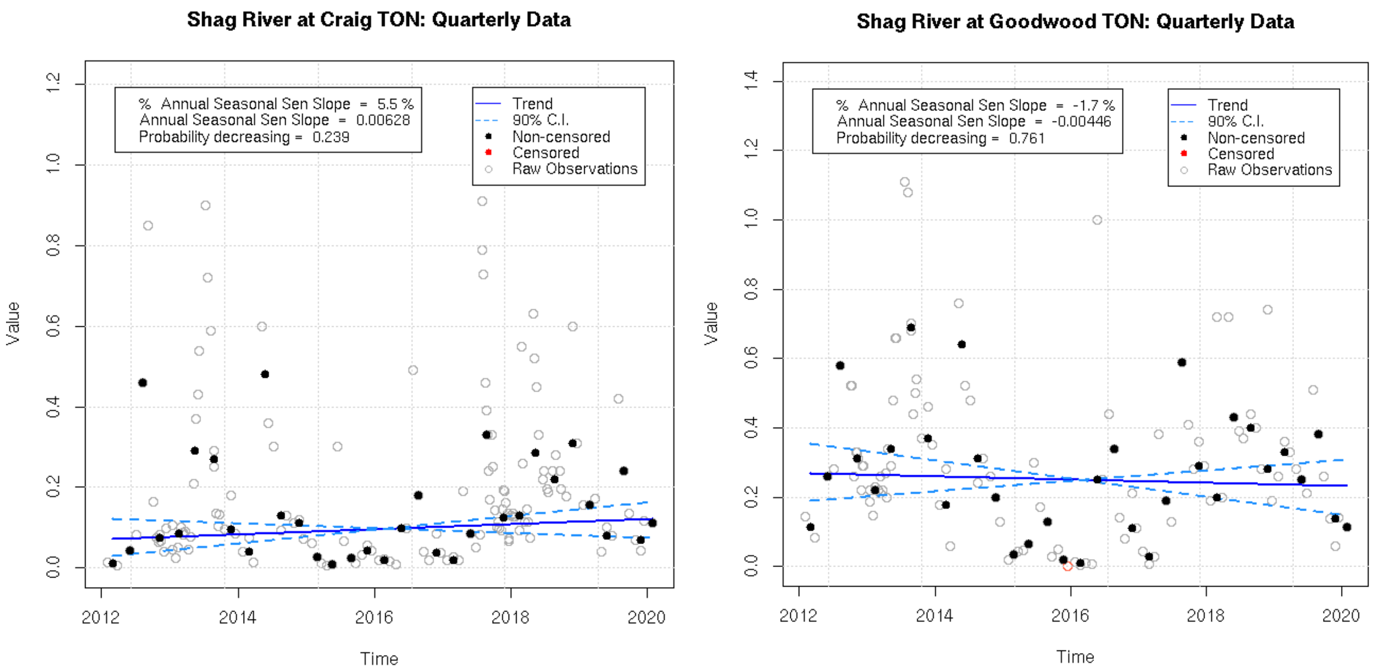


Ammonical nitrogen (NH_4) from Craig and Goodwood monitoring sites (2012 – 2020).

Results from the LWP and TT analysis for NH_4 trends from 2012 – 2020.

Site	Source	Seasonal	Sample	Non-detect	P	Sen Slope	% Change	Prob.	Trend
Craig	TT	FALSE	33	n/a	0.249	0	0	0.901	Decreasing trend possible
Goodwood	TT	FALSE	33	n/a	0.901	0	0	0.549	Trend extremely unlikely
Craig**	LWP	FALSE	33	80	0.89	0	0	0.6	Increasing as likely as not
Goodwood**	LWP	FALSE	33	58	0.34	0	0	0.83	Decreasing likely

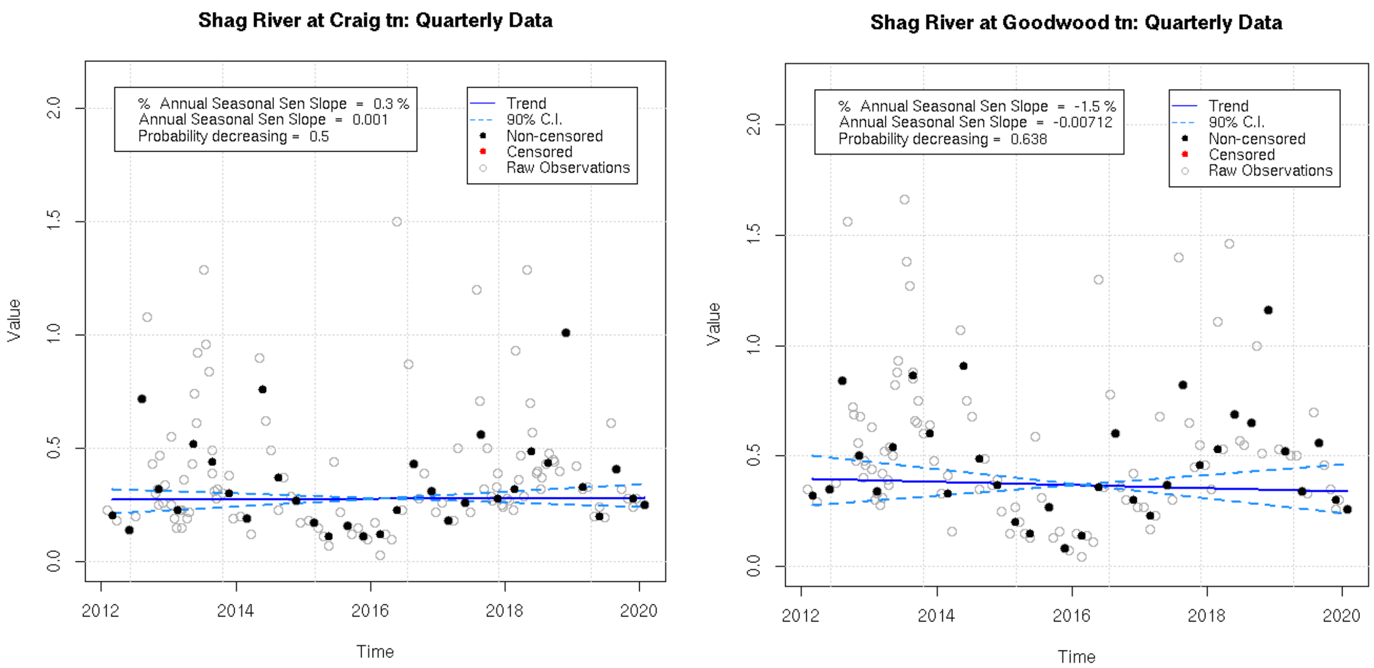
****Sen slope calculation influenced by censored values, trend category indeterminant**



Total Oxidized Nitrogen (TON) from Craig and Goodwood monitoring sites (2012 – 2020).

Results from the LWP and TT analysis for TON trends from 2012 – 2020.

Site	Source	Seasonal	Sample	Non-detect	P	Sen Slope	% Change	Prob.	Trend
Craig	TT	TRUE	33	n/a	0.479	0.006	6.487	0.761	Increasing trend about as likely as not
Goodwood	TT	TRUE	33	n/a	0.479	-0.005	-1.8	0.796	Decreasing trend about as likely as not
Craig	LWP	TRUE	33	0	0.479	0.006	5.46	0.8	Increasing trend unlikely
Goodwood	LWP	TRUE	33	1	0.479	-0.004	-1.68	0.76	Decreasing trend likely

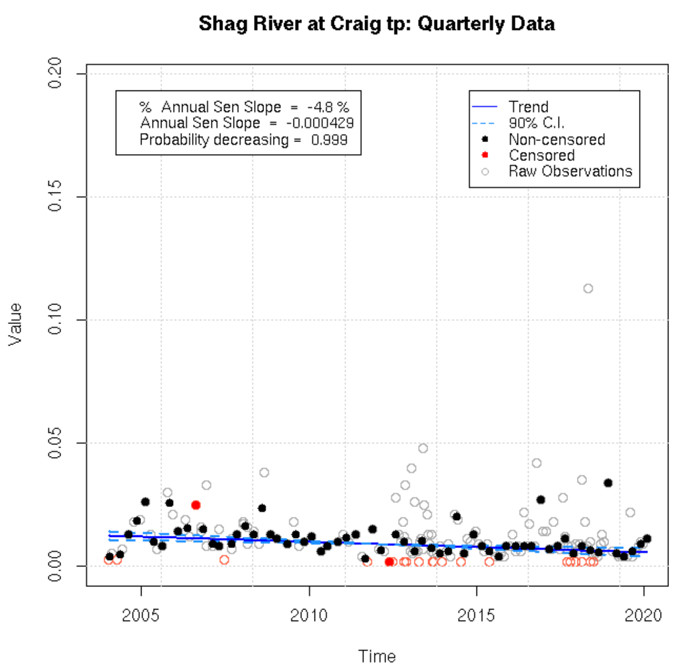


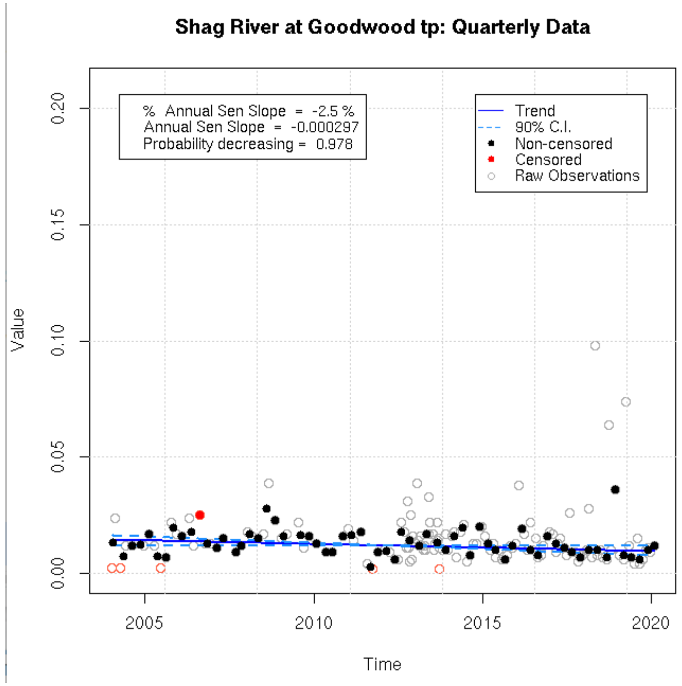
Total Nitrogen (TN) from Craig and Goodwood monitoring sites (2012 – 2020).

Results from the LWP and TT analysis for TN trends from 2012 – 2020.

Site	Source	Seasonal	Sample	Non-detect	P	Sen Slope	% Change	Prob.	Trend
Craig	TT	TRUE	33	n/a	0.336	0.001	0.357	0.761	Trend exceptionally unlikely
Goodwood	TT	TRUE	33	n/a	0.468	-0.007	-1.921	0.796	Trend Unlikely
Craig	LWP	TRUE	33	0	1	0.001	0.33	0.5	Increasing trend as likely as not
Goodwood	LWP	TRUE	33	0	0.72	-0.007	-1.51	0.64	Decreasing trend as likely as not

Shag River: *2004-2020* Water Quality Trends

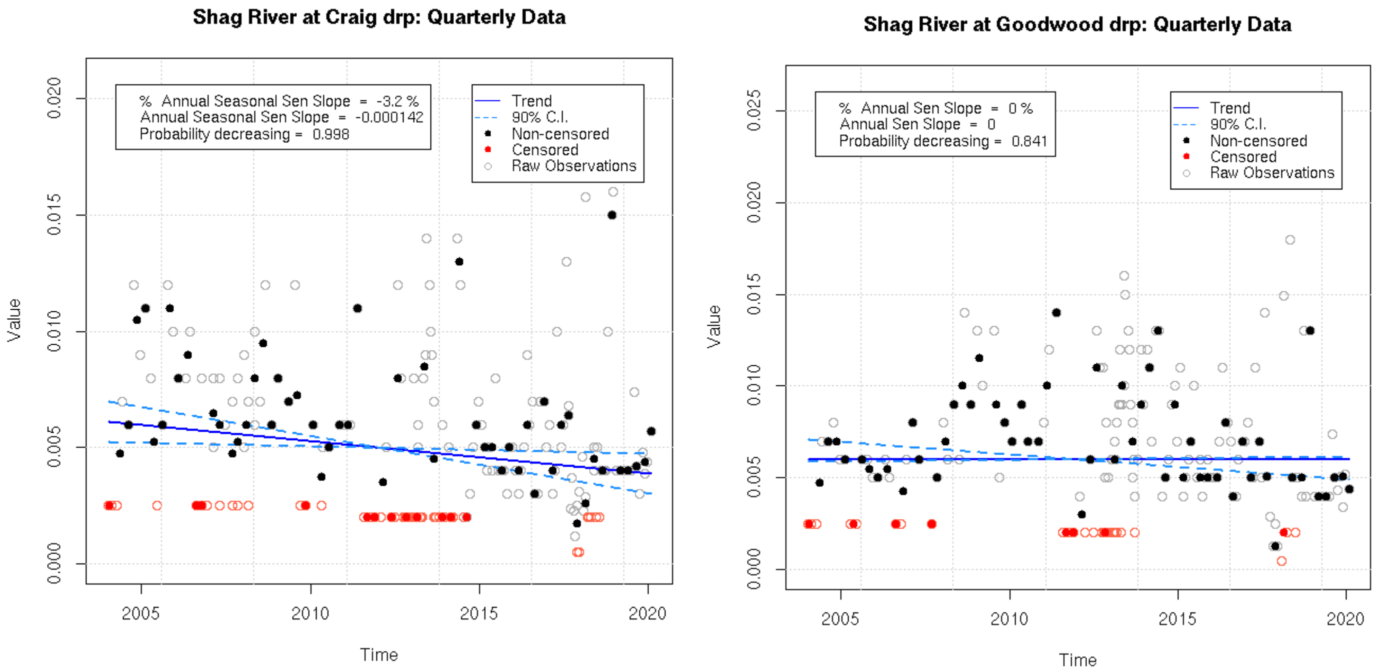




Total Phosphorous (TP) from Craig and Goodwood monitoring sites (2004 – 2020).

Results from the LWP and TT analysis for TP trends from 2004 – 2020.

Site	Source	Seasonal	Sample	Non-detect	P	Sen Slope	% Change	Prob.	Trend
Craig	TT	FALSE	65	n/a	0.002	0	-5.236	0.999	Decreasing trend virtually certain
Goodwood	TT	FALSE	64	n/a	0.02	0	-2.041	0.991	Decreasing trend very likely
Craig	LWP	FALSE	65	21	0.002	-0.0004	-4.76	0.999	Decreasing trend virtually certain
Goodwood	LWP	FALSE	64	6	0.045	-0.0003	-2.47	0.984	Decreasing trend virtually certain

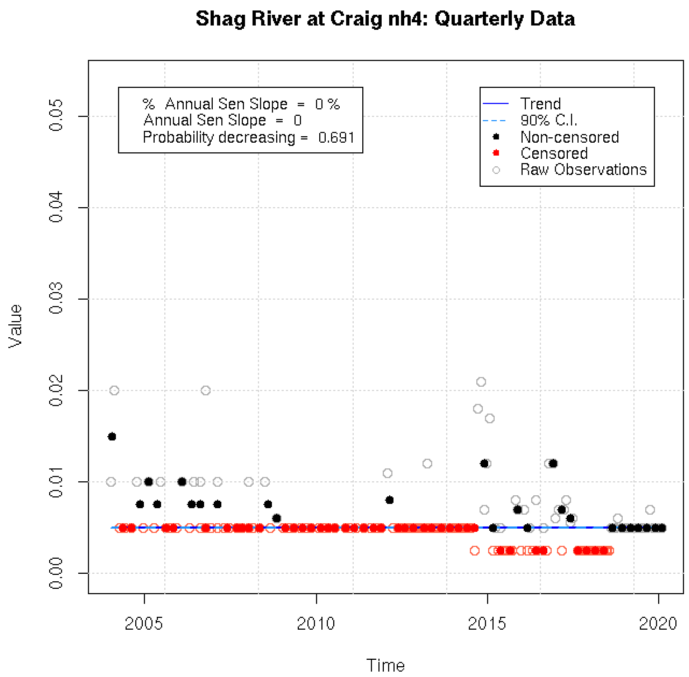


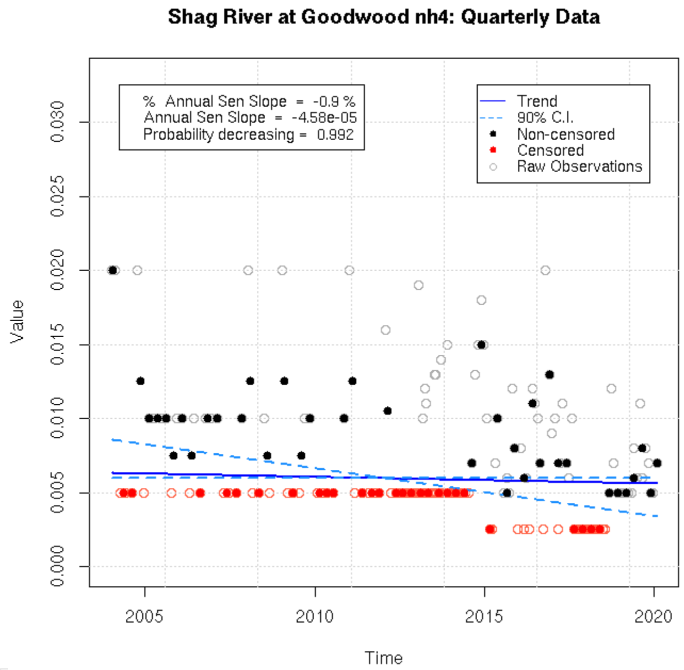
Dissolved Reactive Phosphorous (DRP) from Craig and Goodwood monitoring sites (2004 – 2020).

Results from the LWP and TT analysis for DRP trends from 2004 – 2020.

Site	Source	Seasonal	Sample	Non-detect	P	Sen Slope	% Change	Prob.	Trend
Craig	TT	TRUE	65	n/a	0.021	0	-2.856	0.99	Decreasing trend very likely
Goodwood	TT	FALSE	64	n/a	0.402	0	-0.833	0.812	Decreasing trend as likely as not
Craig	LWP	TRUE	65	51	0.003	-0.0001	-3.15	0.99	Decreasing virtually certain
Goodwood**	LWP	FALSE	64	26	0.318	0	0	0.75	Decreasing likely

****Sen slope calculation influenced by censored values, trend category indeterminant**



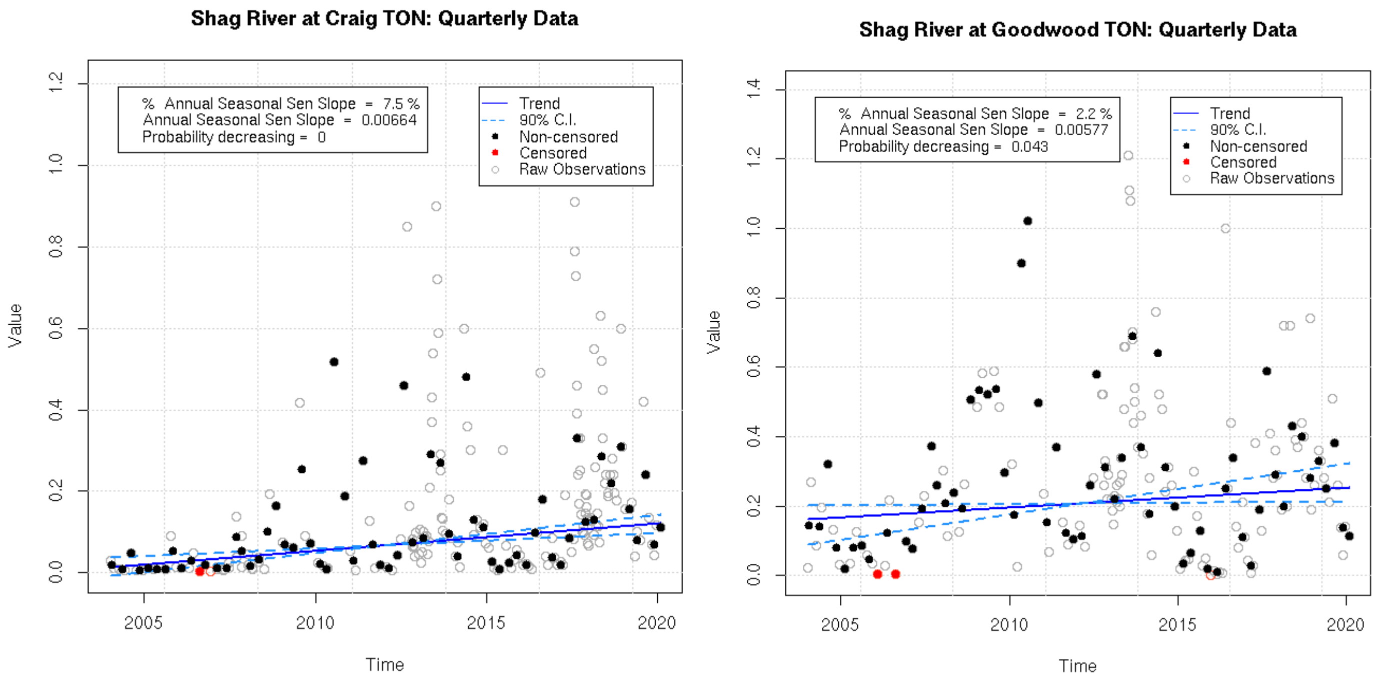


Ammoniacal Nitrogen (NH_4) from Craig and Goodwood monitoring sites (2004 – 2020).

Results from the LWP and TT analysis for NH_4 trends from 2004 – 2020.

Site	Source	Seasonal	Sample	Non-detect	P	Sen Slope	% Change	Prob.	Trend
Craig	TT	FALSE	65	n/a	0	0	0	1	Decreasing trend virtually certain
Goodwood	TT	FALSE	64	n/a	0.02	0	0	0.991	Decreasing trend very likely
Craig**	LWP	FALSE	65	118	0.618	0	0	1	Decreasing trend likely
Goodwood**	LWP	FALSE	65	83	0.016	0	-0.916	0.999	Decreasing trend virtually certain

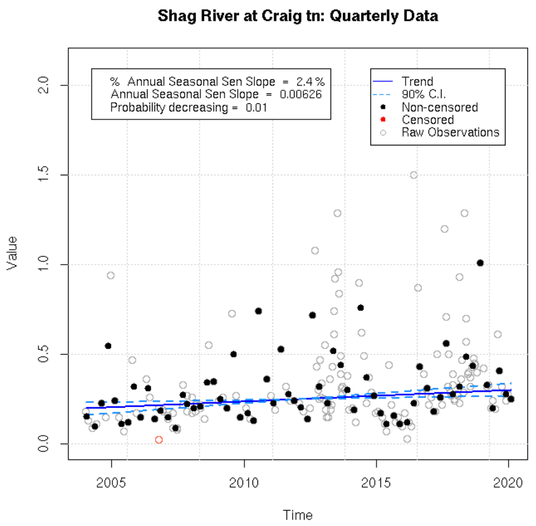
****Sen slope calculation influenced by censored values, trend category indeterminant**

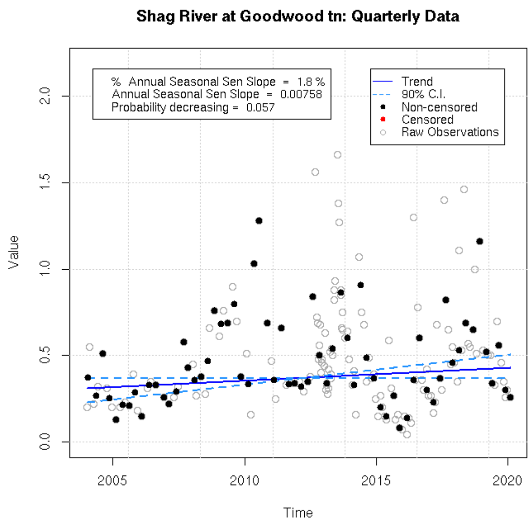


Total Oxidized Nitrogen (TON) from Craig and Goodwood monitoring sites (2004 – 2020).

Results from the LWP and TT analysis for TON trends from 2004 – 2020.

Site	Source	Seasonal	Sample	Non-detect	P	Sen Slope	% Change	Prob.	Trend
Craig	TT	TRUE	65	n/a	0	0.007	9.754	1	Increasing trend virtually certain
Goodwood	TT	TRUE	64	n/a	0.086	0.006	2.787	0.957	Increasing trend likely
Craig	LWP	TRUE	65	2	0	0.006	7.54	1	Increasing trend virtually certain
Goodwood	LWP	TRUE	65	3	0.086	0.005	2.22	1	Increasing trend likely





Total Nitrogen (TN) from Craig and Goodwood monitoring sites (2004 – 2020).

Results from the LWP and TT analysis for TN trends from 2004 – 2020.

Site	Source	Seasonal	Sample	Non-detect	P	Sen Slope	% Change	Prob.	Trend
Craig	TT	TRUE	65	n/a	0.022	0.006	2.522	0.99	Increasing trend very likely
Goodwood	TT	TRUE	64	n/a	0.113	0.008	2.053	0.943	Increasing trend possible
Craig	LWP	TRUE	65	1	0.021	0.006	2.41	1	Increasing trend virtually certain
Goodwood	LWP	TRUE	65	0	0.113	0.008	1.78	0.9	Increasing trend very likely

Table breakdown:

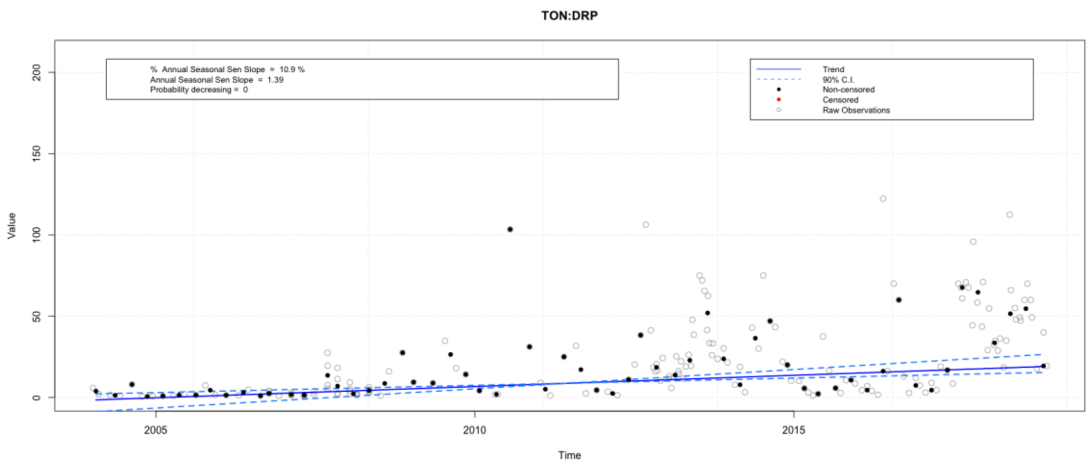
Source = source of analysis
Seasonal = whether data was significantly seasonal (Kruskall Wallis test $p < 0.05$)
Sample = # of samples used in the calculation of the Sen-Slope (it takes the median value of all observed *quarterly* data)
Non-detect = # of samples that were considered non-detects and interpolated (LWP) or halved (TT)
P = p value of the Mann Kendall Test
Sen Slope = slope parameter of a non-parametric regression and is calculated as the median of all possible inter-observation slopes
% change = change over time
Probability of trend = likelihood of observed trend (for LWP, probability is reported as probability of a *decreasing* trend, so if trend is increasing, then the probability of the trend is 1 -… (the values in the tables reflect this correction)
Trend = trend direction/magnitude, derived from Kendall S-statistics and *p*-values for LWP-trends, and Sen-slope and confidence intervals for Time Trends.

Appendix C

N:P data and trend analysis for Shag River Craig Road monitoring site

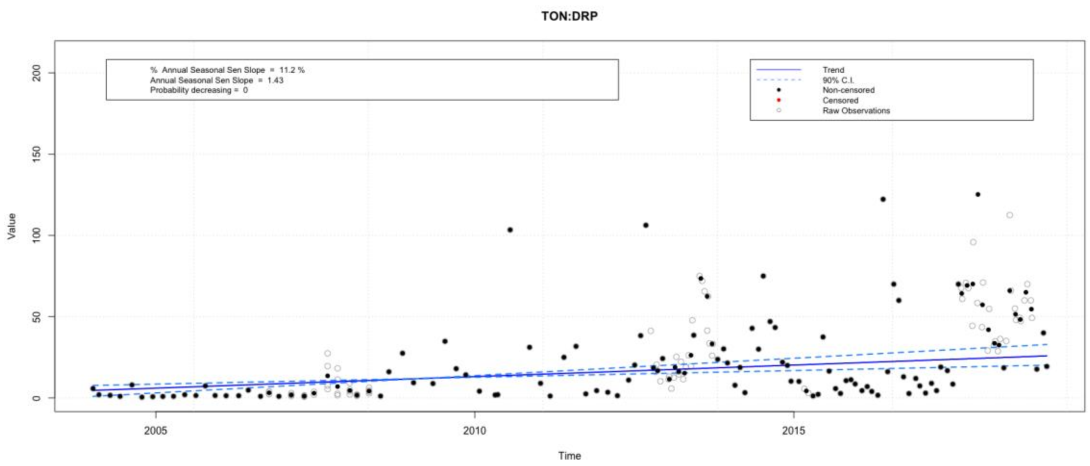
Date	DIN:DRP ratio	Date	DIN:DRP ratio	Date	DIN:DRP ratio	Date	DIN:DRP ratio
7/01/04	5.8	5/05/08	3.8	8/08/13	65.6	31/07/17	70.0
10/02/04	2.0	5/05/08	6.3	23/08/13	41.4	16/08/17	67.6
14/04/04	1.6	10/07/08	1.1	28/08/13	62.5	22/08/17	60.9
10/06/04	1.0	27/08/08	16.1	5/09/13	33.5	12/09/17	70.8
17/08/04	8.0	13/11/08	27.5	20/09/13	26.0	26/09/17	67.6
13/10/04	0.5	15/01/09	9.4	24/09/13	33.3	19/10/17	44.3
14/12/04	0.8	6/05/09	8.9	22/10/13	23.8	24/10/17	95.8
10/02/05	0.9	14/07/09	34.8	25/11/13	30.2	17/11/17	58.4
12/04/05	1.0	16/09/09	18.0	17/12/13	21.5	23/11/17	192.0
15/06/05	2.0	10/11/09	14.2	29/01/14	7.8	13/12/17	43.5
18/08/05	1.5	27/01/10	4.2	27/02/14	18.8	19/12/17	71.0
11/10/05	7.4	27/04/10	1.8	27/03/14	3.3	15/01/18	29.1
6/12/05	1.5	12/05/10	2.0	7/05/14	42.9	23/01/18	54.8
7/02/06	1.4	22/07/10	103.4	13/06/14	30.0	19/02/18	32.4
20/04/06	1.4	10/11/10	31.2	10/07/14	75.0	26/02/18	34.8
14/06/06	4.8	12/01/11	9.0	18/08/14	47.0	14/03/18	28.8
23/08/06	1.0	8/03/11	1.2	16/09/14	43.3	27/03/18	36.3
11/10/06	2.4	26/05/11	25.0	28/10/14	22.0	17/04/18	18.5
11/10/06	3.8	3/08/11	31.8	25/11/14	20.0	1/05/18	35.0
11/10/06	2.5	28/09/11	2.5	16/12/14	10.3	21/05/18	112.5
11/10/06	4.0	29/11/11	4.5	30/01/15	10.2	28/05/18	66.0
6/12/06	1.0	1/02/12	3.5	2/03/15	5.6	20/06/18	55.0
15/02/07	1.9	27/03/12	1.4	25/03/15	3.0	26/06/18	48.0
15/02/07	3.0	30/05/12	11.0	21/04/15	1.2	17/07/18	49.3
15/02/07	1.1	4/07/12	20.3	20/05/15	2.2	23/07/18	47.3
15/02/07	1.8	7/08/12	38.3	17/06/15	37.5	13/08/18	60.0
30/04/07	1.0	6/09/12	106.3	22/07/15	16.5	30/08/18	70.0
30/04/07	1.6	4/10/12	41.3	28/08/15	5.8	19/09/18	60.0
30/04/07	0.8	19/10/12	18.5	25/09/15	2.8	25/09/18	49.3
30/04/07	1.2	31/10/12	16.0	27/10/15	10.7	23/10/18	17.7
25/06/07	3.8	6/11/12	20.5	24/11/15	11.2	30/11/18	40.0
25/06/07	2.0	12/11/12	16.8	18/12/15	8.6	19/12/18	19.4
11/09/07	19.6	28/11/12	10.3	26/01/16	4.5		
11/09/07	27.4	11/12/12	24.3	25/02/16	7.0		
11/09/07	5.4	14/01/13	11.5	22/03/16	4.0		
11/09/07	7.6	18/01/13	13.1	26/04/16	1.7		
7/11/07	11.4	30/01/13	5.8	26/05/16	122.2		
7/11/07	18.2	13/02/13	12.5	21/06/16	16.2		
7/11/07	1.6	27/02/13	25.3	26/07/16	70.0		
7/11/07	2.6	12/03/13	16.2	24/08/16	60.0		
16/01/08	4.0	13/03/13	14.5	20/09/16	13.0		
16/01/08	2.2	26/03/13	22.3	21/10/16	2.7		
16/01/08	9.2	8/04/13	11.5	29/11/16	12.0		
16/01/08	5.1	23/04/13	19.0	22/12/16	7.4		
26/02/08	1.6	9/05/13	26.3	24/01/17	3.0		
26/02/08	2.2	22/05/13	19.5	27/02/17	9.0		
26/02/08	1.3	30/05/13	47.8	28/03/17	4.5		
26/02/08	1.8	7/06/13	38.6	21/04/17	19.0		
5/05/08	2.8	10/07/13	75.0	29/05/17	16.8		
5/05/08	4.7	25/07/13	72.0	29/06/17	8.5		

COLOUR	KEY
	N-limited
	Co-limited
	P-limited



Site	Source	Seasonal	Sample	Non-detect	P	Sen Slope	% Change	Prob. Of trend	Trend
Craig	LWP	TRUE	60	n/a	6.8E-08	1.4	10.8	0.725	Increasing trend exceptionally likely

The black points represent the values used in the analysis for each quarter (one observation per quarter = median of observations).



This is the same analysis but using data as monthly rather than quarterly. The main difference is that the % change is higher in the monthly analysis and the p value is smaller.

Appendix D

Disturbance Map for the Macraes Goldmine Area