Before a joint hearing of the

Otago Regional Council **RM 20.024**

Waitaki District Council

Under	the Resource Management Act 1991
In the matter of	applications by Oceana Gold (New Zealand) Limited for resource consents for the Deepdell North Stage III Project

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STATEMENT OF EVIDENCE OF SIOBAN DOREEN HARTWELL FOR OCEANA GOLD (NEW ZEALAND) LIMITED

4 August 2020

1. QUALIFICATIONS AND EXPERIENCE

1.1 My name is Sioban Hartwell.

1.2 I am currently employed by GHD in the position of New Zealand Market Lead Water.

1.3 I have a degree in Civil Engineering (B.Eng) and am a chartered Civil Engineer and a Fellow of Engineering New Zealand, with over 25 years' experience. My experience has been gained through involvement with a wide range of water infrastructure projects in New Zealand, Australia and the USA with many of these projects being for mining clients.

1.4 Relevant to this evidence, I have prepared mine water management plans for a number of mine sites in New Zealand including for the Millerton, Cypress and Mt William North areas at Stockton, the Globe Progress mine near Reefton, and the Martha Mine in Waihi. Mine water management plans generally encompass hydrological assessments, water balance analysis, water treatment options reviews, erosion and sediment control reviews and assessment of effects of site discharges and water abstractions on receiving water flows and water quality.

1.5 I have overseen the development of a water balance model for the Macraes mine and its use to assess the potential impacts of the proposed Deepdell North III Project (the Project) on receiving water quality.

1.6 In preparing this evidence I have reviewed the following:

i. Deepdell North III Project Assessment of Environmental Effects (AEE), January 2020 prepared by Oceana Gold (New Zealand) Limited (OGNZL)
ii. Waste Rock Stack Seepage Assessment (letter report), Babbage August 2019
iii. Water Management Summary Report for Macraes Phase III Project, April 2011 prepared by Golder Associates.
iv. Records of site water quality and flow monitoring provided by OGLNZ from the period of 1990 to 2019 for the Macraes site.

1.7 The reports and statements of evidence of other experts giving evidence relevant to my area of expertise, include:

i. Evidence presented of Greg Ryder relating to Assessment of Aquatic Biota.

ii. The parts of the section 42A report relevant to my area of expertise.

iii. Evidence of James Blyth on behalf or ORC relating to surface water.

iv. Evidence of Michael Greer on behalf of ORC relating to water quality.

v. Submissions relevant to my area of expertise.

1.8 I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note 2014. This evidence has been prepared in accordance with it and I agree to comply with it. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

2. SCOPE OF EVIDENCE

2.1 I have been asked by OGNZL to prepare evidence in relation to surface water management for the Project. This includes:

i. Characterisation of receiving waters in terms of hydrology and water quality.

ii. Site water balance modelling

iii. Assessment of potential impacts on downstream water quality from development of the Project.

2.2 I confirm that my evidence relates to the proposal known as Deepdell North III as described in Section 3 of the AEE

2.3 I confirm that I am an author of the GHD report dated November 2019 entitled Deepdell North Stage III Project - Receiving Water Quality Analysis and an associated letter prepared for OGLNZ (March 2020) in response to an ORC Section 92 Request for Information relating to the GHD Goldsim model.

3. EXECUTIVE SUMMARY

3.1 The study completed by GHD specifically assessed the potential impact of the Project on downstream water quality. The analysis was completed with a water balance model (WBM) and shows a low potential for future non-compliance with current resource consent conditions.

3.2 Based on the WBM outputs, the current adaptive management approach that OGNZL is applying to site water management continues to be applicable. No immediate risk of non-compliance is predicted; however, the modelling has identified a very low probability future potential from 2045 onwards.

3.3 The adaptive management approach OGNZL is currently applying includes the following key features:

a. Ongoing monitoring to confirm WBM projections and to identify and track changes in downstream water quality.

b. Ongoing refinement of WRS construction to improve seepage water quality.

c. Trialling of passive water treatment systems so that suitable methods for the site have been tested and can be implemented for the post closure period if deemed necessary at the time.

d. Construction of a freshwater dam on Camp Creek (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.

3.4 Future mitigations could also include introduction of localised treatment systems, amending WRS construction practises, delaying the diversion of flows from rehabilitated areas and reducing the footprint of future WRS's.

3.5 Given there are a range of mitigation options available and OGNZL is actively investigating a number of measures I do not consider it necessary at this point in time for OGNZL to commit to a specific mitigation solution.

Rather the ongoing adaptive management approach being currently applied should be continued.

3.6 The study also looked at the potential introduction of a consent limit for nitrates in line with the National Policy Statement for Freshwater Management 2014 as amended 2017 (NPSFM) Attribute B values. Analysis indicates that these values will not be exceeded in receiving waters.

3.7 OGNZL is currently investigating sources of nitrates in runoff and a study completed by GNS showed both country rock and unburnt explosives as potential sources of nitrates. Before any new consent conditions are added for nitrates, in my opinion the sources in the surrounding catchments warrant further investigation.

4. RECEIVING WATER FLOW CHARACTERISTICS

4.1 The Project is located within the Shag River/Waihemo catchment as shown in Figure 1. The river flows in a south-easterly direction and enters the ocean close to Matakaea. The catchment landuse consists primarily of agriculture and forestry. For the Project the relevant tributaries are the Deepdell Creek and its tributary Highlay Creek.

4.2 The Deepdell Creek is characterised by extended periods of low flow, particularly through summer months. Flow records show some occasions of no visible surface flow. Flood events are generally of a short duration.

4.3 Highlay Creek is also ephemeral with periods through the summer of no visible flow. Key flow metrics for the Deepdell Creek and Shag River at the Grange are summarized in Table 1. There is no flow gauging in the Highlay Creek, hence flow estimates have been derived based on a “pro rata” approach for catchment areas with the flow gauge at DC04.

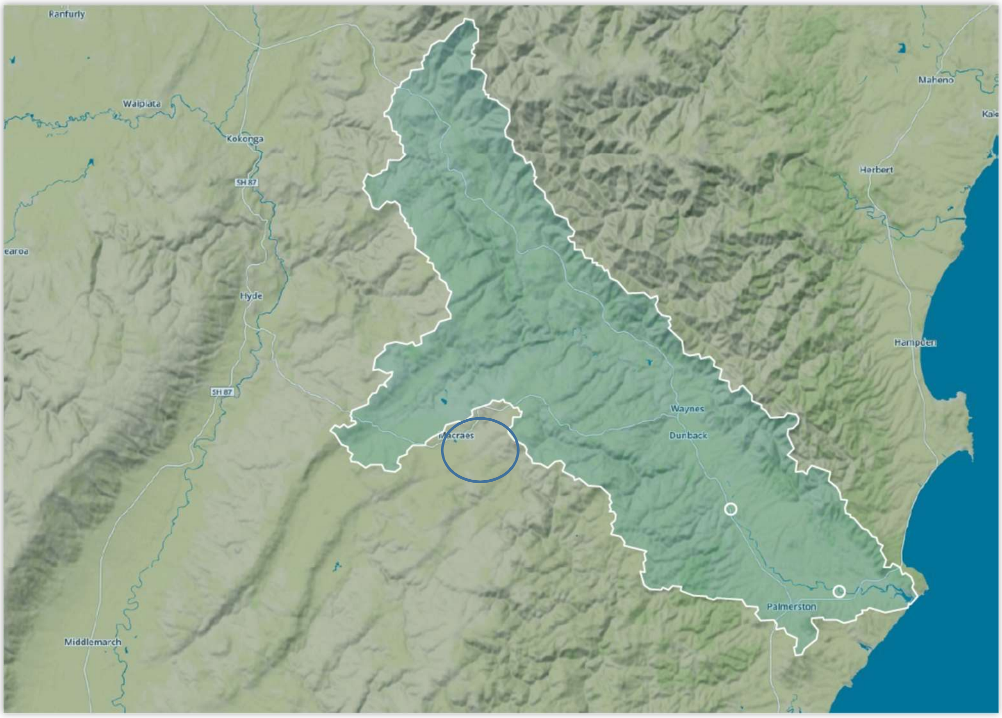

Figure 1: Shag-Waihemo catchment (figure reproduced from LAWA.org.nz)

TABLE 1: RECEIVING WATER FLOW CHARACTERISTICS

Metric	**Highlay Creek at Deepdell confluence (Inferred)**	**Deepdell Creek at DC04 (2011 to 2019)**	**Shag at the Grange (1989-2019)**
Catchment Area (km^2)	7.7	40.8	319
95th percentile flow (l/s)	0.7	3.5	101
50th percentile flow (l/s)	5.7	30	560
Mean Annual minimum flow (7 day)	0.8	4	164
Minimum Flow	0	0	21

5. RECEIVING WATER QUALITY

5.1 The key surface water quality compliance points that are relevant to the Project are DC08 and Shag River at Loop Road. The locations of these are shown in Figure 2.

Figure 2: Water Quality Compliance Locations

5.2 Current water quality compliance values specified in existing resource consents are summarised in Table 2.

TABLE 1: RELEVANT WATER QUALITY COMPLIANCE CRITERIA

Compliance Parameter	Deepdell Creek at DC08	Shag River at Loop Road
pH (unitless)	6 – 9.5	7 – 8 .5
Arsenic g/m^3	0.15	0.01
Cyanide WAD g/m^3	0.1	0.1
Copper (2) g/m^3	0.009	0.009
Iron g/m^3	1	0.2
Lead (2) g/m^3	0.0025	0.0025
Zinc (2) g/m^3	0.12	0.12
Sulphate g/m^3	1,000	250

Notes:

1) All units g/m^3 unless otherwise stated.
2) Metal limits hardness adjusted as per equations 1 to 3 below.
   1. Copper (g/m^3) = (0.96exp$^{0.8545[\ln(hardness)}$] – 1.702) / 1000
   2. Lead (g/m^3) = (1.46203 – [ln(hardness)(0.145712)] exp$^{1.273[\ln(hardness)}$] -4.705) / 1000
   3. Zinc (g/m^3) = (0.986exp$^{0.8473[\ln(hardness)}$] + 0.884) / 1000

5.3 OGNZL has advised GHD that compliance has been achieved with resource consent surface water criteria (Table 2) at sites DC07, DC08, Shag River at Loop Road and Shag River at McCormick's on all but 3 occasions since monitoring began in 1990.

5.4 A number of studies have been undertaken since mine operation commenced to assess the impacts of mining on downstream water quality and to analyse the potential impacts of various extensions during operation and post closure.

5.5 A substantial extension termed the Macraes Phase III Project was the subject of a number of studies completed by Golder (2011). The analysis undertaken by Golder included assessment of various mitigations required to maintain compliance with downstream resource consent conditions. The study showed that there was potential for non-compliance and set out a number of mitigations to prevent this occurring. The mitigation measures noted by Golder that are most relevant to the Project are reproduced below for reference:

- Ongoing monitoring to confirm model projections and assess effects. The development of the site-wide Goldsim model (discussed in this evidence) is the most recent update to site water balance and water quality analysis and follows a number of other updates since 2011 that OGNZL has commissioned.
- Ongoing pumping of Tailings Storage Facility (TSF) water as well as various collection systems across the mine that intercept water in ponds and drains for process re-use and to prevent release.
- Pumping of TSF and other water sources to Frasers Pit following cessation of mine operations for up to 20 years following closure of each facility to allow discharge flow rates to decrease to the point

where other passive mitigation measures can be installed if deemed necessary.

- Construction of a fresh water dam on Camp Creek 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. The dam provides the opportunity also for seasonal or flow matched discharges of freshwater to effectively mitigate the sulphate concentrations in the Shag River. OGNZL holds the appropriate resource consents for the construction of this dam.[1]
- Use of passive water treatment systems in targeted locations.

5.6 The mitigation measures listed above and the associated adaptive management approach remain applicable to the site and guide OGNZL's approach to site water management. Since 2011 OGNZL has also initiated a number of programs of work to assess improved source control of contaminants and to trial passive treatment systems.

5.7 In relation to source control, OGNZL has completed a number of studies on waste rock geochemistry, construction methodology and capping. This has resulted in a change to WRS construction in the Coronation North mine area to improve seepage water quality.

5.8 For the Project I understand that OGNZL plan to adopt learnings from these studies including segregation of materials based on sulphur content, paddock dumping on each lift in the WRS to reduce the effects of particle size separation and resulting advection of oxygen into the WRS, a construction methodology that facilitates progressive rehabilitation and additional material on the outer face of the WRS to act as a barrier to oxygen.

5.9 OGNZL is also currently reviewing a range of passive treatment options so that systems that are effective for site conditions can be applied post

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[1] The dam is consented but has not yet been constructed.

closure. Treatment systems currently being trialed include activated passive treatment, constructed wetlands and irrigation of seepage water.

6. EMERGING CONTAMINANTS - NITRATES

6.1 Resource consent conditions that apply to site discharges do not currently include any nitrogen compounds. However, the 2014 Plan Change 6a (Water Quality) to Otago Regional Councils' Regional Plan is being implemented and some of the Regional Plan changes relate to the management of nitrogen compound loads and concentrations in surface waters around the region. In addition, the NPSFW includes target values for nitrates.

6.2 I understand that the ORC has committed to a progressive implementation programme for implementing NPSFW policies. In relation to this OGNZL commissioned WGA to undertake a study on site sources of nitrogen compounds including assessment of the nitrogen loads from existing and potential future mine water discharges to the Deepdell and Shag River catchments. The objective of the study was to establish whether current site discharges would meet Plan Change 6A and NPS Freshwater criteria as they relate to nitrogen compounds; and if required to identify mitigation measures to meet these criteria.

6.3 Potential sources of nitrogen identified by WGA that could be entrained in either surface or groundwater from the mine site include:

- Residues from the use of ammonium nitrate explosives.
- Cyanide in tailings slurry from the ore processing plant.
- Other nitrogen containing chemicals and reagents used during ore processing – e.g nitric acid
- The weathering of freshly exposed minerals in the waste rock.
- The use of fertiliser for rehabilitation purposes.
- Nitrogen fixing in the soils through plant growth over rehabilitated areas of the mine.

- Animal wastes where grazing animals may access rehabilitated areas of the mine.
- Natural and anthropogenic nitrogen in the mine site water supply and wastewater.

6.4 Following completion of the WGA study OGNZL initiated a number of actions to better understand the sources of nitrogen compounds on the Macraes site. This includes increased monitoring of site water sources and receiving waters in order to increase the sample database.

6.5 In addition, OGNZL commissioned GNS (2019) to undertake a study on mine derived source isotopes of NO_3 in order to identify the most likely source of nitrates in site runoff and seepage. The study identified both unburnt ammonium nitrate from explosives and source rock as nitrate sources. This highlighted that mine activity might not be the sole source of nitrates i.e. nitrates may also be sourced from country rock. GNS recommended further sampling and analysis to resolve ambiguities identified through the study.

6.6 Ryder (2019) has completed a study on the ecological values of the Deepdell Creek and Shag River and has recommended that the NPSFW Attribute B is an appropriate target for the Deepdell Creek and Shag River. Accordingly, for this report receiving water quality has been compared to the Attribute B values for nitrate as an indication of whether compliance with similar future consent conditions will be an issue. Attribute B values are as follows:

- Nitrate-N g/m^3 (NO3-N) – Annual median [>1.0 and ≤2.4] and Annual 95th percentile [>1.5 and ≤3.5]
- Ammoniacal-N g/m^3 (NH4-N) – Annual median [>0.03 and ≤0.24] and Annual 95th percentile [>0.05 and ≤0.40]

6.7 Monitoring data for Deepdell Creek and the Shag River indicates current compliance with Attribute B values.

7. RECEIVING WATER QUALITY ANALYSIS

7.1 A water balance model (WBM) was developed by GHD in Goldsim to assess how water gains and downstream water quality changes over the life of the

Macraes mine. This model essentially updates models prepared previously by others (Golder, WGA) used to predict future water quality outcomes in receiving waters.

7.2 Runoff areas from all catchments is represented in the WBM using a relationship developed between rainfall and stream flow (runoff) and catchment type. The overall catchment balance is checked in the model at key nodes including the gauge locations. A calibration of the WBM was completed with measured river flow data that extends back to 1995.

7.3 I note that in response to the ORC RFI further detail was provided on model flow and water quality calibration and in his evidence Mr James Blyth comments that the model is suitably calibrated. I concur with his statement that further monitoring and collection of hydrological and water quality data will help validate the model and I see model calibration as an ongoing process.

7.4 A key purpose of the model is to assess how future changes, such as mine area extension and/or addition of a new WRS impacts downstream water quality; and what mitigations might be needed to stay within consent conditions. The Macraes Goldsim water balance model was developed in late 2018 and has been subject to ongoing calibration since that time.

7.5 The surface water quality parameters applied to the WBM have been derived based on water quality monitoring data provided by OGNZL. and represent mean values. Within the water balance analysis, the model applies a normal distribution from mean to each water source by adopting a 20% standard deviation to represent the variances observed in the monitoring data.

7.6 Assumed water quality for surface water sources used in the WBM are included as Table 3 and Table 4 (Attachments).

7.7 Understanding how sulphate concentrations in WRS seepage change over time is key to predicting receiving water quality in the future. In low flow conditions the contributions from groundwater and seepage make up the majority of receiving water flows; seepage is thus a key contributor to the overall water quality.

7.8 OGNZL engaged Babbage to analyse available seepage water quality data from all of their WRS's in order to assess whether the concentrations of certain parameters (in particular, sulphate), are at equilibrium (stable) or likely to increase over time. Babbage (2019) approached the study by collating the water chemistry monitoring data available from OGNZL, and assessed if there were any correlations with time or geographical data, such as WRS volumes or areas.

7.9 Babbage developed a relationship between "Age", Average WRS depth and sulphate concentrations in seepage: Their equations were used by GHD to generate predicted future sulphate concentrations in seepage from the Deepdell East WRS (refer Table 5 Attachments).

7.10 For each day simulated by the model a mass balance is derived to calculate downstream water quality. This approach is used to capture the majority of likely outcomes, therefore capturing the risk associated with water quality exceedances at the compliance point.

7.11 The WBM was modified to represent the introduction of the Project. The "baseline" for the project in the WBM includes the new Deepdell East WRS, Deepdell North pit development and the Back Road WRS which is already planned and consented for the site. The baseline also assumes that the Camp Creek dam will be constructed by January 2022 and releasing a constant 10 l/s of fresh water to the Deepdell Creek.

7.12 Key dates represented in the model are listed in Table 2.

Table 2: Key dates

Model Input	**Activity**	**Date**
Deepdell East III Pit	Pump start	Nov 2020
Deepdell East III Pit	Pump stop.	Dec 2022
Deepdell East III WRS	Construction starts	Nov 2020
Deepdell East III WRS	Construction complete	Dec 2022

Model Input	Activity	Date
Camp Creek Dam	Active	Jan 2022
Back Road WRS	Construction starts	Jan 2021
All mining ceases	Rehabilitation	Jan 2025
All rehabilitation complete	All runoff and seepage in catchment to Deepdell Creek	Jan 2045

7.13 The WBM uses a risk-based Monte Carlo approach. When assigning water quality to an element on any given day (e.g. WRS seepage) the model will randomly generate a water quality concentration using a normal distribution approach. This means that while most of the time water quality values will approach mean values there will be values generated that represent variation and uncertainty in the source data, and represent the risk of relatively high concentration inputs. This approach is useful for assessing the potential risk of exceeding downstream water quality consent compliance values. However, it is a conservative approach, and this must be recognised when assessing results.

7.14 Model output graphs are attached for reference. The median values are considered the most likely outcomes and the 95th percentile values are a low probability outcome (i.e 5% chance of being met or exceeded).

7.15 At DC08 sulphate values for the baseline condition are predicted to vary over time around a median of 100 to 200 g/m^3 (seasonal variation); with 95th percentile results occasionally reaching 400 to 600 g/m^3 through the post closure period. Predictions through the operational period and post closure period indicate median concentrations below current measurements and this represents the dilution effects of the Camp Creek Dam coming online. Initially a gradual increase in predicted sulphate concentrations from WRS seepage sources occurs and this aligns with the analysis completed by Babbage.

7.16 Values are predicted to remain consistently under the compliance limit. Arsenic and iron concentrations are predicted well below compliance values.

7.17 At Loop Road the median results similarly stay within compliance over the 40 year time period run in the model. Predictions are similar to those values currently measured which demonstrate reduced impact of dilution from the Camp Creek Dam at Loop Road due to the relatively higher base flows.

7.18 The Monte Carlo simulation does identify the potential to exceed the 95th percentile guidance values for both arsenic and sulphate in the long term.

7.19 Mining ceases by 2025, and 2045 is the period in the model when direct management of discharges has ceased and it is assumed that all water generated on the mine is diverted back to natural catchments (i.e. there is no reuse or water being pumped into the underground workings or pits). This introduces surface runoff that has been classified in the model as "rehab impacted" as well as WRS runoff and seepage. The classification is broad and potential water quality improvement from the various sources will be better than assumed in the model.

7.20 The mean concentration of sulphate in this type of runoff (rehab impacted) is assumed to be 470 g/m^3 and the mean assumed arsenic concentration is 0.02 g/m^3. In a Monte Carlo analysis, there will be some simulations where the upper possible deviation from these values are applied. As noted previously, the 95th percentile analysis runs are a low probability of occurrence. This risk-based analysis provides useful guidance of risk, however the median values are those that are most likely to occur.

7.21 At both sites a rise in concentrations is indicated between 2055 and 2058, which corresponds with modelled overtopping of the Golden Point pit. This is considered to be a conservative result as the pit lake water quality used in the model is based on current measured values. The pit receives water from a number of poor quality sources that will not contribute post closure.

7.22 Figure 3 shows the Highlay Creek in relation to the new WRS. The figure shows that part of the WRS shown in yellow (18.8ha) will drain towards the

Highlay Creek. The WRS area is relatively small compared to the overall catchment upstream of the Deepdell Creek confluence (2%).

7.23 Samples (#17) taken from the creek at site HC01 indicate median sulphate concentrations below 10 g/m^3 and a maximum recording of 70 g/m^3. The median Nitrate value (Nitrate-N) is 0.09 g/m^3 and the maximum reading is 0.49 g/m^3.

7.24 A simple mass balance analysis was initially undertaken to assess what change WRS seepage might make to the stream water quality. The analysis showed some elevation in parameters due to the introduction of seepage, but not beyond compliance values applicable at DC08. For example, median sulphate values post closure were predicted to increase from 7 g/m^3 to 59 g/m^3 in low flow conditions. A more detailed analysis was completed in response to the ORC RFI as I cover later in my evidence (clause 9.2).

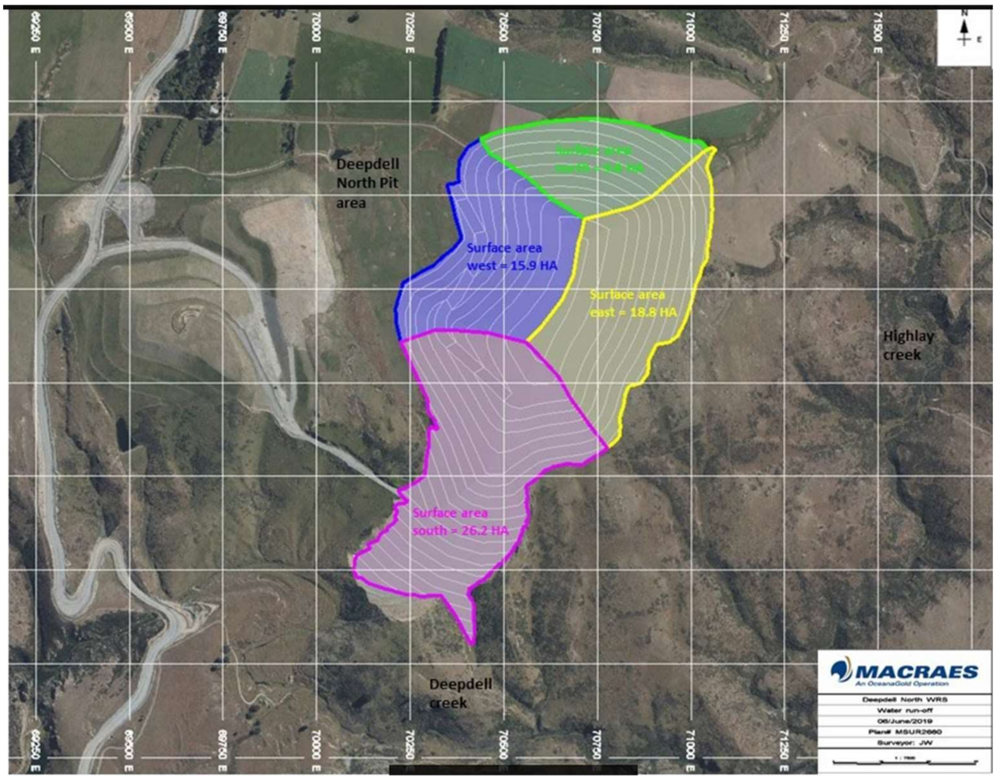

FIGURE 3: HIGHLAY CREEK IN RELATION TO DEEPDELL EAST WRS

7.25 For reference a Location Plan (Figure 5), Project Plan (Figure 6) and map of water quality and flow gauging sites (Figure 7) are attached to my evidence.

8. PIT LAKE DEVELOPMENT

8.1 In the 40 year period run through the model, a pit lake begins to form post closure but does not spill within the time period covered. The overflow point is set at RL 465m and the lake is approaching RL 430m in 2060. This is shown in Figure 4. The groundwater study completed by GHD and covered by the evidence of Dusk Mains indicates the lake is unlikely to ever reach the overflow point.

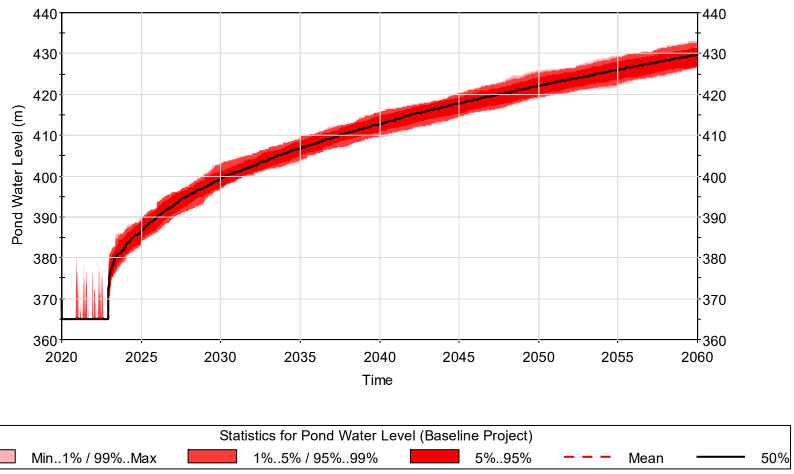

FIGURE 4: DEEPDELL NORTH PIT LAKE DEVELOPMENT

9. S42A STAFF RECOMMENDING REPORT

9.1 I have read the Hearings report issued by the ORC and associated draft consents. I note that the report (section 8.11) proposes stricter and additional compliance criteria for the Highlay Creek and Camp Creek compliance points to reduce adverse effects on the Deepdell Creek and Shag River catchments. The values recommended by Dr Greer are included in the draft consent compliance criteria (p 180) for arsenic, cyanide, copper, and zinc.

9.2 Contaminant concentrations within Highlay Creek and its Western Tributary were not modelled for the initial Project water quality analysis that supported the AEE. However, in response to the ORC RFI a predictive analysis was conducted to assess the water quality at three locations including the

Western Tributary and the existing monitoring points of HC01 and HC02, as shown in the attached Figure 9. The results of this analysis are attached as Table 7.

9.3 The analysis indicates compliance will be achieved with the proposed criteria; although I note that a compliance value for sulphate is not included (TBC).

9.4 I have reviewed the draft compliance and monitoring schedules for both the Deepdell East WRS and the Deepdell North Pit Lake and consider these reasonable.

9.5 I note that in addition to the current compliance points within the Deepdell Creek (DC08) and Shag River at Loop Road, a new compliance point is proposed in Highlay Creek at HC02. For all of these sites monthly sampling is proposed which aligns with current site practise and I support.

9.6 The water quality compliance criteria at DC08 and Shag River at Loop Road are as per current values with the exception of the proposed addition of Nitrate, Dissolved Inorganic Nitrogen (DIN) and Dissolved Reactive Phosphorous (DRP). The values for these are set at "TBC" hence I cannot comment at the stage on the potential for non-compliance.

9.7 I note that the metals values proposed for HC02 are more stringent than at DCO8 and align with values proposed in the evidence of Dr Michael Greer. My analysis indicates future compliance No value for sulphate is included hence I cannot comment at the stage on the potential for non-compliance with sulphate values.

9.8 In relation to the Deepdell North Pit Lake, I note that the lake is not expected to overflow within the term of the consent. I agree with conditions for monitoring of lake levels and water quality as it fills as this is important to check predictions against and adjust future management practise if needed.

10. MATTERS RAISED IN SUBMISSIONS

10.1 I have reviewed the submissions that relate to my evidence.

10.2 The Kā Rūnaka submission notes a lack of confidence that "*the mitigation measures proposed adequately address negative effects of the Project on wai Māori due to a lack of information on potential hydrological impacts on the Deepdell Creek catchment*". Support for proposed mitigation measures is however noted. I consider that the adaptive management approach is appropriate for the site and is sufficiently flexible for OGLNZ to respond – e.g by adding additional mitigation measures in future if needed.

10.3 The Macraes Community note failure of OGNZL to meet consent conditions. I have been advised by OGNZL that there have been only 3 breaches of downstream water quality compliance values since 1990 as follows:

- An exceedance of sulphate values in Deepdell Creek in 2006 was due to an on-site operational issue that was corrected.
- Two exceedances reported at the Shag River at McCormicks are the result of an operational issue and are also likely to have been sampled from the wrong sampling point due to an error by the field technician who had been sampling McCormicks Creek itself not the Shag River downstream of the McCormicks Creek confluence.
- A review by OGNZL indicated the elevated concentrations measured at sites DC07 and DC08 in 2015 were due to very low natural flows in Deepdell Creek at the time and therefore a very low mine water dilution ratio.

10.4 I note that the Department of Conservation (DOC) submits that the application does not have regard to several components of the NPSFW and that the effects of the proposal on aquatic life is unclear. Specifically, DOC notes that "*the proposal will still result in the loss of naturalness, natural character and aquatic habitat in the catchment, and effects on freshwater community structure*". I cannot comment on impacts on aquatic habitat, however based on the analysis consider there to be minimal change to receiving water quality associated with the Project

11. CONCLUSION

11.1 In conclusion I consider that the Project will have minimal impact on downstream water quality. However, should monitoring indicate that downstream water quality is deteriorating; the adaptive management approach OGNZL is applying broadly to water management at the site allows for implementation of a range of mitigation measures.

Sioban Hartwell

4 August 2020

ATTACHMENTS – TABLES AND FIGURES

Table 3: Projected surface water quality from mine activity –mean values (g/m^3)

Parameter	Natural	Impacted	[1]Rehab Impact	Pit	Ponds	TSF
Ammonia	0.011	0.012	0.012	0.8	0.011	0.012
Arsenic	0.0018	0.04	0.02	0.2	0.0018	0.04
Copper	0.001	0.0012	0.001	0.02	0.001	0.0012
Hardness	65	1200	630	880	65	1200
Iron	0.05	0.032	0.14	0.9	0.24	0.032
Lead	0.00015	0.0002	0.00019	0.001	0.00015	0.00022
Nitrate	0.05	0.094	0.4	2.0	10.5	0.1
Sulphate	24	930	470	1400	1500	930
Zinc	0.001	0.001	0.001	0.0056	0.001	0.001

Notes

1. Rehab impact – areas other than WRS that have been rehabilitated

Table 4: Projected surface water quality for Deepdell East III WRS (g/m^3)

Parameter	Initial Deepdell WRS	Final Deepdell WRS	Rehab Deepdell WRS
Ammonia	0.5	0.02	0.01
Arsenic	0.01	0.01	0.01
Copper	0.0018	0.0013	0.0011
Hardness	200	1030	220
Iron	0.08	0.1	0.08
Lead	0.00015	0.0003	0.00015
Nitrate	1.0	0.4	0.4
Sulphate	470	150	150
Zinc	0.001	0.001	0.0012

Table 5: Projected seepage water quality for Deepdell East WRS (g/m^3)

Parameter	Initial Deepdell WRS	Final Deepdell WRS
Ammonia	0.5	0.02
Arsenic	0.01	0.01
Copper	0.0018	0.0013
Hardness	200	1030
Iron	0.23	0.1
Lead	0.001	0.0003
Nitrate	10.5	14
Sulphate	100	522
Zinc	0.001	0.001

Table 6: Highlay Creek Predicted Water Quality (g/m^3)

Parameter	HC01 Water Quality Monitoring (May 2018 - Sept 2019)[1]		Deepdell East WRS Seepage	Point 1, Western Tributary		Point 2, HC01		Point 3, HC02	
	Median	95th %	Mean	Median	95th %	Median	95th %	Median	95th %
Ammonia	0.01	0.01	0.02	0.012	0.016	0.011	0.013	0.010	0.012
Arsenic	0.001	0.002	0.01	0.003	0.007	0.001	0.004	0.001	0.003
Copper	0.0008	0.0013	0.0013	0.001	0.001	0.001	0.001	0.001	0.001
Hardness	33	67	1030	206	634	88	327	76	279
Iron	0.12	0.26	0.1	0.12	0.17	0.12	0.22	0.12	0.23
Lead	0.0001	0.0001	0.0003	0.0001	0.0002	0.0001	0.0002	0.0001	0.0001
Nitrate	0.09	0.41	14	2.5	8.4	0.9	4.1	0.7	3.4
Sulphate	7	22	522	96	316	35	157	29	132
Zinc	0.001	0.0025	0.001	0.001	0.002	0.001	0.002	0.001	0.002

Note: Values for some parameters may be elevated over actuals where lower detection limits are recorded.

[1] Water quality from the natural catchments is based on recent measurements taken at HC01 between May 2018 and September 2019.

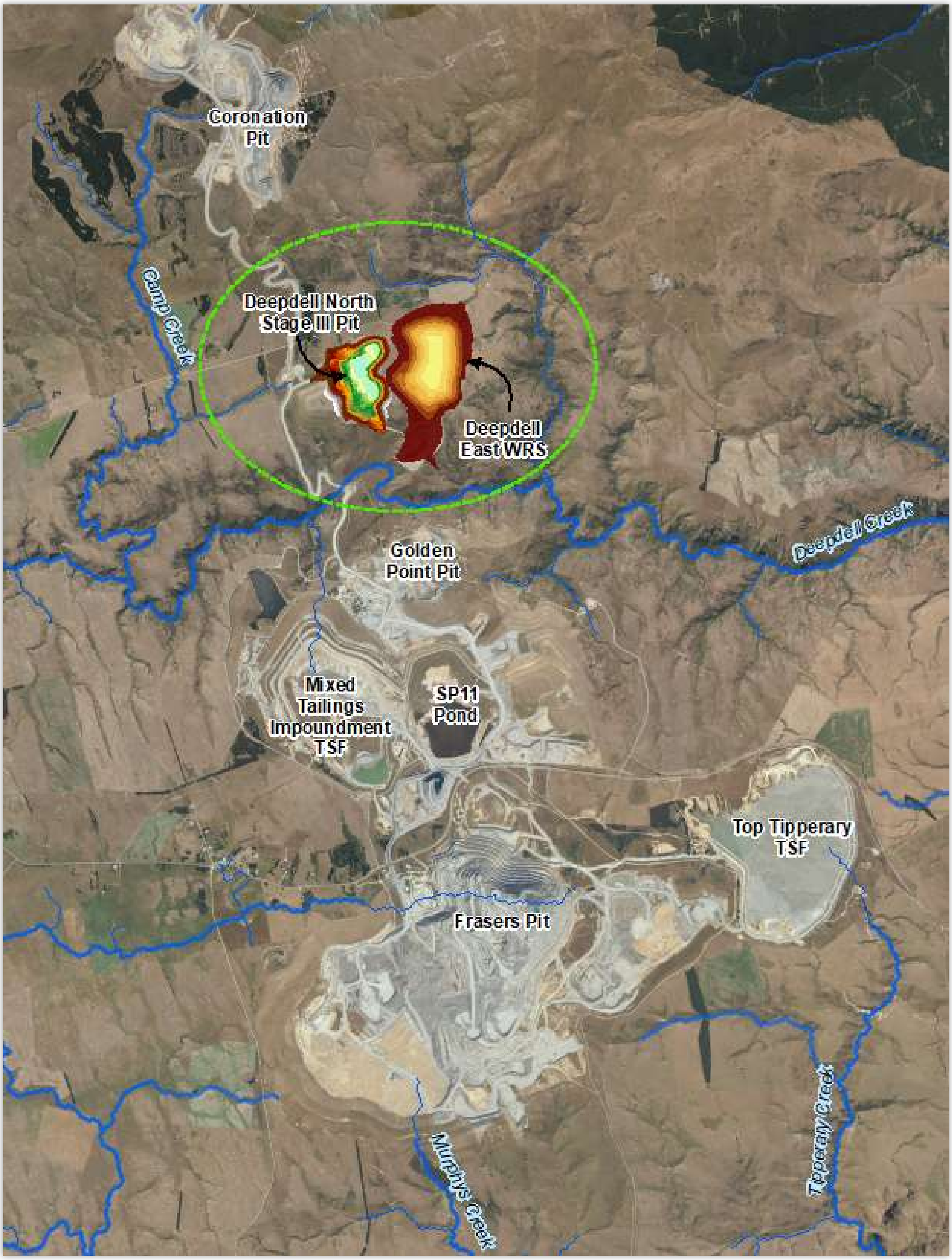

Figure 5: Deepdell North Stage III project location plan

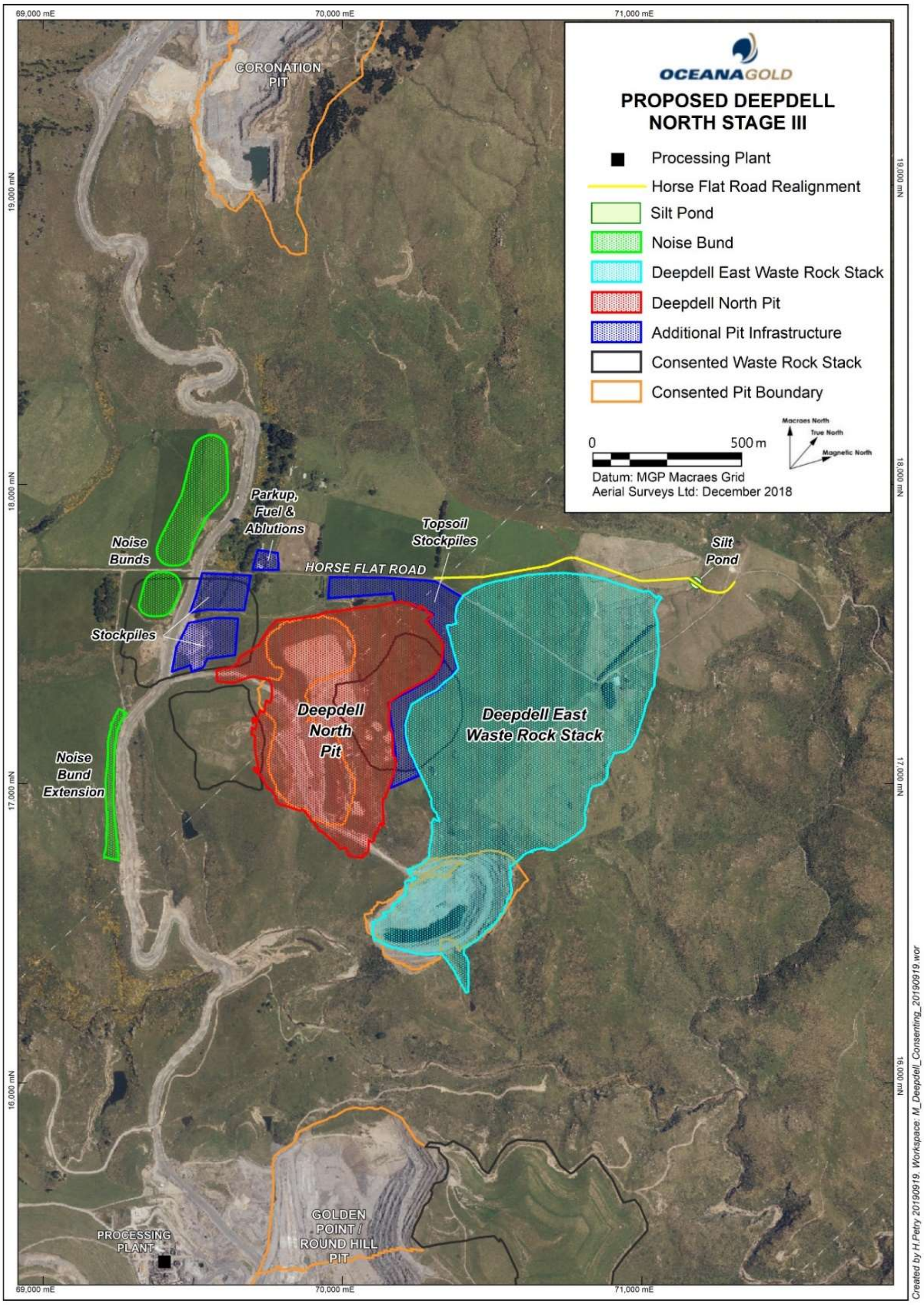

Figure 6: Deepdell North Stage III Project

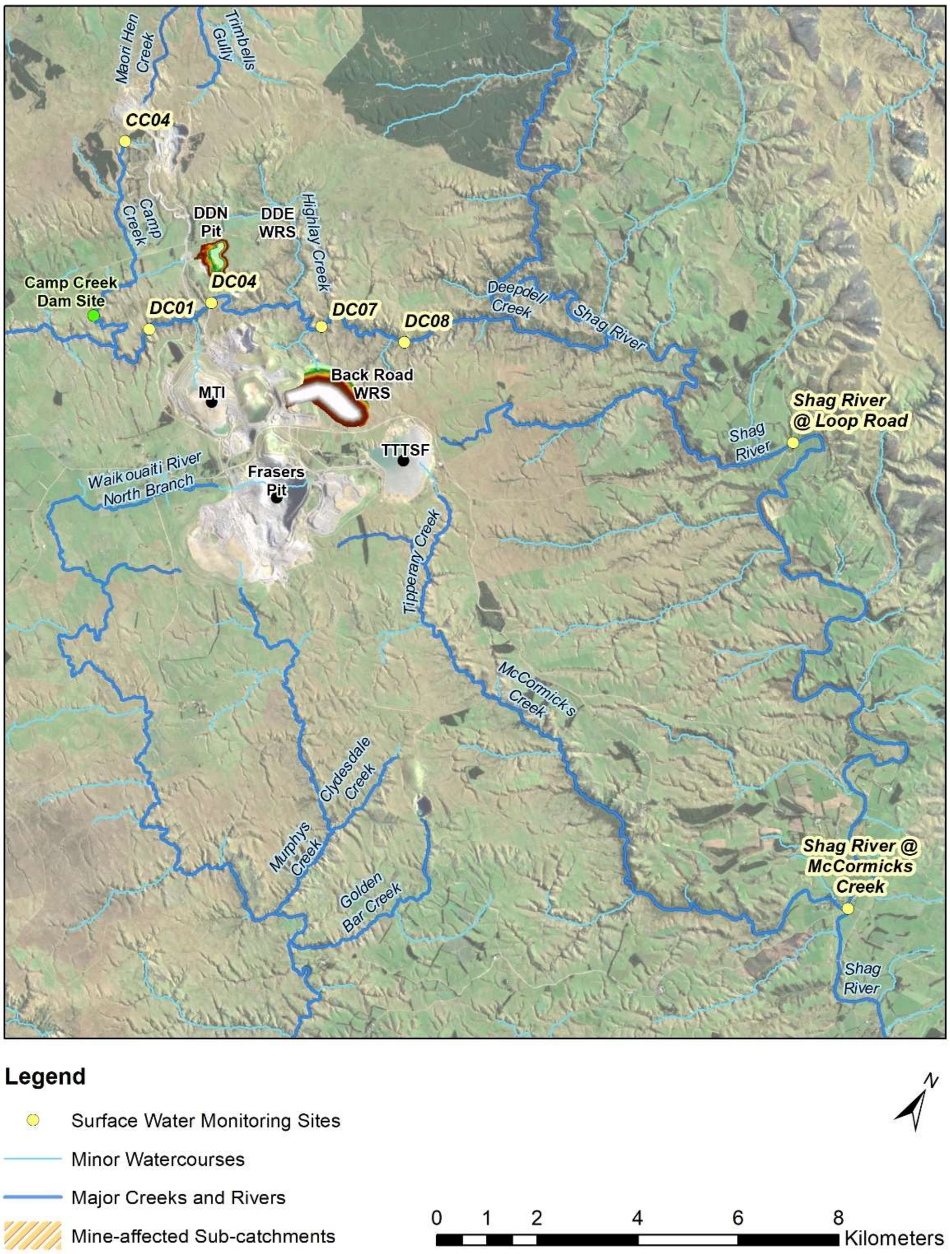

Figure 7:Macraes mine drainage system and monitoring locations

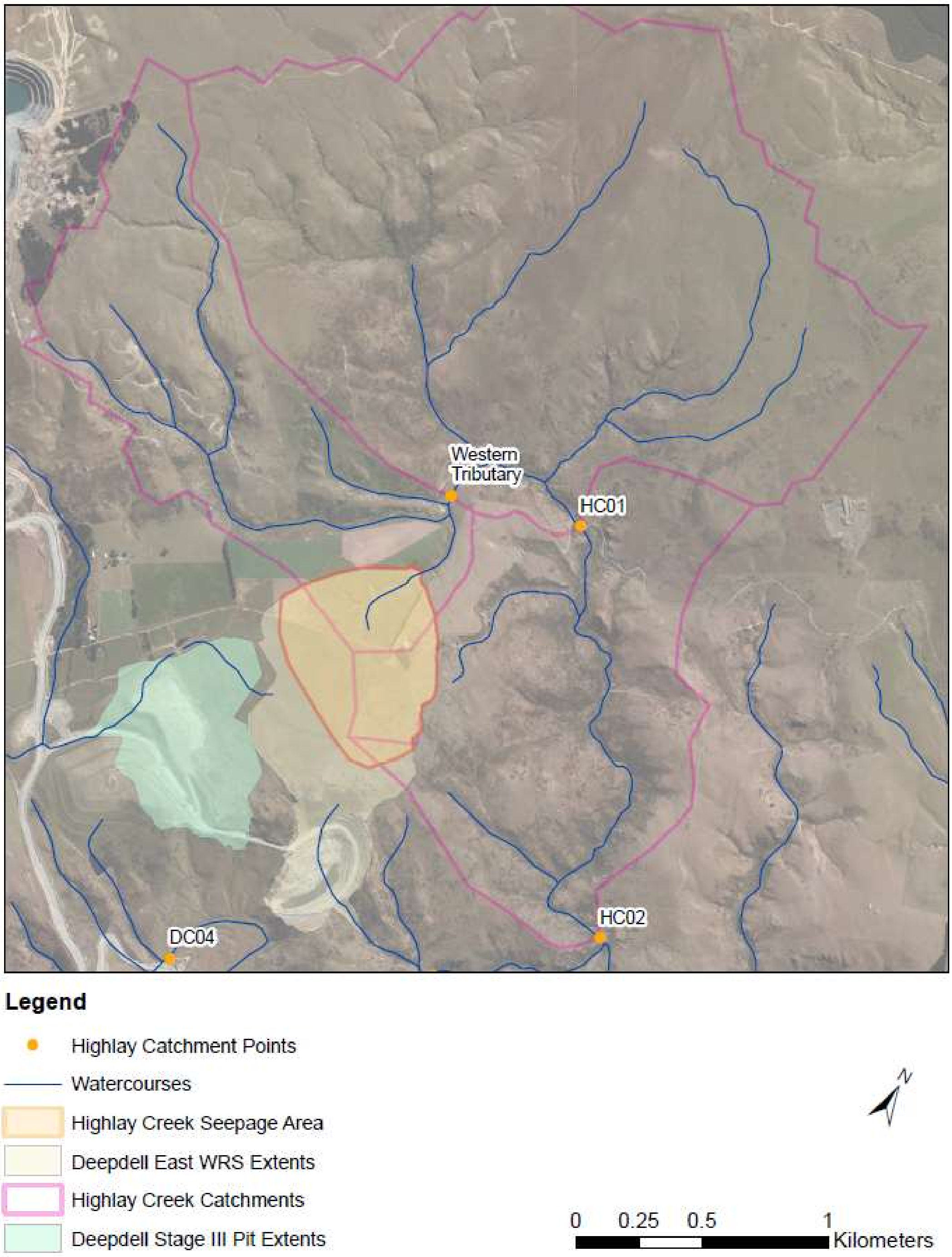

Figure 8: HIghlay Creek Water Quality Analysis Points

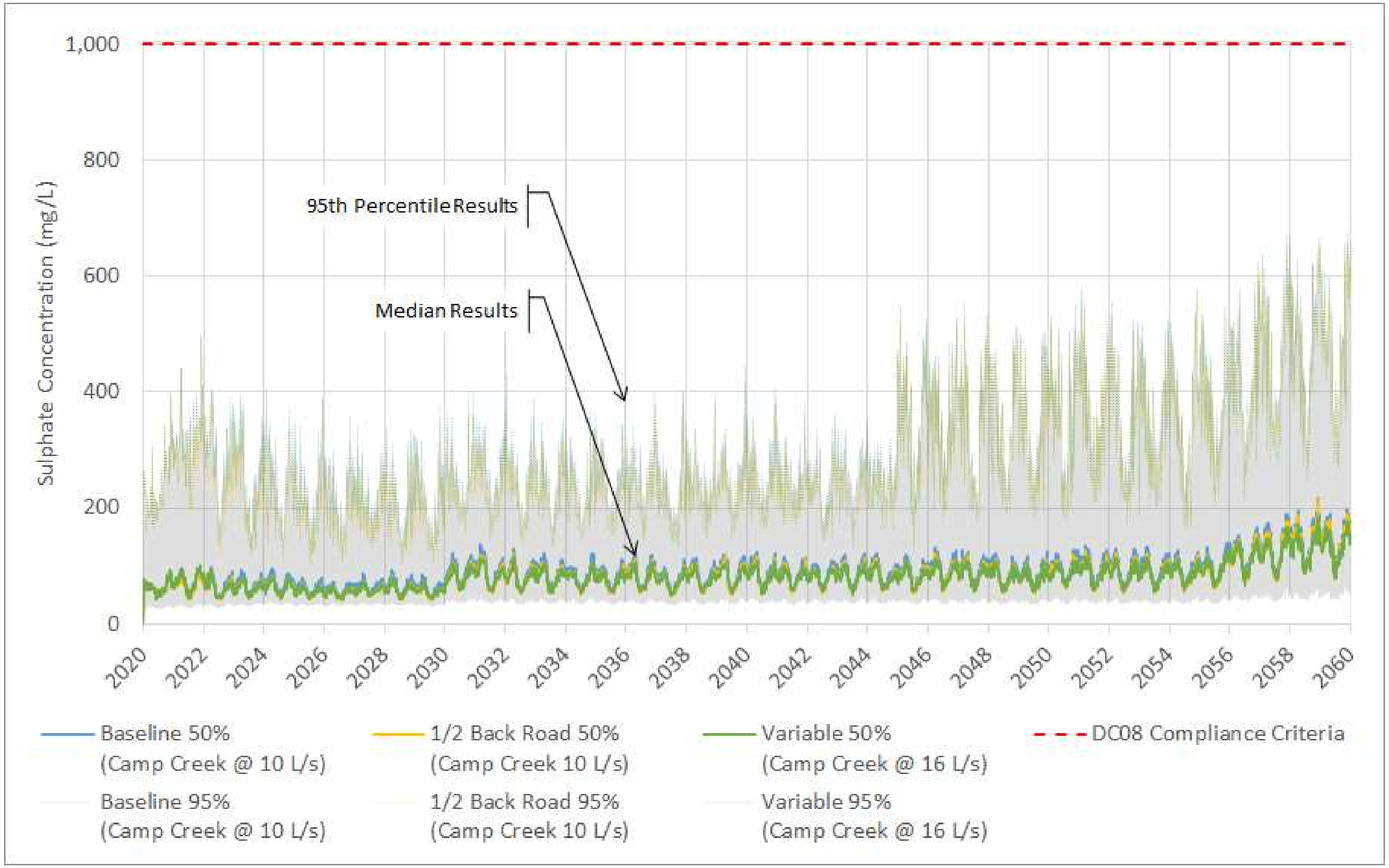

Figure 9: Predicted Sulphate concentrations over time at DC08 (50th and 95th percentile values)

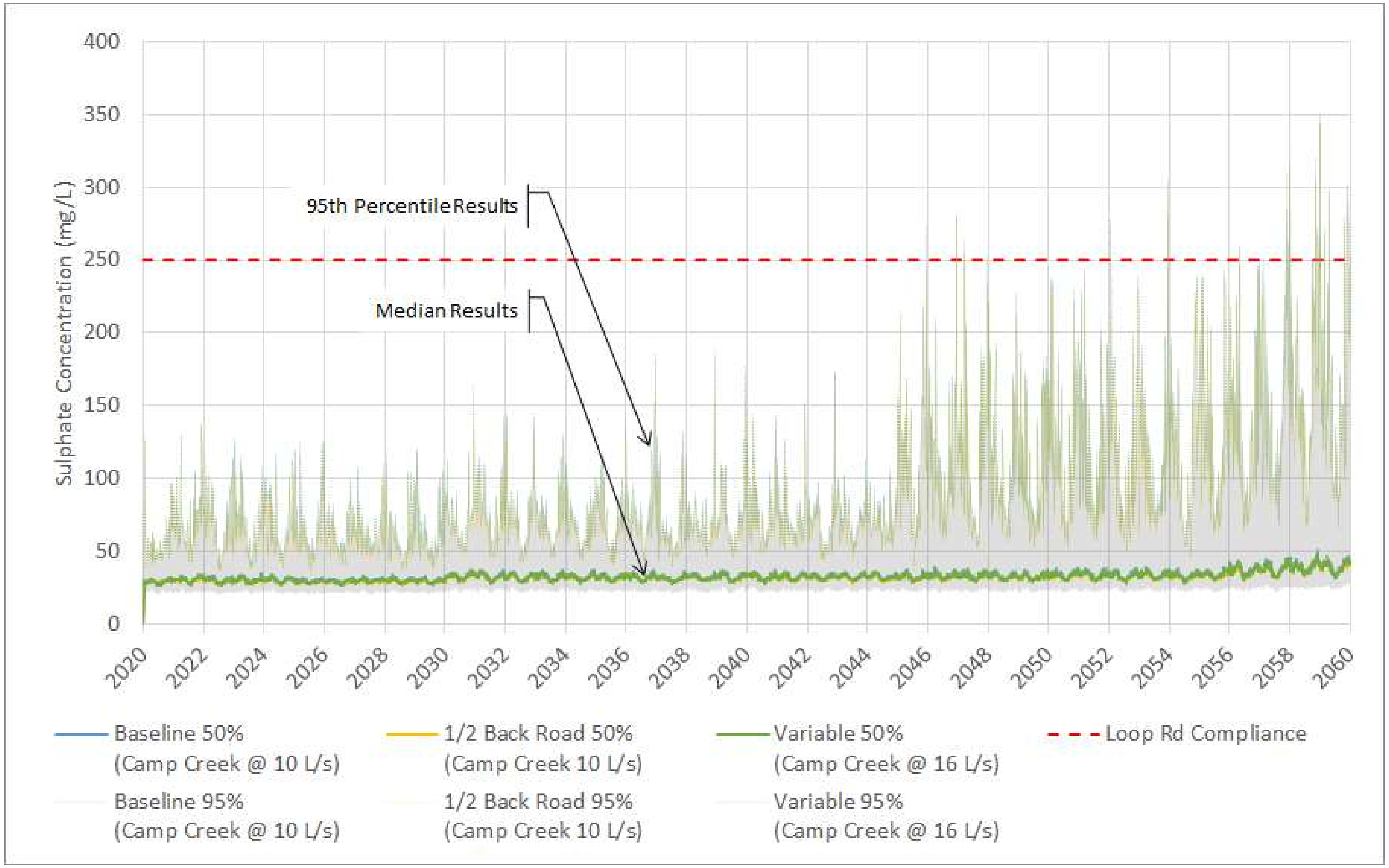

Figure 10: Predicted Sulphate concentrations over time at Shag River (50th and 95th percentile values)

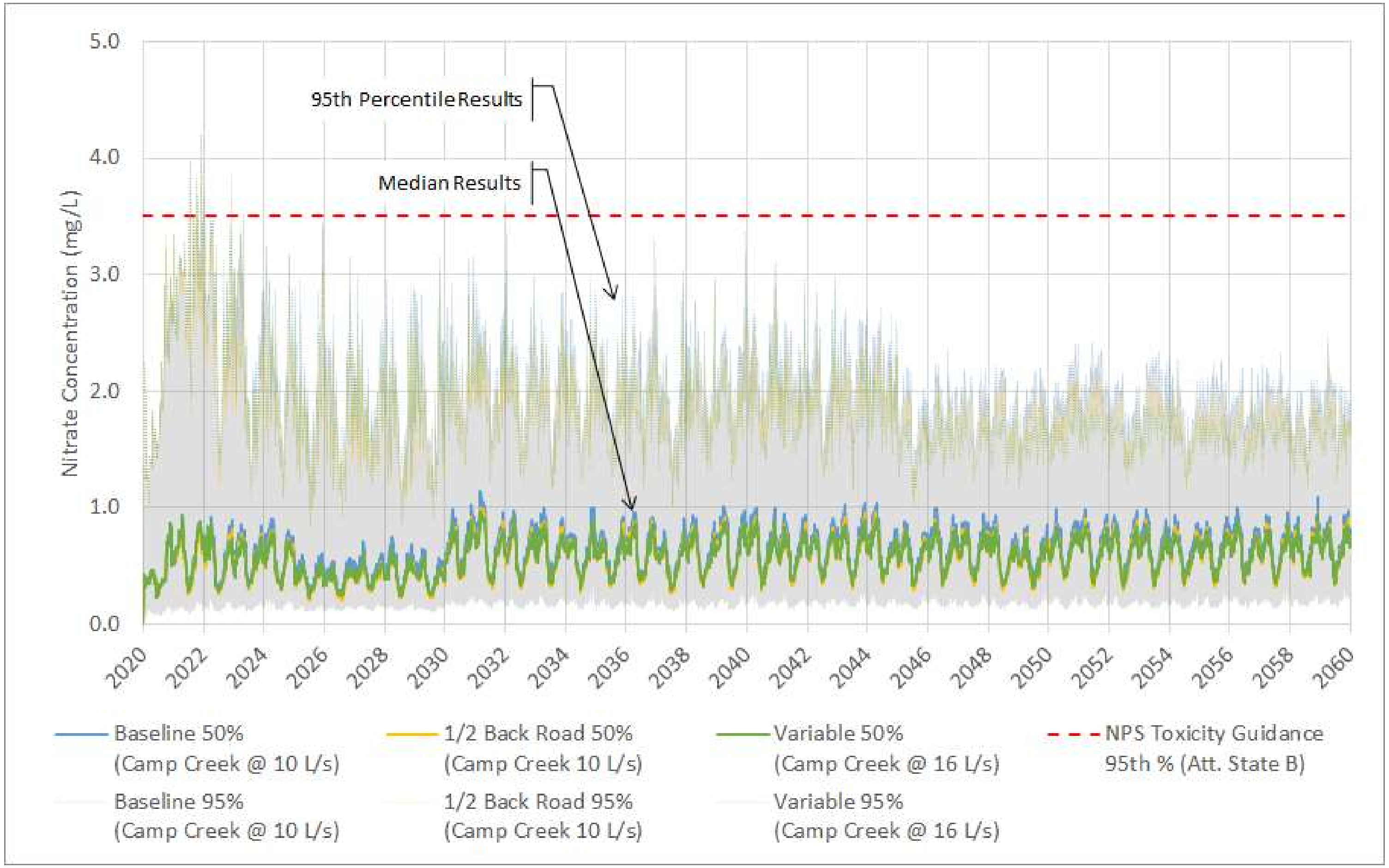

Figure 11: Predicted Nitrate-N concentrations over time at DC08 (50th and 95th percentile values)

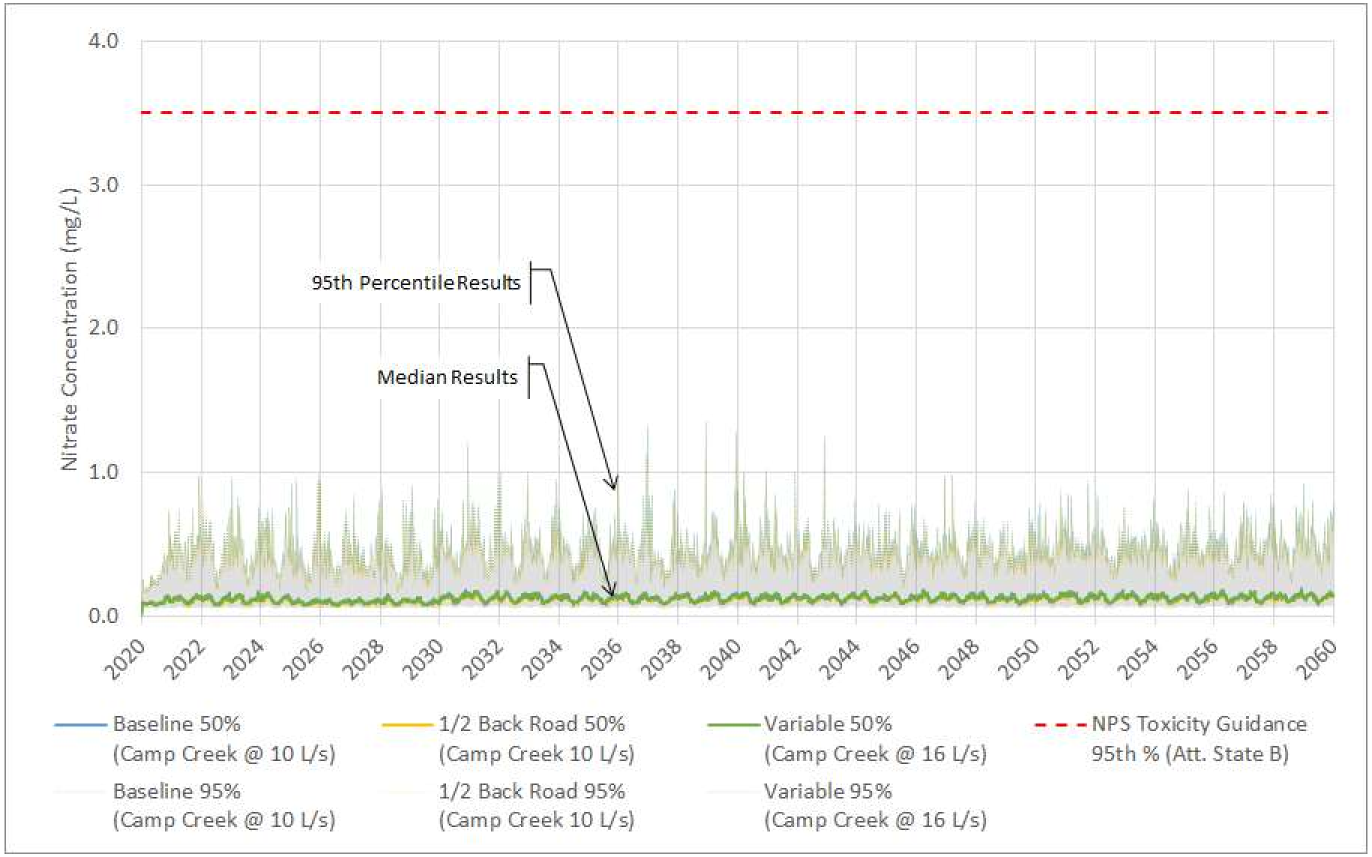

Figure 12: Predicted Nitrate-N concentrations over time at Shag River (50th and 95th percentile values)