SURFACE WATER AND GROUNDWATER ENVIRONMENTAL MONITORING AND ACTION PLAN, OCTOBER 2020 DRAFT (version 2), CURRAGHINALT PROJECT

Prepared For

Dalradian Gold Limited

Report Prepared by

SRK Consulting (UK) Limited

UK7511

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1 INTRODUCTION

1.1 Purpose

This is the draft October 2020 version of the Surface water and Groundwater Environmental Monitoring and Action Plan (SGEMAP or "the Plan") prepared by SRK Consulting (UK) Limited ("SRK") on behalf of Dalradian Gold Ltd (DGL) for the Curraghinalt Project.

The scope of this plan covers monitoring of environmental performance in the surface water and groundwater in the environment, and actions that may be triggered in the event of an unexpected occurrence.

The criteria used to trigger early warning actions are referred to as assessment limits. Assessment limits can provide an indication of unexpected events in the receiving environment and/or allow sufficient time to ensure compliance limits are not breached.

The levels presented in this monitoring plan are designed to be protective of compliance levels and associated obligations and statutory conditions. Compliance limits are fixed by statutory criteria whereas assessment limits, and locations where such levels are set in the plan and are the application of the precautionary principle based upon the environmental impact assessment (EIA) process. The assessment limits and monitoring regime will be subject to annual reviews.

The plan includes the following information:

Monitoring and action plan for groundwater and surface water for approval by DfI.

Data collection during the different phases of the Project comprising:

- construction phase
- operational phase of the mine,
- recovery phase and post-recovery phase

It also provides for:

- surface water flows
- groundwater levels (water levels and piezometric levels); and
- water quality (surface waters, shallow and deep groundwater)

The monitoring plan details:

- sample locations
- sample frequency
- parameters to be monitored on site and parameters to be quantified via laboratory analysis
- data management & reporting to NIEA, and
- review intervals on the monitoring plan

An action plan including early warning trigger levels addresses the following issues:

- the volume of dewatering from the mine is significantly bigger or smaller than predicted
- the quality of dewatered and discharged water is of poorer quality than predicted
- Assessment level actions should unexpected events occur. There is a project Emergency Response Plan Protocol.

It should be noted and understood that the plan is prepared on the basis that some of the above project phases can run in parallel with each other. The plan draws on, and is informed by, the baseline information and discharge information that is already available from the exploratory stage of the development process.

The SGEMAP forms part of the Groundwater and Surface Water Impact Assessments and should be read in conjunction with the following project documents:

- Waste Management Plan
- Outline Construction and Environmental Management Plan (CEMP)
- The Mine Design Parameters Statement
- Emergency Response Plan

This document builds on the environmental monitoring recommendations provided in the Environmental Statement (ES) for the Curraghinalt Project dated November 2017[1] and in the Surface Water Impact Assessment (Appendix C4 of the second Addendum to the ES, SRK, 2020a) and Groundwater Impact Assessment (SRK, 2020b at Appendix C6 of the second Addendum to the ES).

1.2 Plan Review and Register

1.2.1 Overview

The SGEMAP is a 'live' document. Such documents require regular updates as the project develops (Event Updates) and Periodic Reviews to ensure the monitoring and actions are current. The frequency of these updates is described below and Table 1-1 gives the history register for this Monitoring and Action Plan to ensure that reviews are clearly tracked and transparent.

[1] Hereon referred to as ES, 2017.

Table 1-1: Monitoring and Action Plan Document History Register

Version No.	Production Date	Change Authors	Document Changes
1	July 2019	SRK	Draft version of document
2	October 2020	SRK	Aligned with SWIA (SRK 2020a), GIA (SRK 2020b) and Proposed Discharge Consent Criteria (Kaya, 2020a and 2020b) – see note 1

Note 1: all references are provided in Section 6 of the report.

1.2.2 Event Updates and Periodic Review

Event Updates that will trigger a review of the monitoring plan include:

1. Update to the underground mine design
2. Changes in design of a process or facility that could have any associated potential emissions to water;
3. Assessment Action related monitoring changes (which may be temporary or continuing, as determined by the outcome of the Assessment Action review).

Items 1 and 2 are explained further in Mine Design Parameters Document Appendix B9, 'Mine Design Update'.

Periodic Reviews of the monitoring plan will occur on an annual basis with the compilation of the Annual Monitoring Report.

Changes to the monitoring plan will be agreed with the regulator prior to implementation and the Monitoring and Action Plan will re-issued.

1.2.3 Change Implementation

SGEMAP updates will use the following general procedure:

1. Review the change in mine design or process for source - pathway - receptor (SPR) linkages and manage changes to the target mine conditions consistent with the ES;
2. Based on SPR linkages determine monitoring location for surface water and groundwater that both monitor the receptor and where possible, the pathways to provide early warning of unexpected events, should they occur; and
3. Update the SGEMAP, agree updates with regulators and re-issue the SGEMAP for implementation.

1.3 Sampling and Monitoring Handbook

All sampling and monitoring set out in the SGEMAP will be in accordance with the procedures and protocols included in the Field Hand Book for Surface Water Monitoring and Sampling (ES, 2017; Appendix C3 Annex B) and the Sampling Methodology for groundwater (ES, 2017; Appendix C5 Annex D).Sampling and monitoring will also be in accordance with the following protocols:

- ISO 5667-1:2006(E) Water quality — Sampling — Part 1: Guidance on the design of sampling programmes and sampling techniques

- ISO 5667-3:2012(E) Water quality — Sampling — Part 3: Preservation and handling of water samples
- ISO 5667-6:2014(E) Water quality — Sampling — Part 6: Guidance on sampling of rivers and streams
- ISO 5667-11:2009(E) Water quality — Sampling — Part 11: Guidance on sampling of groundwaters

2 DATA MANAGEMENT AND REPORTING

2.1 Data Management System

All groundwater, surface water data are obtained and stored within the Environmental Data Management System (EDMS). The system was design and initiated by SRK for the baseline data collection phase of the project and is now administered by DGL for on-going collection.

The EDMS has been built around MS Access and uses MS Excel to capture and present the data. Specific templates have been created for the various data streams managed within the system and these and other electronic data deliverables (EDD) are processed and entered into the central database. The centralisation of data collection and storage enables effective monitoring and quick retrieval of data in an auditable manner.

The system manages several different data streams used to monitor local surface and groundwater and these are:

Groundwater		Surface water	
Level/ Piezometric Pressure:	• Manual measurements • Transducer measurements • Vibrating Wire Piezometer measurements	Level and Flow:	• Transducer measurements • Flow meter measurements
Quality:	• Field parameters • Laboratory parameters	Quality:	• Field parameters • Laboratory parameters

The database has been designed in MS Access and is open to allow free direct access to the data in the underlying tables; alternatively, data can be exported to MS Excel or CSV as required. For presentation and monitoring purposes standard queries have been established for each of the data streams to display quantities of data recorded (completeness checking) and time series charts for ease of quality control and quality assurance. This information is displayed using MS Excel with a live link to the MS Access database.

Non-reportable data, determined through the QA/QC process, can be flagged, dated and commented on within the database. This permits an auditable record of erroneous data.

The data workflow starts with the controlled management of the templates that are issued to data capture staff. These and other data deliverables, such as downloaded logger files or laboratory results, are then returned to the data administrator on completion. The data administrator records the receipt of the original files in a received folder. These files are then processed in order to collate the data in a standard format. The processed files are imported into the database at which point they are verified. The source of the data is recorded alongside the data on import. On acceptance, the data can then be reviewed using the standard queries and charts to confirm validity.

The user interface in the MS Access database also includes GIS and allows the user to confirm the placement of new and existing monitoring locations against a background map

The EDMS process for monitoring data collection is shown in Figure 2-1. New monitoring points will be incorporated into the database during construction, operation and closure phases as required.

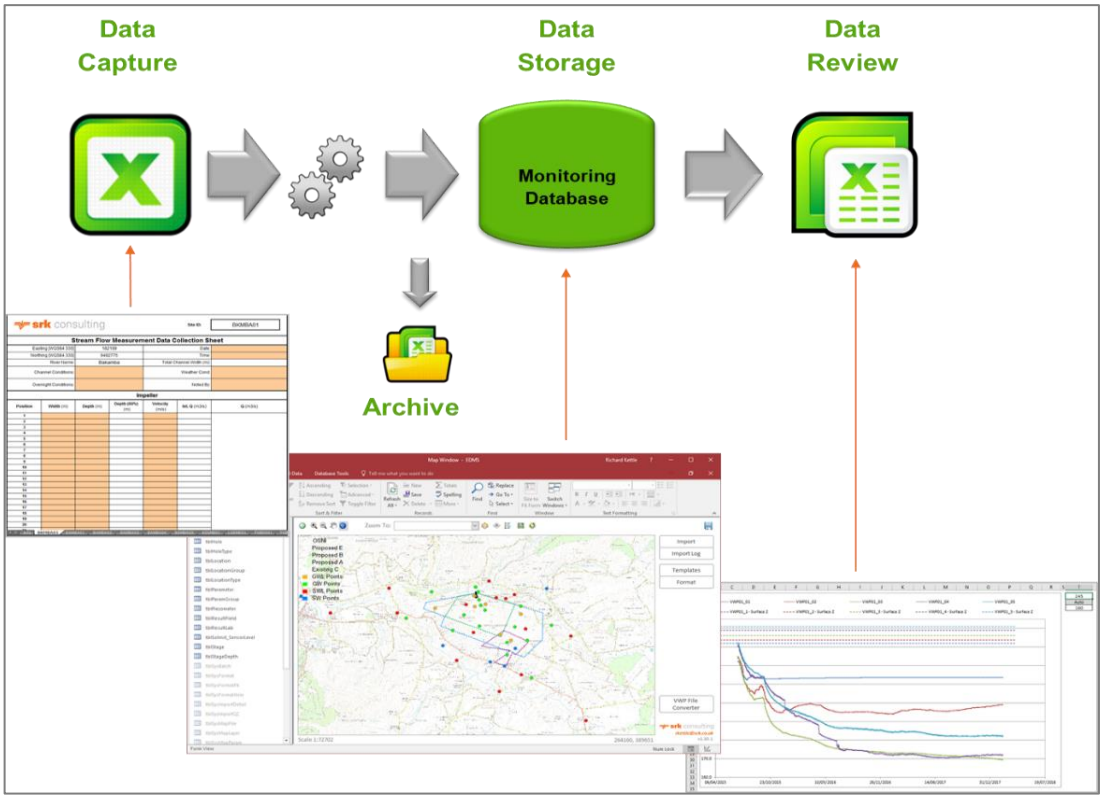

Figure 2-1: Graphic of the general EDMS process from data capture, processing, storage and review, and validation with examples of an input sheet, the database and an automated output review chart

2.2 Reporting

2.2.1 Overview

Reporting to regulators will comprise periodic reporting and reporting associated with assessment actions as summarised in Sections 2.2.2 and 2.2.3 below.

2.2.2 Annual Reporting

Annual reports will contain an annual data summary including a presentation of monitoring data, an analysis of results, a summary of any exceedances of assessment limits or compliance levels at allocated monitoring points[2], and associated responses.

The annual report will also document any changes to the monitoring programme (see Sections 4.6 and 5.3.4) further to event updates and periodic review.

[2] See Section 3.5 for an explanation of these terms

Annual reports will be completed within the first quarter of the following year end and submitted to the regulator.

2.2.3 Assessment Reporting

Assessment and action reports will be produced within one quarter following verification.

3 GENERAL PRINCIPLES

3.1 Aim of the monitoring plans

The aim of monitoring is to:

- Provide an on-going dataset with which to monitor against baseline conditions throughout mining;
- Provide continued data to confirm that the mine and associated pollution controls are performing as designed in terms of environmental compliance;
- provide confirmation that no significant derogation of water levels, flows or quality is occurring due to the mining operation in sensitive receptors such as rivers and protected habitats;
- Identify trends and use updated forecasts to confirm that no significant derogation could occur in the future and/ or identify measures to improve ensure that no material derogation will occur beyond impacts previously assessed;
- Identify when the site no-longer presents the potential to cause any significant risk of pollution or associated harm to human health or the wider water environment, and thereby when the requirement to continue monitoring can be modified or ended;
- allow for review and recommendations for the improvement of the water monitoring regime and management of monitoring in relation to variation to the underground mine design.

3.2 Monitoring Phases

3.2.1 Baseline

The baseline data for the Project is used to provide a dataset with which to characterise conditions prior to development of the mine (i.e. the EDMS; refer to Section 2.1). The baseline is informed by the EIA process and existing discharge consents.

Baseline monitoring will continue through planning and up until start of construction. Beyond this ‘baseline phase’, baseline monitoring will still be undertaken, for example during operations in areas where no mining or exploration has taken place.

Potential changes to baseline water conditions will also be determined in active operational areas through the monitoring of up-gradient monitoring points (refer to Section 4.5.2).

3.2.2 Construction Monitoring

The construction period will cover the development of the proposed infrastructure site, access roads and the mine portal and decline. The construction phases are detailed in the Outline Construction Environmental Monitoring Plan (CEMP).

Monitoring will continue at the existing infrastructure site during the construction period.

The construction phase monitoring at the proposed infrastructure site will include monitoring specific to set tasks, such as the placement of access roads, which is detailed in the CEMP. The CEMP is a live document and will be updated prior to and during construction. A summary of general continued environmental surface water and groundwater monitoring as part of the SGEMAP is given in this report (see section 4.3).

3.2.3 Operational Monitoring

The operational monitoring period covers the operation of the mine, processing area and DSF, including management of effluent from specific discharge points (i.e. from the water treatment plant(s)).

For the underground mine the monitoring plan during operations can respond to changes in the mine plan and sub-surface data collected, such as additional fault information and flow rate data.

The additional monitoring points assessed in this Plan will be installed in advance of the Operational phase of the development.

Up-gradient points are used to monitor changes in baseline characteristics during both the operational and closure phases. These will be at locations up-gradient of facilities which will assess and record any changes in water flow or quality not influenced by the mine.

3.2.4 Closure Monitoring

Surface water and groundwater monitoring will continue at agreed intervals throughout closure until regulatory sign-off. The closure phases can be split into two periods based on the recovery of groundwater levels:

1) Recovery phase: initially following mine closure water levels in the underground mine area will be slowly recovering and groundwater flow in the vicinity of the underground mine will be towards the mine. Surface water and groundwater environmental monitoring will continue with monitoring facilities installed to monitor rebound of water in the mine to confirm any passive treatment requirements well in advance against discharge consent criteria.

   The infrastructure and processing areas will be closed, with equipment and buildings removed, waste areas fully restored and long-term surface water drainage channels installed. Surface water and groundwater monitoring will continue in this area until approval by regulators.

2) Post recovery phase: As mine water levels fully recover, hydraulic containment of the workings will cease and flow will be outwards from the underground mine to the adit portal area and Curraghinalt Burn, and to the surrounding groundwater to a lesser extent. Monitoring will continue at the adit and in surrounding groundwater monitoring wells and surface watercourses until approval by regulators.

3.2.5 Source-Pathway-Receptor (SPR) Linkages

An overview of the likely SPR linkages for the different monitoring phases for both surface water and groundwater, as determined in the impact assessments included in the ES (2017), is presented in Table 3-1 below.

Table 3-1: Summary of source-pathway-receptor (SPR) linkages for surface water and groundwater for each mine phase and monitoring targets

S-P-R No.	Phase	Source (risk type)	Pathway	Main Receptors	Monitoring Areas
1	C	Access tunnel dewatering (water level)	Lateral drainage in peat	• Local peatland	• Peatland
2	C O Cl	Site discharge, including treated contact water, clean pond overflow, treated sewage (water quality and flow)	Pollanroe Burn	• Pollanroe Burn • Owenreagh River	• Pollanroe Burn • Owenreagh River • Curraghinalt Burn • Owenkillew River
3	C O	Run-off associated with construction at proposed infrastructure site (including western diversion ditch which extends into catchment of the Unnamed Stream) (water quality)	Overland flow	• Pollanroe Burn • Unnamed Watercourse	• Pollanroe Burn • Unnamed Watercourse
4	C O	Accidental spills and contaminant migration (water quality)	Seepage to groundwater (Note: site run-off will be captured and treated)	• Groundwater resource • Private abstractions • Pollanroe Burn and tributaries; Owenreagh River	• Sumps and collection ditches • Groundwater system • Private abstractions • Pollanroe Burn and tributaries; Owenreagh River
5	O	Mine dewatering (water level and flow)	Groundwater system. Excess water stored on site and treated.	• Pollanroe Burn • Owenkillew and tributaries • Private abstractions • Peatland (where groundwater supported)	• Groundwater system • Owenkillew and tributaries • Private abstractions • Peatland
6	O Cl	Mine backfill (water quality)	Groundwater system (Note: pathway to be confirmed alongside monitoring (recovery) of mine water levels)	• Owenkillew and tributaries • Groundwater resource	• Groundwater system • Owenkillew and tributaries
7	O Cl	Contaminant seepage from the DSF and ponds (water quality)	Groundwater system	• Pollanroe Burn and tributaries, Owenreagh River • Groundwater resource • Private abstractions	• DSF Underdrain outfall • Pond under drain outfall • Groundwater system • Owenkillew and tributaries
8	O Cl	Runoff over DSF (water quality)	Overland flow (Note: site run-off will be captured and treated during operations. At closure DSF reclaimed and runoff will pass through passive treatment)	• Pollanroe Burn • Owenreagh River	• Owenreagh and tributaries

Phase: C = construction
O = operation
Cl = closure and post-closure

3.2.6 Monitoring plan development

Mining will progress in accordance with the Mine Design Parameters Statement and the Plan review will take into account those parameters which manage the mine development as it progresses.

The framework for how the monitoring will be reviewed in conjunction with other reviews such as the mine design is discussed in Section 1.2.

3.3 Surface Water Baseline and Impact Assessment

3.3.1 Surface Water Quality

The baseline surface water quality assessment for the project included analysis of a comprehensive suite of water quality parameters at locations across the project area. This work is described in the Surface Water Impact Assessment (SRK, 2020a and annexes therein).

The suite of parameters used in the baseline assessment formed the starting point for the scoping assessment for key water quality parameters. The full list of parameters is outlined in Table 3-2.

Baseline updates with re-evaluated baseline concentrations (and flow conditions) will be produced through the life of the project.

The parameters considered in the tables are those identified from a screening assessment undertaken as part of the derivation of site discharge criteria. The screening process was based on selecting parameters which had the potential to be elevated by the project.

3.3.2 Relevant Water Quality Standards and Guidelines

The Surface Water Baseline Study provides a detailed exploration and summary of relevant water quality standards and guidelines for the study area. The key standard and guideline values considered in this assessment are provided in Table 3-3.

The key legislation used was:

- SR 351 The Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015
- The Water Supply (Water Quality) Regulations (Northern Ireland) 2007 (SR 147) as amended by SR 2009/246, SR 2010/128 and SR 2015/363
- Standards for copper, manganese, nickel and zinc refer to bioavailable concentrations of these parameters, which depend on the receiving water chemistry. Calculations of the bioavailable concentrations were conducted.

Other legislation relevant to nitrate and total suspended solids (TSS) was considered relevant for the project:

- European Union agri-environmental indicator for nitrate
- Freshwater Fish Directive. This legislation has been revoked (2013), but it contained a standard for total suspended solid (TSS) concentrations that was not taken forward to other primary legislation. In the light of no other standards for TSS and given the likely importance of this parameter, the standard value from the Freshwater Fish Directive was used.

Boron, molybdenum and uranium were also identified as having the potential for elevated concentrations at the mine site (produced by mining activities). The most appropriate standards for these parameters were identified as those published by the Canadian Council of Ministers of the Environment (CCME); Water Quality Guidelines for the Protection of Aquatic Life. Available at http://st-ts.ccme.ca/en/index,html, based on values from October 2016.

EPH and mineral oil were measured during baseline studies, but there are no standards for these parameters. These parameters will be important for the operational mine and construction period, and an appropriate, practical standard for these parameters, encompassing all hydrocarbons is 'Visible oil and grease', with a qualitative standard of 'no trace'.

The British Standard BS EN 16859:2017 includes a thorough review of Freshwater Pearl Mussel literature although, in the absence of a guideline value for TSS related to TSS concentrations (mg/L) in BS EN 16859:2017, results of this assessment are compared to the 10 mg/L guideline value for TSS presented in an unpublished draft 2013 report prepared for NIEA that outlines management measures related to Freshwater Pearl Mussels in the Owenkillew catchment.

EQS values and drinking water standards guidelines are outlined Table 3-3 and non-statutory guideline values in Table 3-4.

3.3.3 Sensitivity of receiving waters

The sensitivities of the watercourses considered in this assessment to changes in water quantity and water quality are outlined in Table 3-5 and Table 3-6 respectively.

Changes in surface water quality have the potential to impact aquatic life and the overall ecology of a watercourse, including land species that use the water. Changes in surface water quality can also impact human uses, including drinking water.

3.3.4 Proposed Discharge Criteria from Proposed Infrastructure Site

Proposed discharge criteria have been prepared in support of the application for a Water Licence for discharge into the Pollanroe Burn (a tributary to the Owenreagh River) at Curraghinalt (Kaya, 2020a).

The proposed water discharge limits are summarised for the proposal infrastructure outfall to the Pollanroe Burn in Table 3-7. This table also includes (far right-hand column) the proposed discharge criteria included in the ES (2017) for comparison.

3.3.5 Proposed Discharge Criteria from Proposed Mineral Extraction Area

Proposed discharge criteria have been prepared in support of the application for a Water Licence for discharge into the Curraghinalt Burn (a tributary to the Owenkillew River) at Curraghinalt (Kaya, 2020b).

The proposed water discharge limits are summarised for the proposed discharge to the Curraghinalt Burn in Table 3-8. This table also includes (far right-hand column) the proposed discharge criteria included in the ES (2017) for comparison.

3.3.6 Compliance Calculations

Monte Carlo “forwards” modelling has been undertaken as part of the proposal discharge criteria assessment (Kaya, 2020c) to assess the impact of the calculated maximum discharges on the Owenreagh River and Owenkillew River. The calculations take the conservative assumption that all discharges are at the maximum allowed concentration.

The results show that for all parameters where the current baseline is below the EQS, the change in baseline conditions (with discharges from the mine equal to the maximum allowable concentration) is 10% or less of the EQS.

The results of the assessment are at Table 3-**9** and Table 3-**10** for the Owenreagh River and Owenkillew River respectively.

The monitoring data from the SGEMAP stations potentially impacted by the mining activities will be reviewed annually and compared to the predictions.

Table 3-2: Full list of parameters considered in Surface Water Baseline Assessment

Parameter	Symbol		Unit	Limit of Detection	Method
Physical Parameters					
pH	pH		s. u.	<0.01	TM73/PM0
Electrical Conductivity @25 °C	EC_Lab		µS/cm	<2	TM76/PM0
Total Dissolved Solids	TDS		mg/l	<10	TM20/PM0
Total Suspended solids	TSS		mg/l	<10	TM37/PM0
Anions and Nutrients					
Total Alkalinity as $CaCO_3$	$AlkCaCO_3$_Total		mg/l	<1	TM75/PM0
Sulphate	SO4		mg/l	<0.05	TM38/PMO
Chloride	Cl		mg/l	<0.3	TM38/PM0
Fluoride	F		mg/l	<0.3	TM27/PM0
Total ammonia	NH4_N		mg/l	<0.03	TM38/PM0
Nitrite as N	NO2_N		mg/l	<0.006	TM38/PM0
Nitrate as N	NO3_N		mg/l	<0.05	TM38/PM0
Total Phosphorus	P_Total		µg/L	<0.7	TM30/PM14
Molybdate Reactive Phosphorus	MRP		µg/L	<0.5	TM30/PM14
Orthophosphate as PO_4	PO4_PO4		mg/l	<0.06	TM38/PM0
Cyanides					
Free Cyanide	CN_Free		µg/L	<1	TM89/PM0
Total Cyanide	CN_Total		µg/L	<1	TM89/PM0
Organic Carbon, BOD and COD					
Total Organic Carbon	TOC		mg/l	<2	TM60/PM0
Biological Oxygen Demand (Settled)	BOD_Settled		mg/l	<1	TM58/PM0
Chemical Oxygen Demand (Settled)	COD_Settled		mg/l	<7	TM57/PM0
Microbiological					
Faecal Coliforms	Coli_Faecal		CFU/100 mL	<1	Subcontracted
Total Coliforms	Coli_Total		CFU/100 mL	<1	Subcontracted
Enterococci	Enterococci		CFU/100 mL	-	Subcontracted
Hydrocarbons					
Extractable Petroleum Hydrocarbons (EPH) (C8-C40)	EPH_C8C40		µg/L	<10	TM5/PM30
Mineral Oil (C10-C40)	MineralOil_C10-C40		µg/L	<10	TM5/PM30
Total (T) and dissolved (D) metals					
Silver	Ag_T	Ag_D	µg/L	<5	TM30/PM14
Aluminum	Al_T	Al_D	µg/L	<1.5	TM30/PM14
Arsenic	As_T	As_D	µg/L	<0.9	TM30/PM14
Boron	B_T	B_D	µg/L	<2	TM30/PM14
Barium	Ba_T	Ba_D	µg/L	<1.8	TM30/PM14
Beryllium	Be_T	Be_D	µg/L	<0.5	TM30/PM14
Cadmium	Cd_T	Cd_D	µg/L	<0.03	TM30/PM14
Calcium	Ca_T	Ca_D	µg/L	<0.2	TM30/PM14
Cobalt	Co_T	Co_D	µg/L	<0.1	TM30/PM14
Chromium	Cr_T	Cr_D	µg/L	<0.2	TM30/PM14
Total Dissolved Chromium III	Cr (III)		µg/L	<2	NONE
Hexavalent Chromium	Cr (VI)		µg/L	<2	TM38/PM0
Copper	Cu_T	Cu_D	µg/L	<3	TM30/PM14
Iron	Fe_T	Fe_D	µg/L	<4.7	TM30/PM14
Dissolved (CVAF) and Total Mercury	Hg_T	Hg_D	µg/L	<0.01	TM61/PM38
Potassium	K_T	K_D	mg/l	<0.1	TM30/PM14
Magnesium	Mg_T	Mg_D	mg/l	<0.1	TM30/PM14
Manganese	Mn_T	Mn_D	µg/L	<1.5	TM30/PM14
Molybdenum	Mo_T	Mo_D	µg/L	<0.2	TM30/PM14
Sodium	Na_T	Na_D	mg/l	<0.1	TM30/PM14
Nickel	Ni_T	Ni_D	µg/L	<0.2	TM30/PM14
Lead	Pb_T	Pb_D	µg/L	<0.4	TM30/PM14
Antimony	Sb_T	Sb_D	µg/L	<2	TM30/PM14
Selenium	Se_T	Se_D	µg/L	<1.2	TM30/PM14
Tin	Sn_T	Sn_D	µg/L	<5	TM30/PM14
Tellurium	Te_T	Te_D	µg/L	<5	TM30/PM14
Thallium	Tl_T	Tl_D	µg/L	<0.9	TM30/PM14
Thorium	Th_T	Th_D	µg/L	-	TM30/PM14
Titanium	Ti_T	Ti_D	µg/L	<5	TM30/PM14
Uranium	U_T	U_D	µg/L	<5	TM30/PM14
Vanadium	V_T	V_D	µg/L	<0.6	TM30/PM14
Zinc	Zn_T	Zn_D	µg/L	<1.5	TM30/PM14

Table 3-3: Legislated EQS Values and Drinking Water Standards

Parameter	Unit	Environmental Standards		
		SR 351		Drinking Water Standards
		Annual Average	Other	(WSR; max concentrations)
Physical				
pH	-		[a] 6.6 - 9.0 or 5.1 – 9.0 (absolute range)	
BOD	mg/L		3 (90%ile)	
Temperature	°C		20 (max)	
TSS	mg/L			
Electrical conductivity	µS/cm			2500
Nutrients/Salts				
Total Ammonia	mg/L N		0.2 (90%ile)	0.39[b]
Nitrate	mg/L N			11.3[c]
Nitrite	mg/L N			0.15[d]
Chloride	mg/L			250
Fluoride	mg/L			1.5
Sulphate	mg/L			250
Metals (Dissolved)				
Aluminium	µg/L			200
Antimony	µg/L			5
Arsenic	µg/L	50		10
Boron	µg/L			1000
Cadmium	µg/L	0.08	450 (max)	5
Chromium (III)	µg/L	4.7	32 (max)	
Chromium (VI)	µg/L	3.4		
Total Chromium	µg/L	8.1		50
Copper	µg/L	[e]1		2000
Iron	mg/L	1		0.2
Lead	µg/L	7.2		10
Manganese	µg/L	[e]123		50
Mercury	µg/L		0.07 (max)	1
Molybdenum	µg/L			
Nickel	µg/L	[e]4.0	34 (max)	20
Selenium	µg/L			10
Sodium	mg/L			200
Silver	µg/L	0.5	1 (max)	
Uranium	µg/L			
Zinc	µg/L	[e]11.9		

a pH range of 6.6 to 9.0 is for 'Clear Waters' with Dissolved Organic Carbon < 10mg/L. A pH range of 5.1 to 9.0 is for 'Humic Waters' with Dissolved Organic Carbon > 10 mg/L. There are Total Organic Carbon concentrations >10 mg/L on average in the Owenreagh River, but no data on Dissolved Organic Carbon. The average pH in the Owenreagh River is 6.74 with a standard deviation of 0.49, suggesting natural pH can be lower than the range for 'Clear Water'
b WSR standard is 0.5 mg/L ammonia as NH4. Value of 0.39 mg/L presented in table is ammonia as N.
c WSR standard is 50 mg/L nitrate as NO3. Value of 11.3 mg/L is nitrate as N.
[d] WSR standard is 0.50 mg/L nitrite as NO_2. Value of 0.15 mg/L is nitrite as N.
[e] SR351 standards refer to the bioavailable equivalent concentrations of copper, zinc, manganese and nickel

Table 3-4: Non-statutory Guideline Values

Parameter	Unit	Standard	Source of guideline / Comment
Physical			
pH	s.u.	6.2 – 7.3	[a] BS EN 16859:2017
BOD	mg/L	1 - 1.4	BS EN 16859:2017
TSS	mg/L	25	Freshwater Fish Directive
TSS	NTU	10	BS EN 16859:2017. *Relationships between turbidity and TSS concentrations (mg/L) need to be developed in the field. Testing is ongoing.*
Nutrients/Salts			
Total ammonia	mg/L N	0.01 – 0.05 (mean)	BS EN 16859:2017
Nitrate	mg/L N	0.125 – 0.5 (median)	BS EN 16859:2017
Nitrate	mg/L N	[b]5.6	EU agri-environmental indicator for nitrate
Metals (Dissolved)			
Barium	µg/L	1300	[c] WHO
Boron	µg/L	1500	[d] CCME
Cobalt	µg/L	3	[e] SEPA
Molybdenum	µg/L	73	CCME
Uranium	µg/L	15	CCME

[a] BS EN 16859:2017: Guidance standard on monitoring Freshwater Pearl Mussel populations and their environment
[b] EU Agri-environmental standard is 25 mg/L nitrate as NO_3. Value of 5.6 mg/L presented in table is nitrate as N.
[c] World Health Organisation. Guidelines for Drinking Water Quality, 4th Edition incorporating the first addendum
[d] Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (October 2016)
[e] Scottish Environment Protection Agency (SEPA), WAT-SG-53, Environmental Quality Standards and Standards for Discharges to Surface Waters

Table 3-5: Sensitivity of watercourses for surface water quantity assessment

Watercourse	Sensitivity	Basis
Pollanroe Burn and minor tributaries	Low	Minor watercourse with limited ecological value. No flood alleviation benefits or important morphological diversity (i.e., is small upland watercourse)
Unnamed Watercourse and minor tributaries	Low	Minor watercourse with limited ecological value. No flood alleviation benefits or important morphological diversity (i.e., is small upland watercourse)
Owenreagh River, main channel	High	Important sensitive and protected ecosystem
Curraghinalt Burn and minor tributaries	Low	Minor watercourse with limited ecological value. No flood alleviation benefits or important morphological diversity (i.e., is small upland watercourse)
Attagh Burn and minor tributaries	Low	Minor watercourse with limited ecological value. No flood alleviation benefits or important morphological diversity (i.e., is small upland watercourse)
Glenealy Burn and minor tributaries	Low	Minor watercourse with limited ecological value. No flood alleviation benefits or important morphological diversity (i.e., is small upland watercourse)
Owenkillew River, main channel	High	Important sensitive and protected ecosystem

Table 3-6: Sensitivity of watercourses for surface water quality assessment

Watercourse	Sensitivity	Reason for selection
Pollanroe Burn	Low	Small watercourse with no significant ecological value
Unnamed Watercourse	Low	Small watercourse with no significant ecological value
Owenreagh River	High	Important sensitive and protected ecosystem
Curraghinalt Burn	Low	Small watercourse with no significant ecological value
Attagh Burn	Low	Small watercourse with no significant ecological value
Glenealy Burn	Low	Small watercourse with no significant ecological value
Owenkillew River	High	Important sensitive and protected ecosystem

Table 3-7: Proposed Discharge Criteria at Proposed Infrastructure Site Outfall (from: Kaya, 2020a)

Parameter	Unit	Proposed Discharge Criteria	Discharge Criteria from 2017 ES
Physical			
pH	-	6.2-9.0	6.6-9.0
Temperature	^{o}C	20 (max) or 2^{o}C above ambient[a]	20
TSS	mg/L	50	50
BOD	mg/L	5.81	7.3
Nutrients / Salts			
Total Ammonia	mg/L N	0.36	0.39
Nitrate	mg/L N	11.3	11.3
Nitrite	mg/L N	0.15	0.22
Chloride	mg/L	250	250
Fluoride	mg/L	1.5	1.5
Sulphate	mg/L	250	250
Dissolved metals			
Aluminium	µg/L	200	200
Antimony	µg/L	5	5
Arsenic	µg/L	10	10
Barium	µg/L	1300	-
Boron	µg/L	1000	3100
Cadmium	µg/L	0.28	0.37
Chromium (III)	µg/L	20	21
Chromium (VI)	µg/L	10	15
Chromium (CrIII + CrVI)	µg/L	30	36
Cobalt	µg/L	11.5	-
Copper	µg/L	40.0	75
Iron	mg/L	0.68	1.12
Lead	µg/L	10	5.5
Manganese	µg/L	218	140
Mercury	µg/L	0.094	0.15
Molybdenum	µg/L	68	150
Nickel	µg/L	20	20
Selenium	µg/L	10	10
Silver	µg/L	3.24	2.0
Sodium	mg/L	200	200
Uranium	µg/L	30	33
Zinc	µg/L	73.3	94

[a] *2^{o}C increase in annual 98%ile temperature*

Table 3-8: Proposed Discharge Criteria for Discharges to the Curraghinalt Burn (from: Kaya, 2020b)

Parameter	Unit	Proposed Discharge Criteria	Discharge Criteria from 2017 ES
Physical			
pH	-	6.2 – 9.0	6.6-9.0
Temperature	°C	20 (max) or 2°C above ambienta	20
TSS	mg/L	50	50
BOD	mg/L	1.35	17.9
Nutrients / Salts			
Total Ammonia	mg/L N	0.39	0.39
Nitrate	mg/L N	11.3	11.3
Nitrite	mg/L N	0.15	0.22
Chloride	mg/L	250	250
Fluoride	mg/L	1.5	1.5
Sulphate	mg/L	250	250
Dissolved metals			
Aluminium	µg/L	200	200
Antimony	µg/L	5	5
Arsenic	µg/L	10	10
Barium	µg/L	1300	-
Boron	µg/L	1000	9000
Cadmium	µg/L	0.67	1.6
Chromium (III)	µg/L	40	96
Chromium (VI)	µg/L	10	69
Chromium (CrIII + CrVI)	µg/L	50	50
Cobalt	µg/L	52.0	-
Copper	µg/L	9.43	310
Iron	mg/L	1.98	1.74
Lead	µg/L	10	10
Manganese	µg/L	69.7	160
Mercury	µg/L	0.339	1
Molybdenum	µg/L	70	440
Nickel	µg/L	20	20
Selenium	µg/L	10	10
Silver	µg/L	5.33	2
Sodium	mg/L	200	200
Uranium	µg/L	30	90
Zinc	µg/L	192	470

[a] *2°C increase in annual 98%ile temperature*

Table 3-9: Post-development average concentrations in the Owenreagh River at Pollanroe Burn (Kaya, 2020a)

Parameter	Unit	EQS (Annual Average unless stated)	Observed Quality Upstream of Discharge (Average unless stated)	Calculated Quality Downstream of Discharge (Average unless stated)	Increase in Concentration in Receiving River as Percent of EQS (Average unless stated)
Physical					
TSS	mg/L	25	5.8	7.02	5%
BOD	mg/L	3 (90%ile)	2 (90%ile)	2.3 (90%ile)	10%
Nutrients/Salts					
Total Ammonia	mg/L N	0.2 (90%ile)	0.11 (90%ile)	0.13 (90%ile)	10%
Nitrate	mg/L N		0.24	0.53	-
Nitrite	mg/L N		0.0032	0.0071	-
Chloride	mg/L		13.52	19.7	-
Fluoride	mg/L		0.15	0.19	-
Sulphate	mg/L		1.62	8.04	-
Metals (Dissolved)					
Aluminium	µg/L		53.6	57.8	-
Antimony	µg/L		1.22	1.35	-
Arsenic	µg/L		0.56	0.83	-
Barium	µg/L		8.15	41.9	-
Boron	mg/L	1.5	0.0046	0.031	2%
Cadmium	µg/L	0.08	0.029	0.037	10%
Chromium (III)	µg/L	4.7	2.27	2.74	10%
Chromium (VI)	µg/L	3.4	2.22	2.43	6%
Chromium (CrIII + CrVI)	µg/L	8.1	4.49	5.30	10%
Cobalt	µg/L	3	0.085	0.39	10%
Copper	µg/L	8.89	1.24	2.13	10%
Iron	mg/L	1	0.62	0.62	0%
Lead	µg/L	7.2	0.33	0.61	4%
Manganese	µg/L	162	79.1	82.3	3%
Mercury	µg/L	0.07 (95%ile)	0.005 (95%ile)	0.012 (95%ile)	10%
Molybdenum	µg/L	73	0.15	1.20	1%
Nickel	µg/L	10.2	0.23	0.75	8%
Selenium	µg/L		0.60	0.85	-
Silver	µg/L	0.5	2.5	2.51	2%
Sodium	mg/L		8.63	13.6	-
Uranium	µg/L	15	2.5	3.22	5%
Zinc	µg/L	20.3	4.75	6.77	10%

Table 3-10: Post-development average concentrations in the Owenkillew River upstream of Curraghinalt Burn (Kaya, 2020b)

Parameter	Unit	EQS (Annual Average unless stated)	Observed Quality Upstream of Discharge (Average unless stated)	Calculated Quality Downstream of Discharge (Average unless stated)	Increase in Concentration in Receiving River as Percent of EQS (Average unless stated)
Physical					
TSS	mg/L	25	6.31	6.78	2%
BOD	mg/L	3 (90%ile)	2 (90%ile)	2.3 (90%ile)	10%
Nutrients/Salts					
Total Ammonia	mg/L N	0.2 (90%ile)	0.062 (90%ile)	0.072 (90%ile)	5%
Nitrate	mg/L N		0.12	0.18	
Nitrite	mg/L N		0.003	0.0038	
Chloride	mg/L		9.78	11.1	
Fluoride	mg/L		0.15	0.16	
Sulphate	mg/L		1.35	2.69	
Metals (Dissolved)					
Aluminium	µg/L		68.8	69.97	
Antimony	µg/L		1.20	1.25	
Arsenic	µg/L		0.81	0.93	
Barium	µg/L		8.77	15.6	
Boron	mg/L	1.5	0.0053	0.0105	<1%
Cadmium	µg/L	0.08	0.027	0.035	10%
Chromium (III)	µg/L	4.7	2.64	2.85	5%
Chromium (VI)	µg/L	3.4	2.64	2.66	<1%
Chromium (CrIII + CrVI)	µg/L	8.1	5.28	5.48	3%
Cobalt	µg/L	3	0.16	0.46	10%
Copper	µg/L	1.5	1.16	1.31	10%
Iron	mg/L	1	0.92	0.93	1%
Lead	µg/L	1.2	0.26	0.35	8%
Manganese	µg/L	123	92.3	92.1	<1%
Mercury	µg/L	0.07 (95%ile)	0.005 (95%ile)	0.012 (95%ile)	10%
Molybdenum	µg/L	73	0.16	0.37	<1%
Nickel	µg/L	4.00	0.58	0.69	1%
Selenium	µg/L		0.60	0.65	
Silver	µg/L	0.5	2.5	2.51	2%
Sodium	mg/L		6.13	7.17	
Uranium	µg/L	15	2.5	2.65	1%
Zinc	µg/L	10.9	3.92	5.01	10%

3.4 Groundwater Baseline and Impact Assessment

3.4.1 Groundwater Quality

The baseline groundwater quality assessment for the project included analysis of a comprehensive suite of water quality parameters at locations across the project area. This work is described in the Groundwater Impact Assessment (SRK, 2020b; Annexes A, B and C). Monitoring of these parameters will continue through the life of the project.

The suite of parameters used in the baseline assessment formed the basis for the scoping assessment for key water quality parameters. The full list of parameters is set out in Table 3-11.

Analysis of hydrochemical monitoring data since 2012 shows a system of fresher water in the peatlands, shallow weathered bedrock and in the valley alluvium, with increasing content of Total Dissolved Solids (TDS) with depth. All groundwaters are fresh (i.e. non-saline) based on TDS being less than 1,500 mg/L (the maximum measured TDS is 408 mg/L in the weathered bedrock).

The average concentration of major cations (calcium, potassium, sodium, magnesium) and alkalinity increases with lithological unit depth. Conversely sulphate generally decreases with depth in the bedrock. The overall increase in TDS and major ions with depth is likely to be a result of the reduced recharge and possible increased water mineralisation with age of the groundwater.

pH in the upland peatland groundwater is naturally acidic. Acidity appears to reduce with depth.

Table 3-12 summarises the general water quality characteristics in the entire study area by groundwater unit.

3.4.2 Relevant Water Quality Guidelines

Concentrations have been compared with drinking water guideline values for Northern Ireland (DAERA - NI, 2009)[3] and Water Framework classification standards (DAERA - NI, 2009 & 2010)[4] for a general comparative analysis of background groundwater quality.

Exceedances of average (mean) concentration level were determined for arsenic, iron, zinc and manganese in the exploration tunnel area and in the proposed infrastructure area. The same parameters with mean concentration exceeding guideline values were also found in boreholes situated across the wider study area.

Exceedance of drinking water guidelines value were also reported for lead at the P95 percentile range in the alluvium, weathered bedrock and bedrock of the wider study area. Both lead and arsenic are classified as hazardous substances in groundwater (JAGDAG, 2017)[5].

[3] DAERA - NI. (2009). The Private Water Supplies Regulations (Northern Ireland)

[4] DAERA - NI. (2009 & 2010). Water Framework Directive Water Framework Directive (Priority Substances Classification and Shellfish Waters) Regulations (Northern Ireland).

[5] JAGDAG. (2017, January 13). New Hazardous Substances Determinations. Retrieved January 18, 2017, from Water Framework Directive UK: https://www.wfduk.org

3.4.3 Groundwater Vulnerability and Use

The site is located within the Gortin Groundwater body (NIEA, 2012). The status of the groundwater body is defined as 'good' in the North Western River Basin Management Plan Summary (NIEA, 2015). Consistent with the hydraulic test results for project the NIEA define flow in the groundwater body as generally restricted to shallow areas of the weathered bedrock, faults and in areas of superficial sands, gravels and silts comprising glacial and alluvium deposits.

Neither the project application area nor the wider groundwater study area contains any public groundwater water supplies or intersect any groundwater source protection zones. Published groundwater vulnerability maps based on infiltration to shallow soils define a high soil to groundwater vulnerability in the Infrastructure Area, with Classes 5 and 4a. However the mapping does not appear consistent with glacial till proved in groundwater investigation in the western part of the infrastructure area and likely to be present across the Mullydoo and Crocknahmoghil ridge (SRK UK, 2017c).

Details of private abstractions were initially recorded within a conservative potential piezometric drawdown distance from the mine extraction boundary. The final list of abstractions modelled together with the groundwater modelling predictions for these abstractions is presented at Table 8.5 of the groundwater impact assessment (SRK, 2020b), also reproduced at Appendix A to this report.

3.4.4 Groundwater Risk Assessment Targets and Assessment points

Risk assessment targets were defined in accordance with key Northern Ireland regulations, and in the absence of interpretative guidance documents for Northern Ireland, appropriate guidance documents issued for England and Wales. Key documents and the measures required to protect the receptors are outlined in Table 3-13.

Compliance points and targets for the various processes and receptors have been set either in accordance with legislation and related guidance (DEFRA, 2016), or in its absence, best practice.

The compliance points and targets for water level are set out in Table 3-14 below.

In accordance with regulations and associated guidance for water quality compliance points are defined as:

- For hazardous substances:
    - the compliance point for discernible hazardous substances is the point at which the substance enters groundwater at the downgradient limit of the source (following immediate dilution if relevant). Discernibility for hazardous substances is taken as exceedance of natural background concentration (75th percentile value, P75) or UKTAG laboratory 'limit of quantification' (UKTAG, 2017), if natural background concentrations are below the limit of quantification.

- For non-hazardous substances:
    - The primary risk assessment point for the underground mine is the down-hydraulic gradient boundary of the site. For the DSF, which is adjacent the site boundary and has groundwater underdrains beneath the facility, non-hazardous substances were assessed below the DSF following mixing with natural groundwater. The combined input from the underdrains, groundwater baseflow and the site discharge to the Pollanroe Burn were also assessed separately in the surface water impact assessment.
    - For non-hazardous substances, the approach to setting target limits varied for the underground mine and the DSF/ponds areas. Target limits were defined as follows:

      Underground mine

      - Where the background concentration is below the Environmental Standard: background concentration plus 20% of the Environmental Standard (P75 + 20% of the Environmental Standard);
      - Where background concentration is above 75% of the Environmental Standard: background concentration plus 10% of the background concentration (P75 + 10%).

      DSF and ponds

      - Where the background concentration is below the Environmental Standard /Discharge Consent Criteria: background concentration plus 20% of the discharge criteria (P75 + 20% of the Environmental Standard or discharge criteria[6]);
      - Where the background concentration is above 75% of the Environmental Standard / Discharge Consent criteria: background concentration plus 10% of the background concentration (P75 +10%).

Categorised hazardous and non-hazardous substances in groundwater (as of 2017; metals and inorganics of relevance only) are arsenic, chromium (VI), lead and mercury and compounds. Design target concentrations used in the groundwater impact assessment are set out in the assessment tables in below in Table 3-15, based on the methodology outlined above and further documented Annex F of the groundwater impact assessment (SRK, 2020b)

3.4.5 Proposed Groundwater Compliance Limits

With the exception of hazardous substances, compliance limits are only proposed for substances that, based on geochemical modelling of the underground mine waste and the DSF, were predicted to have concentrations in the source zone above median background groundwater quality.

[6] Whichever is the lowest of the two values

The methodology used to determine the proposed compliance limits values is documented in Annex F to the Groundwater Impact Assessment (SRK, 2020b), and can be summarised by the following method points:

1. set compliance limit for non-hazardous substances as the relevant environmental standard for groundwater
2. set compliance limit for hazardous substances as 50% of the relevant environmental standard for groundwater
3. check if the values from method 1 or 2 exceed the typical range of background groundwater concentrations, by comparing the value to the P95 of background. If it exceeds, compliance value of P95 x1.25 is used.

The proposed water quality parameters for groundwater compliance and their proposed limits are given in Table 3-16.

Table 3-11: Parameters considered in the Groundwater Baseline Assessment

Parameter	Symbol		Unit	LoD	Method
pH	pH_Lab		pH units	<0.01	TM73/PM0
Electrical Conductivity @25C	EC_Lab		µS/cm	<2	TM76/PM0
Total Dissolved Solids	TDS		mg/l	<10	TM20/PM0
Total Alkalinity as $CaCO_3$	AlkCaCO3_Total		mg/l	<1	TM75/PM0
Sulphate	SO4		mg/l	<0.05	TM38/PM0
Sulfide	Sulfide		µg/l	<10	TM106/PM0
Chloride	Cl		mg/l	<0.3	TM38/PM0
Fluoride	F		mg/l	<0.3	TM27/PM0
Total Organic Carbon	TOC		mg/l	<2	TM60/PM0
BOD (Settled)	BOD_Settled		mg/l	<1	TM58/PM0
Total Suspended Solids	TSS		mg/l	<10	TM37/PM0
Silica	SiO2		mg/l	<0.01	TM52/PM0
Free Cyanide	CN_Free		mg/l	<0.001	TM89/PM0
Total Cyanide	CN_Total		mg/l	<0.001	TM89/PM0
Nitrite as N	NO2_N		mg/l	<0.006	TM38/PM0
Nitrate as N	NO3_N		mg/l	<0.05	TM38/PM0
Nitrate as NO_3	NO3_NO3		mg/l	<0.2	TM38/PM0
Ammoniacal Nitrogen as N	NH3_N		mg/l	<0.03	TM38/PM0
Dissolved and Total Silver	Ag_D	Ag_T	µg/l	<5	TM30/PM14
Dissolved and Total Aluminium	Al_D	Al_T	µg/l	<1.5	TM30/PM14
Dissolved and Total Arsenic	As_D	As_T	µg/l	<0.9	TM30/PM14
Dissolved and Total Boron	B_D	B_T	µg/l	<2	TM30/PM14
Dissolved and Total Barium	Ba_D	Ba_T	µg/l	<1.8	TM30/PM14
Dissolved and Total Beryllium	Be_D	Be_T	µg/l	<0.5	TM30/PM14
Dissolved and Total Calcium	Ca_D	Ca_T	mg/l	<0.2	TM30/PM14
Dissolved and Total Cadmium	Cd_D	Cd_T	µg/l	<0.03	TM30/PM14
Dissolved and Total Cobalt	Co_D	Co_T	µg/l	<0.1	TM30/PM14
Dissolved and Total Chromium	Cr_D	Cr_T	µg/l	<0.2	TM30/PM14
Dissolved and Total Copper	Cu_D	Cu_T	µg/l	<3	TM30/PM14
Dissolved and Total Iron	Fe_D	Fe_T	µg/l	<4.7	TM30/PM14
Dissolved and Total Mercury	Hg_D	Hg_T	µg/l	<0.5	TM30/PM14
Dissolved and Total Mercury (CVAF)	Hg_D_CVAF	Hg_T_CVAF	µg/l	<0.01	TM61/PM38
Dissolved and Total Potassium	K_D	K_T	mg/l	<0.1	TM30/PM14
Dissolved and Total Magnesium	Mg_D	Mg_T	mg/l	<0.1	TM30/PM14
Dissolved and Total Manganese	Mn_D	Mn_T	µg/l	<1.5	TM30/PM14
Dissolved and Total Molybdenum	Mo_D	Mo_T	µg/l	<0.2	TM30/PM14
Dissolved and Total Sodium	Na_D	Na_T	mg/l	<0.1	TM30/PM14
Dissolved and Toal Nickel	Ni_D	Ni_T	µg/l	<0.2	TM30/PM14
Dissolved and Total Lead	Pb_D	Pb_T	µg/l	<0.4	TM30/PM14
Dissolved and Total Antimony	Sb_D	Sb_T	µg/l	<2	TM30/PM14
Dissolved and Total Selenium	Se_D	Se_T	µg/l	<1.2	TM30/PM14
Dissolved and Total Tin	Sn_D	Sn_T	µg/l	<5	TM30/PM14
Dissolved Strontium	Sr_D		µg/l	<5	TM30/PM14
Dissolved and Total Tellurium	Te_D	Te_T	µg/l	<5	TM30/PM14
Dissolved and Total Thallium	Tl_D	Tl_T	µg/l	<0.9	TM30/PM14
Total Titanium	Ti_T		µg/l	<5	TM30/PM14
Dissolved and Total Uranium	U_D	U_T	µg/l	<5	TM30/PM14
Dissolved and Total Vanadium	V_D	V_T	µg/l	<0.6	TM30/PM14
Dissolved and Total Zinc	Zn_D	Zn_T	µg/l	<1.5	TM30/PM14
EPH >C10-C16	EPH>C10C16		µg/l	<10	TM5/PM30
EPH >C16-C24	EPH>C16C24		µg/l	<10	TM5/PM30
EPH >C24-C40	EPH>C24C40		µg/l	<10	TM5/PM30
EPH >C8-C10	EPH>C8C10		µg/l	<10	TM5/PM30
EPH >C8-C40	EPH>C8C40		µg/l	<10	TM5/PM30
GRO (>C6-C10)	GRO>C6C10		µg/l	<10	TM36/PM12
GRO (>C6-C8)	GRO>C6C8		µg/l	<10	TM36/PM12
GRO (>C8-C10)	GRO>C8C10		µg/l	<10	TM36/PM12

Table 3-12: Summary of Groundwater Quality Baseline for Different Groundwater Units

Lithology	pH	TDS (mg/l)	Typical water type	Comments
Peatland	Acidic. Mean average: 4.4s.u.	Fresh. Typically 40 to 190mg/l	Na + Cl	Limited number of samples compared to other units. Acidic water, Highest total organic carbon concentrations, averaging 58mg/l
Alluvium and glacial fluvial	Moderate acidic to neutral. Mean average: 5.9s.u.	Fresh. Typically 20 to 120mg/l	Ca + HCO_3	Low concentrations of dissolved metals. Highest average concentration of nitrate
Weathered Bedrock	Moderate acidic to neutral. Mean average: 6.1s.u.	Fresh. Typically 10 to 400mg/l	Ca + HCO_3 or Na + HCO_3	The highest average nitrate concentrations were found in this unit down gradient of the exploration tunnel area. Highest arsenic found in the weathered bedrock across the wider study area
Bedrock	Moderately acidic to slightly alkaline. Mean average: 6.8s.u.	Fresh. Typically 10 to 320mg/l	Ca + HCO_3 or Na+ HCO_3	Highest manganese concentrations and typically slightly higher trace metals

Table 3-13: Potential receptors and protection measures from key legislation or guidance

Receptors	Key Documents	Relevant measures
Groundwater resource (water quality)	Groundwater Regulations (Northern Ireland) 2009 as amended. Article 7 of the Water Framework Directive (WFD: 2000/60/EC) for "Waters used for the abstraction of drinking water." Key guidance: • EA (2017c) Groundwater Protection Technical Guidance • DEFRA/EA (2016) Groundwater Risk Assessment for Environmental Permits • WFD Common Implementation Strategy (CIS) guidance documents	Prevents the input of *discernible* hazardous substances to groundwater[7]. Limit the input of non-hazardous substances to prevent pollution of groundwater receptors and resources. Non-hazardous substances are defined as all potential pollutants not defined as hazardous. To avoid pollution by non-hazardous substances inputs of pollutants must be limited to ensure that: • There is no deterioration in the status of the groundwater body (currently defined as 'good' for the Gortin Groundwater body); • There is no significant and sustained upward trend in pollutants; • The concentrations of pollutants remain below a level ensuring that harm to a receptor does not occur. Stated by the Water Management Unit of the NIEA in its letter dated 24 February 2016. All groundwater bodies (except Neagh groundwater body) are designated as Drinking Water Protected Areas under Article 7 of the WFD (2000/60/EC)
Owenkillew and tributaries (water level)	• WFD • North Western River Basin Management Plan	No specific quantitative measures other than preventing derogation of water flow in the water body and the catchment water balance
Owenkillew and Owenreagh tributaries (water quality)	• WFD (Priority Substances and Classification) Regulations (Northern Ireland) 2011 as amended	Provides maximum concentration limitations for substances in surface water bodies (implementing the Priority Substances Directive 2008/105/EC). From discussion with the NIEA it is understood these limits are applied in the Owenkillew and Owenreagh Rivers. Therefore, to maintain these standards, agreed surface water discharge criteria for both the Curraghinalt Burn and Pollanroe Burn will be based on relevant compliance standards for the combined flow derived from both groundwater baseflow and site discharges to the Curraghinalt Burn and Pollanroe Burn. Essentially this means that the standard applied will be the discharge values based on achieving the compliance criteria for the rivers.
Private abstractions (water level and water quality)	• The Private Water Supplies Regulations (Northern Ireland) 2017 Also: • The Water Supply (Water Quality) Regulations (Northern Ireland) 2007	No specific measures for the protection of water levels or water quality at private abstractions however there is a requirement for local authorities to adopt a risk-based drinking water safety planning approach to private water supplies. Acceptable water quality is assumed as defined in Public Water Supply limits. In terms of groundwater water quality, groundwater resource is also protected under the Groundwater Regulations.
Groundwater-dependant peatland habitats (water level)	Specific protection for wetland habitats (which may form peatland) with designations (e.g. SPA, SAC, ASSI) Habitats Regulations 1995. Groundwater dependant terrestrial ecosystems (GWDTE) also protected under the WFD.	Protection against derogation of habitat. For groundwater dependant bog-land small variations in water level (or groundwater flux) could impact habitat.

[7] Hazardous substances are taken as those revised by JAGDAG on 12th January 2017 (JAGDAG, 2017). The NIEA provided a position statement dated 13 January 2017 stating that new licence and permit applications and supporting baseline report account of the revised list of groundwater substances (NIEA, 2017)

Table 3-14: Water level compliance points and target values

Receptor	Target	Target Source
Owenkillew stretch adjacent to the mine (mine dewatering)	Assessed in the Surface Water Impact Assessment report (SRK, 2020)	
Tributaries to the Owenkillew River e.g. the Curraghinalt Burn (mine dewatering)	Assessed in the Surface Water Impact Assessment report (SRK, 2020)	
Peatland (mine dewatering)	Less than 0.1m change in groundwater level	Based on the likelihood that limited water level changes affect peatland vegetation
Abstractions (mine dewatering)	Less than 5% change in well water level	Estimated as an initial screen of significance for changes to an operational well of limited yield

Table 3-15: Calculated target concentrations for the groundwater quality impact assessment (SRK, 2020b)

Parameter	Relevant Environmental Standard for Groundwater (mg/l)	Environmental Standard Source (mg/l)	Target Limit: Proposed Mine Area		Target Limit: Proposed Infrastructure Area	
			Groundwater target limit (mg/l)	Target Methodology	Groundwater target limit (mg/l)	Target Methodology
Arsenic	0.010	SR 212_2017	0.019	Background groundwater concentration (P75)	0.027	Background groundwater concentration (P75)
Chromium VI	0.01	UKTAG 2017	0.005	50% of the Environmental Standard[1]	0.005	50% of the Environmental Standard[1]
Mercury	0.001	SR 212_2017	0.00002	UKTAG Limit of Quantification	0.00002	UKTAG Limit of Quantification
Lead	0.01	SR 212_2017	0.0002	UKTAG Limit of Quantification	0.0063	Background groundwater concentration (P75)
Aluminium	0.20	SR 212_2017	0.19	Background P75 + 20% of Environmental Standard	0.10	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Boron	1	SR 212_2017	*0.21*	Background P75 + 20% of Environmental Standard	*0.21*	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Barium	1.3	WHO_2017	0.76	Background P75 + 20% of Environmental Standard	0.36	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Beryllium	0.004	US-EPA_2009	*0.0011*	Background P75 + 20% of Environmental Standard	*0.0011*	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Cadmium	0.005	SR 212_2017	*0.001*	Background P75 + 20% of Environmental Standard	*0.0007*	Background P75 + 20% of Discharge Consent Value
Chromium (total)	0.05	SR 212_2017	0.011	Background P75 + 20% of Environmental Standard	0.0074	Background P75 + 20% of Discharge Consent Value
Copper	2	SR 212_2017	0.44	Background P75 + 20% of Environmental Standard	0.0128	Background P75 + 20% of Discharge Consent Value
Iron	0.2	SR 212_2017	4	Background P75 + 10% of background	30	Background P75 + 10% of background
Manganese	0.05	SR 212_2017	4.1	Background P75 + 10% of background	1.9	Background P75 + 10% of background
Molybdenum	0.07	WHO_2017	*0.0148*	Background P75 + 20% of Environmental Standard	*0.0141*	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Nickel	0.02	SR 212_2017	0.0139	Background P75 + 20% of Environmental Standard	0.0200	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Antimony	0.005	SR 212_2017	*0.002*	Background P75 + 20% of Environmental Standard	*0.002*	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Selenium	0.01	SR 212_2017	*0.0026*	Background P75 + 20% of Environmental Standard	*0.0026*	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Silver	0.07	SR351 + Dilution	*0.0171*	Background P75 + 20% of Environmental Standard	*0.0017*	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Thallium	0.002	US-EPA_2009	*0.0009*	Background P75 + 20% of Environmental Standard	*0.0009*	Background P75 + 20% of Environmental Standard / Discharge Consent Value

Parameter	Relevant Environmental Standard for Groundwater (mg/l)	Environmental Standard Source (mg/l)	Target Limit: Proposed Mine Area		Target Limit: Proposed Infrastructure Area	
			Groundwater target limit (mg/l)	Target Methodology	Groundwater target limit (mg/l)	Target Methodology
Uranium	0.03	US-EPA_2009	*0.0085*	Background P75 + 20% of Environmental Standard	*0.0085*	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Zinc	3	SR351 + Dilution	0.8	Background P75 + 20% of Environmental Standard	0.3	Background P50 + 10% of background[2]
Chloride	250	SR 212_2017	65.1	Background P75 + 20% of Environmental Standard	64	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Nitrate (as N)	11.3	SR 212_2017	4.36	Background P75 + 20% of Environmental Standard	2.5	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Nitrite (as N)	0.15	SR 212_2017	0.033	Background P75 + 20% of Environmental Standard	0.033	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Ammonia (as N)	0.39	SR 212_2017	0.2	Background P75 + 20% of Environmental Standard	0.22	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Fluoride	1.5	SR 212_2017	*0.45*	Background P75 + 20% of Environmental Standard	*0.45*	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Sodium	200	SR 212_2017	49.7	Background P75 + 20% of Environmental Standard	54	Background P75 + 20% of Environmental Standard / Discharge Consent Value
Sulphate	250	SR 212_2017	59	Background P75 + 20% of Environmental Standard	56	Background P75 + 20% of Environmental Standard / Discharge Consent Value

- *Blue italics* highlights that the background used in the target calculation is based on detection limit values only. All detection limit values are taken as a value of 0.5LOD
- Hazardous substances in groundwater are presented in **underlined bold**. Targets values are presented to 2 significant figures. Chromium (total) is not defined as a hazardous substance; only Chromium VI is a hazardous substance.
- Parameters which have background concentrations which naturally exceed DWS or Discharge Consent criteria, therefore targets established above DWS are highlighted in grey. Please see 2019 Groundwater Monitoring Report (Annex C) for a full suite analysis highlighting parameters that naturally exceed Environmental Standards
- Limit of Quantification target method: used for hazardous substances, where the background concentration is lower than the Limit of Quantification
- Discharge consent criteria are taken from draft criteria submitted to the NIEA, documented in Proposed Discharge Criteria for Owenkillew River and Curraghinalt Burn, Gortin, County Tyrone, BT79 7SF, April 2020, Kaya Consulting.
- P75 concentration used is the maximum P75 for each groundwater unit for wells for the relevant area (i.e. maximum P75 for alluvium or glaciofluvial, weathered bedrock, bedrock). The wells used for each area in statistical assessment are defined in in the 2019 Groundwater Monitoring Report (Annex C to the groundwater impact assessment, 2020b). The values used for P75 are listed at Addendum B to this document.

[1] For Chromium VI the laboratory limit of detection exceeds the Limit of Quantification. Therefore the 0.5LOD values for background groundwater also exceed the Limit of Quantification. This would lead to exceedances purely based on groundwater mixing calculations. The 50% DWS method in Addendum section A5 is used for the target limit and the recommended compliance limit for this parameter

[2] The maximum P75 concentration for zinc in the infrastructure area exceeds the Draft Discharge Consent value

UKTAG 2017: UK Technical Advisory Group (UKTAG) on the Water Framework Directive Technical Report on Groundwater Hazardous Substances, March 2017

US-EPA 2009: US EPA National Primary Drinking Water Regulations. 2009

WHO_2017: WHO Guidelines for Drinking Water Quality - Fourth Addition 2017. Annex 3 - Chemical Summary Tables

Table 3-16: Proposed Compliance Limits

Parameter	Proposed Underground Mine Area		Proposed Infrastructure Area	
	Recommended Compliance limit (mg/l)	Selection and methodology for limit	Recommended Compliance limit (mg/l)	Selection and methodology for limit
Arsenic	0.041	Note 3. Method 3	0.055	Note 1. Method 3
Chromium VI	0.005	Note 1. Method 2	0.005	Note 3. Method 2
Mercury	0.0005	Note 1. Method 2	0.0005	Note 3. Method 2
Lead	0.010	Note 1. Method 3	0.009	Note 3. Method 3
Boron	1	Note 1. Method 1	1	Note 1. Method 1
Barium	1.3	Note 1. Method 1	1.3	Note 1. Method 1
Beryllium	0.004	Note 1. Method 1		Note 1. Method 1
Cadmium	0.005	Note 1. Method 1	0.005	Note 1. Method 1
Chromium (total)	0.05	Note 1. Method 1	0.05	Note 1. Method 1
Molybdenum	0.07	Note 1. Method 1	0.07	Note 1. Method 1
Nickel		[Note 2]	0.02	Note 1. Method 1
Antimony	0.005	Note 1. Method 1	0.005	Note 1. Method 1
Selenium	0.01	Note 1. Method 1	0.01	Note 1. Method 1
Silver	0.07	Note 1. Method 1		[Note 2]
Thallium	0.003	Note 1. Method 3		[Note 2]
Uranium	0.03	Note 1. Method 1	0.03	Note 1. Method 1
Chloride	250	Note 1. Method 1		[Note 2]
Nitrate	11.3	Note 1. Method 1	11.3	Note 1. Method 1
Ammonia (as N)	0.39	Note 1. Method 1	0.39	Note 1. Method 1
Fluoride	1.5	Note 1. Method 1		[Note 2]
Sodium	200	Note 1. Method 1		[Note 2]
Sulphate	250	Note 1. Method 1	250	Note 1. Method 1

Table Notes

Hazardous substances in groundwater are presented in **underlined bold**.

Compliance criteria for non-hazardous substances are only recommended for parameters where the predicted source concentration is greater than the background groundwater concentration. The comparison of predicted values to background groundwater quality (P50) [P50 concentrations used given in Addendum B to Annex F of the Groundwater Impact Assessment, (2020b)].

Note 1: Substance is predicted in geochemical characterisation assessment* (base-line model) to be above average background groundwater concentration. This includes operations and closure results for both the DSF and the underground mine area). [*SRK, 2020. A Geochemical Characterisation Report for the Curraghinalt Gold Deposit, Northern Ireland]

Note 2: Substance is predicted in geochemical characterisation assessment* (base-line model) to be below average background groundwater concentration. This is added for clarification where the substances have been flagged for a compliance limit in the other area.

Methods used for determining compliance limits refer to points 1 to 3 in Section 3.4.5. These methods are discussed further in Annex F of the Groundwater Impact Assessment, (2020b)

3.5 Action Plan

3.5.1 Assessment limits and Compliance Limits

Assessment limits: assessment limits are limits that are designed as early warning triggers for either immediate action or for further assessment.

Assessment limits can provide an indication of unexpected events in the receiving environment and/or allow sufficient time to ensure compliance limits are not breached.

In relation to water quality, assessment limits are defined in guidance (Environment Agency, 2004) as limits that can:

- Identify unambiguous adverse trends, and;
- Allow for variation in water quality baseline conditions, and;
- Allow enough time to take corrective /remedial action.

Assessment limits based on baseline reference data will be updated based on the current monitoring database prior to commencement of that phase (i.e. at the start of the construction, operational and closure phase).

Assessment limits may also need to change during a phase due to either up-gradient changes in water level, flow or quality that reflect changes in off-site or baseline conditions.

Assessment limits are not compliance levels or levels that indicate pollution, but water levels, flows or concentrations that indicate an unexpected change from the norm such that the compliance level could be breached, or pollution could occur, should the current trend continue.

Compliance limits: The term ‘compliance’ is reserved for statutory conditions, which may be established in the site permit (e.g. consented water quality discharge limits for the water treatment plant would constitute compliance limits).

Compliance limits set by regulators are inherently higher than assessment limits.

The assessment limits presented in this monitoring plan are designed to be protective of compliance levels and associated obligations and statutory conditions. Compliance limits are fixed by statutory criteria whereas assessment limits, and locations where such levels are set in the plan, will be modified as the project progresses based on annual reviews and on-going recommendations.

3.5.2 Assessment Actions

Assessment actions are a set of responses to be triggered should assessment limits be exceeded. As such they are protective measures designed to ensure that compliance limits are not breached.

Assessment actions will vary according to type of exceedance, the significance of the exceedance and the sensitivity of receptors involved as applicable.

In general, assessment actions conform to the following three steps:

1. Validate trend and exceedance;
2. Assess the relevance and significance of the exceedance in terms of proximity to relevant compliance thresholds and on-going operations at the mine site;
3. If applicable, employ mitigation measures to reduce impact significance.

Assessment actions are identified according to the following ID system:

XXYZn, where:

XX = SW for surface water, GW for groundwater

Y = C for construction phase, O for operations phase

Z = M for mine site, P for proposed infrastructure site/processing plant site

n = sequential number for each assessment action

For example, assessment action SWOM2 is the second assessment action relating to surface water during the operation phase at the mine site.

3.5.3 Setting Assessment limits

As stated above, assessment limits presented in this monitoring plan are designed to be protective of compliance levels and associated obligations and statutory conditions. The following summarises the basis of the criteria used for establishing assessment limits for the operational phase of the project (Note; construction phase criteria are developed using a similar approach but with some additional considerations).

Surface Water Flows

For the Pollanroe Burn where the compliance condition at the site water treatment plant outfall will be a compensation flow agreed with the regulators, the assessment limit criteria is set at flows less than the minimum compensation flow plus 20%.

For other watercourses the assessment limit criteria is based on when the observed difference in low flows (Q95) becomes significantly larger than predicted in EIA (ES, 2017).

Surface Water Quality

For the Pollanroe Burn and Curraghinalt Burn the assessment limit criteria is within 80% of the proposed discharge criteria set out in Table 3-7 and Table 3-8 above for the Pollanroe Burn and Curraghinalt Burn respectively. This is on the basis that the sensitivity of these watercourses is assessed to be low (Table 3-5 and Table 3-6).

For the Owenreagh and Owenkillew Rivers downstream of the above burns the assessment limit criteria is set on the basis of a change in baseline concentrations which is greater than predicted in EIA (ES, 2017) for three consecutive sampling occurrences. The predicted concentrations are set out in Table 3-9 and Table 3-10 for the Owenreagh and Owenkillew Rivers respectively.

Groundwater Levels

Assessment limits for groundwater level are based on project-specific criteria that are considered protective of the groundwater system and of groundwater users.

Groundwater Quality

Assessment limits for groundwater quality are based on project-specific criteria of an increasing trend over the assessment limit concentrations. Assessment limit concentrations are set at the groundwater design target limits used for the groundwater impact assessment (See Table 3-15 and Section 3.4.4). An increasing water quality trend above the assessment limit is defined as a concentration exceedance for 3 consecutive monitoring periods as detailed in the groundwater plan (Section 5). In addition to the above design target limits, hydrocarbons will also be assessed in groundwater samples at wells in the infrastructure area. The assessment action level for hydrocarbons will be the analysis detection limit.

4 SURFACE WATER MONITORING PLAN

4.1 Overview

4.1.1 Water flow and quality for surface water

Surface water monitoring consists of stream flow monitoring and water quality testing throughout the life of mine. The monitoring considers the environmental monitoring program that will measure flow and water quality in the watercourses downstream of the mine site (i.e. receiving environment) and upstream.

Additional operational monitoring will be required to support the mine discharge permit (e.g. flow and water quality at the mine outfall locations) and to support water management at the mine site (e.g. monitoring of water levels in water management ponds, monitoring of flows from underground mining).

4.1.2 Flow monitoring

The objectives of the surface water flow monitoring program will be to;

- Allow comparison of flows during operations with baseline conditions,
- Assess any impacts of mining activity on flows in the receiving waters and to compare observed impacts to those predicted in the impact assessment,
- Increase the flow data set for streams adjacent to the project, so they can be compared to Rivers Agency regional flow monitoring data.

Flow gauging stations that have been constructed during the baseline monitoring programme will continue to be operated through the life of mine (construction, operations and closure). The stations selected for on-going monitoring throughout the life of mine were chosen based on the quality of the existing rating curves and flow data, and the location of the sites with respect to mining operations and environmental impact. The locations are found at Table 4-1.

The number of sites will be reviewed at the end of each annual monitoring period.

Quarterly inspections of the selected streamflow gauges will take place to download water level readings, undertake spot flow surveys and assess if maintenance or repairs are required.

The manual (spot) flow measurements will take place quarterly to continue to update and improve the existing rating curves. Level readings will be processed and converted to flow measurements for annual reporting purposes.

Annual reports will include observed daily average water level and calculated flow data (tabulated and in graphical form), manual flow measurement results, site rating curves, site photographs and a summary of key hydrological parameters for each gauge (e.g. annual runoff, monthly average flows, summer low flows and annual flow duration curves and peak observed flow).

Details of the monitoring programs, frequency of monitoring and monitoring locations are presented in Section 4.2 below.

4.1.3 Water quality

The objectives of the water quality monitoring program are to:

- Provide monthly water quality data in streams lying downstream of the proposed and existing infrastructure sites to allow comparison of water quality during mining operations with environmental standards and baseline conditions,
- Provide water quality data in receiving watercourses that can be compared to predicted water quality in the impact assessment,
- Provide adequate background, reference data for streams and upstream stretches of watercourses unaffected by mining activities, which can be compared to watercourses lying downstream of the proposed and existing infrastructure sites.

Water quality sampling locations were selected from the baseline monitoring stations. Streams upstream and downstream of important mine discharge locations, and upstream and downstream of critical mixing locations, were selected. It is important to utilise baseline monitoring stations as it will allow comparison of water quality samples during the mine life with baseline conditions.

The results of the in-stream water quality sampling will be reported in end of year environmental monitoring reports and will include all water quality sampling data, description of sampling methods and appropriate QA/QC documentation. The results will be compared to environmental standards and guidelines, as well as the predicted results in this impact assessment.

4.1.4 Surface water discharges

Surface water discharges from the project during construction and operations will be regulated by site discharge permits, with associated water quality criteria (refer to Section 3.3.4 and 3.3.5).

4.1.5 Closure

At closure, the project infrastructure will be reclaimed. In the long-term the main potential project influences on surface waters quality will be from seepage from the DSF at the proposed infrastructure site and adit flows and groundwater at the existing infrastructure site.

Water quality parameters at closure are predicted to comply with the requirements of the operational discharge permit.

4.2 Baseline Surface Water Monitoring

4.2.1 Surface Water Flow Monitoring

Continuous water level monitoring stations have been constructed at 13 sites on watercourses surrounding the project area. Of these two have been decommissioned. The remaining stations where there is active monitoring are listed in Table 4-1 and shown on Figure 4-1.

4.2.2 Surface Water Quality Monitoring

Monthly baseline water quality sampling has been undertaken at 24 sampling stations in the project area. A list of the sampling stations is provided in Table 4-2, with locations shown in Figure 4-2. Some of the sampling stations have two ID numbers (reflecting a rationalisation of sampling station names during the 2014 to 2016 baseline sampling). The ID to be taken forward is highlighted in bold in Table 4-2.

Table 4-1: Baseline flow monitoring stations

Station ID	Location	Easting (m)	Northing (m)	Catchment Area (km^2)
FL01	Tributary to Owenkillew River - Curraghinalt Burn (u/s Atty's Bridge)	257116	386658	1.0
FL03	Owenkillew River at Greenan Bridge	258763	386801	96.0
FL04	Glenlark River at Glenlark Bridge	257626	387440	21.9
FL05	Owenkillew River at Drumlea	253161	387111	134.5
FL06	Owenreagh River at Drumlea Bridge	253539	385900	84.8
FL07	Owenreagh River at Aghnamirigan Bridge	256183	383624	74.3
FL08	Owenkillew River downstream of Owenreagh River confluence	250556	385916	240.4
FL09	Owenreagh River - Cashel Bridge	258090	382117	51.5
FL10	Owenkillew River - near confluence with Camanransy Burn	261276	384791	64.9
FL11	Tributary to Owenreagh River - Sruhanalticarra Burn at B46 crossing	259054	382927	0.98
FL13	Tributary to Owenreagh River - Pollanroe Burn at Bridge on B46	258330	383384	1.5

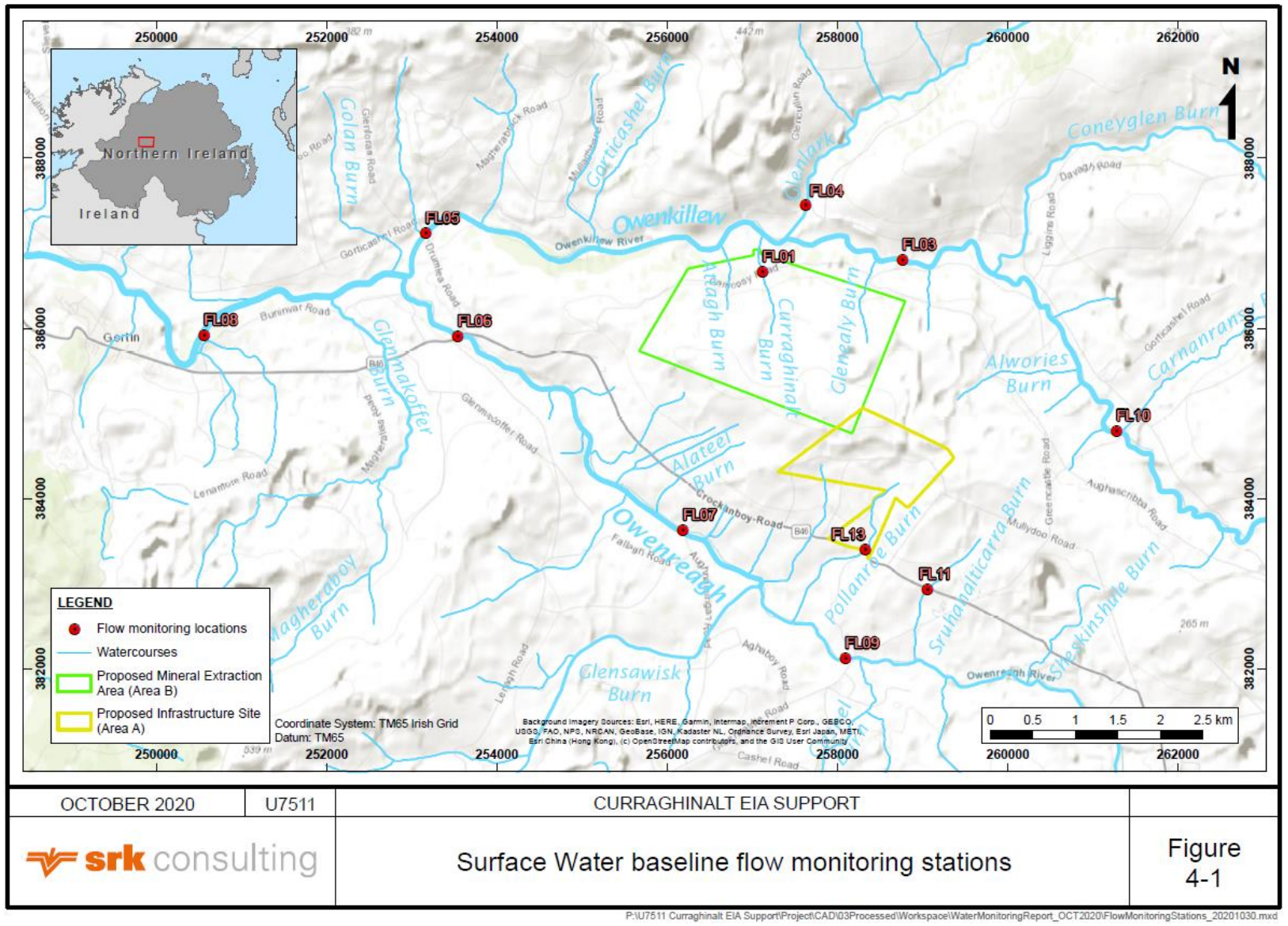

Figure 4-1: Surface Water baseline flow monitoring stations

Table 4-2: Surface water sampling point locations, description and dates of water quality data

Location ID	Easting (m)	Northing (m)	Description	Start Date	Frequency
Owenkillew River (Upstream of Confluence with Owenreagh)					
SWN03/**SW23**	260562	386096	Glenhull Bridge	Jul 2015	Quarterly
SWN04/**SW24**	261383	384775	Near confluence with Camanransy Burn	Jul 2015	Quarterly
SW05	257150	387077	U/S of Curraghinalt Burn confluence	Jul 2015	Monthly
SW06	257109	387114	D/S of Curraghinalt Burn confluence	Jul 2015	Monthly
SW07	258764	386801	D/S of Greenan Bridge	Jul 2015	Quarterly
SW08	253161	387111	U/S of Drumlea Road Bridge	Jul 2015	Quarterly
Tributaries to Owenkillew River					
SWN01/**SW21**	257639	387440	Glenark River at Glenark Bridge	Jun 2016	Annual
SWN02/**SW22**	260205	387079	Coneyglen Burn at Coneyglen Bridge	Jun 2016	Annual
SW02	257119	386659	Curraghinalt Burn U/S of Attys Bridge	Jul 2015	Monthly
SW03	258377	386593	Glenealy Burn U/S of Glenealy Bridge	Jul 2015	Quarterly
SW04	257100	387009	Curraghinalt Burn D/S of discharge point from existing infrastructure site	Jul 2015	Monthly
Owenreagh River					
SWN06/**SW26**	256201	383615	Aghnamirigan Bridge	Jul 2015	Monthly
SW09	253540	385901	U/S of Drumlea Bridge	Jul 2015	Monthly
SW10	261873	380730	Formil Bridge	Jun 2016	Annual
SW11	258200	382140	Cashel Bridge	Jul 2015	Monthly
Tributaries to Owenreagh River					
SWN05/**SW25**	258319	383383	Pollanroe Burn at Pollanroe Bridge	Apr 2016	Monthly
SWN07/**SW27**	255563	384327	Unnamed tributary	Jul 2015	Monthly
SWN08/**SW28**	258651	384165	Pollanroe Burn U/S of bridge	Jul 2016	Radon only
SWN09/**SW29**	259074	382931	Sruhanalticarra Burn at bridge of B46	Jul 2015	Monthly
SWN10/**SW30**	257689	383551	Unnamed burn on B46 west of SWN8 at Fashioners Bridge	Jul 2016	Monthly
Owenkillew/Strule River (Downstream of Confluence with Owenreagh)					
SW12	250520	385364	Owenkillew River U/S of Gortin	Jul 2015	Monthly
SW13	249269	386689	Owenkillew River D/S of Gortin	Jul 2015	Monthly
SW14	241084	386052	River Strule U/S of Moyle Bridge	Jun 2016	Annual
SW15	239388	386266	River Strule U/S of A5 Bridge	Jun 2016	Annual

Note: For sites with two location IDs, ID shown in bold is name taken forward
U/S = Upstream; D/S = Downstream

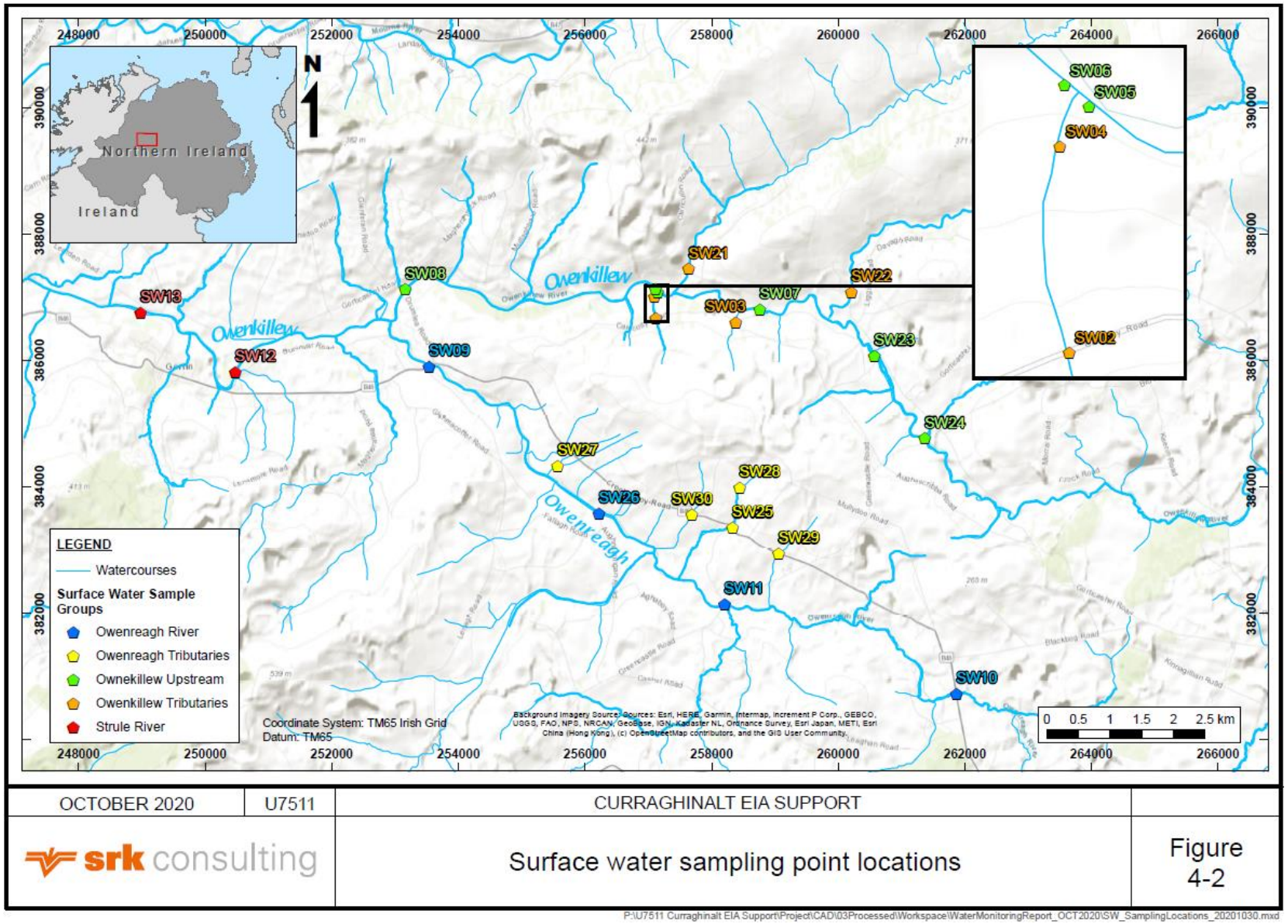

Figure 4-2: Surface water sampling point locations (coloured by group)

4.3 Construction Phase Monitoring Plan – Site Monitoring

The construction phase surface water monitoring plan is outlined as part of the Outline Construction Environmental Management Plan (CEMP). The CEMP provides an overview of monitoring activities that are specific to each start-up construction area, with the purpose of monitoring for discharge compliance; see Table 4-3 below which is an excerpt from the CEMP.

The location of these monitoring activities will vary depending on the location of the construction works, with outlines of the construction works and their sequencing presented in the CEMP.

4.3.1 Surface Water Quality Monitoring Locations

A reverse osmosis (RO) water treatment plant will be installed and commissioned at the existing infrastructure site. This will manage wastewater from the existing adit site during the initial period of mine development when the adit will be used to provide access to the underground mine.

At the proposed infrastructure site during start-up (Phase 1 Stage 1), and for approximately the first 2 months, there will be five construction areas (Figure 4-3). Each construction area will have a temporary overland outfall comprising a lagoon/detention pond and a Siltbuster (or similar) plant with hydrocarbon interceptor.

A summary of each of the five construction areas, proposed treatment and predicted discharge flow is given in Table 4-4.

At Phase 1 Stage 2 of construction, runoff water from working areas will continue to be captured in a similar fashion to Stage 1, but thereafter and for the remainder of the construction phase runoff water will be pumped to the western end of the west pond to support initial settlement of suspended solids. Water from the west pond will form a feed for the reverse osmosis (RO) water treatment plant (WTP) which has been designed to manage water volumes and quality (including process water) for the full mine lifecycle.

Table 4-3: Surface Water Sampling, Monitoring and Reporting (from: CEMP)

Sampling, Monitoring and Reporting (section 4.5 of the CEMP)

A programme of water monitoring will be carried out during the construction phase.

The extent and frequency of the monitoring will be proportionate to the level of activity. Such monitoring will be required in order to:

- *Confirm that the mitigation measures and the silt and water management plan are performing as designed;*
- *Confirm reassurance that the construction activities are not having a significant impact upon the environment;*
- *Confirm whether investigation is required and additional mitigation measures are needed, e.g. additional silt fences or modular units (Siltbuster)This monitoring will commence prior to the start of construction activities to establish the baseline conditions at each work site.*

The surface water monitoring programme will be site-specific and tailored to provide a statement of the state of the water environment. Given the nature of the development, it is considered that the surface water monitoring programme will comprise:

- *An initial site walkover.*
- *Daily visual inspections of surface water management features, such as culverts and receiving watercourses, in order to establish whether there is increased erosion or deposition and sediment.*
- *Daily visual inspections of watercourses during construction and decommissioning stages, particularly during periods of high rainfall, in order to establish that levels of suspended solids have not been increased by site activities.*
- *Daily sampling and field testing of discharges from Siltbuster equipment to the environment. With specific reference to the areas of construction drainage as set out in Figure 3-1 all areas will be monitored upstream, at the point of leaving the construction area and at the point of discharge. Suspended solids and pH will be monitored.*
- *Periodic and ad-hoc sampling of surface waters in order to complement the programme of visual inspection. The parameters for the wider sampling programme are set out in the Surface Water and Groundwater Environmental Monitoring and Action Plan (Appendix B).*

Monthly Reporting

There will be a system of monthly reporting implemented. Reports will assess the previous months performance discuss the following month's works and discuss issues arising. Contractors will submit their monthly work schedule, two monthly rolling programme which clearly show the works areas for the following month and their anticipated discharge rates. These will be based on the works areas affected and the potential of a 1 in 75 year storm event happening.

Table 4-4: Stage 1 Construction Phase Drainage (refer to Figure 4-3 for Construction Areas)

Ref Area	Approx. Area of Exposed Ground (ha)	Description of Area	Proposed Discharge Treatment	Temporary Detention Pond Volume (m^3)	Q_{75} Discharge Flow (l/s)
1	0.750	ROAD & Compound Access road to the west of the Pollanroe Burn to include temporary car park and stockpile areas	Temporary detention pond and Siltbuster Temporary overland outfall restricted to greenfield rates	117 Approx. dimensions (3 x 27.9m)	5.5
2	0.661	ROAD Road construction from south of Pollanroe Burn up to WTP.	Temporary detention pond and Siltbuster (or similar). Temporary overland outfall restricted to greenfield rates	103 Approx. dimensions (3 x 24.5m)	4.8
3	0.512	WTP Pad WTP construction pad	Temporary detention pond and Siltbuster (or similar). Temporary overland outfall restricted to greenfield rates	81 Approx. dimensions (3 x 19.3m)	3.7
4	0.594	Section of West Pond Initial stage of construction of the west pond.	Temporary detention pond and Siltbuster (or similar). Temporary overland outfall restricted to greenfield rates	93 Approx. dimensions (3 x 22.1m)	4.3
5	1.479	Portal & Laydown Portal construction in advance of tunneling activity and supporting laydown area.	Temporary detention pond and Siltbuster (or similar). Temporary overland outfall restricted to greenfield rates	230 Approx. dimensions (6 x 27.4m)	10.8

Detailed procedures and methods covering the planning, design, management and monitoring of silt control measures, explosives management, and spill mitigation/prevention/response measures will be agreed in advance with the Northern Ireland Environment Agency (NIEA) Water Management Unit. Concrete truck wash out will not be permitted at the site.

4.3.2 Monitoring Frequency and Parameters

During Phase 1 construction on the infrastructure site, monitoring of discharges from the five temporary treatment points will be undertaken as follows:

- Water flow (i.e. discharge rate): continuous monitoring via inline flow meter/orifice plate
- pH, conductivity/total dissolved solids, turbidity/TSS; four times daily readings from water quality sondes and/or from discrete samples
- Water quality sampling weekly using a selection of compliance levels to be taken from Table 3-9. These have been established as being protective of the receiving water environment at full mine site discharge rates and threshold concentrations can therefore also be conservatively deployed for small temporary discharge consents (during the first 2 months of construction). As a minimum, suspended solids (50mg/L), pH (6.2 to 9), and visible oil and grease are considered applicable.

During Phase 2 onwards on the infrastructure site and at the existing infrastructure site continuous monitoring of effluent discharge from the RO WTPs will be undertaken. There will be continuous monitoring of the following parameters:

- Water flow (i.e. discharge rate):
- pH, conductivity/total dissolved solids, turbidity/TSS
- Water quality sampling using the parameters for surface water as given in Table 3-7; monthly.

4.3.3 Response Measures to Exceeding Discharge Limits

During Stage 1 of Phase 1 (a period of approximately 2 months) treatment and disposal of runoff water will occur via temporary discharge consents to overland outfall. As stated above however, procedures and measures relating to water pollution prevention will be agreed with the NIEA in advance. This is anticipated to include criteria whereby any potential for breaches of compliance levels in the consents will result in mitigation measures being adopted whereby relevant discharges cease and the issue resolved prior to restart of treatment and discharge.

From Stage 2 of Phase 1 onwards the main WTP at the proposed infrastructure site will be operational and treatment and disposal will be undertaken with a permanent discharge consent in place. The RO WTP facilities will be equipped with alarms. The alarm system is industry standard and linked to control offices and mobile phones. The alarm will indicate the issue that has triggered the alarm.

If the alarm is triggered the water treatment system, including discharge pumps, will shutdown automatically. This will trigger a specific response protocol. This includes adjustment of the treatment balance, control of the flows into and out of the plant.

The discharge of water will only be resumed once the source of the alarm trigger has been identified and corrected ensuring discharge of compliant water only.

The Assessment Action designed to provide an early earning trigger and detailed in the environmental monitoring section below (Section 4.4) will provide an additional level of mitigation and intervention beyond that outlined above. This intervention is specifically detailed in Assessment Action SWCP1 “Assessment at the downstream monitoring stations for key parameters during construction activities”.

The final CEMP will include an Environmental Emergency Response Plan (EERP) to cover all potential pollution incidents which may occur during the construction phase.

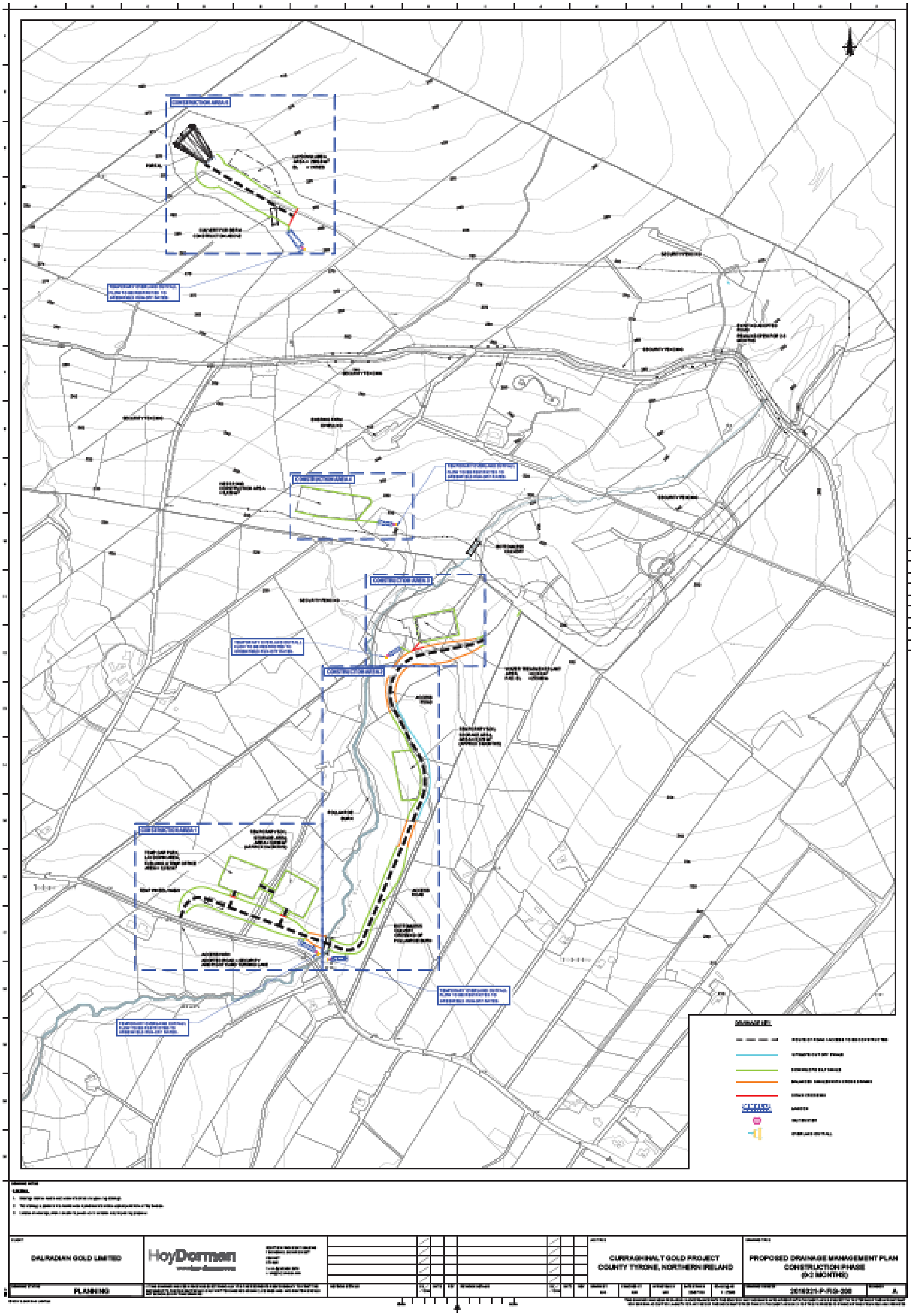

Figure 4-3: Proposed Drainage Management Plan Construction Phase (from CEMP)

4.4 Construction Phase Monitoring Plan – Environmental Monitoring

The environmental monitoring described in the SGEMAP below focusses on monitoring of any impacts in the receiving water downstream of the construction activities and in continuing the baseline monitoring work at the site.

4.4.1 Proposed Infrastructure Site

Surface Water Flow Monitoring

The baseline flow monitoring stations identified for the operations period (and discussed below) will be operational during the construction period.

Releases of water from the construction sites will be monitored under temporary discharge consents (Section 4.3).

Surface Water Quality Monitoring

The most significant potential impact to surface water quality during construction will be the release of key parameters most likely to be elevated during construction activities; particularly Total Suspended Solids (TSS), oils and hydrocarbons and nutrients from blasting activities (e.g., nitrate, total ammonia and total alkalinity); refer to section 4.3.

Within the Pollanroe Burn water quality samples will be taken at the baseline monitoring station SWN05.

Within the Owenreagh River monitoring is proposed upstream and downstream of the Pollanroe Burn to allow an assessment of impacts of water from the Pollanroe Burn to the Owenreagh River. This will also extend the record of baseline monitoring on the Owenreagh River. Monitoring will take place at the following baseline monitoring locations (refer to Figure 4-2):

- SW10 - located upstream of the site to allow monitoring of any changes in water quality in the upper catchment;
- SW11 - located just upstream of the confluence with the Pollanroe Burn;
- SWN06 - located downstream of the Pollanroe Burn;
- SW09 - located close to the confluence of the Owenkillew and Owenreagh Rivers.

Monitoring will also take place on the Unnamed Watercourse (station SWN10) and the Sruhanalticarra Burn (SWN09). Water quality at these two locations should be unaffected by the project and, as such, these will act as reference sites only with data collected to provide a continuous record through construction to add to the baseline data set.

Samples will be taken monthly using methods outlined in the Sampling and Monitoring Handbook (refer to Section 1.3). Continuous monitoring of turbidity/TSS will be undertaken in the Owenreagh River at sample locations SW11 and SWN06.

A summary of the sampling locations, sampling frequency and assessment limit at which actions are triggered is provided Table 4-5. Parameters for surface water quality analysis are given in Table 3-2.

Hydromorphological Monitoring

Construction activities could cause changes to the channel and banks of the Pollanroe Burn and Owenreagh River close to the confluence with the former due to erosion of banks or channels within the watercourses, or the release of sediment during construction. Regular visual inspections of watercourses downstream of construction activities forms part of the CEMP and no additional hydromorphological monitoring is proposed in this monitoring and action plan.

Surface Water Assessment limits and Actions: Proposed Infrastructure Site, Construction Phase

Surface water assessment limits for the planned monitoring at the proposed infrastructure site during construction are given in Table 4-5.

Where assessment limits are not allocated, monitoring is undertaken for the purpose of collecting baseline data.

Section 3.5 sets out the basis of how assessment limits have been developed for this plan.

Table 4-5: Proposed infrastructure area surface water monitoring, with assessment limits – Construction Phase

Baseline Station ID and Location	Purpose	Parameter / *measurement frequency*	Assessment limit
Surface Water Quality			
SWN05: Pollanroe Burn	Monitoring concentrations in Pollanroe Burn to allow comparison with site discharge criteria and drinking water standards (refer to Section 3.3.4 and Table 3-7) for key parameters with the potential to be elevated by construction activities, e.g. TSS	Monthly samples	For first few months of construction prior to installation of WTP; Within 80% of the consent level of receiving water guideline concentrations and Drinking Water concentrations. Once WTP installed assessment limits and actions are same as for operations period.
SW10: Owenreagh River upstream of mine site	Record of water quality in river upstream of mine site to (i) allow calculation of relative input from Pollanroe Burn, (ii) identify any increases in background concentrations that are independent of the mine	Monthly samples and continuous turbidity measurement	None, data used to provide reference station
SW11: Owenreagh River upstream of confluence with Pollanroe Burn	As above	Monthly samples	None, data used to provide reference station
SWN06: Owenreagh River downstream of confluence with Pollanroe Burn	Record water quality in the Owenreagh River downstream of the mine to allow (i) comparison with receiving water guideline values, (ii) assess any changes in water quality from baseline	Monthly samples and continuous turbidity measurement	For first few months of construction prior to installation of WTP; Concentrations more than 20% higher than samples at SW11. Once WTP installed assessment limits and actions are same as for operations period.
SW09: Owenkillew River, upstream of confluence with Owenreagh River	As above	Monthly samples	None, data used to provide reference station
SWN10: Unnamed Watercourse	Monitoring concentrations in Unnamed Watercourse to allow comparison with receiving water guidelines and allow assessment of any changes from baseline conditions, relating to construction of diversion ditch	Monthly Samples	Within 80% of the consent level of receiving water guideline concentrations and Drinking Water concentrations as for the Pollanroe Burn above (reference SWN05)
SWN09: Sruhanalticarra Burn – reference site	Reference site on watercourse unaffected by construction activities	As above	None, data used to provide reference station

Assessment limit Actions

SWCP1: Assessment at the downstream monitoring stations for key parameters during Phase 1 construction activities:

For the downstream monitoring stations any exceedance of assessment limits for the parameters set out above will be actioned:

Actions will include:

- Investigation of possible source for exceedance on site and cross reference to corresponding discharge compliance level records;
- Identification of source of exceedance and removal of source if applicable;
- review of mitigation measures to ensure functioning as required and determine if additional measures could beneficially be incorporated

Any migration towards discharge compliance levels will already have been detected by the monitoring at the construction sites and identified by temporary discharge consent monitoring. However, monitoring undertaken as part of the SGEMAP will provide a further validation of modelling already undertaken and that the receiving environment is protected.

4.4.2 Underground Mine

Surface Water Flow Monitoring

Baseline flow monitoring stations identified for the operational period (and discussed below) will be active during the construction period. The results will be reported on an annual basis, but no assessment limits are proposed for these monitoring stations.

Surface Water Quality Monitoring

Water quality sampling will be undertaken at the sampling locations identified for the operational phase, see Section 4.5. Given the limited construction activities at the underground mine no assessment limits are set for water quality sampling. The main purpose of the monitoring in relation to the underground mine during construction will be to maintain a continuous water quality baseline record through to the operational period.

Compliance with discharge consents in terms of construction activities is outlined in Section 4.3.

4.5 Operational Phase Monitoring Plan

4.5.1 Introduction

The operational phase SGEMAP is separated into a monitoring plan for the proposed infrastructure site and a monitoring plan at the surface in relation to the underground mine. Separate plans are required because of the contrasting scale of operation, areas covered and processes/activities being performed.

This monitoring plan focusses on watercourses outside of the two mine infrastructure areas, monitoring flows and water quality in natural streams potentially impacted by mining activities and streams unaffected by mining activities that can be used as references.

The SGEMAP does however include monitoring of water quality in the water management ponds within the proposed infrastructure area.

4.5.2 Proposed Infrastructure Site

Surface Water Flow Monitoring

Monitoring within the Proposed Infrastructure Area

Mine contact water will be captured and routed to a series of water management ponds (East and West Water Management Ponds) before discharge to the Water Treatment Plant and from there to the Pollanroe Burn.

The following activities will be undertaken as part of operations of the proposed infrastructure facility and are not included as part of the SGEMAP:

- continuous monitoring of water levels in the water management ponds
- continuous monitoring of the water level in the Clean Water Pond
- continuous monitoring of flows passing through the Water Treatment Plant
- annual inspections of the integrity of all water management infrastructure within the mine site area.

Monitoring outside of Mine Site Area

The most significant potential impacts to surface water flows caused by the proposed infrastructure site are changes to flows in the Pollanroe Burn and the Unnamed Watercourse to the west, as outlined in the Surface Water Impact Assessment (ES, 2017; Appendix C4).

Potential changes to flows result from:

1. diversion of part of the Unnamed Watercourse catchment to the Pollanroe Burn, and
2. the management of surface water within the mine site area, with mine contact water retained on site before being treated and discharged through an outfall to the Pollanroe Burn.

Flow monitoring locations comprise:

- Outfall from the proposed infrastructure site to the Pollanroe Burn. This will comprise a new monitoring station (“FLoutfall”).
- Flow monitoring on the Pollanroe Burn downstream of the outfall using the baseline flow monitoring station FL13.
- Flow monitoring on the Unnamed Watercourse near its mouth. This will be a new monitoring station (FL14) that will be installed prior to the beginning of construction activities. This is subject to access being granted to establish a flow monitoring station at this location. If access is not granted this monitoring location will be removed from the next update of the Plan.

The Surface Water Impact Assessment (ES, 2017; Appendix C4) indicates that there would be negligible changes to flow conditions in the Owenreagh River, but monitoring will be undertaken upstream and downstream of the Pollanroe Burn to continue monitoring of impacts of flows from the latter. The objective of continued monitoring on the Owenreagh River is to continue the verification of the record of baseline monitoring on this watercourse and to provide a flow context for the interpretation of water quality monitoring data. Flow monitoring locations are:

- FL09 – located upstream of the Pollanroe Burn;
- FL07 – located downstream of the Pollanroe Burn and Unnamed Watercourse;
- FL06 – located upstream of confluence of Owenreagh and Owenkillew Rivers.

It is also proposed to continue monitoring at baseline station FL08 on the Owenkillew River downstream of the confluence with the Owenreagh River and at baseline station FL11, to provide a reference flow record in a small catchment not affected by the mine site.

Methods of flow monitoring are expected to be the same as those used in the development of flow records for the baseline monitoring station (refer to Section 1.3). The results will be a continuous flow record that will be reported as hourly and daily flows.

A summary of the sampling locations, sampling frequency and assessment limit at which actions are triggered is provided in Table 4-5. Flow monitoring stations are shown in Figure 4-1.

Surface Water Quality Monitoring

Monitoring within the Proposed Infrastructure Area

The SGEMAP will include weekly sampling of water quality within the East and West Water Management Ponds and the Clean Water Pond.

Water quality monitoring of the East and West Water Management Ponds will allow on-going confirmation of consistency in mine water quality (from underground mine water or from runoff/seepage from mine areas, including DSF), calibration of geochemical and other water quality predictions and will provide information to operators of the WTP as to the quality of inflowing water to the WTP. Water quality monitoring of the Clean Water Pond will inform observed water quality in the Pollanroe Burn downstream of the mine outfall.

Samples will be taken using methods outlined in Section 1.3.

There will be continuous monitoring of water quality in the WTP, which will be undertaken by the operators of the WTP. These monitoring activities are not part of the SGEMAP.

Discharges from the mine site will be managed through a site water discharge licence, which will be regulated by DAERA through a monitoring and reporting program that is separate from the SGEMAP.

Discharge criteria (maximum concentrations) have been proposed within the Environmental Statement (Table 3-9 and 3-10). The final set of criteria will be determined by NIEA before construction activities commence and provided in new or modified discharge consents.

Continuous monitoring within the WTP will include turbidity/TSS and electrical conductivity/TDS. The latter will confirm on-going mass removal of dissolved solids to provide confidence that the RO is fully functioning, and that discharge criteria are achieved. Water will not be able to be discharged from the WTP with any unexpected suspended or dissolved solids concentrations at the outfall and therefore beyond the agreed compliance levels in the discharge consent.

Monitoring outside of Proposed Infrastructure Area

The most significant potential impact to surface water quality during operations will be the discharge of treated water from the proposed infrastructure site. Water will be treated before discharge at an outfall into the Pollanroe Burn. Therefore, the discharges have the potential to impact water quality in the Pollanroe Burn and Owenreagh River downstream of the confluence of the former.

Discharges at the outfall will be managed by a water discharge license that will be regulated by DAERA through a monitoring and reporting program that is separate from the SGEMAP.

As part of the SGEMAP, monthly monitoring of the outfall quality will be undertaken, in addition to the required monitoring/sampling to manage the water discharge licence, with all samples taken during the same monitoring trip in the watercourses downstream of the mine site.

Within the Pollanroe Burn water quality samples will be taken downstream of the outfall at baseline monitoring station SWN05. This station is located sufficiently close to the confluence of the Pollanroe with the Owenreagh River to provide an indication of the concentrations in the Pollanroe Burn before it enters the Owenreagh. By locating the monitoring point at a baseline station, it will be possible to directly compared the pre- and post-development water quality.

Within the Owenreagh River monitoring is proposed upstream and downstream of the Pollanroe Burn to allow an assessment of impacts of water from the Pollanroe Burn to the Owenreagh River. This will also extend the record of baseline monitoring on the Owenreagh River. Monitoring will take place at the following baseline monitoring locations:

- SW10 - located upstream of the site to allow monitoring of any changes in water quality in the upper catchment;
- SW11 - located just upstream of the confluence with the Pollanroe Burn;
- SWN06 - located downstream of the Pollanroe Burn;
- SW09 - located close to the confluence of the Owenkillew and Owenreagh Rivers.

The continuation of monitoring at baseline stations will allow comparison of pre- and post-development water quality. Sites SW11, SWN06 and SW09 are also locations where water quality predictions were made in the Environmental Statement; therefore, sampling at these points will allow comparison of observed post-development concentrations with those predicted in the ES (refer to Table 3-**9** in this report).

Monitoring will also take place on the Unnamed Watercourse (station SWN10)[8] and the Sruhanalticarra Burn (SWN09). Water quality at SWN09 should be unaffected by the project and this will act as a reference site.

Samples will be taken monthly, using methods outlined in Section 1.3.

A summary of the sampling locations, sampling frequency and assessment limit at which actions are triggered is provided in Table 4-5. Figure 4-2 shows water quality sample locations. Parameters for surface water quality analysis are given in Appendix B.

Hydromorphological Monitoring

Discharges from the mine infrastructure area could cause changes to the channel and banks of the Pollanroe Burn and Owenreagh River close to the confluence with the former due to erosion of banks or channels within the watercourses.

Annual hydromorphological surveys will be undertaken of the Pollanroe Burn and Owenreagh River within 250 m downstream of the Pollanroe Burn confluence. Surveys will be undertaken by a geomorphologist and will include a photographic survey of the channel. The first survey will be taken prior to construction activities and will be performed at a similar time every subsequent year until otherwise agreed with regulators.

Surface Water Assessment limits and Actions: Proposed Infrastructure Site, Operational Phase

Surface water assessment limits for the planned monitoring at the proposed infrastructure site during operations are given in Table 4-6.

Where assessment limits are not allocated, monitoring is undertaken for the purpose of collecting baseline data.

Section 3.5 sets out the basis of how assessment limits have been developed for this plan.

[8] NOTE: this is subject to access being granted to establish a flow monitoring station at this location. If access is not granted this monitoring location will be removed from the next update of the Plan.

Table 4-6: Proposed infrastructure area surface water monitoring, with assessment limits – Operational Phase

Baseline Station ID and Location	Purpose	Parameter / measurement frequency	Assessment limit
Surface Water Flow			
FLoutfall - Mine outfall to Pollanroe Burn	Record of flows from the mine outfall, to be combined with water quality analyses to identify loadings from mine to Pollanroe Burn for confirmatory water quality calculations. Confirmation of minimum flow from site to Pollanroe Burn	Water level – logged every 15 minutes. Rating curve developed based on manual flow measurements	Flows less than minimum compensation flow +20% agreed with regulators
FL13: Pollanroe Burn, downstream of outfall	Record of flows downstream of outfall to allow calculation of relative input from mine outfall to the Pollanroe Burn. Allows comparison with estimates of changes in flow in watercourse presented in EIA. Confirmation of minimum flow from site to Pollanroe Burn	As above	Flows less than minimum compensation flow +20% agreed with regulators
FL14 - Unnamed watercourse at its mouth	Record of flow to assess changes to flow in watercourse. Allows comparison with estimates of changes in flow in watercourse presented in EIA.	As above	Statistical difference in number of days per year flows fall below Q95 between observed and theoretical number of days
FL09: Owenreagh River, upstream of Pollanroe Burn	Record of flows in river upstream of mine site to allow calculation of relative input from Pollanroe Burn to support confirmatory water quality calculations	As above	None, data used to support water quality assessments
FL07: Owenreagh River, downstream of Pollanroe Burn and Unnamed Watercourse	Record of flows	As above	None, data used to support water quality assessments
FL06: Owenreagh River, upstream of Owenkillew River		As above	None, data used to support water quality assessments
FL08: Owenkillew River downstream of confluence with Owenreagh River	Main watercourse downstream of site.	As above	None, data used to support water quality assessments
FL11: reference site	Reference site on watercourse unaffected by mining activities	As above	None, data used to provide reference station
Surface Water Quality			
MINE SITE MONITORING: East and West Water Management Ponds (Operational and closure phase only)	Monitoring concentrations in water management ponds to allow comparison with geochemical and water quality predictions	Monthly sample	Increasing trend over two quarters
MINE SITE MONITORING: Clean Water Pond	Monitoring concentrations in Clean Water Pond to allow comparison with receiving water guidelines	Monthly sample	Change in baseline concentrations compared to previous year's baseline data
MINE SITE MONITORING: SWoutfall - Mine outfall to Pollanroe Burn	Monitoring concentrations in outfall to Pollanroe Burn	Monthly sample	Concentrations in excess of 80% of site discharge criteria

Baseline Station ID and Location	Purpose	Parameter / measurement frequency	Assessment limit
SWN05: Pollanroe Burn, downstream of outfall	Monitoring concentrations in Pollanroe Burn to allow comparison with receiving water guidelines and predictions of the impact of mine discharges on water quality in the Pollanroe Burn made during the EIA	Monthly sample	Concentrations in excess of 80% of site discharge criteria
SW10: Owenreagh River upstream of mine site	Record of water quality in river upstream of mine site to (i) allow calculation of relative input from Pollanroe Burn, (ii) to support confirmatory water quality calculations, (iii) identify any increases in background concentrations that are independent of the mine	Monthly samples and continuous turbidity measurement	None, data used to provide reference station
SW11: Owenreagh River upstream of confluence with Pollanroe Burn	As above	Monthly sample	None, data used to provide reference station
SWN06: Owenreagh River downstream of confluence with Pollanroe Burn	Record water quality in the Owenreagh River downstream of the mine to allow (i) comparison with receiving water guideline values, (ii) assess any changes in water quality from baseline, (iii) allow confirmatory water quality calculations that will identify if changes in water quality are consistent with those predicted in EIA	Monthly samples and continuous turbidity measurement	Changes in baseline concentrations greater than predicted in EIA (ES, 2017). for three consecutive occurrences
SW09: Owenkillew River, upstream of confluence with Owenreagh River	As above	Monthly sample	Changes in baseline concentrations greater than predicted in EIA (ES, 2017) for three consecutive occurrences.
SWN10: Unnamed Watercourse	Monitoring concentrations in Unnamed Watercourse to allow comparison with receiving water guidelines and allow assessment of any changes from baseline conditions, focussing on potential impact from peat storage area	Monthly sample	Change in baseline concentrations compared to previous year's baseline data
SWN09: Sruhanalticarra Burn – reference site	Reference site on watercourse unaffected by mining activities	Monthly sample	None, data used to provide reference station
Hydromorphology			
Pollanroe Burn downstream of outfall	To assess if discharges from the mine site have impacted the channel form or banks of the Pollanroe Burn.	Annual survey	Significant changes in channel form or banks that can be attributed to mine outfall

Assessment limit Actions

SWOP1: Low flows in Pollanroe Burn:

The assessment limit for surface water flow in the Pollanroe Burn will be the maintenance of the compensation flow in the channel downstream of proposed infrastructure site facility. During operations water will be released from the Clean Water Pond or Water Treatment Plant to maintain a compensation flow.

1. Assess the number of days per year flows fall below the Q95 to identify if there is a statistical difference between the observed and theoretical number of days (i.e. in a particularly dry year there will be more days below the Q95 than in an average year);
2. Review of actual discharge consent flow rates at FLoutfall to confirm against compliance level obligations. Include in annual reporting.
3. Mitigation actions will include; adjustment of low flow compensation pumps, review of water storage within on-site water management ponds and Clean Water Pond during summer months to maintain the rate of treatment and discharge to the Pollanroe Burn during drier periods.

SWOP2: Concentrations in water management ponds

1. If concentrations in the East and West Water Management Ponds are shown to increase over two quarters this may indicate a change in loadings to the ponds from mine water sourced from the underground workings or from runoff/seepage from the DSF. This will result in the following actions;
2. The increasing trend will be communicated to the Ecological Clerk of Works (or equivalent) who will inform and discuss with the operators of the WTP;
3. Review of geochemical and water quality modelling within the mine site area to assess the source of the increase;
4. Confirmation with WTP operators that increase in concentrations will not impact the standard operational performance of the WTP and the ability of the mine to meet the water discharge criteria.
5. Review if concentrations remain within range considered within the EIA

SWOP3: Water quality in Pollanroe Burn:

If any exceedance of assessment limits occurs within Pollanroe Burn (80% discharge compliance levels) actions will include:

1. Investigate possible source of exceedance on site and cross reference to corresponding discharge assessment limit records;
2. Review against baseline concentrations and those predicted in the EIA and including if background concentrations in the Pollanroe (from parts of the catchment not impacted by the mine) have exceeded these discharge criteria.
3. Identification of source of exceedance and removal of source if applicable;

4. Assessment of potential source of increased loading and if considered likely to be associated with the mine site review of mitigation measures (including WTP) to ensure functioning as required and determine if additional measures could beneficially be incorporated

SWOP4: Downstream water quality in the Owenreagh River:

If the predicted changes to baseline concentrations is greater than predicted in the Environmental Statement (over one quarter of sampling i.e. 3 rounds) in the Owenreagh River;

1. Contact mine Ecological Clerk of Works (or equivalent) to communicate parameter of concern
2. Cross reference to discharge consent compliance criteria
3. Review data from other sites to assess if this is trend visible at other stations or is attributable to non-mine related sources (e.g., from increased concentrations upstream)
4. Assess potential source of increased loading and, if considered likely to be associated with the mine site, review mitigation measures (including WTP) to ensure functioning as required and determine if additional measures required.

SWOP5: Evidence of morphological change in the Pollanroe Burn:

If there is evidence of morphological change in the Pollanroe Burn following the annual survey, there will be a review of options to regulate release flow rates from the outfall

SWOP6: Any change in baseline concentrations larger than predicted during annual review process (applies to Clean Water Pond and site SWN10):

At the end of each year the monitoring data will be reviewed and reported. Temporal trends in the data will be reviewed and any change in baseline concentrations larger than predicted as part of the EIA process will be flagged and an Action Plan initiated that will include:

1. Assessment of potential sources. This will include a review of mine related on non-mine related sources, including a review of all on-site water quality monitoring data (i.e. water quality within the water management ponds, treatment plant effluent data, groundwater monitoring data).
2. Increased sampling frequency at key sites, e.g. period of weekly sampling the assess if changes or trends are real or a feature of sample numbers.
3. Identification of mitigation options.

4.5.3 Underground Mine

Surface Water Flow Monitoring

On-going flow monitoring is proposed on watercourses neighbouring the mine and also at reference sites. Flow monitoring will take place at the following baseline stations:

- FL01 - on the Curraghinalt Burn,
- FL03 - on the Owenkillew River, located upstream of the Curraghinalt Burn (a new monitoring station)

- FL05 - on Owenkillew River downstream of the Curraghinalt Burn and Attagh Burn
- New station on Attagh Burn, to be installed in 2019 (FL16, named to be consistent with new water quality monitoring station SW16)
- FL04 - on the Glenark River (reference monitoring location).

If the water treatment plant at the existing infrastructure site is operational, flow records will continue to be taken automatically. The results will provide a continuous flow record that can be reported as hourly and daily flows.

A summary of the sampling locations, sampling frequency and assessment limit at which actions are triggered is provided in Table 4-7.

Surface Water Quality Monitoring

The most significant potential project influences to surface water quality during operations are:

1. from the discharge of treated water from the existing infrastructure site, or
2. changes to baseflows to the streams as a result of lowering of local groundwater table due to mine dewatering.

Changes have the potential to impact the Curraghinalt Burn, Attagh Burn or Owenkillew River. During operations the drawdown of groundwater within the underground mine will prevent the discharge of mine water to the natural groundwater (See Section 5.3.3). In addition, during the operational phase lowering in the groundwater table will decrease or stop existing discharges from the mine adit to the Curraghinalt Burn. Therefore, there is expected to be no impact due to underground mining activities on surface water quality during the operational period. Surface water quality monitoring will nonetheless be continued.

Within the Curraghinalt Burn water quality samples will be taken at baseline monitoring stations SW02 and SW04. By locating the monitoring point at a baseline station, post-development water quality can be compared to baseline conditions.

On the Owenkillew River, monitoring is proposed upstream and downstream of the Curraghinalt Burn and further downstream towards the confluence with the Owenreagh River. This will extend the record of baseline monitoring on the Owenkillew River. Monitoring will take place at the following baseline monitoring locations:

- SW07 - located upstream of the Curraghinalt Burn to allow monitoring of any changes in water quality in the upper catchment
- SW05 - located just upstream of the confluence with Curraghinalt Burn
- SW06 - located downstream of the Curraghinalt Burn
- SW08 - located close to the confluence of the Owenkillew and Owenreagh Rivers

Monitoring will also take place on the Attagh Burn (new monitoring station, FL16, to be installed in 2019) and the Coneyglen Burn (SW22). Water quality at SW22 will be unaffected by the project and this will act as a reference site.

Samples will be taken with reference to protocols in Section 1.3.

A summary of the sampling locations, sampling frequency and assessment limit at which actions are triggered is provided in Table 5-6.

Surface Water Assessment limits and Actions: Underground Mine Site, Operational Phase

Surface water assessment limits for the planned monitoring at the underground mine site during operations are given in Table 4-7.

Where assessment limits are not allocated, monitoring is undertaken for the purpose of collecting baseline data.

Section 3.5 sets out the basis of how assessment limits have been developed for this plan.

Table 4-7: Underground mine related surface water monitoring, with assessment limits (note: table continues onto next page)

Baseline Station Location	Purpose	Parameter / *measurement frequency*	Assessment limit
Surface Water Flow			
FL01: Curraghinalt Burn	Record of flows from the Curraghinalt Burn	Water level – logged every 15 minutes. Rating curve developed based on manual flow measurements	Observed difference in low flows (Q95) significantly larger than predicted in EIA (ES, 2017)
FL03: Owenkillew River, upstream of Curraghinalt Burn	Record of flows in river upstream of mine site to allow calculation of relative input from Curraghinalt Burn to support confirmatory water quality calculations	Water level – logged every 15 minutes. Rating curve developed based on manual flow measurements	Observed difference in low flows (Q95) significantly larger than predicted in EIA (ES, 2017)
FL05: Owenkillew River, downstream of Curraghinalt and Attagh Burns	Record of flow to assess changes to flow in watercourse. Allows comparison with estimates of changes in flow in watercourse presented in EIA (ES, 2017).	Water level – logged every 15 minutes.	Observed difference in low flows (Q95) significantly larger than predicted in EIA (ES, 2017)
FL16 - Attagh Burn	Record of flow to assess changes to flow in watercourse. Allows comparison with estimates of changes in flow in watercourse presented in EIA (ES, 2017).	Rating curve developed based on manual flow measurements	Observed difference in low flows (Q95) significantly larger than predicted in EIA (ES, 2017)
FL04: reference site	Reference site on watercourse unaffected by mining activities	Water level – logged every 15 minutes. Rating curve developed based on manual flow measurements	None, data used to provide reference station
Surface Water Quality			
SW02 and SW04: Curraghinalt Burn	Monitoring concentrations in Curraghinalt Burn to allow comparison with baseline, receiving water guidelines and predictions of the impact of mine discharges on water quality in the Curraghinalt Burn made during the EIA (ES, 2017)	Monthly sample	Concentrations in excess of 80% of site discharge criteria

Baseline Station Location	Purpose	Parameter / *measurement frequency*	Assessment limit
SW05: Owenkillew River upstream of Curraghinalt Burn	Record of water quality in river upstream of mine site to (i) allow calculation of relative input from Curraghinalt Burn, (ii) to support confirmatory water quality calculations, (iii) identify any increases in background concentrations that are independent of the mine	Monthly samples and continuous turbidity measurement	None, data used to provide reference station
SW06: Owenkillew River downstream of confluence with Curraghinalt Burn	Record water quality in the Owenkillew River downstream of the mine to allow (i) comparison with receiving water guideline values, (ii) assess any changes in water quality from baseline, (iii) allow confirmatory water quality calculations that will identify if changes in water quality are consistent with those predicted in EIA (ES, 2017)	Monthly samples and continuous turbidity measurement	Changes in baseline concentrations greater than predicted in EIA (ES, 2017).
SW08: Owenkillew River, upstream of confluence with Owenreagh River	As above/	Monthly sample	None, data used to provide reference station
SW16 - Attagh Burn	Monitoring concentrations in Attagh Burn to allow comparison with guidelines and standards and allow assessment of any changes from baseline conditions, focussing on potential impact from peat storage area	Monthly sample	Change in baseline concentrations compared to previous year's baseline data
SW22 — Reference site	Reference site on watercourse unaffected by mining activities	Monthly sample	None, data used to provide reference station

Assessment Actions

SWOM1: Flow in the Curraghinalt Burn:

Any changes to flows in the Curraghinalt Burn and downstream due to the mine are predicted to impact baseflow conditions. If there is an identified decrease in the Q95 flow in the channel compared to the calculated Q95 from the baseline report (ES, 2017; Appendix C3) the following actions will be initiated:

1. Assess the number of days per year flows fall below the Q95 to identify if there is a statistical difference between the observed and theoretical number of days (i.e. in a particularly dry year there will be more days below the Q95 than in an average year)
2. Review of groundwater levels and groundwater modelling to refine the predicted changes in baseflows made during the EIA (ES, 2017).
3. Assess impact of any change in baseflow on channel hydraulics (wetted perimeter, water depth etc).
4. Discuss with mine engineers about grouting underground and details of any encountered inflows.

5. If no improvement to flow in the burn, treat sufficient mine water and discharge under consent to augment surface flows.

SWOM2: Downstream water quality

1. If the predicted changes to baseline concentrations is greater than predicted in the Environmental Statement (over one quarter of sampling i.e. 3 rounds) in the Owenkillew River;
2. Contact mine site environmental officer to communicate parameter of concern
3. Cross reference to discharge consent compliance criteria
4. Review data from other sites to assess if this is trend visible at other stations or is attributable to non-mine related sources (e.g., from increased concentrations upstream) help with actions
5. Assess potential source of increased loading and, if considered likely to be associated with the mine site, review mitigation measures (including WTP) to ensure functioning as required and determine if additional measures required.

SWOM3: Any change in baseline concentrations larger than predicted during annual review process:

At the end of each year the monitoring data will be reviewed and reported. Temporal trends in the data will be reviewed and any change in baseline concentrations larger than predicted in the EIA will be flagged and an Action Plan initiated that will include:

1. Assessment of potential sources. This will include a review of mine related on non-mine related sources, including a review of all on-site water quality monitoring data (i.e. water quality within the water management ponds, treatment plant effluent data, groundwater monitoring data).
2. Increased sampling frequency at key sites, e.g. period of weekly sampling the assess if changes or trends are real or a feature of sample numbers
3. Identification of mitigation options

Hydromorphological Monitoring

No hydromorphological monitoring is proposed in relation to the underground mine works. The impacts of the mine on flows are too small to produce changes in channel form.

4.6 General approach to surface water monitoring at closure

It is anticipated that monitoring at all locations identified for the operations period will continue into the closure period, until such time that agreement can be made with regulators that ongoing monitoring is no longer required.

Additional monitoring locations are anticipated at the outlets of areas where passive treatment is proposed as well as monitoring within these treatment areas. The monitoring requirements will be formalised as the closure plan is developed through the life of the mine. Passive treatment is proposed at the downstream end of the proposed infrastructure area (if required), associated with the east and west water management ponds.

The approach to monitoring and the assessment limits will continue to evolve through the annual review process with recommendations for variations in assessment limits and locations reflecting the change in SPR linkages that will come with closure, for example, reduction in surface discharge rates. Compliance levels will be maintained throughout the mine lifecycle unless otherwise varied through the application.

5 GROUNDWATER MONITORING PLAN

5.1 Baseline Groundwater Monitoring Plan

5.1.1 Introduction

The existing baseline groundwater level and quality monitoring plan is detailed in the hydrogeology baseline report (SRK, 2020b; Annex A).

A summary of the baseline monitoring locations is presented in Table 5-1. This table includes where water level measurements and water quality samples are taken together with current minimum frequencies of measurement and periods of data collection for each location.

Monitoring for the project to date can be separated into three phases of monitoring:

1. Historic monitoring of the adit extension area (GW01 to GW10);
2. Baseline monitoring for the whole project;
3. Application period monitoring for the whole project (period of continued baseline monitoring until determination).

Groundwater monitoring locations GW01 to GW10 were installed as part of the assessment for the existing infrastructure site in the north of the Crocknamoghil hill, comprising an adit extension, waste rock store and ancillary facilities.

The remaining 47 monitoring locations have been installed throughout the baseline data collection period, comprising wells GW15 to GW59 and fully grouted-in vibrating wire piezometers (VWPs) VWP01 to VWP03.

A further two monitoring wells have been installed in 2018 in the application period, since the compilation of the original baseline study (see SRK, 2020b; Annex B). These are wells GW61 and GW62. These are deep monitoring wells constructed in boreholes drilled to around 700m below ground level (full mine depth) and used to gain additional water level, water quality and hydraulic property data at depth.

During the application period a number of groundwater monitoring wells were reported by DGL as having been vandalised. Monitoring wells listed as vandalised at the time of reporting are GW21, GW35, GW36, GW41, GW42, GW49, GW50 and GW53. Where these monitoring wells are specified in this plan for future monitoring, it is proposed that either the existing monitoring will be salvaged, or a replacement well drilled nearby.

5.1.2 Groundwater level monitoring

The groundwater level monitoring network for the project extends across the proposed mine area, the proposed infrastructure site and more widely across Crocknamoghil, Mullydoo Hills and Crockanboy Hills. This monitoring targets different geological units and, within the bedrock, at various weathered intervals as well as at different depths through the fresh bedrock in the depth interval where mining is envisaged. This has included the installation of vibrating wire piezometers in the deep bedrock for the collection of water level data in the mine site area.

Locations used for groundwater level monitoring during the baseline and application period are shown in Figure 5-1 and Figure 5-2.

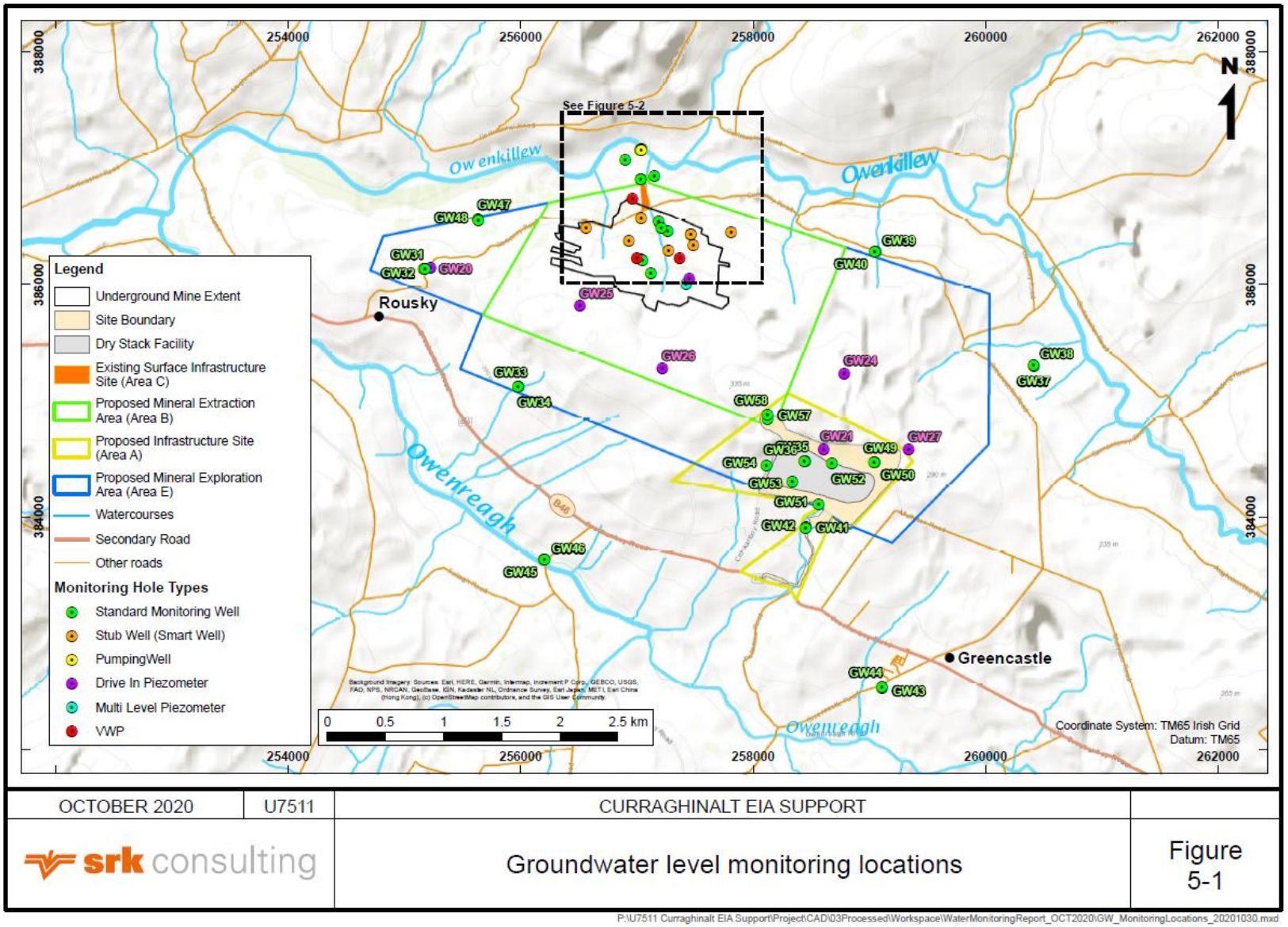

Figure 5-1: Groundwater level monitoring locations; whole project

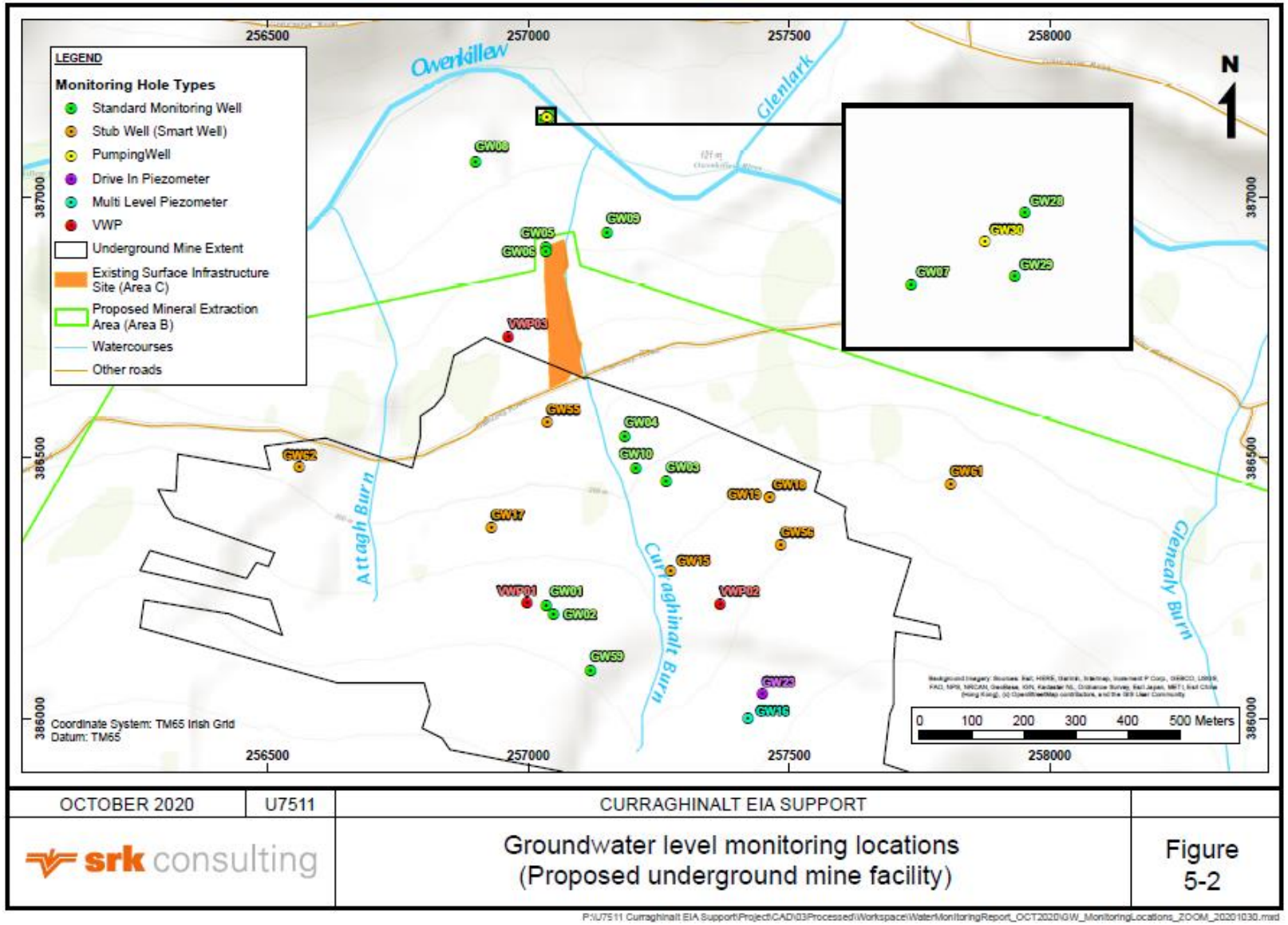

Figure 5-2: Groundwater level monitoring locations; existing exploration tunnel area

5.1.3 Groundwater Water Quality Monitoring

The locations used for monitoring of water quality for the baseline and during the application period are indicated in Table 5-1.

Locations used for groundwater quality monitoring during the baseline and application period are shown in Table 5-1 and Figure 5-4.

5.1.4 Baseline Groundwater Monitoring Frequency

The monitoring frequency during the baseline period was monthly (minimum) for groundwater levels and quarterly for groundwater quality sampling. Higher frequency water level monitoring occurs at locations where there are automated water level loggers and at VWPs where the sensors are connected to logging units.

5.1.5 Baseline Groundwater Quality Parameters

Water quality samples are measured in the field for parameters including pH, electrical conductivity, dissolved oxygen, redox potential and temperature and in a certified independent laboratory for a baseline suite of water quality parameters detailed in Appendix B.

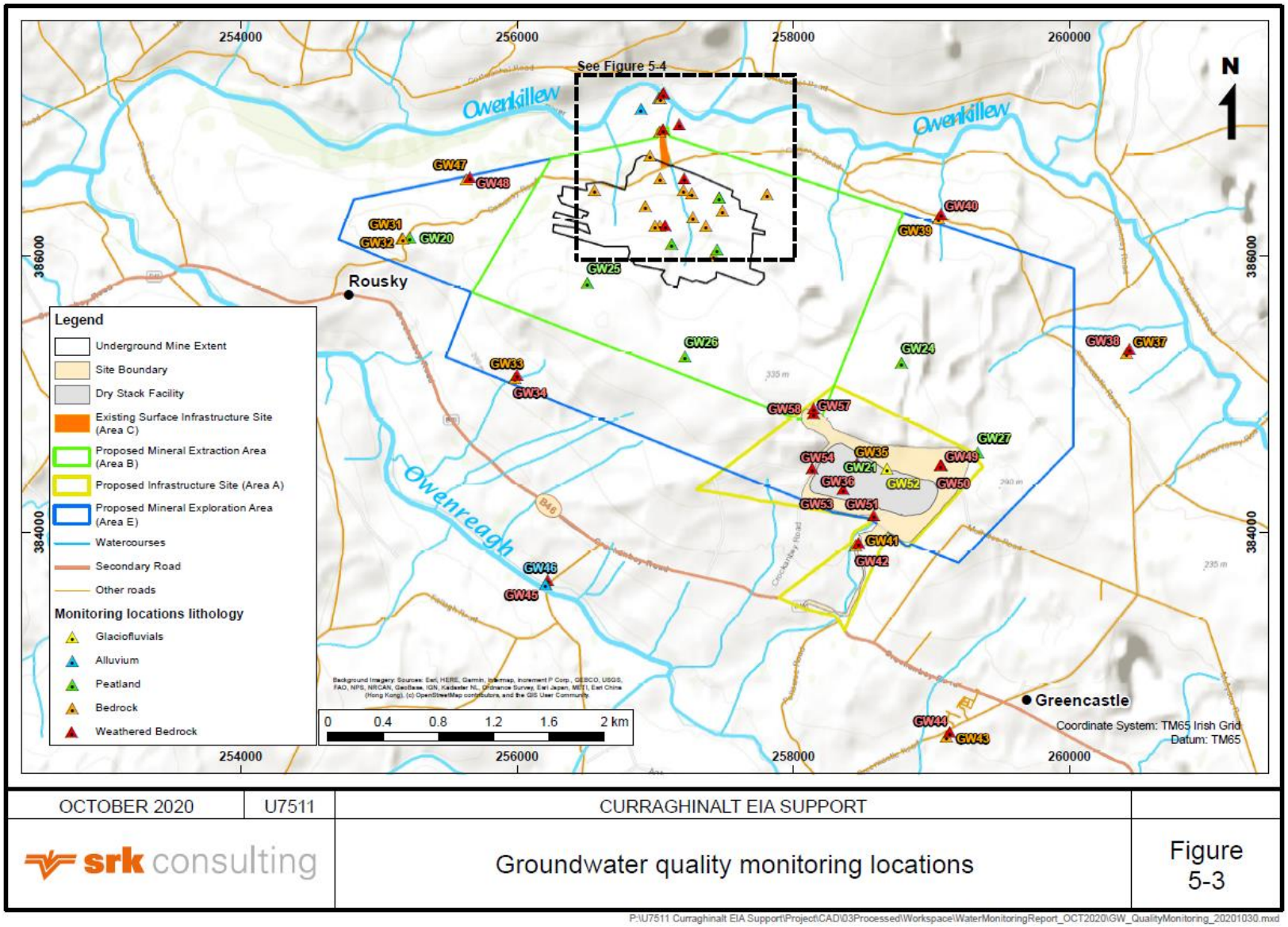

Figure 5-3: Groundwater quality monitoring locations

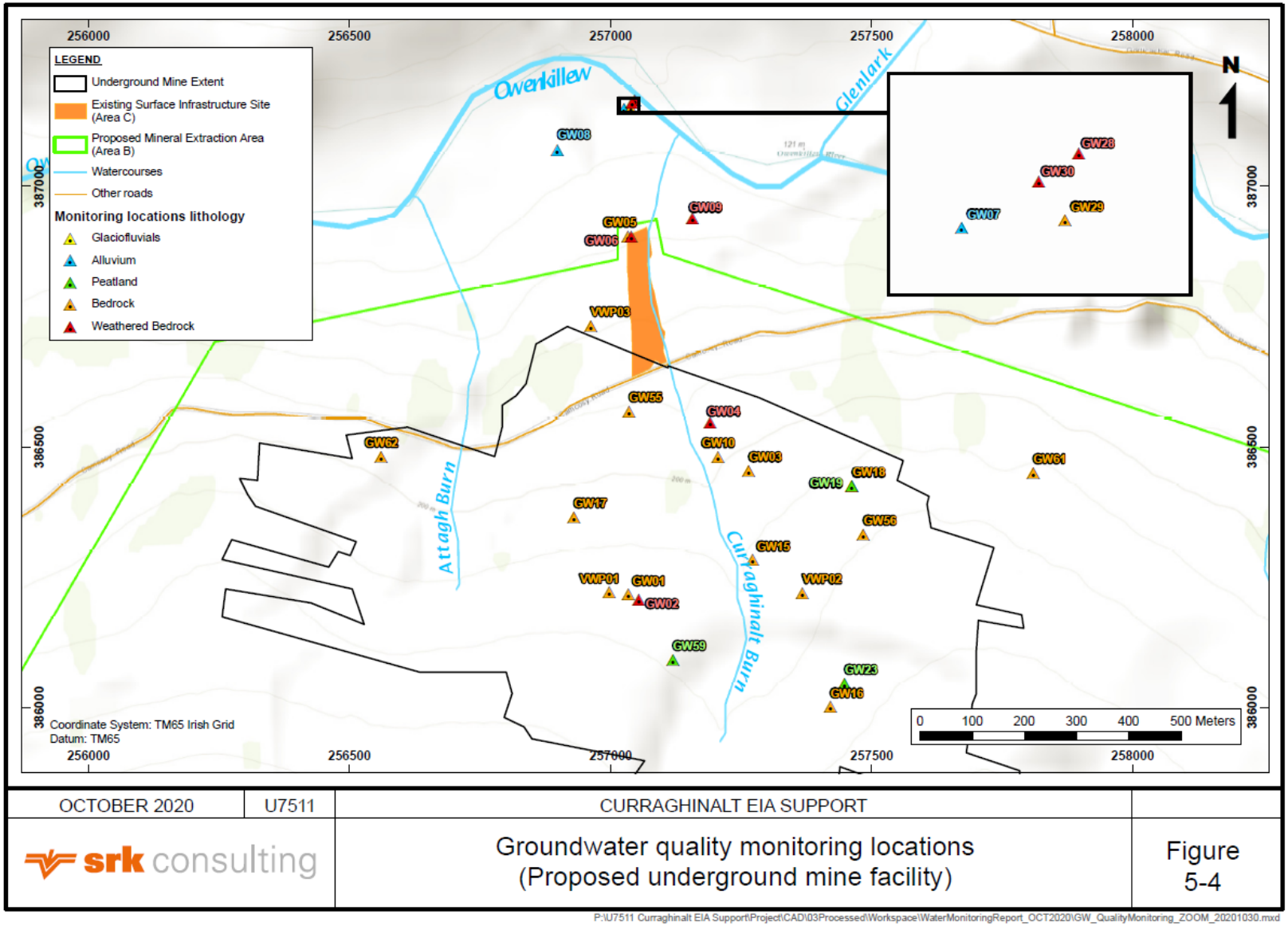

Figure 5-4: Groundwater quality monitoring locations: existing exploration tunnel area

Table 5-1: Groundwater monitoring locations for the baseline and application period

Well ID	Lithology/Target	Water level Monitoring Equipment	Minimum Water Level Monitoring Frequency	Start of Water Level Monitoring (and end if applicable)	Water Quality Monitoring Frequency during original baseline period	Water Quality Monitoring Frequency During Application Period*
GW01	Bedrock	Orpheus Mini Logger	Hourly	29/09/2012	Quarterly	Quarterly
		Electronic Dip Meter	Monthly	10/09/2012		
GW02	Weathered Bedrock	Electronic Dip Meter	Monthly	10/09/2012	Quarterly	Quarterly
GW03	Bedrock	Electronic Dip Meter	Monthly	10/09/2012	Quarterly	Quarterly
GW04	Weathered Bedrock	Orpheus Mini Logger	Hourly	26/09/2012	Quarterly	Quarterly
		Electronic Dip Meter	Monthly	10/09/2012		
GW05	Bedrock	Orpheus Mini Logger	Hourly	16/10/2012	Quarterly	Quarterly
		Electronic Dip Meter	Monthly	29/11/2012		
GW06	Weathered Bedrock	Electronic Dip Meter	Monthly	29/11/2012	Quarterly	Quarterly
GW07	Superficial (Alluvium)	Orpheus Mini Logger	Hourly	26/09/2012	Quarterly	Quarterly
		Electronic Dip Meter	Monthly	10/09/2012		
GW08	Superficial (Alluvium)	Electronic Dip Meter	Monthly	10/09/2012	Quarterly	Quarterly
GW09	Weathered Bedrock	Electronic Dip Meter	Monthly	29/11/2012	Quarterly	Quarterly
GW10	Bedrock	Electronic Dip Meter	Monthly	10/09/2012		Quarterly
GW15	Bedrock	Solinst Logger	Hourly	09/07/2015		
GW16	Bedrock	Electronic Dip Meter	Monthly	06/11/2015		
GW17	Bedrock	Electronic Dip Meter	Monthly	06/11/2015		
GW19	Bedrock	Solinst Logger	Hourly	13/02/2016		
GW20(R)	Peat	Solinst Logger	15-minutes	30/09/2015 (28/04/2017)		
GW21	Peat	Solinst Logger	15-minutes	01/10/2015		
GW22	Peat	Solinst Logger	15-minutes	01/10/2015		
GW23(V)	Peat	Solinst Logger	Hourly	10/12/2015	Quarterly	
GW24	Peat	Solinst Logger	Hourly	10/12/2015	Quarterly	
GW25	Peat	Solinst Logger	Hourly	10/12/2015	Quarterly	
GW26	Peat	Solinst Logger	Hourly	10/12/2015	Quarterly	
GW27(R)	Peat	Solinst Logger	Hourly	10/12/2015 (24/07/2018)	Quarterly	
GW28	Weathered Bedrock	Solinst Logger	Hourly	13/02/2016		
		Electronic Dip Meter	Monthly	19/02/2016		
GW29	Bedrock	Solinst Logger	Hourly	13/02/2016		
		Electronic Dip Meter	Monthly	19/02/2016		
GW30	Weathered Bedrock	Solinst Logger	Hourly	13/02/2016 (17/05/2016)		
		Electronic Dip Meter	Monthly	19/02/2016		
GW31	Bedrock	Electronic Dip Meter	Monthly	17/02/2016	Quarterly	
GW32	Bedrock	Electronic Dip Meter	Monthly	17/02/2016	Quarterly	Quarterly
GW33	Bedrock	Electronic Dip Meter	Monthly	17/02/2016	Quarterly	
GW34	Weathered Bedrock	Electronic Dip Meter	Monthly	17/02/2016	Quarterly	
GW35(V)	Bedrock	Electronic Dip Meter	Monthly	19/02/2016 (Jan 2020)	Quarterly	Quarterly [n]
GW36(V)	Weathered Bedrock	Electronic Dip Meter	Monthly	19/02/2016 (Jan 2020)	Quarterly	Quarterly [n]
GW37	Bedrock	Solinst Logger	Hourly	13/02/2016	Quarterly	
		Manual Dip Measurement	Variable*			
GW38	Weathered Bedrock	Solinst Logger	Hourly	13/02/2016	Quarterly	
		Manual Dip Measurement	On logger download			
GW39	Bedrock	Solinst Logger	Hourly	13/02/2016	Quarterly	Quarterly
		Manual Dip Measurement	On logger download			
GW40	Weathered Bedrock	Electronic Dip Meter	Monthly	19/02/2016	Quarterly	Quarterly
GW41(V)	Bedrock	Solinst Logger	Hourly	13/02/2016 (Jan 2020)	Quarterly	
		Manual Dip Measurement	On logger download			
GW42(V)	Weathered Bedrock	Solinst Logger	Hourly	13/02/2016 (Jan 2020)	Quarterly	Quarterly [n]
		Manual Dip Measurement	On logger download			
GW43	Bedrock	Electronic Dip Meter	Monthly	17/02/2016		
GW44	Weathered Bedrock	Electronic Dip Meter	Monthly	17/02/2016		
GW45	Weathered Bedrock	Solinst Logger	Hourly	13/02/2016	Quarterly	Quarterly
		Manual Dip Measurement	On logger download			
GW46	Superficial (Alluvium)	Solinst Logger	Hourly	13/02/2016	Quarterly	Quarterly
		Manual Dip Measurement	On logger download			
GW47	Bedrock	Solinst Logger	Hourly	13/02/2016		
		Manual Dip Measurement	On logger download			
GW48	Weathered Bedrock	Solinst Logger	Hourly	13/02/2016		
		Manual Dip Measurement	On logger download			
GW49(V)	Weathered Bedrock	Electronic Dip Meter	Monthly	17/02/2016 (Jan 2020)	Quarterly	Quarterly [n]
GW50(V)	Weathered Bedrock	Electronic Dip Meter	Monthly	17/02/2016 (Jan 2020)		
GW51	Weathered Bedrock	Electronic Dip Meter	Monthly	17/02/2016		Quarterly
GW52	Superficial (Glacial outwash)	Electronic Dip Meter	Monthly	17/02/2016	Quarterly	Quarterly
GW53(V)	Weathered Bedrock	Electronic Dip Meter	Monthly	17/02/2016 (Dec 2020)		Quarterly [n]
GW54	Weathered Bedrock	Electronic Dip Meter	Monthly	17/02/2016		
GW55	Bedrock	Electronic Dip Meter	Monthly	27/04/2016		
GW56	Bedrock	Electronic Dip Meter	Monthly	28/06/2016		
GW57	Weathered Bedrock	Electronic Dip Meter	Monthly	29/04/2016		
GW58	Weathered Bedrock	Electronic Dip Meter	Monthly	29/04/2016		
GW59	Peat	Solinst Logger	Hourly	22/04/2016		
		Manual Dip Measurement	On logger download			
GW61	Bedrock	Not Yet Monitored**				To be quarterly
GW62	Bedrock	Not Yet Monitored**				To be quarterly
VWP01	Bedrock	Vibrating Wire Piezometer	Hourly	26/06/2015		
VWP02	Bedrock	Vibrating Wire Piezometer	Hourly	06/07/2015		
VWP03	Bedrock	Vibrating Wire Piezometer	Hourly	05/01/2016		

Table Notes:
(R) indicates removed. Peat wells GW20 and GW 27 have been removed. (V) indicates vandalised. Monitoring wells GW21, GW35, GW36, GW41, GW42, GW49, GW50 and GW53 have been reported by DGL as vandalised.
Quarterly [n]: currently not sampled

* Water quality monitoring frequency at wells located in the proposed infrastructure area reduced/suspended due to site safety concerns. Loggers installed in some wells (not indicated)

** At the time of reporting wells GW60 and GW61 are being cleaned to remove the effects of grout in the sample section of the wells

5.2 Construction Phase Monitoring Plan

The construction phase monitoring plan is separated into a monitoring plan for the proposed infrastructure site and a monitoring plan for the underground mine. Separate plans are required because of the contrasting scale of operation and processes/activities being performed.

The monitoring requirements for water related to changes in the construction programme will be continuously reviewed as part of the implementation of the CEMP.

5.2.1 Proposed Infrastructure Site

For the construction phase, confirmatory monitoring for the potential for impacts from dewatering from the mine decline portal and the excavation of the clean water pond will take place. This monitoring, combined with habitats monitoring in the area, will be used to confirm that no localised impact to adjacent peatlands is occurring.

Monitoring wells with the provisional IDs of GW63 and GW64 (see Figure 5-5) are sited for this purpose and should be installed at the start of the construction phase. Depending on materials encountered, these new multilevel well locations will monitor 3 horizons: the peat (P), the upper section of the superficial sediments, if present (U) and the weathered bedrock (L). Peat compaction will also be monitored at these locations via graded survey rods.

New monitoring wells with the provisional IDs GW65 to GW69 are primarily sited for monitoring of facilities during operations. However, these wells should be installed at the start of the construction phase to a) gather baseline data prior to operations and b) monitor groundwater during construction activities.

New monitoring wells for installation are listed in Table 5-2. Planned groundwater monitoring wells for the proposed infrastructure site during construction and operations are shown in Figure 5-5 and detailed in Table 5-3.

Table 5-2: New monitoring wells to be installed at the proposed infrastructure area

New Monitoring Well ID	Installation Type	Installation Phase
GW65 (U+L)	Standpipe Wells	Construction
GW66 (U+L)	Standpipe Wells	Construction
GW64 (P+U+L)	Standpipe Wells	Construction
GW63 (P+U+L)	Standpipe Wells	Construction
GW67 (U+L)	Standpipe Wells	Construction
GW68 (U+L)	Standpipe Wells	Construction
GW69 (U+L)	Standpipe Wells	Construction

U= upper installation (where superficial sediments are present), L= weathered bedrock installation, P = peat installation

Groundwater Assessment limits and Actions: Proposed Infrastructure Site, Construction Phase

Groundwater assessment limits for the planned monitoring at the proposed infrastructure site during construction is given in Table 5-3. Where assessment limits are not allocated, monitoring is undertaken for the purpose of collecting baseline data.

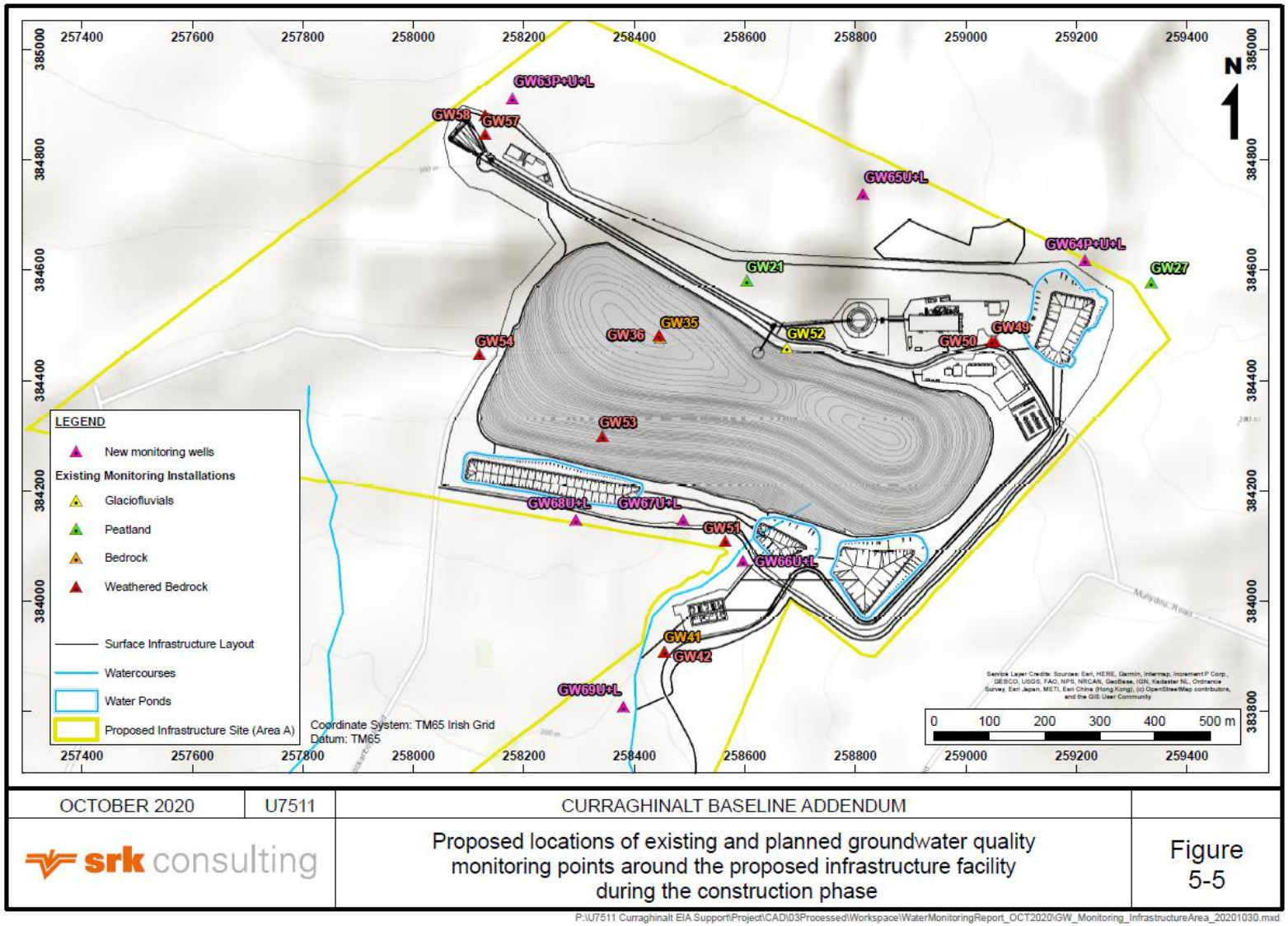

Figure 5-5: Proposed locations of existing and planned groundwater quality monitoring points around the proposed infrastructure facility during the construction phase

Table 5-3: Proposed groundwater monitoring at the infrastructure site during the Construction Phase, with assessment limits

Monitoring Location Group	Purpose	Parameter / *measurement frequency*	Assessment limits
Peat: Water Level and Ground Level			
GW27, GW63P and GW64P	Confirmatory monitoring for potential pressure head reduction from decline portal and pond cutting drainage	Peat water level – *logged hourly / or measured manually monthly*	Declining trend outside P5 water level -20%* for 4 consecutive quarters
Anchored survey rods at GW27, GW63P and GW64P	Measuring the potential for peat compaction (elevation loss) due to local construction works	Ground level – *measured manually monthly*	
Bedrock and superficial: Groundwater Level and Groundwater Quality			
Up-gradient monitoring wells from the DSF and plant area: GW63U+L, GW64U+L, GW65U+L	Tracking of up-gradient (background) concentrations during construction, operations and closure	Water level – M*onthly*	None. Used for reporting of background concentrations during construction phase
		Water quality – *Quarterly*	None. Used for reporting of background concentrations during construction phase
Down-gradient groundwater monitoring wells: GW49, GW50, GW51, GW52, (GW53), (GW35), (GW36), GW54, GW66U+L, GW67U+L, GW68U+L, GW69U+L, GW41, GW42	Compliance point for hazardous substances in operations and closure	Water level – *Monthly*	None. Used for reporting of background concentrations during construction phase
	Confirmatory monitoring for non-hazardous substances in construction, operations and closure	Water quality – *Quarterly*	Increasing trend over groundwater target concentrations (Table 3-15) for 3 consecutive records**

Table Notes:

U= upper monitoring well (where superficial sediments are present), L= weathered bedrock monitoring well, P = peat monitoring well

Existing locations GW35, GW36 and GW53 will provide temporary upgradient monitoring points for earlier phases of DSF construction, prior to development of the west section of the DSF. GW52 may need to be removed for construction works

* P5 (5^{th} percentile) water levels to be determined at each location prior to commencement of construction phase (following removal of spurious data)

** As the DSF and ponds are not operated in this phase, data is collected primarily to increase baseline data extent. However, construction can present other risks such as fuel spills, therefore the same action levels are applied as during operations.

Parameters for groundwater quality analysis are as given in Appendix C

Assessment limit actions

GWCP1: Decline of groundwater levels within the peat:

1. As blanket bog peat is not considered to be groundwater supported, the primary risk to peat is from drainage channels cut into the peat or parts of the development direct abutting the peat. The portal of the decline will be sealed, with the peat adjacent to the portal removed. Bunds will restrict lateral drainage in the peat adjacent to where it is removed. No drains will be cut into the peat as part of the development. With the above measures, measurable dewatering in the peat local to the mine portal and decline is not anticipated. For the clean water pond, as peat is stripped it is not expected the pond underdrainage would have any influence on peat (due to distance from the pond).
2. However, should water levels fall below the assessment limit, data will be compared with trends in rainfall, surrounding groundwater level and recorded inflows, and a visual survey of pond and portal areas will be undertaken. The results would be used to determine if changes in peat water levels are consistent with a drier climate period (in which case no further action is required) or associated with the dewatering for mine infrastructure (in which case the next bullet is actioned). future surveys of modifications to peat drainage channels (unrelated to the project), will also be required.
3. If the reducing trend is determined to be related to activities associated with the mine infrastructure, an options appraisal of additional mitigation or remediation measures will be conducted and agreed with the appropriate authority prior to implementation. Measures would involve one or more of the following:
    - Water level augmentation through additional bunding or improved bunding to increase recharge from precipitation in affected areas.
    - Water level augmentation though a groundwater recharge trench or similar
    - GWCP2: Increasing trend in groundwater quality at the infrastructure site:

As the DSF is not operated in this phase, data is collected primarily to increase baseline data extent. However, construction can present other risks such as fuel spills, therefore the same action levels are applied as during operations.

Assessment actions would depend on the type of parameter exceeding. Hydrocarbon exceedance would lead to identification of the source, affect soil removal and remediation of any affected groundwater, if applicable. Other parameters would follow the method used during operations (Section 5.2.1).

1. Resample the well and adjacent wells at least every 2 weeks for 4 consecutive occasions, with additional QA/QC samples/checks, result and trend verification.
2. Assess significance for groundwater and baseflow to Pollanroe Burn. If significant, mitigation measures such as capture wells can be used, subject to agreement with the appropriate authority prior to implementation.

5.2.2 Proposed Underground Mine

New groundwater monitoring locations designed primarily for the operational phase of the underground mine will be installed early during the construction phase. This is to a) enable collection of baseline data at each point prior to development of the underground mine and b) provide data during relevant underground construction works. Construction works that will lead to dewatering activities in the underground mine are:

- Tunnelling and decline connection activities at the existing Camacosy Road adit entrance
- Completion of the main decline for the underground mine.

Groundwater points for the operational phase of the underground mine to be installed in the construction phase are shown in Figure 5-6 and listed in Table 5-4. The general monitoring plan for the construction phase is given in Table 5-5, together with. The location of groundwater monitoring points for operations is covered in section 5.3.3.

Table 5-4: New monitoring installations for the proposed mining area

New Monitoring Well ID	Installation Type	Installation Phase
GW69 (U+L)	Standpipe Wells	Construction
GW70 (U+L)	Standpipe Wells	Construction
GW71 (U+L)	Standpipe Wells	Construction
GW72 (U+L)	Standpipe Wells	Construction
GW73	Peat Piezometer	Construction
GW74	Peat Piezometer	Construction
GW75	Peat Piezometer	Construction
GW76	Peat Piezometer	Construction
VWP04	VWP	Construction

Groundwater Assessment limits and Actions: Proposed Underground Mine, Construction Phase

Groundwater assessment limits for the planned monitoring at the proposed underground site during construction is given in Table 5-5.

Where assessment limits are not allocated, monitoring is undertaken for the purpose of collecting baseline data.

Section 3.5 sets out the basis of how assessment limits have been developed for this plan.

Table 5-5: Proposed groundwater monitoring at the underground mine during the Construction Phase, with assessment limits

Monitoring Location Group	Purpose	Parameter / *measurement frequency*	Assessment limits
Bedrock and Superficial Group: Water Level and Water Quality			
- Water level and water quality: GW01 to GW10 inclusive, GW26, GW27, GW30, *GW39, GW40, GW47, GW48,* GW55, GW59, GW60, GW61 and new wells GW69 to GW72 inclusive.	Confirmatory monitoring of pressure head reduction for assessment of decline construction dewatering and risk to private groundwater abstractions and local surface watercourses	Water level / piezometric water level – *logged hourly / or measured manually weekly*	Mine Monitoring Wells: A deviation in drawdown trend from that predicted of greater than 20% (for 3 consecutive quarters)
- Water level only: - GW15, GW16, GW17, GW18, GW19, GW,28, GW29, *GW33, GW34, GW37, GW38, GW45, GW46,* GW55, GW56 - VWPs 1 to 4	Water quality collected for baseline data	Water quality – quarterly (except VWP installations)	None: water quality collected for baseline data
- Monitoring at private groundwater supplies**	Water level – *logged hourly / or measured manually monthly*	Water level – *logged hourly / or measured manually monthly*	Private abstractions: a lowering trend of P5 dynamic water or rest water level* by greater than 20% for 3 consecutive monthly measurements (following review of abstraction rate changes)*
	Water quality - *quarterly*	Water quality - *quarterly*	Water quality: as mine monitoring wells (i.e. collection of baseline water quality data)
	Abstraction rate (where a pump is used)	Abstraction rate (where a pump is used)	None for abstraction rate: used to assess water level
Peat /soil zone: Groundwater Level and Ground Level			
- Anchored survey rods: valley peatland areas directly above the mine workings near monitoring well locations GW23, GW59, GW73, GW74, GW75 and GW76.	Measuring the potential for compaction (elevation loss) due to dewatering in the later stages of mining		Declining trend for 4 quarters at annual assessment

Table Notes:

Locations in italics are shown in Figure 5-1

* Reference water levels for private water supplies to be defined at each location based on data for the first year of the construction phase. Reference levels will be defined as P5 (5th percentile) minimum dynamic water levels, or rest level if well not in use for long periods (following removal of spurious data). Assessment limit is P5 minus 20%.

**Monitoring at specified private groundwater supplies will be offered to users. See main text Groundwater - Operations Phase, proposed underground mine, for details

Parameters for groundwater quality analysis are as given in Appendix C

[1] No impact to private groundwater supplies are predicted due to dewatering of the mine during its construction. An assessment limit is given, however, in this phase as it is expected that baseline data for dynamic water levels, quality and abstraction rates will be collected at private water supply sources.

Assessment actions

GWCM1: A lowering of groundwater levels in wells beyond assessment limits for mine area monitoring wells or at specified private abstractions, or the decline of peat water level / peat thickness beyond assessment limits:

1. Conduct a survey of decline tunnels, exploration tunnels and underground borehole seals and stopes for increased inflows and seal fractures/inflow zones as required.

   For the blanket bog peatland, changes in peat water level are more likely to be the result of climate variations and/or modifications to peat drainage channels. Monitoring data will be first be reviewed against climate and drainage variations but alternative causes will also be evaluated.

2. Re-assess groundwater model and risk to receptor.

3. Seal specific underground exploration tunnels to allow rebound and continue to monitor at an increased frequency.

4. If an increased risk to a private abstraction source is identified, implement increased monitoring frequency. Alternative supplies for groundwater abstraction sources will depend on the type of abstraction (i.e. domestic or farming), the volume of water typically used and the frequency of use. Options for alternative supplies include (but are not limited to), drilling of a new well in a different location on the same property, piped water via either a new groundwater or surface water abstraction from further distance outside the property, installation of a holding tank at the property and regular tankering of water to the property

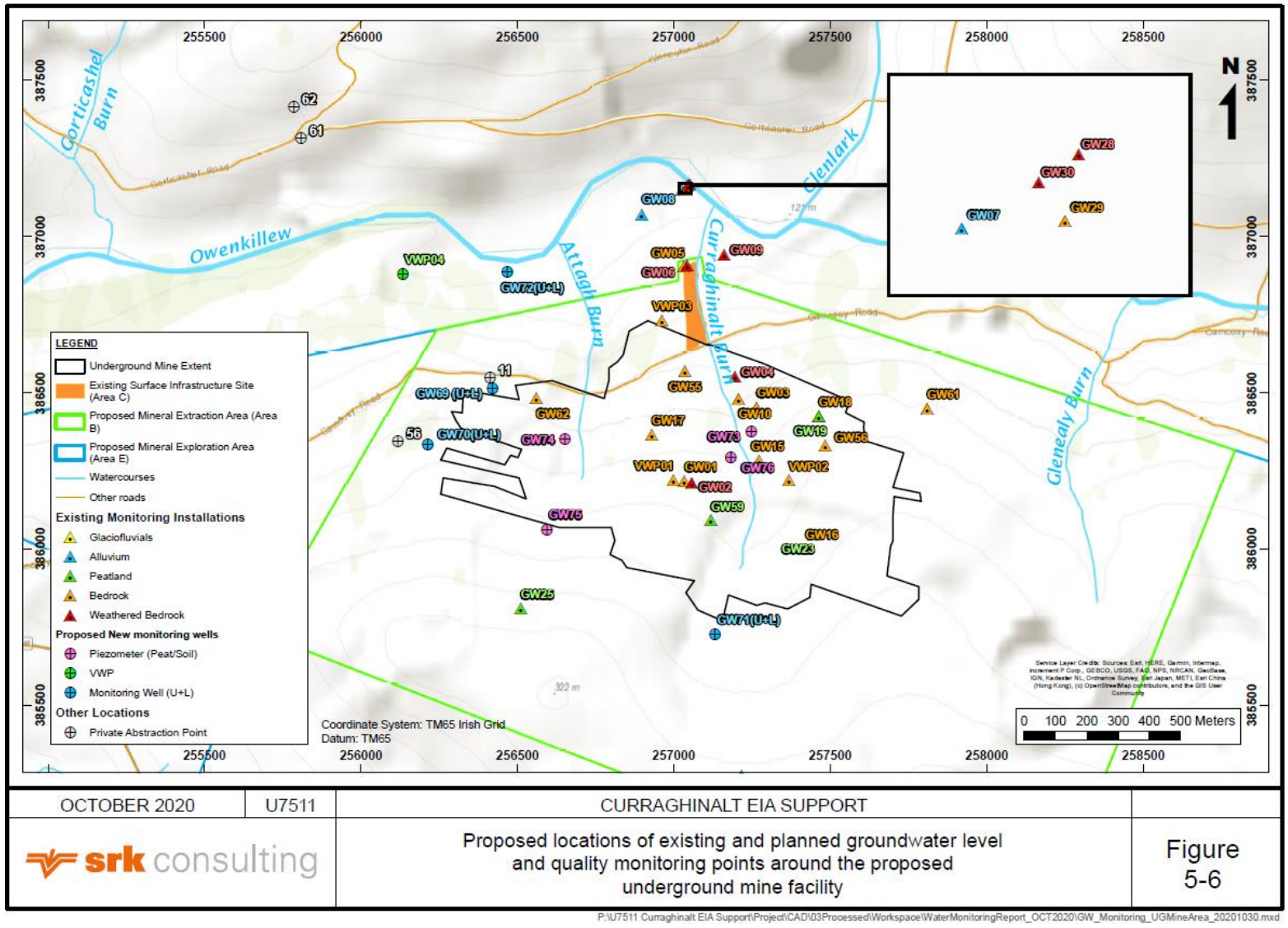

Figure 5-6: Proposed locations of existing and planned groundwater level and quality monitoring points around the proposed underground mine facility

5.3 Operational Phase Monitoring Plan

5.3.1 Introduction

The operational phase monitoring plan is separated into a monitoring plan for the proposed infrastructure site and a monitoring plan for the underground mine. Monitoring locations are as present in Figure 5-5 and Figure 5-6. Table 5-6 and Table 5-8 presents the monitoring locations, measurements and frequency, and the assessment limits for this phase.

5.3.2 Proposed Infrastructure Site

The principal source terms at the proposed infrastructure site where there is a potential groundwater pathway or and/or receptor linkage are; the Dry Stack Facility (DSF), process water ponds and accidental spills as defined in S-P-R numbers 4 and 7 in Table 3-1. On this basis, except for continued confirmatory peat water level monitoring (see construction phase), groundwater monitoring in this area is principally focused on water quality characterisation.

The hydraulic gradient of groundwater downgradient of the process areas, DSF and ponds is towards the Pollanroe Burn. The underdrainage systems for the ponds and DSF outfall directly to the Pollanroe Burn. Therefore, the groundwater and underdrainage systems represent the pathways to the Pollanroe Burn and confirmatory groundwater monitoring is used to provide evidence that no significant seepage is occurring along these pathways.

Upgradient monitoring points will be used to track variations in background groundwater levels and quality up-gradient of the proposed infrastructure site.

Groundwater quality monitoring will be offered at actively used private abstractions situated immediately down hydraulic gradient of the proposed infrastructure site and up-hydraulic gradient of the Owenreagh River.

Groundwater Assessment limits and Actions: Proposed Infrastructure Site, Operational Phase

Groundwater assessment limits for the planned monitoring at the proposed infrastructure site during operations is given in Table 5-6.

Where assessment limits are not allocated, monitoring is undertaken for the purpose of collecting baseline data.

Section 3.5 sets out the basis of how assessment limits have been developed for this plan.

Table 5-6: Proposed groundwater monitoring at the infrastructure site during the Operational Phase, with assessment limits

Monitoring Location Group	Purpose	Parameter / *measurement frequency*	Assessment limits
Peat: Water Level and Ground Level			
GW27, GW63P and GW64P	Confirmatory monitoring for potential pressure head reduction from decline portal and pond cutting drainage.	Peat water level – *logged hourly / or measured manually monthly*	Declining trend outside P5 water level -20%* for 4 consecutive quarters
Anchored survey rods at GW64P and GW70P	Measuring the potential for peat compaction (elevation loss) due to infrastructure development.	Ground level – *measured manually monthly*	
Bedrock and superficial: Groundwater Level and Groundwater Quality			
Up-gradient monitoring wells from the DSF or plant area: GW63U+L, GW64U+L, GW65U+L	Tracking of up-gradient (background) concentrations during operations and closure	Water level – M*onthly* Water quality – *Quarterly*	None; used to provide time varying background concentrations for assessment limits
DSF and pond underdrains (outfall points)	Confirmatory monitoring for underdrains of ponds and DSF	Flow – Automated Water quality – *Monthly*	Increasing water quality trend over groundwater target concentrations (Table 3-15) for 4 consecutive monthly records** No assessment limit for flow
Down-gradient groundwater monitoring wells: GW49, GW50, GW51, GW52, (GW53), (GW35), (GW36), GW54, GW66U+L, GW67U+L, GW68U+L, GW69U+L, GW41, GW42	Compliance point for hazardous substances Confirmatory monitoring for non-hazardous substances	Water level – *Monthly* Water quality – *Quarterly*	None for water level at the proposed infrastructure site Water quality: groundwater target concentrations (Table 3-15) ** for 3 consecutive quarters
Monitoring at private abstractions	Measurement of water quality at receptor	Water level – *logged hourly / or measured manually monthly* Water quality - *quarterly*	A lowering trend of P5 dynamic water or rest level by greater than 20% for 3 consecutive monthly measurements (following review of abstraction rate changes)* Water quality: groundwater target concentrations (Table 3-15)** for 3 consecutive quarters

Table Notes:

U= upper monitoring well (where superficial sediments are present), L= weathered bedrock monitoring well, P = peat monitoring well.

Existing locations GW35, GW36 and GW53 will provide temporary upgradient monitoring points for earlier phases of DSF construction, prior to development of the west section of the DSF. GW52 may need to be removed for construction works

* Baseline reference water levels to be defined at each location prior to commencement of operational phase. Reference levels will be defined as minimum water levels (following removal of spurious data). Assessment limit is P5 minus 20%.

** Groundwater quality assessment limits are based on design target limits given Table 3-15. Assessment limits will be reviewed throughout the project based on monitored levels and any assessment updates)

Parameters for groundwater quality analysis are as given in Appendix B

Assessment limit actions

GWOP1: Declining trend in peat water levels

The assessment actions for peat water levels in the operational phase for the infrastructure area are as the construction phase.

GWOP2: Increasing groundwater quality trend at the proposed infrastructure site:

1. Notify Plant Manager to check infrastructure for leaks or damage and, if found, carry out any immediate repairs. Increase sample frequency for underdrainage systems.
    a) If the trend is determined at a groundwater well: Resample the well and adjacent wells at least every 2 weeks for 4 consecutive occasions, with additional QA/QC samples/checks, result and trend verification. Increase sample frequency for underdrainage systems.
    b) If the trend is determined in an underdrainage system: increase sample frequency for underdrainage systems (increase sample frequency to weekly if a minor increasing trend or daily if a considerable increase in concentrations of multiple parameters is determined). Carry out additional QA/QC samples, check results and trend verification. All samples should be placed on a rapid turnaround analysis. If a considerable increase has been recorded on repeat readings and exceeds drinking water standards, and/or baseline values, whichever is higher: Plant Manager to install pump back system and/or divert to water treatment plant whilst QA/QC verification, significance and cause of trend is determined.
    c) For a private abstraction: if a mine-related trend is determined above the safe drinking water level for hazardous substances or drinking water standard for non-hazardous substances (or baseline values where background exceedances exceedance of the environmental standard occur), an alternative water supply would be offered. Monitoring of other supplies in close proximity (using the groundwater parameter suite in Appendix B) would increase in frequency with supply replacement offered for any affected supplies. An investigation would be instigated to determine the affected area of impaired groundwater quality and mitigation measures (capture wells) would be used to control the extent of the groundwater affected to an area local to the proposed infrastructure site.

5.3.3 Proposed Underground Mine

During the operational phase the primary source of risk for groundwater is dewatering from the underground mine and exploration workings (See Table 3-1). Therefore, confirmatory monitoring of the influence of this depressurization[9] effect in the bedrock on shallower units (i.e. alluvial sediments and shallow weathered bedrock) that supports well supplies, stream baseflow and habitats is needed. Although considered to be entirely rainwater supported, the water levels in the peat will also be monitored to confirm the peat is unaffected by the groundwater dewatering.

[9] Depressurisation relates to the reduction of piezometric groundwater pressure at depth. This can lead to a change in phreatic groundwater level observed at the water table depending on the vertical hydraulic conductivity. This process is further explained in Box 3 of the Groundwater Impact Assessment (2020b)

Figure 5-6 shows the existing and proposed location of groundwater monitoring facilities for the operational period. Additional monitoring facilities are to be installed around and above the proposed mine area for monitoring groundwater during the construction phase.

Groundwater level points for monitoring the effects of dewatering are located between receptors and the mine workings. VWPs are used to inform vertical pressure head gradients during mining. Additional monitoring points may be required as exploration plans develop or as underground mine plans are updated, as outlined in Section 1.2.

Recommended private abstractions for groundwater level monitoring (and water quality) during the operational period of the mine have been determined for the proposed 2019 mine plan (See Table 8.5, SRK 2020b; note: this table is also reproduced at Appendix A to this report).

In the future, private abstractions which are monitored will need to be reviewed based on any changes to the mine plan. In this situation monitoring will be offered to private groundwater abstractors in the area based on the depth of the abstraction and distance from the mine workings. Table 5-7 provides a general guide for wells depths and distances at which the offer of confirmatory monitoring would be triggered. These distances are based on analysis of the predicted piezometric drawdown determined from the 2020 Groundwater Impact Assessment (2020b). Beyond these distances the risk of any impact on water level in abstraction wells due to drawdown from mine dewatering is considered negligible. Future groundwater modelling simulating the mine plan changes may also be conducted, and in this case the monitoring recommendations based on the modelling would supersede private abstractions selected through the method outlined above. Water levels will be monitored with data loggers where possible to minimise disturbance to well owners, or with monthly manual measurements otherwise.

Table 5-7: Well depth and distance from mine workings for inclusion within private abstraction water level monitoring program

Well depth (m)	Distance from Mine or Exploration Workings (m)
0 to 20	800
21 to 50	1,000
51 to 180	1,500
>180	2,500

Whilst during the operational phase a state of hydraulic containment would exist around the underground mine (as it is dewatered), and there is negligible risk of groundwater quality effects due to the mine, confirmatory groundwater quality monitoring will also be offered to those same abstractors, where situated down hydraulic gradient based on natural conditions, to provide reassurance. Monitoring results will be made available to well owners with monitored wells.

Based on the groundwater impact assessment no impact to peatland is predicted. Water in the peatland areas around the Crocknamoghil, Mullydoo and Crockanboy Hills is rainwater-fed and largely disconnected (perched) from groundwater in the underlying weathered bedrock. Confirmatory peatland water level monitoring and peat thickness monitoring will be conducted to verify the peat is not impacted by bedrock dewatering.

Groundwater gradients will be towards the mine during mine operations and therefore the primary mechanism for the testing of quality of contact water in paste-filled stopes will be to sample water within the mine. Mine water quality and drain down from backfilled stope areas will be sampled frequently for the purpose of evaluating water management requirements for the mineral processing circuit. Regular verification samples will be supplied to independent laboratories and this would be used to provide validation of backfill drainage.

Dewatering volumes will be reviewed against those predicted in annual monitoring reviews, taking into account mining and backfill rates, annual updates to the mine plan or underground exploration areas.

Groundwater Assessment limits and Actions: Proposed Underground Mine, Operational Phase

Groundwater assessment limits for the planned monitoring at the proposed underground mine during operations is given in Table 5-8. Where assessment limits are not allocated, monitoring is undertaken for the purpose of collecting baseline data.

Section 3.5 sets out the basis of how assessment limits have been developed for this plan.

Table 5-8: Proposed groundwater monitoring for the underground mine during the Operational Phase, with assessment limits

Monitoring Location Group	Purpose	Parameter / *measurement frequency*	Assessment limits
Bedrock and Superficial Group - Water level and Water Quality			
- Water level and water quality: GW01 to GW10, GW26, GW27, GW30, *GW39, GW40, GW47, GW48,* GW55, GW59, GW60, GW61 and new wells GW69 to GW72 - Water level only: GW15, GW16, GW17, GW18, GW19, GW,28, GW29, *GW33, GW34, GW37, GW38, GW45, GW46,* GW55, GW56 - VWPs 1 to 4	Confirmatory monitoring measuring pressure head reduction for assessment of mine and exploration dewatering and potential risks to private abstractions, surface water baseflow and habitats	Water level / piezometric water level – *logged hourly / or measured manually weekly* Water quality – quarterly (except VWP installations)	Mine Monitoring Wells: A deviation drawdown trend from predicted of greater than 20% (assessed quarterly against predicted ranges) Increasing trend over groundwater target concentrations (Table 3-15)** for 3 consecutive quarters
- Monitoring at private abstractions (as specified in Table 8.5 reproduced at Appendix C)	Measurement of water level at receptor	Water level – *logged hourly / or measured manually monthly* Water quality - *quarterly* Abstraction rate (where a pump is used)	Private abstractions: A lowering trend of P5 dynamic water or rest level by greater than 20% (P5 water level minus 20%) for 3 consecutive monthly measurements (following review of abstraction rate changes)* Increasing trend over groundwater target concentrations (Table 3-15)** for 3 consecutive quarters. None for abstraction rate – used to assess water level
Peat /soil zone - Water Level and Ground Level			
- Anchored survey rods: Valley peatland area directly above the mine workings near monitoring well locations GW23, GW59, GW73, GW74, GW75 and GW76.	Measuring the potential water level decline and for compaction (elevation loss) due to bedrock dewatering in the later stages of mining		Declining trend for 4 quarters at annual assessment.
Mine workings - Mine flow and Water Quality			
Underground mine dewatering outflow (to plant) Underground mine quality	Tracking dewatering volumes are within predicted levels Tracking mine water quality is within predicted levels	Total flow – *daily* Water quality - *quarterly*	±25% average from predicted over annual basis. Repeat exceedance of groundwater screening level within 4 quarters of results (groundwater screening levels for inside the mine are given in the Groundwater Impact Assessment, Section 7.4 and Table 7.9)

Table Notes:

Locations in italics are shown in Figure 5-2. Parameters for groundwater quality analysis are as given in Appendix B.

Monitoring at relevant private abstractions will be offered. Locations are based on the impact assessment review for the 2019 mine plan and will be adjusted if the mine plan is altered. See main text in section for details.

* Reference water levels for private water supplies to be defined at each location based on data for the first year of the construction phase. Reference levels will be defined as minimum dynamic water levels, or rest level if well not in use for long periods (following removal of spurious data).

** Groundwater quality assessment limits are based on design target limits given in Table 3-15. Assessment limits will be reviewed throughout the project based on monitored levels and any assessment updates).

Assessment actions

GWOM1: Lowering groundwater levels in mine monitoring wells over 20% of predicted levels in the assessment:

Groundwater levels in bedrock monitoring boreholes are predicted to lower in most cases. If there is a deviation of drawdown trend of greater than 20% from predicted:

1. If this drop in groundwater level migrates to shallower groundwater intervals supporting surface water feature and wells then data will be reviewed to determine at what depth the additional drawdown is occurring and to what extent. Additional monitoring points may be installed or increased monitoring frequency may take place at this stage to aid confirmation. If monitoring data shows no transmission of drawdown to shallower groundwater units (river alluvium), or no affect to river baseflows or to wells then no mitigation action is required. The increased drawdown will be incorporated into the modelling updates.

2. If monitoring data does indicate transmission to shallow units, assessment actions will be triggered relevant to that monitoring area:

    - For surface water flow – see Assessment Action SWOM1
    - For private well water levels – See Assessment Action GWOM2
    - For peat land – See Assessment Action GWOM3

GWOM2: Decrease of water levels at private abstractions beyond Q5 water level minus 20%, or predicted water level drawdown for design:

1. A decrease of water levels beyond assessment limits does not mean the abstraction is not usable. If the action is triggered, the minimum usable water level for the well will be determined.

2. Supply for wells falling below this minimum usable water level will be compensated or alternative water supply would be offered. Alternative supplies for groundwater abstraction sources will depend on the type of abstraction (i.e. domestic or farming), the volume of water typically used and the frequency of use. Options for alternative supplies include (but are not limited to), drilling of a new well in a different location on the same property, piped water via either a new groundwater or surface water abstraction from further distance outside the property, installation of a holding tank at the property and regular tankering of water to the property

GWOM3: Decline of peat water levels or thickness beyond assessment limits:

The peatland is rainfall-fed with only very limited zones of groundwater water in the valleys of the streams near the level of the peat (i.e. in locations where the water in the peat is no-longer perched). The peat in the stream valley areas above the underground mine is currently significantly affected by peat drains and peat stripping activities (not related to the project). If there is a decline in blanket bog peat water levels or thickness beyond assessment limits the following actions will be implemented:

1. For the blanket bog peatland, changes in peat water level are more likely to be the result of climate variations and/or modifications to peat drainage channels. Monitoring data will be first be reviewed against climate and drainage variations before alternative causes are evaluated
2. Form small bunds to slow overland flow increasing peat recharge.
3. If considered there may be some relationship to mining, discontinue mining to any shallower depth in affected area and allow rebound to take place.
4. Employ changes to mine design to prevent future occurrence (for example, deepening of workings from ground surface in a certain geology or area).

GWOM4: Variation of dewatering volumes in the underground mine outside assessment limits:

1. Dewatering volumes will be reviewed both annually and in groundwater model updates. However, if the dewatering rate varies by 25% from predicted, an earlier review would be triggered, to take place within a 6-month period. This review may comprise checking if dewatering is inconsistent with the actual pace of mining and backfilling and/or re-assessment of the groundwater model (to include re-calibration of the model and update to predicted drawdown).
2. If larger dewatering volumes are predicted to the extent that pond capacity is a limitation, the mine water management plan will be updated and discharge rates from the site may need to be increased.

GWOM5: Variation of water quality in the underground mine outside assessment limits:

Mine water quality will be compared to the concentration screening levels developed for mine water quality (See the Groundwater Impact Assessment [2020b], Section 7.4 and Table 7.9). The screening levels are based on the groundwater target limits for the underground mine area as specified in Table 3-15.

1. Exceedance of limits will trigger measures such as modification of mine drainage to reduce volumes migrating to the groundwater system on closure. This would have the effect of raising the screening levels or completely removing the pathway to the groundwater system.

GWOM6: Exceedance of groundwater quality assessment limits at mine monitoring well(s):

1. Resampling of well and adjacent wells at least every 2 weeks for 4 consecutive occasions, with additional QA/QC samples/checks, results and trend verification.
2. Check hydraulic containment of mine based on drawdown data. Re-assess migration direction if needed, significance of the change and area of the mine likely to be leading to the outward migration/break in hydraulic containment.

5.3.4 Review of monitoring locations

As the underground mine plan will change and develop throughout the mine life, the monitoring plan will need to be dynamic. The monitoring plan will need to be reviewed with each update of the mine plan or exploration plan as outlined in as outlined in Section 1.2.

5.4 Approach to Groundwater Monitoring at Closure

5.4.1 Overview

The detailed post-closure monitoring plan will be developed during operations prior to mine closure (i.e. in future versions of the plan). In this way the plan can prescribe closure monitoring based on the actual mine layout and backfill locations, and monitoring data collected to date. The closure monitoring plan will include assessment limits and assessment actions.

In this version, this subsection provides an overview of the general approach to monitoring at mine closure.

5.4.2 Changes to Groundwater Conditions at Closure

The principal changes to the groundwater system at closure identified in the groundwater risk assessment are:

- Rebound of water in the underground mine: Groundwater surrounding the underground workings will rebound during a recovery period to steady state water levels. The adit portal will remain open for the drainage and monitoring of water from the mine, and treatment, if required. Once water levels fully recover inside the mine there is the potential for outward migration into the surrounding groundwater system, however most water will migrate to the outlet of the adit portal due to the interconnection of preferential pathways within the mine and the low formational permeability of the bedrock. During the groundwater rebound period and the immediate period following full recovery, groundwater surveillance will be required to assess rates of recovery and provide confirmation that concentrations are within expected environmental limits, as predicted in the groundwater impact assessment.
- Closure of the DSF and ponds: The DSF will be fully covered and restored, therefore water ingress into the DSF will be considerably reduced. The bulk of the draindown of entrained water in the tailings is predicted to have taken place within 3-6 years following closure, after which flow out of the toe drain would be considerably reduce, together with any seepage through the liner (if any is occurring). Therefore, risks to groundwater will be considerably reduced. Confirmatory monitoring will continue during this infrastructure closure and post-closure phase.

5.4.3 Proposed Infrastructure Site

Post-operations groundwater monitoring will continue at the infrastructure site as part of the care and maintenance scheme. All groundwater monitoring sites as listed in Table 5-6 will continue to be monitored, however at a reduced frequency following complete installation of the DSF cover system. Assessment actions will remain similar to those described in operations. Groundwater monitoring will continue to the satisfaction of the authorities that no further monitoring of the groundwater in this area is required.

5.4.4 Underground Mine

In general, monitoring will continue as during operations to monitor groundwater rebound, however additional monitoring facilities will be installed to enable monitoring of the mine water level and quality of rebounding water in the underground mine. These will likely include monitoring facilities for the collection of samples and/or VWPs to assess groundwater rebound.

The information collected at closure would be:

- Water level and quality in the mine during and post groundwater rebound;
- Groundwater level and quality in the surrounding groundwater system.

Triggers for assessment actions will primarily relate to mine water quality and groundwater quality, as opposed to assessment limits for groundwater level or flow during the operational phase.

Assessment limits for groundwater quality will be those in Table 5-8, however these may be updated during the operational period. The actions will follow a similar format as defined in Section 3.5.2.

At closure, if mitigation measures are required, they would likely involve passive drainage methods that encouraged increased drainage from targeted levels of the underground mine. This would most likely be completed by drilling of sub-horizontal passive relief drains to target mine areas. Mine water arising to surface would be collected and treated through a passive or active treatment system.

For and on behalf of SRK Consulting (UK) Limited

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APPENDIX

A RECOMMENDED WATER LEVEL AND WATER QUALITY MONITORING AT PRIVATE ABSTRACTION DURING MINE OPERATION BASED ON 2019 MINE DESIGN

Project well ID	Supply Type	General Usage (long term)	Purpose	Abstraction Depth Group	Abstractions with a known depth	Abstractions with an unknown depth (1)	Predicted migration of contact water (2)	Impact, monitoring and mitigation (WL= Water Level, WQ = Water Quality)
1	Well	Disused	Domestic	0-10m	0 (Zero)		0% (zero)	No impact predicted
2	Well	Disused	Domestic	0-10m	0 (Zero)		0% (zero)	No impact predicted
4	Well	Used	Domestic	0-10m	0 (Zero)		0% (zero)	Negligible impact predicted WL and WQ monitoring offered (inside infrastructure area)
5	Well	Used	Multiple	0-10m	0.23 to 0.23		0% (zero)	Inside infrastructure area. Removed for development Replacement source will be offered if this well is found to be still utilised
6	Well	Disused	Livestock feed / General Farming	Unknown		Well 5m depth: zero Well 50m depth: zero Well 100m depth: zero Well 200m depth: 0 to 0.04m	0% (zero)	Negligible impact predicted Well disused
7	Well	Used	Domestic	0-10m	0 (Zero)		0% (zero)	No impact predicted
9	Well	Used	Multiple	0-10m	0 (Zero)		0% (zero)	No impact predicted
10	Well	Disused	Livestock feed / General Farming	Unknown		Well 5m depth: zero Well 50m depth: 0.15 to 0.62m Well 100m depth: 1.27 to 3.56m Well 200m depth: 14.94 to 42.66m	0% (zero)	WL impact predicted in some scenarios depending on well depth Well disused. No further action
11	Well	Used	Livestock feed / General Farming	0-10m	0.09 to 0.73		0% (zero)	Water level impact predicted in base case simulation (which leads to drying of the well in some scenarios) WL and WQ monitoring offered and supply replaced if required
17	Well	Used	Livestock feed / General Farming	0-10m	0 (Zero)		0% (zero)	No impact predicted
18	Well	Used	Livestock feed / General Farming	0-10m	0 (Zero)		0% (zero)	No impact predicted
19	Well	Disused	Domestic	10-80m	0 (Zero)		0% (zero)	No impact predicted
20	Well	Disused	Domestic	0-10m	0 (Zero)		0% (zero)	No impact predicted
21	Spring	Disused	Domestic	0-10m	0 (Zero)		0% (zero)	No impact predicted
22	Well	Disused	Domestic	Unknown		Well 5m depth: zero Well 50m depth: zero	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well disused. No further action

Project well ID	Supply Type	General Usage (long term)	Purpose	Abstraction Depth Group	Abstractions with a known depth	Abstractions with an unknown depth (1)	Predicted migration of contact water (2)	Impact, monitoring and mitigation (WL= Water Level, WQ = Water Quality)
						Well 100m depth: zero Well 200m depth: zero to 0.33m		
25	Well	Used	Livestock feed / General Farming	0-10m	0 (zero)		0% (zero)	No impact predicted
26	Well	Used	Domestic	0-10m	0 (zero)		0% (zero)	No impact predicted
28	Well	Used	Domestic	80-150m	0.01 to 0.17		0% (zero)	Negligible WL impact predicted WL and WQ monitoring offered
30	Well	Disused	Domestic	Unknown		Well 5m depth: zero Well 50m depth: zero Well 100m depth: zero Well 200m depth: zero to 0.23m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well disused. No further action
33	Well	Disused	Livestock feed / General Farming	Unknown		Well 5m depth: zero Well 50m depth: zero Well 100m depth: zero Well 200m depth: zero to 0.05m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well disused. No further action
36	Well	Used	Livestock feed / General Farming	Unknown		Well 5m depth: zero Well 50m depth: zero to 0.03m Well 100m depth: zero to 0.03m Well 200m depth: 0.02 to 2.02m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL offered dependant on well depth
37	Well	Used	Domestic	80-150m	0.01 to 0.04		0% (zero)	Negligible WL impact predicted WL and WQ monitoring offered
40	Well	Disused	Livestock feed / General Farming	Unknown		Well 5m depth: Zero Well 50m depth: 0.03 to 0.35m Well 100m depth: 0.30 to 1.18m Well 200m depth: 0.94 to 3.25m	0% (zero)	Inside infrastructure area. Disused well. Well removed for development
41	Well	Used	Livestock feed / General Farming	0-10m	0 (zero)		0% (zero)	No impact predicted
43	Well	Disused	Livestock feed / General Farming	Unknown		Well 5m depth: Zero Well 50m depth: zero to 0.01m Well 100m depth: zero to 0.01m Well 200m depth: 0.01 to 1.03m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well disused. No further action
44	Well	Used	Multiple	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.14m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL offered dependant on well depth

Project well ID	Supply Type	General Usage (long term)	Purpose	Abstraction Depth Group	Abstractions with a known depth	Abstractions with an unknown depth (1)	Predicted migration of contact water (2)	Impact, monitoring and mitigation (WL= Water Level, WQ = Water Quality)
45	Well	Disused	Domestic	10-80m	0 (zero)			
51	Well	Used	Livestock feed / General Farming	Unknown		Well 5m depth: Zero Well 50m depth: -0.01 to 0.01m Well 100m depth: -0.01 to 0.01m Well 200m depth: zero to 0.19m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL offered dependant on well depth
54	Well	Used	Domestic	0-10m	0 (zero)		0% (zero)	Negligible WL impact predicted in some scenarios WL monitoring offered
56	Spring	Used	Livestock feed / General Farming	0-10m	0.40 to 2.51m		0% (zero)	Water level impact predicted. Well predicted to run dry in all mine dewatering scenarios WL monitoring required, and replacement supply offered if required
57	Spring	Disused	Unknown	0-10m	0 (zero)		0% (zero)	No impact predicted
60	Well	Disused	Unknown	Unknown		Well 5m depth: Zero Well 50m depth: zero to 0.01m Well 100m depth: zero to 0.01m Well 200m depth: 0.02 to 2.54m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well disused. No further action
61	Well	Used	Livestock feed / General Farming	150-250m	0 (zero)		0% (zero)	No impact predicted
62	Well	Used	Livestock feed / General Farming	Unknown		Well 5m depth: Zero Well 50m depth: 0.01 to 0.05m Well 100m depth: 0.01 to 0.05m Well 200m depth: 0.21 to 5.63m	0% (zero)	Moderate WL impact predicted in some scenarios Well depth to be determined WL monitoring offered
63	Well	Used	Livestock feed / General Farming	0-10m	0 (zero)		0% (zero)	No impact predicted
64	Well	Disused	Unknown	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.85m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well disused. No further action
65	Well	Used	Livestock feed / General Farming	0-10m	0 (zero)		0% (zero)	No impact predicted
66	Well	Unknown	Unknown	Unknown		Well 5m depth: Zero Well 50m depth: Zero	0% (zero)	Moderate WL impact predicted in some scenarios Well depth and use to be determined

Project well ID	Supply Type	General Usage (long term)	Purpose	Abstraction Depth Group	Abstractions with a known depth	Abstractions with an unknown depth (1)	Predicted migration of contact water (2)	Impact, monitoring and mitigation (WL= Water Level, WQ = Water Quality)
						Well 100m depth: Zero Well 200m depth: zero to 0.06m		
75	Well	Disused	Unknown	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.17m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well disused. No further action
79	Spring	Used	Livestock feed / General Farming	0-10m	0 (zero)		0% (zero) during operations and 2% in closure	Predicted quality below drinking water standard/background. No WL or WQ impact predicted WL and WQ monitoring offered
80	Spring	Used	Livestock feed / General Farming	0-10m	0 (zero)		0% (zero)	No impact predicted WL and WQ monitoring offered
82	Well	Disused	Livestock feed / General Farming	0-10m	0 (zero)		0% (zero)	No impact predicted
84	Well	Used	Multiple	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.13m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL offered dependant on well depth
88	Well	Used	Livestock feed / General Farming	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.17m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL offered dependant on well depth
90	Well	Used	Livestock feed / General Farming	0-10m	0 (zero)		0% (zero)	No impact predicted
101	Well	Used	Domestic	Unknown		Well 5m depth: Zero Well 50m depth: zero to 0.01m Well 100m depth: zero to 0.01m Well 200m depth: zero to 1.11m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL offered dependant on well depth
102	Well	Used	Domestic	Unknown		Well 5m depth: zero to 0.01m Well 50m depth: 0.01 to 0.02m Well 100m depth: 0.10 to 0.14m Well 200m depth: 0.03 to 0.18m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL and WQ monitoring offered dependant on well depth

Project well ID	Supply Type	General Usage (long term)	Purpose	Abstraction Depth Group	Abstractions with a known depth	Abstractions with an unknown depth (1)	Predicted migration of contact water (2)	Impact, monitoring and mitigation (WL= Water Level, WQ = Water Quality)
104	Well	Used	Domestic	Unknown		Well 5m depth: Zero Well 50m depth: 0.03 to 0.08m Well 100m depth: 0.03 to 0.08m Well 200m depth: 0.02 to 0.45m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL and WQ monitoring offered dependant on well depth
105	Well	Used	Livestock feed / General Farming	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.01m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL offered dependant on well depth
106	Well	Disused	Livestock feed / General Farming	Unknown		Well 5m depth: Zero Well 50m depth: 0.05 to 0.39m Well 100m depth: 0.05 to 0.39m Well 200m depth: 1.19 to 22.46m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well disused. No further action
107	Well	Used	Livestock feed / General Farming	0-10m	0 (zero)		0% (zero)	No impact predicted
108	Well	Used	Domestic	Unknown		Well 5m depth: Zero Well 50m depth: zero to 0.02m Well 100m depth: zero to 0.02m Well 200m depth: 0.02 to 2.10m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL offered dependant on well depth
109	Well	Disused	Unknown	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.05m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well disused. No further action
111	Well	Disused	Domestic	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.06m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well disused. No further action
112	Well	Used	Domestic	0-10m	0 (zero)		0% (zero)	Well and associated property removed for development. No replacement required
113	Well	Disused	Livestock feed / General Farming	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: zero to 0.01m Well 200m depth: 0.01 to 0.46m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well disused. No further action
114	Well	Used	Domestic	0-10m	0 (zero)		0% (zero)	No impact predicted
118	Well	Used	Livestock feed / General Farming	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: 0.01 to 0.50m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL offered dependant on well depth

Project well ID	Supply Type	General Usage (long term)	Purpose	Abstraction Depth Group	Abstractions with a known depth	Abstractions with an unknown depth (1)	Predicted migration of contact water (2)	Impact, monitoring and mitigation (WL= Water Level, WQ = Water Quality)
121	Well	Disused	Unknown	0-10m	zero to 0.07m		0% (zero)	Disused well. Well removed for development
123	Well	Used	Domestic	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.02m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL offered dependant on well depth
127	Well	Used	Domestic	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.02m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL offered dependant on well depth
128	Well	Used	Livestock feed / General Farming	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.07m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL offered dependant on well depth
38a	Well	Used	Multiple	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.03m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL and WQ monitoring offered dependant on well depth
38b	Well	Used	Multiple	Unknown		Well 5m depth: Zero Well 50m depth: Zero Well 100m depth: Zero Well 200m depth: zero to 0.02m	0% (zero)	Negligible WL impact predicted in some scenarios depending on well depth Well depth to be determined WL and WQ monitoring offered dependant on well depth

Note: Table 8.5 from the Groundwater Impact Assessment, SRK 2020b

APPENDIX

B BASELINE WATER QUALITY ANALYSIS PARAMETERS

Baseline Sampling – Typical Groundwater Quality Parameters

Field Water Quality Measurements	**Symbol**	**Unit**		**Method**
pH	pH_Field	s.u		Field probe
Electrical Conductivity @25C	EC_Field	µS/cm		Field probe
Dissolved Oxygen	DO	%		Field probe
Temperature	Temperature	Celsius		Field probe
Laboratory Parameters	**Symbol**	**Unit**	**LoD**	**Method**
Major Constituents, TPH & GRO				
pH	pH_Lab	s.u	<0.01	TM73/PM0
Electrical Conductivity @25C	EC_Lab	µS/cm	<2	TM76/PM0
Total Alkalinity as CaCO3	AlkCaCO3_Total	mg/L	<1	TM75/PM0
Chloride	Cl	mg/L	<0.3	TM38/PM0
Sulfate	SO4	mg/L	<0.5	TM38/PM0
Fluoride	F	mg/L	<0.3	TM173/PM0
Dissolved Calcium	Ca_D	mg/L	<0.2	TM30/PM14
Dissolved Potassium	K_D	mg/L	<0.1	TM30/PM14
Dissolved Magnesium	Mg_D	mg/L	<0.1	TM30/PM14
Dissolved Sodium	Na_D	mg/L	<0.1	TM30/PM14
Ammonium as N	NH4N_N	mg/L	<0.03	TM38/PM0
Nitrite as N	NO2_N	mg/L	<0.006	TM38/PM0
Nitrate as N	NO3_N	mg/L	<0.05	TM38/PM0
Nitrate as NO3	NO3_NO3	mg/L	<0.2	TM38/PM0
Free Cyanide	CN_Free	mg/L	<0.001	TM89/PM0
Total Cyanide	CN_Total	mg/L	<0.001	TM89/PM0
Total Organic Carbon	TOC	mg/L	<2	TM60/PM0
Total Dissolved Solids	TDS	mg/L	<35	TM20/PM0
Total Suspended Solids	TSS	mg/L	<10	TM37/PM0
EPH >C10-C16	*EPH>C10C16*	*mg/L*	*<0.01*	*TM5/PM30*
EPH >C16-C24	*EPH>C16C24*	*mg/L*	*<0.01*	*TM5/PM30*
EPH >C24-C40	*EPH>C24C40*	*mg/L*	*<0.01*	*TM5/PM30*
EPH >C8-C10	*EPH>C8C10*	*mg/L*	*<0.01*	*TM5/PM30*
EPH >C8-C40	*EPH>C8C40*	*mg/L*	*<0.01*	*TM5/PM30*
GRO (>C4 – C12)	*GRO>C4C12*	*mg/L*	*<0.01*	*TM36/PM12*
GRO (C4 – C8)	*GRO>C4C8*	*mg/L*	*<0.01*	*TM36/PM12*
GRO (C8 – C12)	*GRO>C8C12*	*mg/L*	*<0.01*	*TM36/PM12*
Dissolved Metals and Metalloids				
Silver	Ag_D	mg/L	<0.005	TM30/PM14
Aluminium	Al_D	mg/L	<0.0015	TM30/PM14
Arsenic	As_D	mg/L	<0.0009	TM30/PM14
Boron	B_D	mg/L	<0.012	TM30/PM14

Field Water Quality Measurements	Symbol	Unit		Method
Barium	Ba_D	mg/L	<0.0018	TM30/PM14
Beryllium	Be_D	mg/L	<0.0005	TM30/PM14
Cadmium	Cd_D	mg/L	<0.00003	TM30/PM14
Cobalt	Co_D	mg/L	<0.0001	TM30/PM14
Chromium	Cr_D	mg/L	<0.0002	TM30/PM14
Chromium III	Cr III_D	mg/L	<0.006	TM0/PM0
Chromium VI	Cr VI	mg/L	<0.006	TM38/PM0
Copper	Cu_D	mg/L	<0.003	TM30/PM14
Iron	Fe_D	mg/L	<0.0047	TM30/PM14
Mercury (CVAF[10])	Hg_D_CVAF	mg/L	<0.00001	TM61/PM38
Manganese	Mn_D	mg/L	<0.0015	TM30/PM14
Molybdenum	Mo_D	mg/L	<0.0002	TM30/PM14
Nickel	Ni_D	mg/L	<0.0002	TM30/PM14
Lead	Pb_D	mg/L	<0.0004	TM30/PM14
Antimony	Sb_D	mg/L	<0.002	TM30/PM14
Selenium	Se_D	mg/L	<0.0012	TM30/PM14
Tin	Sn_D	mg/L	<0.005	TM30/PM14
Strontium	Sr_D	mg/L	<0.005	TM30/PM14
Tellurium	Te_D	mg/L	<0.005	TM30/PM14
Thorium	Th_D	mg/L	<0.01	TM30/PM14
Thallium	Tl_D	mg/L	<0.0009	TM30/PM14
Uranium	U_D	mg/L	<0.005	TM30/PM14
Vanadium	V_D	mg/L	<0.0006	TM30/PM14
Zinc	Zn_D	mg/L	<0.0015	TM30/PM14

Parameters in italics were analysed in annual monitoring rounds only. GRO was analysed on an annual basis prior to 2017.

[10] CVAF - Cold Vapor Atomic Fluorescence which allows low level measurement of mercury

Baseline Sampling – Typical Surface Water Quality Parameters (Non Metals)

Parameter	Symbol	Unit	Limit of Detection	Method
Physical Parameters				
pH	pH	s. u.	<0.01	TM73/PM0
Electrical Conductivity @25 °C	EC_Lab	µS/cm	<2	TM76/PM0
Total Dissolved Solids	TDS	mg/l	<10	TM20/PM0
Total Suspended solids	TSS	mg/l	<10	TM37/PM0
Anions and Nutrients				
Total Alkalinity as $CaCO_3$	$AlkCaCO_3$_Total	mg/l	<1	TM75/PM0
Sulphate	SO4	mg/l	<0.05	TM38/PMO
Chloride	Cl	mg/l	<0.3	TM38/PM0
Fluoride	F	mg/l	<0.3	TM27/PM0
Ammoniacal Nitrogen at NH_4	NH4_NH4	mg/l	<0.03	TM38/PM0
Nitrite as N	NO2_N	mg/l	<0.006	TM38/PM0
Nitrate as N	NO3_N	mg/l	<0.05	TM38/PM0
Nitrate as NO_3	NO3_NO3	mg/l	<0.2	TM38/PM0
Total Phosphorus	P_Total	µg/L	<0.7	TM30/PM14
Molybdate Reactive Phosphorus	MRP	µg/L	<0.5	TM30/PM14
OrthoPhosphate as PO_4	PO4_PO4	mg/l	<0.06	TM38/PM0
Cyanides				
Free Cyanide	CN_Free	µg/L	<1	TM89/PM0
Total Cyanide	CN_Total	µg/L	<1	TM89/PM0
Organic Carbon, BOD and COD				
Total Organic Carbon	TOC	mg/l	<2	TM60/PM0
Biological Oxygen Demand (Settled)	BOD_Settled	mg/l	<1	TM58/PM0
Chemical Oxygen Demand (Settled)	COD_Settled	mg/l	<7	TM57/PM0
Microbiological				
Faecal Coliforms	Coli_Faecal	CFU/100 mL	<1	Subcontracted
Total Coliforms	Coli_Total	CFU/100 mL	<1	Subcontracted
Enterococci	Enterococci	CFU/100 mL	-	Subcontracted
Hydrocarbons				
Extractable Petroleum Hydrocarbons (C8-C40)	EPH_C8C40	µg/L	<10	TM5/PM30
Mineral Oil (C10-C40)	MineralOil_C10-C40	µg/L	<10	TM5/PM30

Baseline Sampling – Typical Surface Water Quality Parameters (Metals)

Parameter	Symbol[1]		Unit	Limit of Detection	Method
Silver	Ag_T	Ag_D	µg/L	<5	TM30/PM14
Aluminum	Al_T	Al_D	µg/L	<1.5	TM30/PM14
Arsenic	As_T	As_D	µg/L	<0.9	TM30/PM14
Boron	B_T	B_D	µg/L	<2	TM30/PM14
Barium	Ba_T	Ba_D	µg/L	<1.8	TM30/PM14
Beryllium	Be_T	Be_D	µg/L	<0.5	TM30/PM14
Cadmium	Cd_T	Cd_D	µg/L	<0.03	TM30/PM14
Calcium	Ca_T	Ca_D	µg/L	<0.2	TM30/PM14
Cobalt	Co_T	Co_D	µg/L	<0.1	TM30/PM14
Total Chromium	Cr_T	Cr_D	µg/L	<0.2	TM30/PM14
Dissolved Chromium III	Cr(III)		µg/L	<2	NONE
Hexavalent Chromium VI	Cr(VI)		µg/L	<2	TM38/PM0
Copper	Cu_T	Cu_D	µg/L	<3	TM30/PM14
Iron	Fe_T	Fe_D	µg/L	<4.7	TM30/PM14
Dissolved (CVAF) and Total Mercury	Hg_T	Hg_D	µg/L	<0.01	TM61/PM38
Potassium	K_T	K_D	mg/l	<0.1	TM30/PM14
Magnesium	Mg_T	Mg_D	mg/l	<0.1	TM30/PM14
Manganese	Mn_T	Mn_D	µg/L	<1.5	TM30/PM14
Molybdenum	Mo_T	Mo_D	µg/L	<0.2	TM30/PM14
Sodium	Na_T	Na_D	mg/l	<0.1	TM30/PM14
Nickel	Ni_T	Ni_D	µg/L	<0.2	TM30/PM14
Lead	Pb_T	Pb_D	µg/L	<0.4	TM30/PM14
Antimony	Sb_T	Sb_D	µg/L	<2	TM30/PM14
Selenium	Se_T	Se_D	µg/L	<1.2	TM30/PM14
Tin	Sn_T	Sn_D	µg/L	<5	TM30/PM14
Tellurium	Te_T	Te_D	µg/L	<5	TM30/PM14
Thallium	Tl_T	Tl_D	µg/L	<0.9	TM30/PM14
Thorium	Th_T	Th_D	µg/L	-	TM30/PM14
Titanium	Ti_T	Ti_D	µg/L	<5	TM30/PM14
Uranium	U_T	U_D	µg/L	<5	TM30/PM14
Vanadium	V_T	V_D	µg/L	<0.6	TM30/PM14
Zinc	Zn_T	Zn_D	µg/L	<1.5	TM30/PM14

Note 1: T = Total D = Dissolved

APPENDIX

C RECOMMENDED WATER QUALITY ANALYSIS PARAMETERS FOR CONSTRUCTION AND OPERATIONS

Water Quality Parameters for Construction and Operations Monitoring

Parameters are recommended for water monitoring during construction and operations based on the results of the Geochemical Assessment, the Groundwater Risk Assessment and the Surface Water Impact Assessment.

Water quality monitoring parameters may be revised during construction or operations as the monitoring database develops.

Detection limits should be selected to achieve standards/targets (where achievable)

Proposed surface water quality monitoring parameters for construction and operations (ex - metals)

Parameter	Symbol
pH	pH
Electrical Conductivity @25 °C	EC_Lab
Total Dissolved Solids	TDS
Total Suspended solids	TSS
Total Alkalinity as $CaCO_3$	Alk$CaCO_3$_Total
Sulphate	SO4
Chloride	Cl
Fluoride	F
Ammoniacal Nitrogen at NH_4	NH4_NH4
Nitrite as N	NO2_N
Nitrate as N	NO3_N
Total Phosphorus	P_Total
Molybdate Reactive Phosphorus	MRP
OrthoPhosphate as PO_4	PO4_PO4
Free Cyanide	CN_Free
Total Cyanide	CN_Total
Total Organic Carbon	TOC
Biological Oxygen Demand (Settled)	BOD_Settled
Chemical Oxygen Demand (Settled)	COD_Settled
Faecal Coliforms	Coli_Faecal
Total Coliforms	Coli_Total
Enterococci	Enterococci
Extractable Petroleum Hydrocarbons (C8-C40)	EPH_C8C40
Mineral Oil (C10-C40)	MineralOil_C10-C40

Proposed surface water quality monitoring parameters for construction and operations (metals)

Parameter	Symbol	
Silver	Ag_T	Ag_D
Aluminum	Al_T	Al_D
Arsenic	As_T	As_D
Boron	B_T	B_D
Barium	Ba_T	Ba_D
Beryllium	Be_T	Be_D
Cadmium	Cd_T	Cd_D
Calcium	Ca_T	Ca_D
Cobalt	Co_T	Co_D
Chromium	Cr_T	Cr_D
Total Dissolved Chromium III	Cr(III)	
Hexavalent Chromium	Cr(VI)	
Copper	Cu_T	Cu_D
Iron	Fe_T	Fe_D
Dissolved (CVAF) and Total Mercury	Hg_T	Hg_D
Potassium	K_T	K_D
Magnesium	Mg_T	Mg_D
Manganese	Mn_T	Mn_D
Molybdenum	Mo_T	Mo_D
Sodium	Na_T	Na_D
Nickel	Ni_T	Ni_D
Lead	Pb_T	Pb_D
Antimony	Sb_T	Sb_D
Selenium	Se_T	Se_D
Tin	Sn_T	Sn_D
Tellurium	Te_T	Te_D
Thallium	Tl_T	Tl_D
Thorium	Th_T	Th_D
Titanium	Ti_T	Ti_D
Uranium	U_T	U_D
Vanadium	V_T	V_D
Zinc	Zn_T	Zn_D

Note 1: T = Total D = Dissolved

Proposed groundwater quality monitoring parameters for construction and operations

Field Water Quality Measurements	**Symbol**
pH	pH_Field
Electrical Conductivity @25C	EC_Field
Dissolved Oxygen	DO
Temperature	Temperature
Laboratory Parameters	**Symbol**
Major Constituents, TPH & GRO	
pH	pH_Lab
Electrical Conductivity @25C	EC_Lab
Total Alkalinity as CaCO3	AlkCaCO3_Total
Chloride	Cl
Sulfate	SO4
Fluoride	F
Dissolved Calcium	Ca_D
Dissolved Potassium	K_D
Dissolved Magnesium	Mg_D
Dissolved Sodium	Na_D
Ammonium as N	NH4N_N
Nitrite as N	NO2_N
Nitrate as N	NO3_N
Total Organic Carbon	TOC
Total Dissolved Solids	TDS
Gasoline range organics (or similar)	*GRO C6 to C10*
Diesel range organics (or similar)	*DRO C10 to C28*
Dissolved Metals and Metalloids	
Aluminium	Al_D
Arsenic	As_D
Boron	B_D
Barium	Ba_D
Beryllium	Be_D
Cadmium	Cd_D
Cobalt	Co_D
Chromium (including Cr3 and Cr6)	Cr_D
Copper	Cu_D
Iron	Fe_D
Mercury - low range (e.g. CVAF[1])	Hg_D_CVAF
Manganese	Mn_D
Molybdenum	Mo_D
Nickel	Ni_D

Field Water Quality Measurements	Symbol
Lead	Pb_D
Antimony	Sb_D
Selenium	Se_D
Tin	Sn_D
Strontium	Sr_D
Tellurium	Te_D
Thorium	Th_D
Thallium	Tl_D
Uranium	U_D
Vanadium	V_D
Zinc	Zn_D

[1] CVAF - Cold Vapor Atomic Fluorescence which allows low level measurement of mercury