

Saint Gobain Mining (Ireland) Ltd.,
Magheracloone, Carrickmacross, Co. Monaghan

Environmental Liabilities Risk Assessment

Report Date:

8th April 2021



KD Environmental Ltd.

1 Swiftbrook Glen, Virginia, Co. Cavan

Report No 2020/55/02

Table of Contents

1.0	Introduction	3
1.1	Site History & Description	4
1.2	Licences/Permitted Activities	5
1.3	IED Licence ELRA Requirements	5
2.0	Methodology	6
2.1	Personnel Interviewed	6
2.2	Documentation Inspected	6
2.3	Site Inspections	6
3.0	Site Evaluation	7
3.1	Operator Performance – Compliance	7
3.2	Gypsum Mine & Quarry – Site Sensitivity	8
3.3	Gypsum mine and quarry – Hydrogeological Links	8
3.4	Drummond mine – Subsidence Management	9
3.3	Site processes and activities.....	10
3.3.1	Opencast mining.....	10
3.3.2	Underground mining	10
3.4	Inventory of buildings, plant and equipment.....	12
3.5	Inventory of raw materials, products and wastes	13
3.6	Identified Risks	14
4.0	Risk Analysis	15
5.0	Risk Evaluation.....	30
6.0	Risk Treatment	32
7.0	Statement of Measures	34
8.0	Worst Case Scenario Identification & Costings.....	38
9.0	Conclusion	42

1.0 Introduction

KD Environmental Ltd. was commissioned by Robert Moore, EHS Regional Partner with Saint-Gobain Construction products (Ireland) Ltd. to carry out an Environmental Liabilities Risk Assessment (ELRA) including the calculation of associated costs for activities at the Saint-Gobain Mining (Ireland) Ltd site at Magheraclone, Co. Monaghan. Saint-Gobain Mining (Ireland) Ltd is owned by Saint-Gobain Construction Products (Ireland) Ltd and IED licence P0519-03 covers both the gypsum mine site and gypsum processing site activities.

This report has been drafted based on information provided by relevant personnel of Saint-Gobain Construction Products (Ireland) Ltd. Site visits were also conducted on 29th September 2020 and 9th March 2021 by David Kelly BSc. MSc. of KD Environmental Ltd.

Disclaimer:

This report has been drafted based on information provided by Saint Gobain personnel. KD Environmental Ltd do not warrant the accuracy of this information and will not be responsible for any opinions which KD Environmental Ltd. has expressed, or conclusions which it has drawn, in reliance upon information which is subsequently proven to be inaccurate. All statements and opinions provided in this report have been reported in good faith and are based on the information gained from Saint Gobain key personnel.

Observations and assessments within this report were made in accordance with the following guidance:

- “Guidance on Assessing and Costing Environmental Liabilities” and the “Guidance on Assessing and Costing Environmental Liabilities – Unit Rates for conversion” issued by the EPA in 2014.
- “Guidance on Financial Provision for Environmental Liabilities” issued by the EPA in 2015
- “EPA Approach to Environmental Liabilities and Financial Provision” issued by the EPA in 2019

Activity Details:

Name: Saint-Gobain Mining (Ireland) Ltd
Address: Knocknacran
Carrickmacross
Co. Monaghan

Licence Number: P0519-03

Activities licensed:

Class 1.3 “The extraction and processing (including size reduction, grading and heating) of minerals within the meaning of the Minerals Development Acts 1940 to 1999, where an activity involves any other operation where either the level of extracted or processed minerals is greater than 200,000 tonnes per annum or the total operational yield is greater than 1,000,000 tonnes, and storage of related mineral waste.

11.1 Waste facility - The recovery or disposal of waste in a facility, within the meaning of the Act of 1996, which facility is connected or associated with another activity specified in this Schedule in respect of which a licence or revised licence under Part IV is in force or in respect of which a licence under the said Part is or will be required.

11.5 Landfills, within the meaning of section 5 (amended by Regulation 11(1) of the Waste Management (Certification of Historic Unlicensed Waste Disposal and Recovery Activity) Regulations 2008 (S.I. No. 534 of 2008) of the Act of 1996, receiving more than 10 tonnes of waste per day or with a total capacity exceeding 25,000 tonnes, other than landfills of inert waste.

1.1 Site History & Description

Saint-Gobain Mining (Ireland) Ltd operated an opencast gypsum mine in the townland of Knocknacran, Co. Monaghan and currently operates an underground gypsum mine in the townland of Drummond, Co. Monaghan. The setting is rural with other surrounding land use being mainly agricultural with low density residential dwelling. The quarry and mine are situated approximately 7km from the town of Carrickmacross in Co. Monaghan and 7km from Kingscourt, Co. Cavan.

The opencast mine began operation in 1989 following the granting of planning permission (PL18/5/67892) and in 2017 under planning permission P17/217 permission was granted to extend the life of the quarry to the year 2033. The underground mine was opened in 2004 under planning permission P03/578.

The opencast mine site covers a total area of 63.2 hectares of which 44.6 hectares is the area for gypsum extraction. The remaining 20.7 hectares is processing plant, non-extraction areas and administration buildings/car parks. The underground mine was estimated to extend over an area of approx. 33.7 hectares in August 2020.



Figure 1: Opencast Mine Area

The opencast mine is bordered on its western boundary by the R179 Kingscourt to Carrickmacross road. The now disused Drumgossat underground mine forms the majority of the northern section of the site, the active Drummond underground mine lies to the south of the site and the quarried gypsum outcrop lies to the eastern section of the site. The main gypsum mineral reserve lies in the west and south sections of the site.

1.2 Licences/Permitted Activities

Saint-Gobain Construction Products and Mining (Ireland) Ltd was issued with Industrial Emissions Directive licence (IED) P0519-03 by the EPA in July 2015 for their manufacturing and mining operations.

Under P0519-03, Saint-Gobain Construction Products and Mining (Ireland) Ltd are permitted to carry out the following activity under Section 90(2) of the Environmental Protection Acts 1992 and 2003;

- Class 1.3 “The extraction and processing (including size reduction, grading and heating) of minerals within the meaning of the Minerals Development Acts 1940 to 1999, where an activity involves any other operation where either the level of extracted or processed minerals is greater than 200,000 tonnes per annum or the total operational yield is greater than 1,000,000 tonnes, and storage of related mineral waste.

- Class 11.1 “The recovery or disposal of waste in a facility, within the meaning of the Act of 1996, which facility is connected or associated with another activity specified in this Schedule in respect of which a licence or revised licence under Part IV which a licence under the said Part is or will be required”

Class 11.5 Landfills, within the meaning of section 5 (amended by Regulation 11(1) of the Waste Management (Certification of Historic Unlicensed Waste Disposal and Recovery Activity) Regulations 2008 (S.I. No. 534 of 2008) of the Act of 1996, receiving more than 10 tonnes of waste per day or with a total capacity exceeding 25,000 tonnes, other than landfills of inert waste;

at Knocknacran, Magheracloone, Drummond, Derrynascobe, Derrynaglah, Ballycartlan, Enagh and Carrickmacross, County Monaghan, and at Lisnabow, Kilmainhamwood and Kells, County Meath.

1.3 IED Licence ELRA Requirements

Condition 12.2 of IED licence P0519-03 requires that;

Condition 12.2.2: *The licensee shall arrange for the completion, by an independent and appropriate qualified consultant, of a comprehensive and fully costed Environmental Liabilities Risk Assessment (ELRA) which addresses the liabilities from past and present activities. The assessment shall include those liabilities and costs identified in Condition 10 for execution of the DMP and CRAMP. A report on this assessment shall be submitted to the Agency for agreement. The ELRA shall be reviewed as necessary to reflect any significant change at the installation, and in any case every three years following initial agreement. Review results are to be notified as part of the AER.*

2.0 Methodology

2.1 Personnel Interviewed

David Kelly BSc. MSc. of KD Environmental Ltd. carried out site reviews on 29th September 2020 and 9th March 2021. During this visit key site personnel were met to discuss potential risk scenarios that could occur on site and to gain relevant information to complete this ELRA.

2.2 Documentation Inspected

All documentation and records were made available for inspection. The following documents were inspected:

- IED License Application
- MSDS data sheets of chemicals used on site
- IED Licence P0519-03
- Mine site closure and decommissioning plan (CRAMP)
- Mine site firewater retention risk assessment (FWRRA)
- Site Layout Plan and Drainage Drawings
- Site Planning Application

Information was also obtained from EPA River monitoring reports. The GSI (Geological Society of Ireland), NPWS (National Parks & Wildlife Services) and National Monuments on-line mapping services were also utilised.

2.3 Site Inspections

A site inspection and assessment of maintenance and storage areas was carried out and a full site above ground walkaround was conducted on 29th September 2020 and 9th March 2021.

3.0 Site Evaluation

3.1 Operator Performance – Compliance

Saint-Gobain Construction Products (Ireland) Ltd. was granted IED licence P0519-03 for their gypsum processing facility and mining operation in 2015. Saint-Gobain Construction Products (Ireland) Ltd. contribute significant resources in order to achieve environmental compliance. On occasion a non-compliance to this IED licence requirements may occur. A full record of environmental non-compliances is available upon request from the environmental office at Saint-Gobain Construction Products (Ireland) Ltd. – a summary for 2020 is given below as reported to the EPA in the Annual Environmental Report.

- **Incident History- Mine and Opencast Quarry**
In 2020, four minor incidents occurred relating to site activities at the gypsum opencast quarry and underground mine. Three of these incidents regarded compliance monitoring exceedences with no major detrimental environmental effects recorded. The other incident was a temporary down-time of a water composite sampler.

In 2018 a major incident occurred at the gypsum mine. A high volume of water ingress into the mine resulted from normal mining activities intersecting an unforeseen fault. As has been normal practice for many years this water was pumped to the old Drumgossat Mine workings to be stored for discharge to the River Bursk during the winter season. The high volume of water meant that the water reached higher levels in the mine than had historically occurred.

In September 2018, a subsidence event took place in the area of the Magheracloone GAA Facility. Investigation by SRK consultants concluded the subsidence occurred due to a unique and complex set of circumstances with the higher than normal level of water in the old mine workings being one factor. The company investigation was independently reviewed by DCCAE consultants whose report is available on the DCCAE website.

The R179 Kingscourt to Carrickmacross road also closed for a number of weeks until the risk from further land subsidence could be determined. This has concluded that loss in underground mine stability was localised and that further mine collapse is unlikely.

The pumping of water to the old Drumgossat mine workings ceased on 28 September 2019.

It is proposed to continue the current land stability monitoring programme over a 30 year duration as this is the expected time frame for the natural flooding of the Drummond mine to be completed. The current monitoring covers lands and roads in the vicinity of Drummond mine. It is proposed that this will continue twice yearly over the first 10 years and annually after that.

- **Compliance History**
In 2020, a total of five compliance limit value exceedences were recorded for the gypsum mine site. Four of these exceedences were due to off site organic loadings of dust which are not related to site activities. Organic loadings from birds and vegetation were the cause of these exceedences and not dust from Saint Gobain activities.
The other compliance exceedence at the mine site was a water emission limit value breaches and had no significant environmental impact.

- **Complaints History**
In 2020, nineteen complaints were received relating to both the gypsum mine and gypsum processing site activities. All complaints were investigated and are now closed with the EPA.
- **Enforcement Category**
The EPA confirmed that the current risk category for the Saint Gobain process and mine facilities is A1. Under the EPA Licensing and Enforcement Charging Policy issued in 2020, A1 is the highest enforcement category.

3.2 Gypsum Mine & Quarry – Site Sensitivity

The topography, surrounding land use and location of site operations has not changed in recent years. There are no protected ecological sites within 1km of the site and no sensitive agricultural receptors within 150m of the site. The surrounding topography is an intermediate terrain dominated by drumlin formations. There is some residential housing in the area which is generally confined to linear settlement patterns, mainly along local roads.

The River Bursk receives water from the mine site (a combination of rain water from the opencast quarry and hardstand areas and water pumped from the underground mine). Prior to discharge, this water passes through a series of settling lagoons. The Bursk is a tributary of the River Glyde. The Glyde flows to the sea at Dundalk Bay and although not a designated salmonid water, this river is known to have salmon run (salmon are listed in Annex II of the Habitats Directive, 92/43/EEC).

Biological monitoring of the River Bursk by KD Environmental Ltd. in 2020 concluded that the water quality both upstream and downstream of the MSE1 discharge has a Q rating of Q3-4 indicating fair to doubtful water quality with slight levels of pollution. The River Bursk is therefore seen as being of Class C sensitivity. The River Bursk is not recognized as a Potentially Eutrophic Coastal or Estuarine water.

The site is situated in an area of a locally important aquifer with a moderate aquifer vulnerability rating (Minerex 2010 groundwater report).

There are no ecological designations or protected areas (SAC, SPA, or NHA) within 1km of the mine site. The nearest protected site is Killyconny Bog Special Area of Conservation (SAC Site Code 000006) approx. 20Km away.

3.3 Gypsum mine and quarry – Hydrogeological Links

In early 2020, Saint Gobain Construction Products Ireland Ltd. commissioned a hydrogeology study of Knocknacran Open Cast Mine and the Underground Mines at Drumgossat and Drummond. This study was conducted by Piteau Associates.

This Piteau Associates report (Ref: Project 4238-R1) is included as appendix to this ELRA report.

In summary, no long term costs associated with water management at the mine is expected as the Drummond mine will be allowed naturally flood following cessation of mining activities. Groundwater monitoring will be continued as per EPA licence schedule and these costs are included in the CRAMP for the mine.

3.4 Drummond mine – Subsidence Management

Drummond Mine has been designed to be self-supporting and not require backfilling.

The mine design is detailed by a third party Rock Mechanic who based on the surveyed geology of the mine and their own inspections, specifies the design of the rooms and pillars. Inspections of the “as built” mine also leads to specific advices where additional specific interventions are required to ensure the safety of the staff who operate within the mine or as a preventive countermeasure to a future subsidence risk.

Regular monitoring of surface levels in the area of Drummond mine has been carried out over many years and continues to be carried out. The data from these level surveys is analysed by a third party specialist and incorporated in the annual subsidence review report. The third party specialist also advises the company of any steps they should take to mitigate any subsidence risks.

This report is issued to Monaghan County Council in compliance with the mines planning permission on an annual basis.

Survey results and subsidence reports are reviewed by the DCCAE at its routine mine review meetings that take place bi-annually. These reviews and any actions arising are reported in the relevant DCCAE mine review reports

3.3 Site processes and activities

3.3.1 Opencast mining

Hydraulic excavators and dump trucks are used to remove topsoil, subsoil, and overburden to expose the gypsum rock. The material which has been removed to expose the gypsum is stored on the site. The gypsum is then extracted in a series of benches. Primary breaking is achieved by blasting. Rock breakers are used to carry out secondary breaking, if required. The broken gypsum rock is loaded onto dump trucks using a hydraulic excavator and transported to the surface primary crusher. The surface primary crusher reduces the run-of-mine rock to less than 300 mm. The minus 300 mm rock is transported by conveyor belt to a vibrating grizzly feeder. Material less than 75 mm passes through the feeder and the oversize rock is directed to the secondary crusher. The secondary crusher reduces the oversize material to less than 75 mm. The rock is then transported by conveyor belt to the stacker-reclaimer (homogenizer) where it is stored under cover awaiting collection either to the plaster and plasterboard factory near Kingscourt or to one of the cement manufacturing companies. Once the entire gypsum mineral has been removed from an area, the area is backfilled using the stored topsoil, subsoil, and overburden.

3.3.2 Underground mining

Gypsum is mined using room and pillar mining. The rock is excavated by drilling and blasting. Room and pillar mining methodology is self-supporting as approx. only 17% of the gypsum is extracted. The remaining 83% is left in the ground to form the roof, floor, and wall support of the excavation. The excavations are laid out in a grid pattern to form rooms (where the gypsum has been removed) and pillars (where the gypsum has been left in place). The rock is loaded onto dump trucks using rubber-tyred loaders and transported to the underground primary crusher. The underground primary crusher reduces the run-of-mine rock to less than 300mm. This material is then transported to surface on a conveyor belt, where it joins the surface processing plant at the secondary crusher.

All mining operations are carried out within the confines of the gypsum deposit. Therefore no waste rock is extracted.

A flow chart illustrating on site processes at the Saint-Gobain Mining (Ireland) Ltd mine and mining facility is given below.

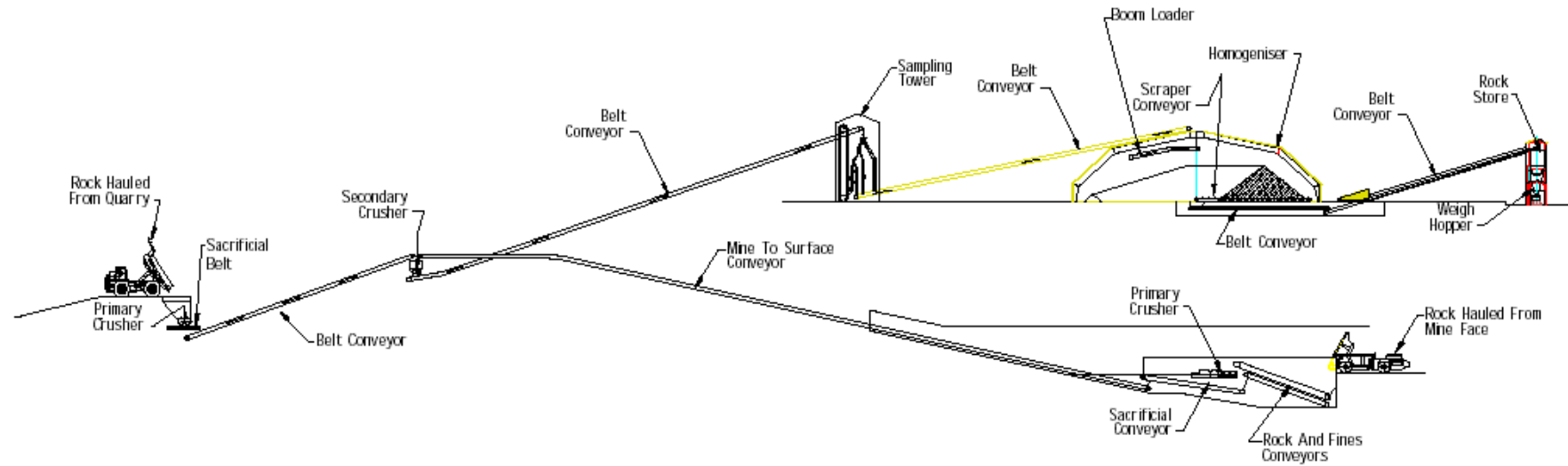


Figure 2: Mine Facility Operational Flow-Chart

3.4 Inventory of buildings, plant and equipment

Table 1. Inventory of Main Site Plant and Equipment

Plant description	Number on site
Crushers	3
Wheel wash	1
Weigh Bridge	1
Homogeniser	1
Lorry Loader	1
Conveyors	7
Autosampler	1
Ventilation fan stations	1
Auxiliary fans	2
Substations	3
Electric Panels	17
Pump station	3
Dumpers	4
Excavators	3
Water Tanker	1
Tractors	1
Diesel Bowser	1
4 x 4	7
IT (FLT)	1
Telescopic Handlers	2
Front End Loader	3

Table 2. Inventory of Site Buildings & Structures

Buildings & Structures
Rock Shed
Offices/ Administration
Workshop/Garage
Laboratory (Within Admin Building)
Car Park x 1
Surface water lagoons x 4
Surfacewater Holding Tanks
Oil Storage Bunds
Homogeniser Building
Sample Tower
Primary & Secondary crusher buildings
Emergency station (mine rescue)

All production buildings associated with the Saint-Gobain Mining (Ireland) Ltd. facility comprise of either concrete block built structures or steel supports with metal cladding.

3.5 Inventory of raw materials, products and wastes

The following table is a detailed recent inventory of raw materials used at the facility:

Table 3. Inventory of Raw Materials/Chemicals on Site

Name	Type	Quantity	Location stored
Castrol 15w/40	Engine oil	200L Barrels x 2	Main oil store at w/shop(bunded)
Castrol AWS 46	Hyd oil	200L Barrels x 2	Main oil store at w/shop(bunded)
Castrol Tecton mono 10W	Engine oil	200L Barrels x 2	Main oil store at w/shop(bunded)
Castrol Tecton mono 20W	Engine oil	200L Barrels x 2	Main oil store at w/shop(bunded)
Castrol tribol 47447-220HT	Grease	250 kg in 50kg drums	Main oil store at w/shop(bunded)
WD-40 general	Lubricant spray	450ml cans x 10	Aerosol locker in workshop
WD-40 Contact cleaner	Cleaner spray	450ml cans x 10	Aerosol locker in workshop
Sulphur free diesel	Diesel	27000L Tank	Main diesel tank at w/shop
Adblue	Adblue	1000L IBC tank	Adblue storage area W/Shop(on bund)
Waste oil	Waste oil	1750 L Tank (bunded)	Storage tanks @ Workshop (Bunded)
Hydraulic oil 46	Hydraulic oil	2740L tank (bunded)	Storage tanks @ Workshop (Bunded)
Hydraulic 10W	Hydraulic oil	1750 L Tank (bunded)	Storage tanks @ Workshop (Bunded)
Heating oil tank	Green diesel	2740L tank (bunded)	Storage tanks @ Workshop (Bunded)
Engine oil 15/40W	Engine oil	1750 L Tank (bunded)	Storage tanks @ Workshop (Bunded)

All chemicals, cleaning materials and oils used at the facility are stored on/within a suitable bund as required. There have been no incidences of major chemical or fuel spills at the facility in recent years.

No hazardous waste is stockpiled on site and is disposed of as produced – E.g Waste Oils, WEEE, Solid Oily Wastes.

3.6 Identified Risks

In 2018, one major incident occurred as summarised in section 3.1 of this ELRA report. The incident involving the ingress of groundwater into the mine, the pumping of this water to the old Drumgossat mine workings and subsequent mine subsidence is unlikely to occur again due to the undertaking of mitigation measures outlined in this report. However, at the request of the EPA and following this incident, risks associated with a large volume of water ingress into the mine and mine subsidence has been assessed in this latest ELRA for the Saint Gobain mine. The risks associated with such and incident are included as risks 15-18 of this report – see Table 4 below.

Table 4: Environmental Risks identified

Risk ID	Process	Potential Risk
1	Diesel Storage	Failure of tanks/bund leading to release of diesel
2	Diesel Use	Failure of diesel pump-line during operation leading to release of diesel
3	Diesel Delivery	Collision on site releasing diesel tanker contents
4	Transport	Collision of site releasing chemicals and oils
5	Oil and Chemical storage	Failure of bund releasing oils and chemicals
6	Oil and Chemical storage	Corrosion of drums releasing oils and chemicals
7	Oil use	Failure of above ground pipeline releasing oils and chemicals
8	Infrastructure	Failure of interceptor releasing oils/chemicals causing groundwater and land contamination
9	Infrastructure	Overtopping of lagoon walls causing uncontrolled release of water
10	Fire	Generation of contaminated firewater
11	Mining Operations	Generation of excessive dust
12	Mining Operations	Failure to meet discharge ELV
13	Infrastructure	Power failure leading to failure of water release controls, contamination of surfacewaters and failure to meet ELV
14	Mine Operations	Uncontrolled explosion due to error in blasting operations in underground mine
15	Infrastructure	Drummond mine subsidence and partial mine subsidence following cessation of mining activities
16	Mine Water Ingress	IED licence compliance risks associated with large volume of groundwater ingress into the underground Drummond mine when it is actively operating
17	Water Storage	Instability in workings of the old Drumgossat mine due to storage of groundwater ingress from the Drummond mine
18	Emission Compliance	Failure to meet IED compliance regarding the MSE1 emission to the River Bursk
19	Mine Water Ingress	Failure of bulk-head in Drummond mine
20	Mine Water Ingress	Striking a fissure in Drummond mine

4.0 Risk Analysis

The environmental incidents and risk in section 3.6 were assessed against likelihood and consequence as per Tables 5 and 6 and the results are presented in Table 7 – Risk Scoring.

Table 5: Risk classification table – likelihood

Rating	Likelihood	
	Category	Description
1	Very Low	Very low chance of hazard occurring
2	Low	Low chance of hazard occurring
3	Medium	Medium chance of hazard occurring
4	High	High chance of hazard occurring
5	Very High	Very high chance of hazard occurring

Table 6: Risk classification table – consequence

Rating	Consequence	
	Category	Description
1	Trivial	No impact or negligible change to the environment
2	Minor	Minor impact/localised or nuisance
3	Moderate	Moderate impact to environment
4	Major	Severe impact to environment
5	Massive	Massive impact to a large area, irreversible in medium term

Table 7: Risk Scoring

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
1	Diesel Storage	Failure of tanks/bund leading to release of diesel	Contamination of open ground surrounding hardstand at the diesel fill, migration of diesel to groundwaters, contamination of water in settling lagoons/emissions to river Bursk	3	Potentially large volume of diesel in tank. The diesel tank bund is at an elevated position with open ground immediately to the rear. Ground gradient slopes to the lagoons with open surface level drain to lagoons nearby.	1	Bund integrity testing every 3 years. Emergency Response team on site. Tank in good condition and separated from other site activity meaning that risk of collision reduced. Bund was hydrostatically tested in 2020 by JC Enviro and passed. Spill kit on site and trained emergency response team.	3

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
2	Diesel Use	Failure of diesel pump-line during operation leading to release of diesel	Contamination of open ground surrounding hardstand at the diesel fill, migration of diesel to groundwaters, contamination of water in settling lagoons/emissions to river Bursk	2	Lower volumes of diesel likely to spill if leak/rupture of diesel pump line. Spill containment procedures in place. Spill clean-up material on site. Diesel line housed inside diesel bund.	3	Water drain at the refuelling area passes through newly installed Class 1 interceptor. . Weekly above ground pipeline checks should include the diesel pump line to reduce this risk. Open ground adjacent to hardstand with No kerbing. The hardstand around this area will be improved in 2021.	6
3	Diesel Delivery	Collision on site releasing diesel tanker contents (tankers may contain up to 12,500L of fuel)	Contamination of open ground where the spill occurs leading to groundwater contamination. Oil entering water drains and leading to contamination of water lagoons and to a breach of emission ELV	4	Large volume spill onto open ground that is susceptible to contamination and into drains that do not pass through the oil/water separator on site.	1	Traffic management plan including speed limits on site. No mobile phone use allowed whilst driving on site.	4

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
4	Transport	Collision on site with drums and IBC releasing chemicals and oils	Contamination of open ground where the spill occurs leading to groundwater contamination. Chemicals and lubrication oils entering water drains and leading to contamination of water lagoons and to a breach of emission ELV	3	Moderate volume spill (IBC is 1,000L) onto open ground that is susceptible to contamination and into drains that do not pass through the oil/water separator on site.	2	Trained staff and controlled Handling procedures. Speed limit on site and No mobile phone use whilst driving.	6
5	Oil and Chemical storage	Failure of bund releasing oils and chemicals	Contamination of open ground surrounding hardstand at the oil/chemical storage bund, migration of hydrocarbons to groundwaters, contamination of water in settling lagoons/emissions to river Bursk	3	Potentially large volume of chemicals and lubricant oils. The chemical and drum storage bund is at an elevated position with open ground immediately to the rear. Ground gradient slopes to the lagoons with open surface level drain to lagoons nearby	1	Bund integrity testing every 3 years. Last performed in 2020 and passed. Emergency Response team on site. Tank in good condition and separated from other site activity meaning that risk of collision reduced.	3

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
6	Oil and Chemical storage	Corrosion of unbanded drums releasing oils and chemicals	Contamination of open ground surrounding hardstand at the oil/chemical storage bund, migration of diesel to groundwaters, contamination of water in settling lagoons/emissions to river Bursk	3	Potentially large volume of chemicals and lubricant oils. The chemical and drum storage bund is at an elevated position with open ground immediately to the rear. Ground gradient slopes to the lagoons with open surface level drain to lagoons near by. Spill clean-up material on site.	1	Oils and chemicals drums are supplied by manufacturers of the oils/chemicals and the supplier is required to meet legislation ensuring that they are in good condition and fit for purpose. Oil drums and containers are banded.	3

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
7	Oil use	Failure of above ground pipeline releasing oils and chemicals	Contamination of open ground surrounding hardstand at the oil/chemical storage bund, migration of diesel to groundwaters, contamination of water in settling lagoons/emissions to river Bursk	2	Infrastructural works in 2020 now mean that the oils pipelines to the workshop now run over hardstand and are fixed to a newly constructed wall. In the event of oil leaks, the leaks will fall onto open ground and into the drainage system where they will be retained in the new Class 1 interceptor. Any spills or drips can also now be quickly spotted	2	Weekly inspection of above ground pipelines is performed by maintenance staff on site. Any spills or drips can also now be quickly spotted as they will fall onto hardstand and the leak quickly repaired	4

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
8	Infrastructure	Failure of interceptor releasing oils/chemicals causing groundwater and land contamination	Release of oils to water lagoons and risk of breach of ELV for MSE1 emission.	3	The failure of the interceptor may not be detected until after contamination has occurred as there is no alarm fitted to the interceptor.	2	Maintenance of interceptor is on PM list. The interceptor was upgraded to Class 1 in 2020.	6
9	Infrastructure	Overtopping of lagoon walls causing uncontrolled release of water	Uncontrolled release of water containing elevated levels of sulphate	3	Risk of water contaminating waterways and River Bursk	1	The lagoon system is a good distance from the River Bursk and this event is most likely in times of flood when the dilution factor offered by the river is highest.	3
10	Fire on Site	Generation of contaminated firewater	Release of combustion gases to atmosphere. Firewater generation leading to surfacewater contamination.	4	No history of fire on site. Low volume of environmentally risk materials stored on site. Low residential density in the vicinity of the mine.	1	A fully trained emergency response team is on site. Fire abatement equipment throughout the site. Fire drills.	4

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
11	Mining Operations	Generation of excessive dust	Breach of ELV for deposition dust at dust sensitive locations leading to complaints from members of the public and failure to meet IED licence obligations.	2	Localised nuisance effect is predicted. No significant environmental impacts. Dust from the site poses no hazardous health or environmental effect as inert particulates. Dust exceedences recorded in 2020 were from organic sources and not process generated dusts.	3	Wheel wash and water bowing in times of dry weather helps to reduce dust generation but in the Summer months this may occur from time to time. A number of dust exceedences in 2020 due to non-operational organic loadings to dust jars. All rock lorries leaving site must be covered.	6

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
12	Mining Operations	Failure to meet water emission ELV	Release of water containing elevated levels of contaminants from MSE1. There is no longer a discharge from point MWS1	2	Pollution of the River Bursk from the MSE1.	3	Monitoring of the MSE1 conductivity and sulphate at MSE1. Controlled work practices. Drainage works on site in 2020 now means there is no discharge at location MSW1.	6
13	Infrastructure	Automated emission shutdown failure leading to failure of water release controls, contamination of surfacewaters and failure to meet ELV	Release of water containing elevated levels of contaminants from MSE1 emission. Localised effect.	2	Pollution of the River Bursk from the MSE1 emission	4	This incident has occurred in the past. Maintenance contract with external service provider, Gilroys, is in place. Emissions constantly monitored and alarms installed. No longer discharging at MSW1	8
14	Mine Operations	Uncontrolled explosion due to error in blasting operations in underground mine	An uncontrolled explosion damaging infrastructure underground leading to pollution incidence e.g. Damage to domestic wastewater holding tank	3	If infrastructure underground was damaged this could result in localised contamination of land and groundwaters with domestic wastewater, oils etc...	2	Highly controlled blasting procedures, use of trained internal and external experts and no explosives stored on site greatly reduces this risk.	6

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
15	Infrastructure	Drummond Mine subsidence following controlled flooding of underground mine after the cessation of mining operations. In this event, the water from the mine will be pumped to the water lagoons on site and emitted to the River Bursk as MSE1 as per the old Drumgossat mine subsidence incident in 2018.	The main environmental effect of a mine subsidence is a loss in water quality due to potentially elevated sulphate levels in the MSE1 emission. This is naturally occurring ground water in the area	2	A number of studies regarding the environmental effects on the emission of waters with elevated Sulphate to the River Bursk were conducted following the old Drumgossat mine subsidence incident in 2018. These studies concluded that there was no toxicological effect on fish and macroinvertebrate populations downstream of the MSE1 emission. Water quality for drinking water abstraction at Tallanstown, Co. Louth did not result after the Drumgossat mine incident. Assessment of the likelihood of a further ingress of water to the mine is considered low as per Piteau report included as appendix 1.	2	Mining in Drummond is carried out and pillars are 6m X 6m to allow for appropriate stability following natural groundwater ingress into the Drummond mine after cessation of mining activities.	4

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
16	Water ingress to mine	Groundwater ingress with Sulphate concentrations that exceed the licensed emission limit	Production of water with Sulphate levels that exceed the emission limits as per IED P0519-03. This water will be emitted via MSE1 into the River Bursk.	2	Toxicology testing on groundwater ingress into the mine in 2018 has shown that groundwater ingress into the mine has a low toxicity level and poses negligible toxicity risks. Third party modelling of the sulphate concentration compares to the actual sulphate concentrations found at various locations on the Lagan River during the discharge of excessive flows of mine water in 2018/2019	2	Underground mining operations are ongoing however the volume of water ingress has significantly decreased. The 2018 incident involved the striking of a fissure – surveying works for underground operations are continual and the operations in the area where the fissure occurred are not currently worked. Assessment of the likelihood of a further ingress of water to the mine is considered low. See Piteau report (appendix 1)	4

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
17	Water storage of Groundwater ingress from the Drummond mine in the old Drumgossatt Mine	Mine subsidence event similar to that which occurred in 2018	Storage of high water volumes at the old Drumgossatt mine workings could potentially result in mine subsidence and land subsidence as in 2018 event.	3	Loss of land and nuisance effect on members of the public with knock on effects such as road closures. The environmental effects of this incident are not severe.	2	Water is no longer stored in Drumgossatt mine. On going water mgt plan in place and water levels being managed to return water levels to historical values. The incident was investigated and the route cause of the collapse of the underground workings and subsequent surface expression is now known. Controls in place are monthly drone survey, monthly road surveys, land closed off to third parties. All lands at risk owned by Saint Gobain.	6

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
18	Emission to River Bursk	Emission at MSE1 with sulphate concentrations that exceeds the permitted limit as per IED licence P0519-03	Emission of water with Sulphate levels that exceed the emission limits as per IED P0519-03. This water will be emitted at MSE1 into the River Bursk. Licence review in train to increase the sulphate ELV from 200mg/l to 1250mg/l at CP1. Future exceedances of the increased ELV will be highly unlikely to occur.	2	<p>Macroinvertebrate and fish surveys in 2018 and 2019 following discharge of water to MSE1 with sulphate concentrations exceeding the limits specified in IED licence P0519-03 showed no effect on macroinvertebrate and fish populations downstream of the emission. No breach of drinking water regulation limits was recorded at Tallanstown Co. Louth where water is abstracted for drinking water from the River Glyde. The emission volume did not exceed 510m³/hr at any time since the Drumgossat mine subsidence event in 2018</p>	2	<p>The 2018 incident involved the striking of a fissure – surveying works for underground operations are continual and the operations in the area where the fissure occurred are not currently worked. Mine plan in place with 50m cautionary zones and probe drilling in place when advancing mine headings. Hydrological assessment by Piteau confirms the likelihood of striking a similar ingress of water is low. Appendix 1. Modelling of the impact of sulphate on the drinking water at Tallonstown has been undertaken for the Review of IEL519/03. Using a conservative approach the model shows that the likelihood of exceeding the drinking water sulphate limit is low.</p>	4

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
19	Water ingress into the underground Drummond mine	Failure of Bulk-Heads installed in the underground mine	<p>Ingress of groundwater into the underground mine is continual as there is no build up of water behind the two bulkheads. This groundwater is pumped to the water settling lagoons and from here discharged with water into the River Bursk as MSE1. Studies have concluded that there was no toxicological effect on fish and macroinvertebrate populations downstream of the MSE1 emission. Water quality for drinking water abstraction is also unaffected at Tallanstown, Co. Louth.</p>	2	<p>There is no build up of water pressure behind the bulk heads in the underground mine and therefore a failure of the bulk heads in retaining water is not relevant and there can be no risk associated with this.</p>	1	<p>The current water flow from behind the bulk head is not under pressure however monitoring of water flow volume is ongoing. There is no cost associated with monitoring water flow as it is now part of the routine dewatering management system for Drummond mine. The future plan for the ongoing operation of the bulk head is to allow no build up of water pressure behind the bulk head hence there are no long term costs involved. The bulk head does not retain water and is not operated to allow a head of water to build up behind it.</p>	2

Risk ID	Process	Potential Risks	Environmental effect	Consequence Rating	Basis of Consequence	Likelihood Rating	Basis of Likelihood	Risk Score (Consequence x Likelihood)
20	Water ingress into the underground Drummond mine	Repeat of fissure strike in Drummond underground mine	<p>.Future exploration boreholes will increase the knowledge of faults and fissures within Drummond mine. Ongoing probe drill still continues as part of Drummond production cycle. Geological structures/fractures have been identified and a 50 m cautionary zone excludes mining in these areas as part of the mine plan. An Assessment of the likelihood of a further ingress of water to the mine is considered low – see Piteau report included as appendix 1.</p>	2	<p>. The consequence rating at worst is a 2 as studies such as fish surveys, macroinvertebrate surveys and toxicity tests on receiving waters identified no environmental impacts following the 2019 incident</p>	<p>Likelihood of striking another fissure is rated as low as the Drummond mine was geologically re-evaluated by Saint Gobain UK mining services. Future exploration boreholes will increase the knowledge of faults and fissures within Drummond mine. Ongoing probe drill still continues as part of Drummond production cycle. Geological structures/fractures have been identified and a 50 m cautionary zone excludes mining in these areas as part of the mine plan. An Assessment of the likelihood of a further ingress of water to the mine is considered low. Piteau report. Appendix 1</p>	2	4

5.0 Risk Evaluation

The risks presented in the risk analysis are ranked in the table below to allow for the prioritization of risks when performing in the risk mitigation measures.

Table 8: Ranked Risks

Risk ID	Process	Consequence rating	Likelihood rating	Risk Score
13	Automated emission shutdown failure	2	4	8
8	Interceptor failure	3	2	6
11	Dust Generation	2	3	6
12	Failure to meet water emission ELV	2	3	6
2	Failure of diesel pump line	2	3	6
14	Uncontrolled explosion	3	2	6
17	Water storage in Drungossat	3	2	6
4	Collision with chemicals/oil delivery	3	2	6
7	Failure of above ground pipe carrying oil	2	2	4
15	Drummond mine subsidence	2	2	4
10	Fire on site	4	1	4
3	Collision with diesel tanker	4	1	4
18	Emission to the river Bursk	2	2	4
20	Repeat fissure strike in underground mine	2	2	4
16	Water ingress to the mine	2	2	4
5	Failure of drum storage bunds	3	1	3
6	Unbunded chemicals and oils	3	1	3
9	Overtopping of lagoon walls	3	1	3
1	Diesel Bund/Tank failure	3	1	3
19	Failure of Bulkhead in underground mine	2	1	2

Table 9: Risk Matrix

Likelihood	V. High	5					
	High	4		13			
	Medium	3		2, 11, 12			
	Low	2		15, 16, 17, 18, 20, 7	8, 14, 4, 17		
	V. Low	1		19	1, 5, 6, 9	3, 10	
			Trivial	Minor	Moderate	Major	Massive
		1	2	3	4	5	
				Consequence			

6.0 Risk Treatment

The output of the risk treatment process is the development of a statement of measures to be taken to minimise the environmental risk of the activity. Of the 20 potential risks identified for the Saint Gobain Mining operation, the highest risk score was 8. This was scored for one identified risks – risk ID 13. In the past many of the highest scoring risks involve a failure of key infrastructure such as pipelines, interceptors and bunds. To reduce these risks infrastructural works were completed on the mine site in 2020 including upgrade of the oil interceptor on site and extending of the hardstand adjacent to the above ground oil pipelines to contain any leaks from these pipelines. The risk ratings associated with oil and diesel storage and use have been re-evaluated in this 2020 ELRA to reflect the improved control measures and reduced environmental risk.

Infrastructural Improvements in 2020

Sept. 2020: Concrete slab extended in front of oil pipelines – see photo below. This slab has a gradient that drains water from the slab to the existing wash bay drainage system on site. Water from the Washbay drain passes through the oil interceptor before entering the water settling lagoons on site.



October 2020: A new wall was built along the boundary of this concrete slab to a height of approx. 1m. The oil pipelines were moved above the existing bund wall and be fixed to the inside of this new wall and the slab boundary. Any leaks or drips will therefore flow into the Washbay drain and on into the new Class 1 oil interceptor.



Nov. 2020: A new Class 1 oil interceptor was installed on site to replace the Class 2 interceptor. The bund integrity of the bunds at the workshop, including the concrete structures, was hydrostatically tested and passed

The statement of measures presented in the following table detail mitigation measures in place for each identified risk with a risk owner responsible for the on-going management of the risk. Further mitigation actions may also be recommended to reduce risk scores. The risks identified must be reviewed regularly by site management to ensure sufficient mitigation measures remain in place.

7.0 Statement of Measures

Table 10: Statement of Mitigation Measures

Risk ID	Potential Risk	Risk Score	Mitigation Measure	Owner
13	Automated emission shutdown failure	8	Risk of pollution to the Pollution of the River Bursk from the MSE1 emission. Maintenance contract with external service provider, Gilroys, is in place. Emissions constantly monitored and alarms installed. No longer discharging from MSW1.	Mine Manager & EHS Department.
8	Interceptor failure	6	In 2020 a new Class 1 interceptor was installed at the mine. This interceptor is alarmed to alert immediately a failure. The emission from the lagoons at MSE1 can be stopped using the automatic shutdown valve as soon as a problem was detected.	Mine Manager
11	Dust Generation	6	Wheel wash and water bowing in times of dry weather helps to reduce dust generation. Recommend to increase the frequency and extent of water bowing in dry weather. Investigation has shown that organic contamination of the dust jars caused exceedences. All rock lorries leaving site must be covered.	Mine Manager & EHS Department
12	Failure to meet water emission ELV	6	Monitoring of the MSE1 conductivity and sulphate at MSE1. Controlled work practices. Drainage works on site in 2020 mean that there is no longer a discharge at MSW1.	Mine Manager & EHS Department.
2	Failure of diesel pump line	6	Spill containment procedures. Spill clean-up material on site. Diesel line housed inside diesel bund. Open ground adjacent to hardstand with No kerbing – diesel spills from the fuelling line may run-off onto open ground. It is planned in 2021 to extend hardstand in this area and kerb perimeter.	Mine Manager
14	Uncontrolled explosion	6	Damage to underground infrastructure leading to pollution instances. Use of controlled procedures and trained experts. No explosives stored on site.	Mine Manager

Risk ID	Potential Risk	Risk Score	Mitigation Measure	Owner
17	Water storage of Groundwater ingress from the Drummond mine in the old Drumgossat Mine leading to land subsidence	6	Water is no longer stored in Drumgossat mine. On going water mgt plan in place and water levels be managed to return water levels to historical values. The incident was investigated and the route cause of the collapse of the underground workings and subsequent surface expression is now known. Controls in place are monthly drone survey, monthly road surveys, land closed off to third parties. All lands at risk owned by Saint Gobain.	Mine Manager
4	Collision with chemicals/oil delivery	6	Traffic management plan including speed limits on site. Staff and driver induction training. No further mitigation.	Mine Manager
7	Failure of above ground pipe carrying oil	4	A weekly visual inspection of the pipeline by the mine facilities manager is also scheduled. Spill kits and trained staff are available on site however the pipeline runs over open ground that is overgrown with vegetation. In 2020 the hardstand the area around and underneath the pipeline was extended to prevent potential oil leaks contaminating open ground. Hardstanding the area underneath the pipeline will allow for easy detection of drips or leaks. Leaks and oils will then enter water drain and go to the interceptor. A new wall was constructed and the oil pipelines were fixed to this	Mine Manager
15	Subsidence of Drummond mine following groundwater ingress	4	Continual monitoring of mine stability during operations. Mining in Drummond is carried out and pillars are 6m X 6m to allow for appropriate stability following natural groundwater ingress into the Drummond mine after cessation of mining activities.	Mine Manager
10	Fire on site	3	A fully trained emergency response team is on site. Fire abatement equipment throughout the site. Lagoons will retain generated firewater.	Mine Manager

Risk ID	Potential Risk	Risk Score	Mitigation Measure	Owner
3	Collision with diesel tanker	4	Traffic management plan including speed limits on site. Staff and driver induction training. No further mitigation.	Mine Manager
18	Emission at MSE1 with sulphate concentrations that exceeds the permitted limit as per IED licence P0519-03	4	The 2018 incident involved the striking of a fissure – surveying works for underground operations are continual and the operations in the area where the fissure occurred are not currently worked. Assessment of the likelihood of a further ingress of water to the mine is considered low. See Piteau report (appendix 1)	Mine Manager
20	Repeat of fissure strike in Drummond underground mine	4	The Drummond mine was geologically re-evaluated by Saint Gobain UK mining services. Future exploration boreholes will increase the knowledge of faults and fissures within Drummond mine. Ongoing probe drill still continues as part of Drummond production cycle. Assessment of the likelihood of a further ingress of water to the mine is considered low. See Piteau report (appendix 1)	Mine Manager
16	Mine Water ingress with Sulphate concentrations that exceed the licensed emission limit	4	The 2018 incident involved the striking of a fissure – surveying works for underground operations are continual and the operations in the area where the fissure occurred are not currently worked. Assessment of the likelihood of a further ingress of water to the mine is considered low. See Piteau report (appendix 1)	Mine Manager
5	Failure of drum storage bunds	3	Bund integrity testing every 3 years. Emergency Response team on site. Tank in good condition and separated from other site activity meaning that risk of collision reduced. Extension of hardstand area around the oil and drum storage bund and upgrade of interceptor to Class 1 has further reduce this risk	Mine Manager
6	Failure of chemicals and oil drums	3	Oils and chemicals drums are supplied by the manufacturers of the oils/chemicals and the supplier is required to meet legislation ensuring that they are in good condition and fit for purpose. Oil and chemical drums are stored in a banded structure. Bunds are integrity tested. No further action recommended.	Mine Manager

Risk ID	Potential Risk	Risk Score	Mitigation Measure	Owner
9	Overtopping of lagoon walls	3	Risk of water run-off contaminating waterways and River Bursk. The lagoon system is a good distance from the River Bursk and this event is most likely in times of flood when the dilution factor offered by the river is highest.	Mine Manager
1	Diesel Bund/Tank failure	3	Bund integrity testing every 3 years. Emergency Response team on site. Tank in good condition and separated from other site activity meaning that risk of collision reduced. The upgrade of interceptor to Class 1 and hydrostatic testing of this bund in 2020 further reduced this risk	Mine Manager & EHS Department.
19	Failure of Bulkheads in underground mine	2	The current water flow from behind the bulk head is not under pressure however monitoring of water flow volume is ongoing. The future plan for the ongoing operation of the bulk head is to allow no build up of water pressure behind the bulk head. The bulk head does not retain water and does is not operated to allow a head of water to build up behind it.	Mine Manager

8.0 Worst Case Scenario Identification & Costings

Table 11: Worst Case Scenario – Based on Risk with Highest Consequences occurring in trigger type event

Scenario	Description	Quantity	Unit	Unit Rate (€)	Cost (€)	Source of Unit Rates
Response to Risk IDs 3, 8 and 10 occurring together in a trigger type effect. If a diesel tanker ruptured, the interceptor could be overloaded causing lagoon contamination. A fire could occur due to the collision. The automated shutoff valve for the MSE1 emission is not designed to detect oil contamination. This could lead to emission of water containing oil contaminating the River Bursk downstream of MSE1.	Fire Fighting	5 x 3 fire units	Hours	See Note 1	€7,028	Fire Service confirmed charges.
	Transport of Firewater from lagoons	1293	m ³	€108	€141,334 Notes 2 and 3	Volume of firewater from 2016 firewater study
	Disposal of Firewater	1293	m ³	€176	€232,785 Notes 2 and 3	Volume of firewater from 2016 firewater study
	Decontamination of the lagoons	3	tanks	€2,720	€8,362	Industry Standard
	Disposal of Decontaminated Water from the lagoons	15	IBCs	€626	€9,612	Industry Standard
	Consultancy fees	15	Days	€628	€9,645	Industry Standard and current provider rate
	Decontamination of interceptor	3	bunds	€2,134	€6,558	Industry Standard
	Disposal of material for the decontaminated interceptor	3	IBCS	€626	€1,923	Industry Standard
	Disassembly and demolition of damaged fixed plant and buildings	2	weeks	€5,333	€10,931	Industry standard
	Haulage of demolition materials	5	Container	€374	€1,914	Cost of 40ft container
	Cleaning of drains and Interceptor	24	Man hours	€108	€2,623	Contractor man hour costs
Disposal of wastewater from cleaning drains and interceptor	5	IBCs	€626	€3,203	Industry Standard	

Removal and treatment of contaminated soil from areas immediately around lagoons	20	Tonnes	€534	€10,931	Industry standard
Transport of contaminated soil from areas immediately around lagoons	20	Tonnes	€22	€437	As per ELRA costing guidance
Ground Contamination – Soil Survey	12	Trial Pits	€97	€1,181	EPA ELRA guidance
Analysis of Trial pit samples (parameter TPH & DRO)	12	Samples	€108	€1,311	Current provider
Groundwater monitoring of existing wells (14 wells)	56 (4 x monitoring events)	Wells	€3,520 (per round of 14 boreholes)	€14,427	Current provider
Groundwater monitoring report	1	Report	€2,987	€3,061	Current provider
Excavation of Contaminated Soil around Workshop	2	Days	€1,601	€3,279	Based on Contractor providing mini digger and 3 general operatives – As per ELRA costing guidance
Transport of Contaminated Soil around the workshop area	30	Tonnes	€22	€656	As per ELRA costing guidance
Treatment of Contaminated soil from around the workshop area	30	Tonnes	€22	€656	As per ELRA costing guidance
Administration costs for transport and removal of contaminated soil	1	Event	€534	€546	As per ELRA costing guidance

Clean up of Riparian zone on River Bursk downstream of MSE1 up to CP1 (70 metres)-removal of soil and vegetation contaminated with oil	2	Days	€1,601	€3,279	Based on Contractor providing mini digger and 3 general operatives – As per ELRA costing guidance
Transport and disposal of material removed from River Bursk riparian zone	150	Tonne	€22	€3,278	As per ELRA costing guidance
Restocking of fish in River Bursk – polluter pays principle	10	1,000 Mixed sex Brown Trout Autumn Yearlings	€214	€2,185	Information from Inland Fisheries Ireland
Extra Surface water Monitoring	20	Samples	€108	€2,185	Based on 10 x daily samples upstream and downstream for TPH and DRO analysis as per current lab provider costs
Environmental consultancy and ecology report pre and post clean-up of River Bursk.	100	Hours	€210	€21,433	Case 3 study of Environmental Liabilities Directive
Administration costs and man hour costs incurred by the local authority and the EPA following an incident	200	Hours	€108	€21,433	Estimated hourly rate and five people working for 5 days
Total				€526,195	
Total + 20%				€631,434	

The costs presented in table 11 are based on the 2020 cost of remediation measures plus a 2.5% per annum increase for inflation. Costs are based on real, current estimated costs from suppliers and relevant bodies as illustrated in the notes below. A contingency of 20% has been allowed on the estimated total costs to allow for any item being under estimated, increases in costs/charges and to future proof the ELRA until next reviewed in 12 months time. No VAT has been applied to the ELRA costings as communicated by the EPA.

Note 1: *Fire Service charges are €638 for the first hour regardless of how many units attend and then €507 per hour per unit after the first hour. The total cost is based on a fire that burns for up to 5 hours and is attended by three fire fighting units based on information from Monaghan Fire Services*

Note 2: *Transport of bulk tank is €2,300 per bulk tank based on 22 tonnes equivalent to €106 per tonne.*

Note 3: *Cost based on volume of firewater generated from the 2016 Firewater Retention Study calculated at 1,293m³ of total firewater.*

Note 4: *Compensatory costs for neighbours in the event of a large land subsidence recurring is not included as the recurrence of such an event is not anticipated and the risk scoring for this risk is low. The insurance cover in place will meet any such compensatory claims in the unlikely event of a land subsidence incidence occurring.*

9.0 Conclusion

An Environmental Liabilities Risk Assessment has been carried out for the activity in accordance with EPA guidance.

The Financial Provision has been based on the combined risks that pose the worst case scenario. This is the maximum liability that may be incurred and as such, financial provision is calculated as **€631,434** (including a 20% contingency) based on this event.

Saint Gobain (Mining) Ireland Ltd. has made the necessary financial provision to cover this liability by means of a public and product liability policy to a limit of €5 million. Confirmation of this insurance is included as Appendix 2 of this ELRA.

Many of the highest scoring risks identified in this ELRA involve a failure of key infrastructure such as pipelines, interceptors and bunds. Some key infrastructural works were conducted in 2020 which reduced the likelihood and consequences of these associated risks.

The risk management of activities at the mine is a dynamic process and will be updated through the addition of new risks or the omission of redundant risks. The Financial Provision will be reviewed annually in accordance with the requirements of Saint Gobain (Ireland) IED licence granted by the EPA to ensure that the financial provision continues to cover the environmental liabilities.



David Kelly BSc. MSc.
Director & Technical Manager
KD Environmental Ltd.

8th April 2021

Appendix 1

Piteau Associates – Hydrogeology Report

HYDROGEOLOGY STUDY OF KNOCKNACRAN OPEN CAST AND DRUMGOOSAT AND DRUMMOND UNDERGROUND MINES



Prepared for

SAINT-GOBAIN MINING IRELAND (LTD.)

February 2020

PROJECT 4238-R1

Piteau Associates
Canon Court West
Abbey Lawn
Shrewsbury
SY2 5DE
United Kingdom

CONTENTS

List of figures	ii
List of tables.....	iii
List of appendices	iv
1. Introduction.....	1
1.1 Background.....	1
1.2 Site description.....	1
1.2.1 Climate	1
1.2.2 Topographic setting	1
1.2.3 Surface water drainage.....	2
1.2.4 Mining.....	4
1.3 Objectives	5
1.4 Available information	5
2. Geology	7
2.1 Stratigraphy.....	7
2.2 Superficial deposits.....	11
2.3 Geological structure	11
2.3.1 Regional structures.....	11
2.3.2 Palaeokarst.....	12
3. Hydrogeology.....	14
3.1 Main aquifer units	14
3.2 Groundwater vulnerability and recharge.....	16
3.3 Groundwater users	20
3.3.1 Public groundwater supplies	20
3.3.2 Group water supply schemes.....	23
3.3.3 Domestic groundwater supplies	23
3.3.4 Mine water storage	23
3.4 Groundwater levels.....	24
3.4.1 General.....	24
3.4.2 Superficial deposits.....	29
3.4.3 Kingscourt Gypsum Formation.....	30
3.4.4 Namurian sandstone and Westphalian shale	34
3.4.5 Drawdown.....	35
3.5 Groundwater chemistry	37
4. Mine water management	41
4.1 Inflow sources.....	41
4.1.1 Drummond Mine	41
4.1.2 Knocknacran open cast	41
4.1.3 Drumgoosat workings	42
4.2 Pumping and water management	42

4.3	Water balance model	44
4.3.1	Reported flows	44
4.3.2	Estimated flows	44
4.3.3	Drumgoosat underground	45
4.3.4	Drummond underground	46
4.3.5	Drummond south end inflow	47
4.3.6	Knocknacran open cast	51
5.	Conceptual groundwater model	51
5.1	Summary of mine inflows	51
5.2	Recharge	51
5.3	Near-surface water table	51
5.4	Groundwater flow	52
5.5	Hydrogeological boundaries	53
5.6	Implications for the R179 and L4900 roads	54
5.7	Implications for the eventual closure of the site	55
6.	Summary and action plan	57
6.1	Hydrogeology	57
6.2	Potential impacts	57
6.3	Eventual site closure	58
6.4	Plan going forward	58
6.4.1	Key issues	58
6.4.2	Monitoring plan	59
6.4.3	Additional studies	59
7.	Limitations	59

LIST OF FIGURES

Figure 1.1: Site location.	3
Figure 1.2: General view of Knocknacran open cast (looking north)	5
Figure 2.1: GSI bedrock geology of the study area (with half-graben cross section)	9
Figure 2.2: Stratigraphy of the Kingscourt Gypsum Formation (Source: Gardiner and McArdle)	10
Figure 2.3: GSI overburden mapping of the study area	13
Figure 3.1: GSI bedrock aquifer units and groundwater supplies	15
Figure 3.2: GSI aquifer recharge mapping	18
Figure 3.3: GSI aquifer vulnerability mapping	19
Figure 3.4: Diagrammatic cross section through the Kingscourt Mullantra PWS (reproduced from CCC, 2011a)	21
Figure 3.5: Diagrammatic cross section through the Kingscourt Descart PWS (reproduced from CCC, 2011 ^b)	22

Figure 3.6: Schematic North-South section through all mines. The figure shows the location of the R179 and L4900 roads	24
Figure 3.7: Groundwater monitoring well locations	25
Figure 3.8: Groundwater monitoring well stratigraphical positions (Source: Minorex, 2019)	26
Figure 3.9: Currently recorded groundwater levels (November 2019)	27
Figure 3.10: Hydrographs for wells thought to be screened in superficial deposits (till)	30
Figure 3.11: Hydrographs for wells screened in the Upper Mudstone Member	31
Figure 3.12: Hydrographs for wells screened in the Upper Gypsum Member	32
Figure 3.13: Hydrographs for wells screened in the Middle Mudstone Member (including dolerites)	33
Figure 3.14: Hydrographs for wells screened in the Lower Gypsum Member	34
Figure 3.15: Hydrographs for wells screened in Namurian sandstone	35
Figure 3.16: Interpreted monitoring well drawdown from baseline conditions	36
Figure 3.17: Time series plot of Drumgoosat well chemistry	40
Figure 4.1: Sketch map showing inflows to the Drummond mine (November 2019)	41
Figure 4.2: Good surface runoff management practices at the Knocknacran open cast, including plating of the bench faces and drainage of the benches	42
Figure 4.3: Estimated mine water balance 2017 to 2019	46
Figure 4.4: Current groundwater levels around the south end of Drummond mine	48
Figure 4.5: North-south cross section through the south end of Drummond mine	49
Figure 4.6: East-west cross section through the south end of Drummond mine	49
Figure 4.7: Location of the cross sections at the south end of Drummond mine	50
Figure 5.1: Water levels in the Drumgoosat workings from January 2018 to June 2019 (note that water levels on the y-axis are mine level – maODM plus 1,000 m)	54
Figure 5.2: Extent of inundation in the Lower Seam close to the R179 with a water level of -37 maODM (left) and -6 maODM (right)	55
Figure 5.3: Water balance model results showing post-mining water level recovery	56

LIST OF TABLES

Table 1-1 Monthly mean precipitation and potential evapotranspiration	2
Table 3-1 Recent groundwater levels in all available monitoring wells	28
Table 3-2 Water levels for South Drummond area monitoring points	29
Table 3-3 Summary of groundwater quality	39
Table 3-4 Sample results from the Drumgoosat well and the south mine inflow water	40
Table 4-1 Estimated groundwater inflows to the Drumgoosat Workings based on 1991 records	

LIST OF APPENDICES

Appendix A: Minerex 2018 Annual Monitoring Report

Appendix B: Preliminary mine site water balance 2017 to 2019

1. INTRODUCTION

1.1 BACKGROUND

This report has been prepared by Piteau Associates for Saint-Gobain Mining Ireland (Ltd.) (SGMI). It describes the assessment undertaken to develop a conceptual hydrogeological model for the infiltration of surface water and the flow of groundwater around and into the Drumgoosat and Drummond underground mines and Knocknacran open cast, Co Monaghan.

The study includes all available geology, groundwater and surface water information for the sites, including the information contained in reports by Minerex (2019), SLR (2019), SGMI (2019) and SRK (multiple dates).

Monaghan County Council (MCC) has requested that a hydrogeological report is prepared according to a scope defined by ARUP consulting which collates all relevant hydrogeological information for Drumgoosat and Drummond underground mines, and the existing Knocknacran open cast mine. This report has been prepared according to the ARUP scope.

The report was presented in draft to MCC, EMD and the EPA at a meeting in the MCC offices on 10th December, 2019. The PowerPoint presentation was distributed to all attendees after the meeting. Verbal and written comments from the agencies have been incorporated into this final version of the report.

1.2 SITE DESCRIPTION

1.2.1 Climate

Precipitation records from the site between 1990 and 2019 show that the annual average rainfall is 955 mm. Dunsany synoptic station (45 km south of the site) has an annual average potential evapotranspiration of 515 mm (2016 to 2019).

Table 1-1 presents the monthly mean values for precipitation and evaporation. As is typical in Ireland, the wettest months coincide with the months of lowest potential evapotranspiration (October to January). The driest months with highest potential evapotranspiration are May and June.

1.2.2 Topographic setting

The topography of the area is gently undulating with a general fall from west to east. The area of the site has an elevation of between 40 and 50 maODM (metres above Ordnance datum, Malin) which is also typical of the area to the east. The elevations gradually increase to the

west, to a ridgeline (and surface water catchment divide) which reaches around 250 maODM about 8 km to the west of site.

The lowest topography close to the study area occurs around the River Bursk (between 25 and 32 maODM). The River Lagan near the south end of the Drummond mine is about 32 maOD, which is considered to be the hydrogeological base level for the mining district.

Table 1-1 Monthly mean precipitation and potential evapotranspiration

Month	Precipitation (mm/mon)	Potential Evapotranspiration (mm/mon)
January	94.9	11.3
February	74.9	17.7
March	72.8	32.3
April	66.1	49.2
May	64.4	78.1
June	67.9	84.9
July	73.3	87.1
August	77.3	67.3
September	64.4	45.6
October	96.5	25.2
November	98.8	9.1
December	103.6	9.4
Total	954.9	514.5

1.2.3 Surface water drainage

The three primary local surface water courses are (Figure 1.1):

- Magheraclone Stream which runs north to south along the western boundary of the site;
- River Bursk (also known as River Rahans) which runs north to south along the eastern boundary and which receives discharge from the site;
- River Lagan (also known as the River Glyde) receives water from both the Magheraclone and Bursk and flows from west to east to the south of the site.

The Corduff Stream also rises in the area above the Drumgoosat mine and flows north to Lough Fea, about 2 km northeast of site (Figure 1.1). Lough Fea is part of the River Bursk catchment. The Bursk flows south into Bursk Lough, then Rahans Lough, and then into the River Lagan. Bursk Lough is also fed by Descart Lough.

The Bursk drainage area is low lying, the loughs along its course have the following areas and elevations:

- Lough Fea is 30 ha in area, elevation of 32 maODM;
- Bursk Lough is 2 ha in area, elevation of 25 maODM;

1.2.4 Mining

The main area of study includes two operational mines and one closed underground mine. The mines have a general north-south alignment along the strike of the Kingscourt gypsum formation (Figure 1.1). The key features of each mine are as follows:

- Drumgoosat underground mine is located in the north of the study area. It was operational between 1963 and 1989. It is up to 100 mbgl depth and has an aerial extent of around 1,700 m × 800 m (80 ha). Pumping records for the mine during operations indicate groundwater inflows were seasonally variable between 20 m³/d in September to 870 m³/d in March. The mine was used to temporarily store excess water from the Drummond underground mine up to the time of the subsidence event on 23/24 September 2018. The northeast part of the Knocknacran open cast is underlain (and quarries into) the southern-most workings of the Drumgoosat underground.
- Drummond underground lies in the southern part of the study area. It has been operational from 2006 to 2008, and from 2013. It extends to about 155 mbgl depth and currently has an aerial extent of around 1,300 m × 300 m (38 ha). Inflows to the Drummond mine have historically been between 1,400 and 2,200 m³/d. In June 2018, the mine workings intersected a fault one, known as the 'June 2018 mine fault'. Inflows from the fault were initially estimated to be around 12,000 m³/d but reduced quickly, and have since reduced to around 1,200 m³/d.
- Knocknacran open cast is in the centre of the mining area. Geological strata exposed in the open cast include overburden, the Upper Gypsum Member, bands of dolerite, mudstone and the Lower Gypsum Member (see Section 2.1). The mine has been operational since 1988 and includes excavation into the southeast third of the Drumgoosat workings. It is currently about 70 m deep (lowest floor elevation about -3 maODM) and has an aerial extent of around 1,110 m × 500 m (55 ha). A general view looking north is shown in Figure 1.2. Sump pumping rates from the mine are not recorded but estimates indicate that they range seasonally between about 10 m³/d in September (low groundwater flow only) and 950 m³/d in April (mostly surface water runoff).

In addition to the three mines within the main area of study, there are two historic underground mines located to the south of the existing Drummond mine. The Cormey mine was worked between 1952 and 1961. It included two shafts, both of which are now capped, but monitoring of water levels can be carried out in '1998 – Cormey Shaft'. Further to the south, the Drumgill mine was worked in the middle part of last century.

Inflows to the current two operating mines are pumped into the site water management system. Some of the higher flows were pumped for storage in the Drumgoosat workings. A well into the Drumgoosat workings is operated to maintain water levels in the interconnected mine area.

All water from the site is pumped to the 'southeast lagoons' from where it is discharged to the River Bursk at the licensed discharge point to the southeast of Knocknacran open cast (Figure 1.1). The license states that a maximum of 12,240 m³/day can be discharged. The discharge of

mine water is automatically adjusted depending on the available flow and assimilative capacity in the river to ensure that water quality standards are not exceeded.

Figure 1.2: General view of Knocknacran open cast (looking north)



1.3 OBJECTIVES

This report details the review of available geological and hydrogeological information alongside the water monitoring database (water levels, surface water and groundwater quality) to:

- Develop a conceptual hydrogeological model for the infiltration of surface water and the flow of groundwater in the mining district;
- Evaluate groundwater conditions to support an assessment of the future stability of the portion of the closed Drumgoosat mine that lies below the R179 and L4900 roads.
- To address issues from the EPA email of 19th December

1.4 AVAILABLE INFORMATION

The information used to compile this report has included mapping datasets, timeseries monitoring data and reports. The key data are summarised as follows:

- SGMI mapping of geological structures;
- Geological Survey of Ireland (GSI) online mapping datasets;
- Location of third-party wells (Golder 2019 survey);

- Environmental monitoring wells – location and geological zone of monitoring, monthly water level data and monthly water chemistry data;
- Drummond pumping log – daily flow data from January 2010 to November 2019; and
- Drumgoosat dewatering well – spot flow measurements from October 2017 to November 2019.

Several pertinent reports are available for the area. Key reports and their conclusions are summarized as follows:

- Drummond Mine Environmental Impact Statement (2003) and Knocknacran Environmental Impact Statement (2017).
 - Geology and water chapters outlining the current and anticipated conditions at the site in relation to previous development projects
- Minerex, 2019a. Annual Groundwater Monitoring Report for Mine and Processing sites for 2018.
 - Presentation of the data collected through 2018 and its interpretation as part of the SGMI environmental permit conditions.
- Minerex, 2019b. Drummond Mine Water Ingress: Assessment of Impact on Groundwater Resources -Rev 1, June 2019. Doc. Ref.: 1632-2093 (Rev 3).
 - Presentation of the data collected in relation to the intersection of June 2018 mine fault in 2018, revaluation of the conceptual model and recommendations regarding management of the water.
- SLR, 2019. Drummond Mine Dewatering Plan (2019 to 2020) SLR Ref: 190311.501.00545.0004.
 - Water management plan for the SGMI site (not only Drummond mine) including dewatering projections, storage and treatment requirements.
- CCC, 2011a. Cavan County Council. Establishment of groundwater source protection zones – Kingscourt Water Supply Scheme, Mullantra Borehole (May 2011).
 - Hydrogeological conceptual model and groundwater supply source zone definition.
- CCC, 2011b. Cavan County Council. Establishment of groundwater source protection zones – Kingscourt Water Supply Scheme, Descart Boreholes (April 2011).
 - Hydrogeological conceptual model and groundwater supply source zone definition.

2. GEOLOGY

2.1 STRATIGRAPHY

The geology of the district has a strong north-south strike, as illustrated in Figure 2.1. The study area is located on the Kingscourt Outlier, a half-graben structure formed of Carboniferous and Permo-Triassic rocks. The Kingscourt Fault forms the western boundary of the Kingscourt Outlier.

Extensive underground mining has historically taken place in the gypsum deposits of the Kingscourt Outlier. The mines extract gypsum from the Permian-age Kingscourt Gypsum Formation, which consists of mudstone with gypsum and anhydrite. The gypsum deposits occur within a north-south striking band, approximately 1.2 km wide and 12 km long. The sandy mudstones and red-brown mudstones of the formation are up to 550 m in thickness and contain two distinct beds of gypsum and anhydrite in the lower portion. These deposits form a cap on the north-south trending Carboniferous outlier within the Lower Palaeozoic Longford Down Massif.

The study area contains five primary stratigraphic units. These are summarised (from youngest to oldest) as follows:

- **Kingscourt Sandstone Formation** – outcrops to the east of the Kingscourt Fault and is the youngest formation of the sequence. This part of the sequence comprises a siltstone member (between 80 to 100 m in thickness), conformably overlain by Lower Triassic red-beds sandstone (up to 300 m thick), which typically comprises deep beds with parallel and cross lamination.
- **Kingscourt Gypsum Formation** – is a mudstone unit with two distinct mineralised beds. The provenance of the gypsum suggests deposition of sediments when arid deserts were occasionally encroached upon by the sea, which then evaporated to precipitate thick deposits of evaporite minerals. Figure 2.2 presents the stratigraphy of the formation which is typically divided into five units.
 - *Lower Mudstone Member* is a transitional mudstone which grades up into the Lower Gypsum from 50% gypsum to good quality gypsum.
 - *Lower Gypsum Member* and anhydrite bed is up to 35 m in thickness and is grey in colour. Above the transition zone with the Lower Mudstone, it comprises a thickly bedded, high quality white to grey nodular gypsum that has been the target of underground mining. This, in turn, transitions upwards into good quality, light brown laminated gypsum with rhythmic banding, which gradually changes to creamy pink or red further up the succession. Next are banded magnesium-rich gypsum layers which can be high in carbonates and show signs of being heavily leached by groundwater. Massive white gypsum is the upper-most section of the Lower Gypsum unit. Sub-outcrop of the Lower Gypsum Member

underlies the Knocknacran open cast area, from the settlement ponds in the east to the extent of Drumgoosat underground workings in the north.

- *Middle Mudstone Member* is a band of mudstone that separates the upper and lower gypsum members. It varies between 6 and 12 m in thickness. The member consists of reddish, micaceous, plastic mudstones, with frequent green reduction spots and laminations near the base.
- *Upper Gypsum Member* is a massive, fine grained, grey-brown to red pure gypsum. It is typically red and is thinner than the lower bed, ranging between 6 and 10 m in thickness. Moving upward in the sequence from the massive red gypsum is inter-banded gypsum and red siltstone, coarse gypsum and finally massive gypsum containing very pure and fine grained grey or cream laminated mineral. The Upper Gypsum subcrop only underlies the western side of the Knocknacran open cast and is well exposed in this location.
- *Upper Mudstone Member* the Upper Gypsum is overlain by the Upper Mudstone, which is between 26 and 36 m in thickness.
- Namurian sandstones of the **Cabra Formation, Corratober Bridge Formation, Clontrain Formation and Carrickleck Formation** – underlying the Kingscourt Gypsum formation and outcropping to the east of eastern-most fault within the graben structure. The formations comprise Namurian-age (Carboniferous) sandstones and interbedded shales. These are poorly cemented and typically very weathered. This tends to result in increased permeability.
- **Carrickleck Sandstone Member** – the basal member of the sandstone sequence. It is distinguishable from the Carrickleck Formation as being buff-coloured ferruginous sandstone.
- **Milverton Group** – Underlying the Carrickleck Sandstone Member and outcropping further to the east, the Milverton Group comprises Dinantian pure bedded limestone. The limestone within this group is extensively karstified with numerous features including caves, enclosed depressions, springs, swallow holes and turloughs.
- **Dolerite and basalt sills** are also present in the Kingscourt sequence. The sills are have been described as being conduits for water, having been hydrothermally altered during intrusion, making them susceptible to weathering and incompetent in places. The primary intrusion is a fine grained homogeneous basalt between the upper and lower gypsum beds, in the Middle Mudstone. The intrusion reaches a maximum thickness of 60 m. It has undergone extensive near-surface lateritic weathering and hydrothermal alteration, and is weathered to a fine grained sand in places. The dolerite sill chiefly occurs to the east of the orebody and thins out towards the west, with the dip of the gypsum beds. There is a secondary intrusion (8 m in thickness) that is typically confined to the Lower Mudstone.
- **Castlerahan Formation** outcrops to the west of the Kingscourt Fault. This Silurian-aged massive quartzo-greywacke has been thrust upwards along the Kingscourt Fault to juxtapose the Permian Kingscourt Sandstone Formation.

- **Westphalian Shales** outcrop to the north of the site are consisting of grey to black shale and carbonaceous or pyritous, thin bedded siltstones and fine grained sandstones. In addition, minor thin beds of coal may be present.

Figure 2.1: GSI bedrock geology of the study area (with half-graben cross section)

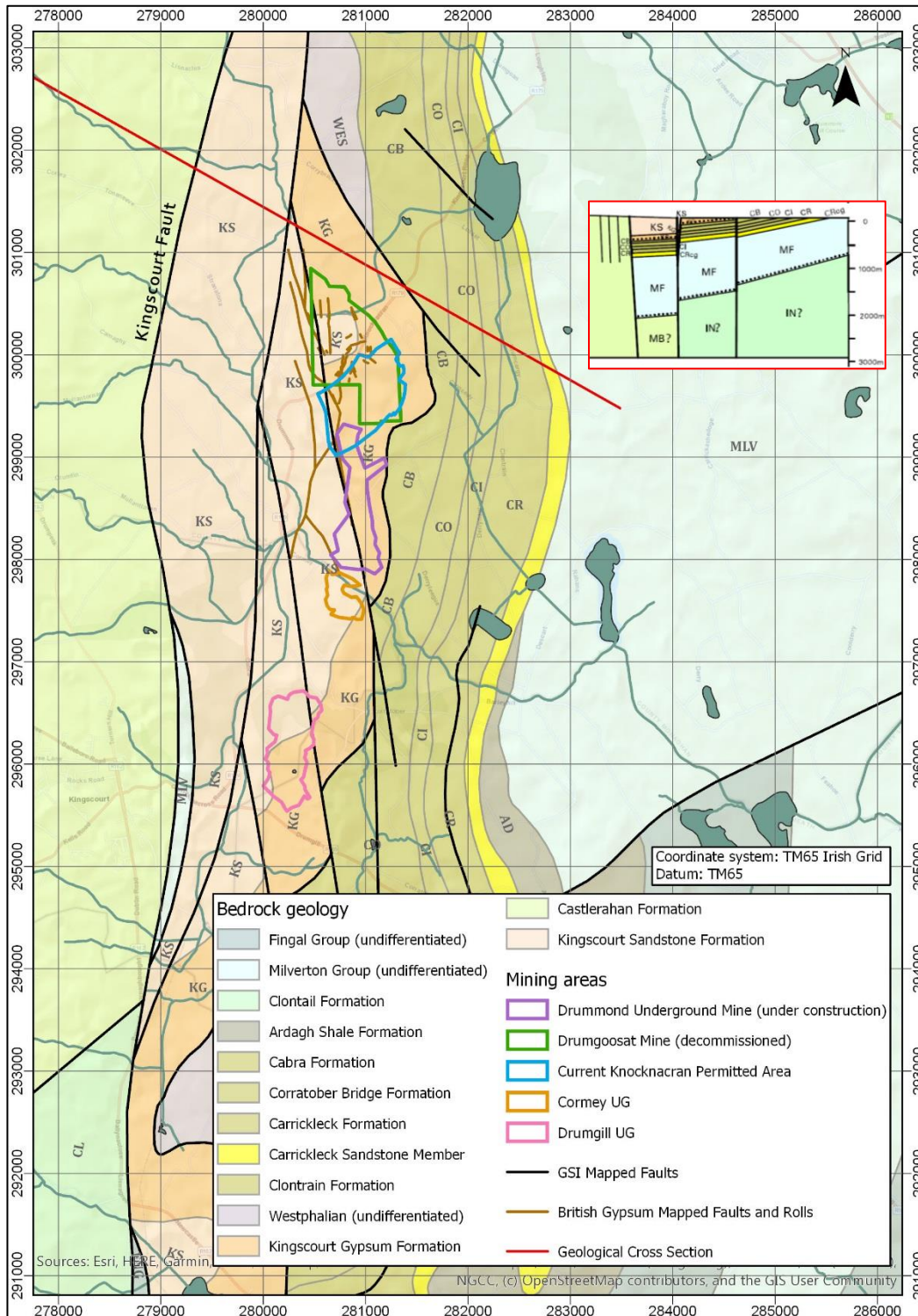
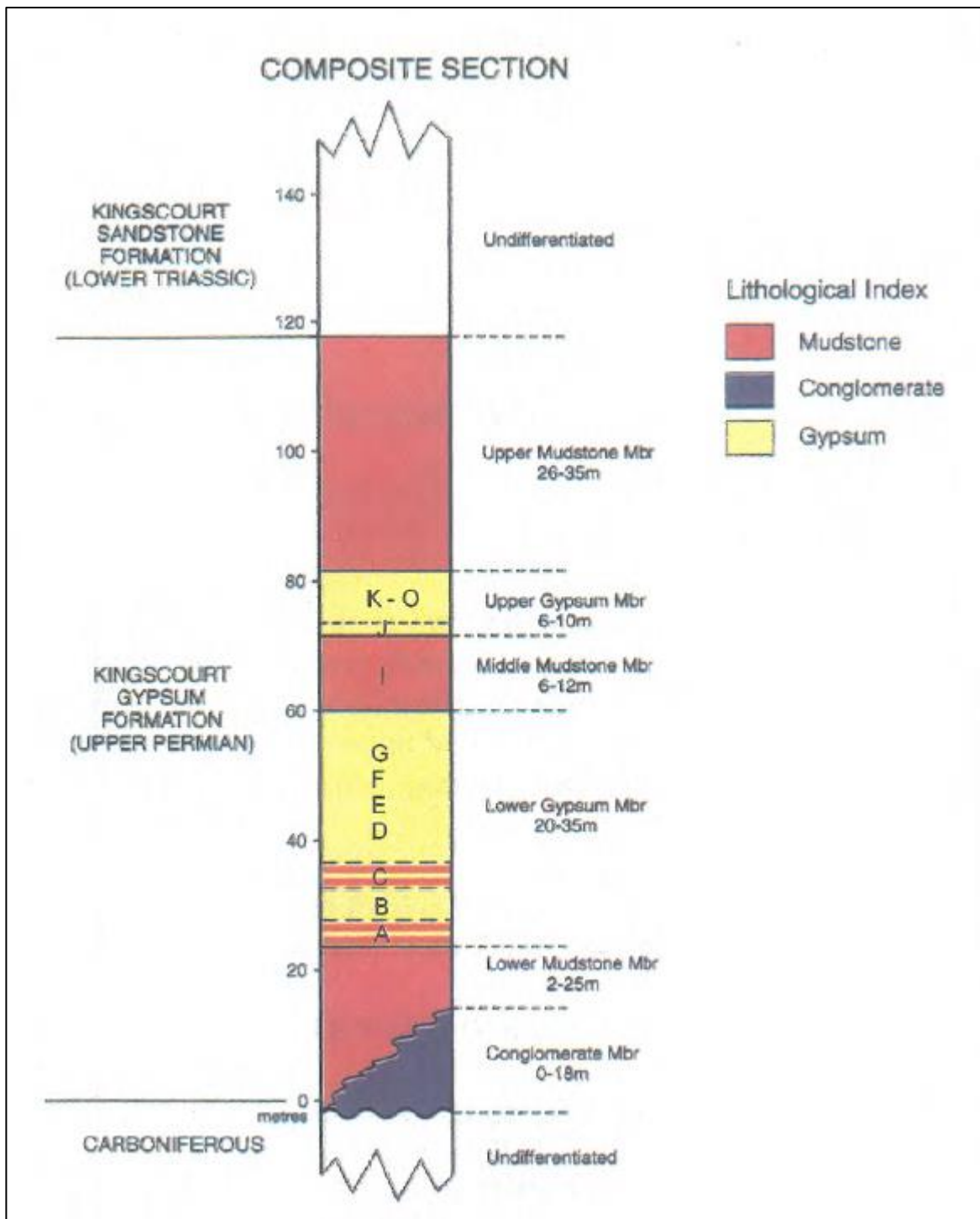


Figure 2.2: Stratigraphy of the Kingscourt Gypsum Formation (Source: Gardiner and McArdle¹)



¹ Gardiner, P.R.R. and McArdle, P., 1992. The geological setting of Permian gypsum and anhydrite deposits in the Kingscourt district, Counties Cavan, Meath and Monaghan. in Bowden, Earls, O'Connor & Pyne (eds.) 1992. The Irish Minerals Industry 1980-90. IAEG, pp 301-316.

2.2 SUPERFICIAL DEPOSITS

The area surrounding the site is principally underlain by till (also known as Boulder Clay) which is predominantly derived from the Lower Palaeozoic sandstones and shales that comprise the underlying bedrock (Figure 2.3). The thickness of the superficial deposits is variable across the area. Thicker till layers are observed at the higher points of the terrain (drumlins), with overburden thickness reaching about 50 m. Away from the drumlins, the overburden can be as thin as 1 m, with areas of bedrock outcrop seen to the east of the site (i.e. there is no overburden present). The average overburden thickness is 13 m according to drill hole logs and the Geological Survey of Ireland (GSI) National Well Database.

To the east, the till is derived from limestones and, to the southeast, tills originating from Namurian sandstones and shales dominate (reflecting the different underlying bedrock geology). Grey brown podzolic and associated gley soils typically comprise the upper portion of the overburden, especially in areas of limestone glacial till (according to the National Soil Survey). Drumlin landscapes are typically characterised by drier mineral and organic soils.

The till layers are traversed by glaciofluvial sand and gravel deposits that follow the channels of local watercourses. These deposits are notable along the course of the Magheraclone Stream, running north to south along the western border of the site, and in the channel of the River Lagan, to the south of the site. Some areas of peat are also present in topographic lows, along with some minor pockets of lacustrine sediments throughout the area.

2.3 GEOLOGICAL STRUCTURE

2.3.1 Regional structures

The dominant structural trend in the area is north to south, consistent with the strike of the main stratigraphical units. The Permo-Triassic bedrock occurs in a series of open folds trending in this orientation, and the strata dip with an angle of between 10° and 30° towards the Kingscourt Fault.

The Kingscourt Fault is located about 1.5 km to the west of the site and makes up the western boundary of the Kingscourt Outlier (half-graben). Several other major faults in the sequence also trend north-south but have opposite throws (up to approximately 150 m) which, in combination, form graben-like structures.

Geophysical interpretation by Young (1975)^[1] found two major geophysical trends; a north-south and an approximately northeast-southwest or “caledonoid” direction. These geophysical trends are typically consistent with the mapped geological structure in the Kingscourt Outlier.

Mapping by British Gypsum shows a set of north-south striking faults, corresponding with the major structural orientations of the area. Two major faults have been observed around the Knocknacran open cast. Both have a north-south trend and appear to extend at least as far as the Cormey workings to the south. One underlies the pit along its southwestern margin. The other occurs approximately 500 m to the west. The faults are believed to downthrow the Upper and Lower gypsum beds by around 10 m and 30 m, respectively. Discontinuous groundwater levels have been identified between exploration holes on either side of the fault that underlies the south western margin of the pit. This suggests that the fault acts as a low permeability barrier to groundwater flow.

Roll and fault information for the Drumgoosat area also shows structures primarily following the north-south orientation although some rolls are orientated in a northeast-southwest direction.

Mapping data for the Knocknacran open cast and a number of underground pillar faces has also identified minor faults that appear to form a dendritic pattern through the centre of the pit. Analysis of the data found that the major discontinuities in the gypsum are near vertical and strike north-south and east-west, with less dominant features striking northeast-southwest and northwest-southeast. The shaley units within the gypsum exhibit well developed bedding, with a regional bedding trend between 15° and 30° to the east.

There is no evidence from the underground workings at Drummond or Drumgoosat to suggest the major north-south trending graben structures are important water-bearing features. Rather, the available data suggests they are barriers to groundwater flow across their strike plane.

2.3.2 Palaeokarst

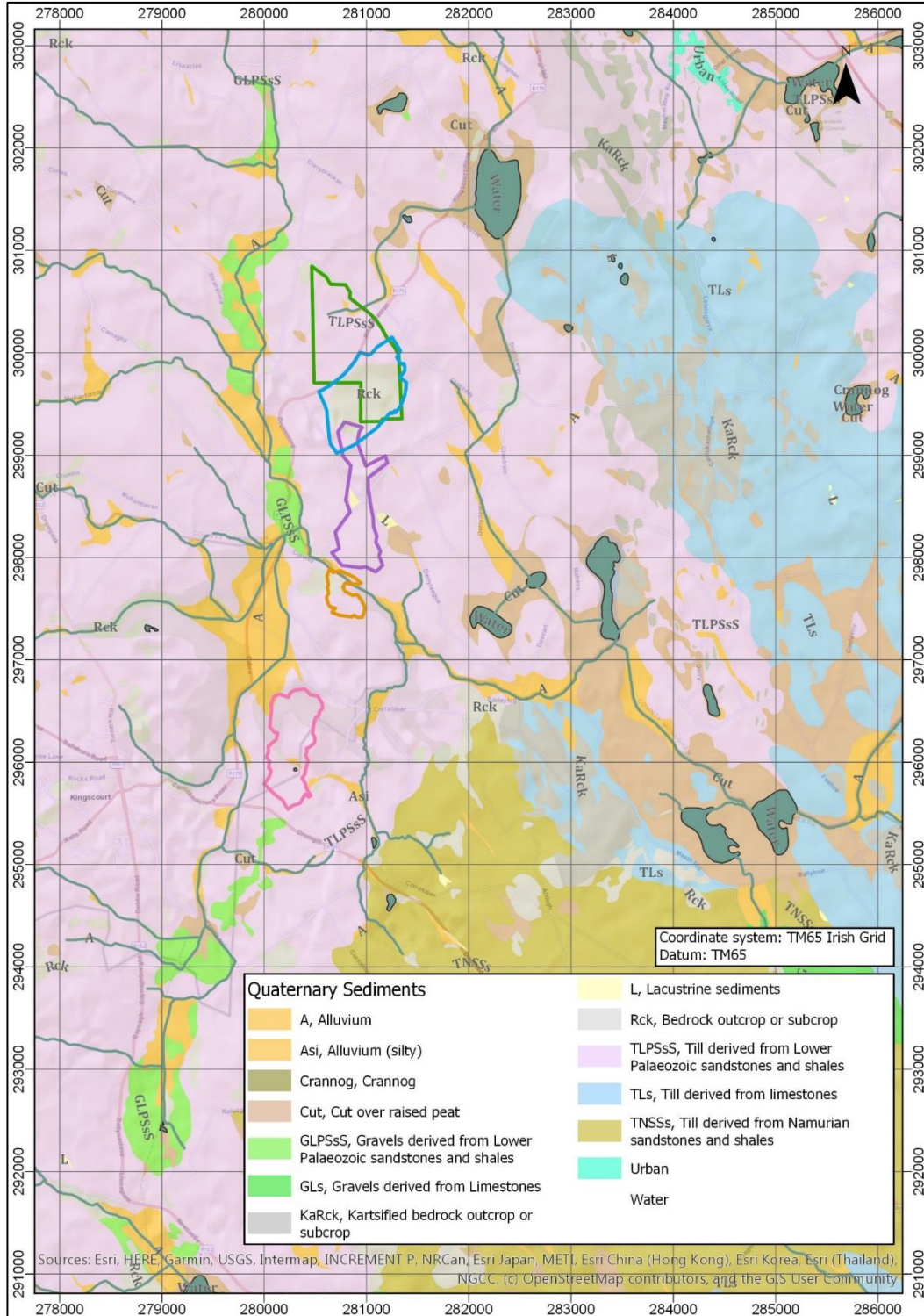
Palaeokarst surfaces are evident on the surfaces of the gypsum beds, with post-depositional solution seen particularly where the existing open cast mine has exposed them to the east of the deposit. The karst surfaces are often mantled by Palaeocene dolerite lava flows of the Antrim Lava Group. Vaughan² suggests that a karst surface and associated cave drainage

^[1] Young DGG (1976) A Geophysical interpretation of the Structural Development of the Kingscourt Graben. Proceedings of the Royal Irish Academy.

² Vaughan APM, Dowling LA, Mitchell, Lauritzen S-E, McCabe AM and Coxon P (2004) Depositional and post-depositional history of warm-stage deposits at Knocknacran, Co. Monaghan, Ireland: implications for preservation of Irish last interglacial deposits. Journal of Quaternary Science Vol 19, pp577-590.

developed in the Permian gypsum before Palaeocene times, however major cave systems have not been observed during mining.

Figure 2.3: GSI overburden mapping of the study area



3. HYDROGEOLOGY

3.1 MAIN AQUIFER UNITS

GSI has carried out aquifer mapping to characterize the groundwater units around the study area (Figure 3.1). According to their interpretation, the principal bedrock aquifer units in the area are:

- **Kingscourt Sandstone Formation** – Permo-Triassic sandstones to the west of the site which are locally important aquifers (“bedrock which is generally moderately productive”);
- **Namurian sandstones** and **Carricleck Sandstone Member** – Namurian sandstones to the east of the site have also been classified as a locally important aquifer;
- **Milverton Group** – Dinantian pure bedded limestones east of the Namurian sandstones are considered to be a regionally important karstified aquifer.

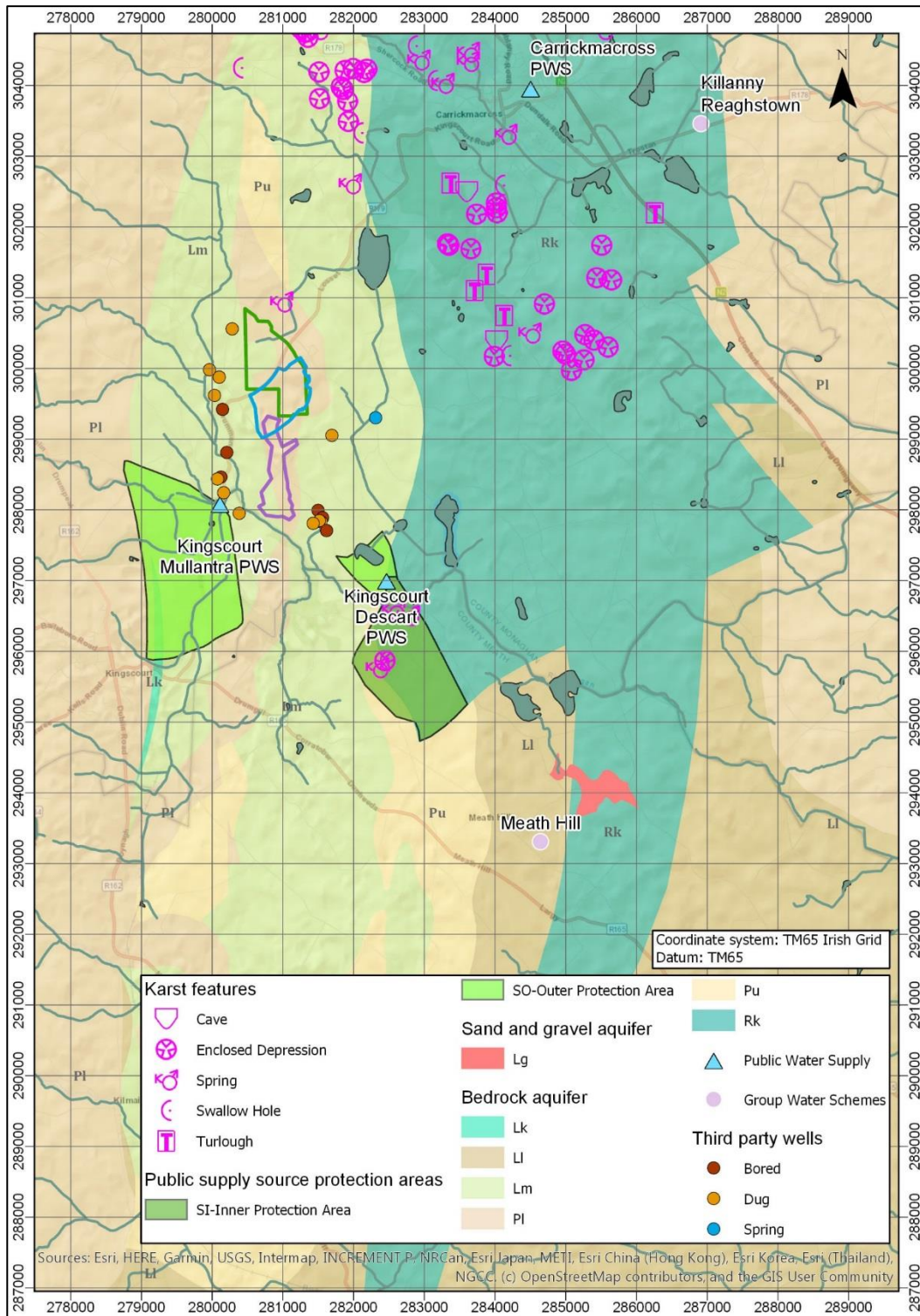
The **Kingscourt Gypsum Formation** (central to the site) and the **Westphalian Shales** to the north are both considered poor aquifers. The GSI describes these as “bedrock which is generally unproductive except for local zones”.

Hydrogeological characterisation of the SGMI mine complex (Minerex, 2019³) also describes the Kingscourt Gypsum Formation gypsum and mudstone members as ‘aquicludes’. Their low permeability restricts the flow of water between aquifer units, despite the evidence of karstification in the gypsum. The dolerites of the formation are considered to be ‘aquitards’, which are characterised by low permeability and low flow rates.

The **Castlerahan Formation** is classified as a poor aquifer and the **Dolerite sills** do not have a designation but have been described as being conduits for water, having been hydrothermally altered during intrusion, making them susceptible to weathering and incompetent in places.

³ Minerex, 2019. Annual Groundwater Monitoring Report for Mine and Processing sites for 2018.

Figure 3.1: GSI bedrock aquifer units and groundwater supplies



3.2 GROUNDWATER VULNERABILITY AND RECHARGE

DELG/EPA/GSI⁴ state that groundwater that readily and quickly receives water (and contaminants) from the land surface is considered to be more vulnerable than groundwater that receives water (and contaminants) more slowly and in lower quantities. The travel time, attenuation capacity and quantity of contaminants are a function of the following natural geological and hydrogeological attributes of the area:

- The sub-soils that overlie the groundwater;
- The type of recharge - whether point source or diffuse;
- The thickness of the unsaturated zone through which the contaminant moves.

All levels of groundwater vulnerability status are observed in the area surrounding the site, as shown in Figure 3.2. Areas of low subsoil permeability provide a protective layer to the groundwater and correspond to a “low” vulnerability designation. Much of the Kingscourt Sandstone Formation to the west of the site shows a “moderate” to “high” designation, with localised areas of “extreme” vulnerability associated with alluvial deposits. The karstified Milverton Group limestones are prevalent to the east of the site and have mostly been assigned “moderate” to “extreme” vulnerability status, with large portions of the area comprising of “rock at or near surface or karst” making it highly vulnerable.

Groundwater recharge in the area is mostly derived from infiltration of precipitation and local runoff. The national groundwater recharge map indicates that natural recharge may locally range between 1 and 800 mm per year (Figure 3.3). This is based on rainfall datasets held by the GSI that include annual rainfall, actual evapotranspiration, soil drainage, subsoil permeability, groundwater vulnerability and bedrock aquifer class.

According to the GSI maps, the recharge within the footprint of the mine area is typically 100 to 200 mm/yr, decreasing to less than 50 mm/yr above Drummond underground. The western margin of the Kingscourt Sandstone Formation is associated with higher recharge, between 350 to 550 mm per year, with small areas of higher (601 to 700 mm) recharge to alluvial gravels.

Recharge in Ireland primarily occurs between October and March when rainfall exceeds evapotranspiration (i.e. when the soil water is at field capacity). From March to October, the opposite is often true when the soil moisture is in deficit. A typical seasonal cycle of the soil moisture balance and recharge may be as follows:

⁴ DELG/EPA/GSI, 1999. Groundwater Protection Schemes. Department of the Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland. Misstear, B. D., Banks, D., and L. Clark. 2006. Water Wells and Boreholes. Wiley & Sons Ltd. ISBN-13: 978-0- 470-87989-7.

- Summer: high rate of evapotranspiration and soil water removal; increasing soil moisture deficit; rainfall events cause near-surface infiltration, but the water is quickly removed from the soil profile by evapotranspiration. Little or no recharge.
- Autumn: high soil moisture deficit, which has been gradually built up over the summer months; infiltration from rainfall events is stored in the near-surface soils, even though evapotranspiration rates are low; little water percolates downward below the extinction depth to recharge.
- Winter: the soil moisture deficit that was built up during the summer months becomes progressively replenished by on-going infiltration due to precipitation events. At some point, the soil moisture deficit is used up, breakthrough occurs, and the percolating water moves downward below the capture zone of the root system. The water is able to move downward below the extinction depth and become recharge to the groundwater system.
- Spring: the soils are fully saturated, and any rainfall or snowmelt is transmitted rapidly downward below the root zone to become recharge. This may also be the period of high water availability, so most or all of the annual recharge may occur during this period. As ambient air temperatures increase, so evapotranspiration rates also rise, and the soil moisture deficit starts to build up as summer approaches.

It should be appreciated that both the annual rainfall amounts, and the seasonal pattern of rainfall, are inherently variable, depending on seasonal precipitation events and longer term cycles. There have been a number of significantly dry or wet periods over recent years. In any one year, the actual recharge is likely to be significantly different from the annual average. Low rainfall in winter may lead to lower than average recharge while a wet spring may produce a large amount of recharge.

Figure 3.2: GSI aquifer recharge mapping

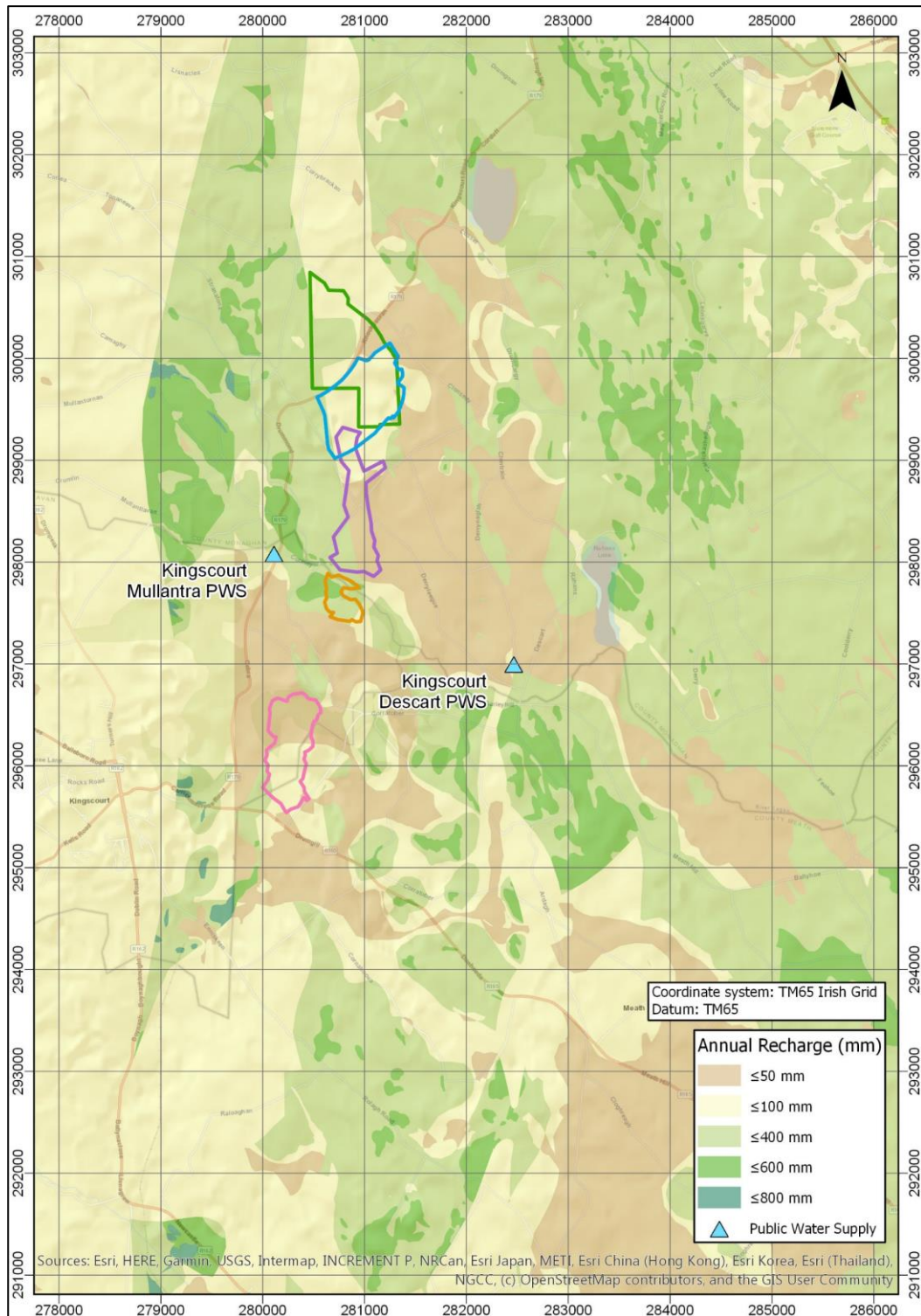
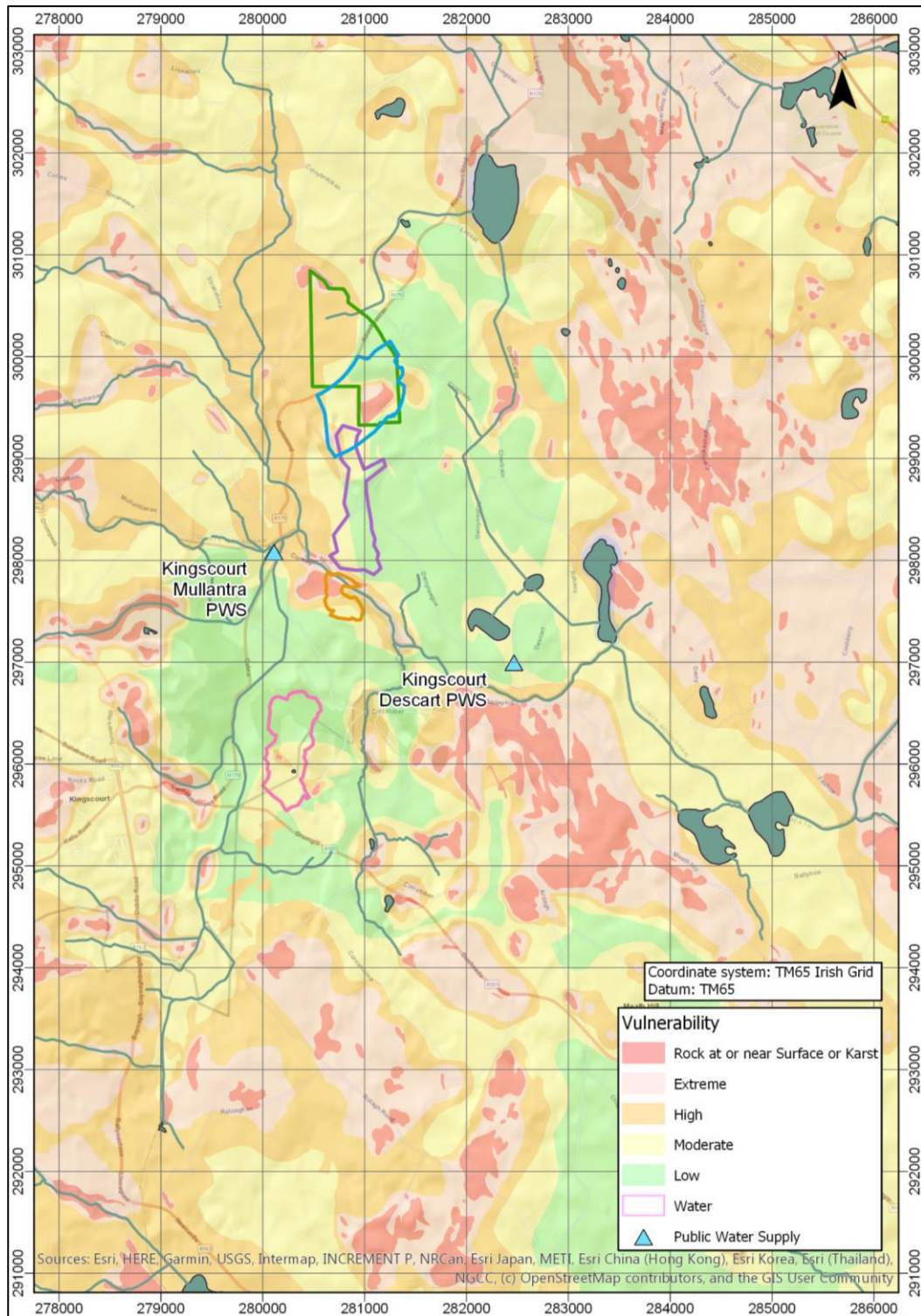


Figure 3.3: GSI aquifer vulnerability mapping



3.3 GROUNDWATER USERS

3.3.1 Public groundwater supplies

Three public groundwater supplies (PWS) are located within 7 km of the study area:

- Kingscourt Mullantra PWS (well name BW01);
- Kingscourt Descart PWS (well names BW02 and BW03);
- Carrickmacross PWS (well names Monanny borehole and Nafferty spring and borehole).

The location of the boreholes and Nafferty spring are shown on Figure 3.1.

Kingscourt Mullantra PWS

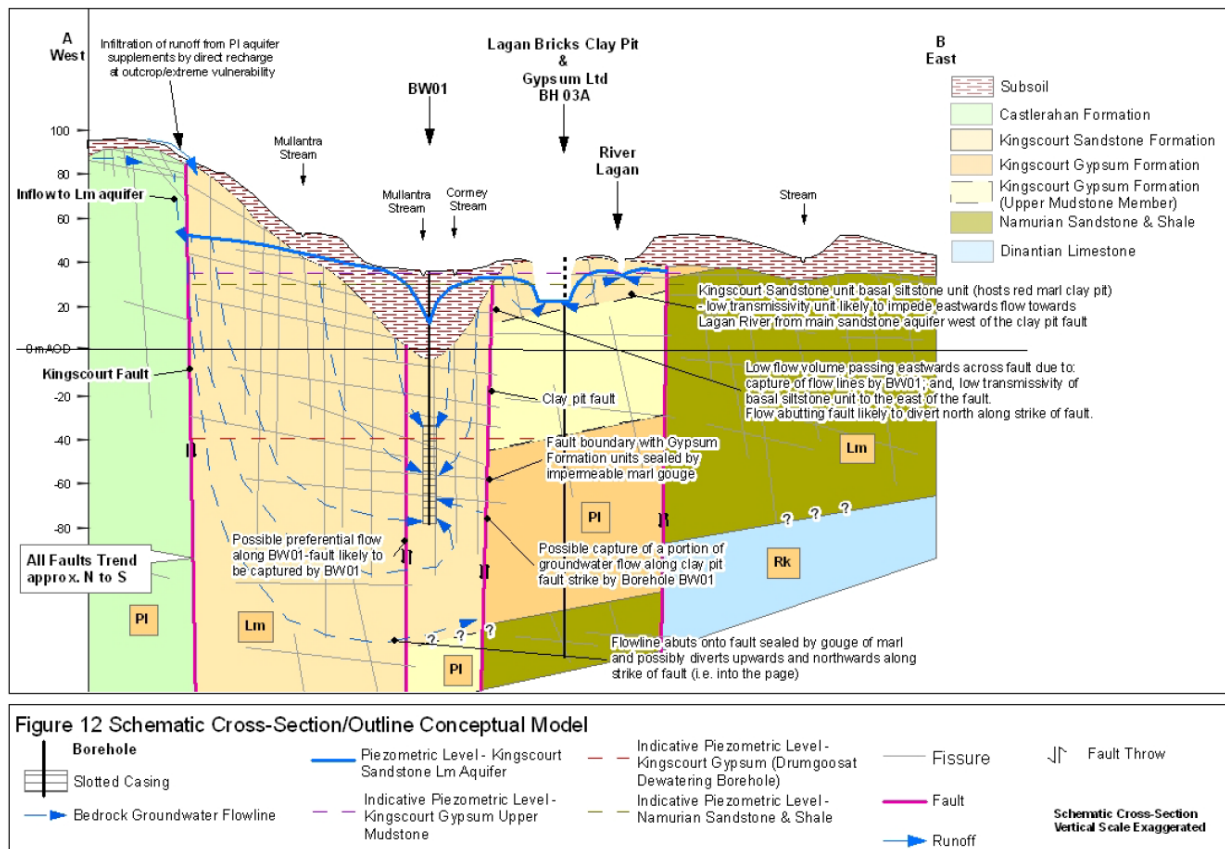
Well BW01 is located about 2 km to the southwest of the study area. Based on the source protection zone report⁵, it is drilled to a depth of 120 m, with screen between 71 and 113 mbgl. A diagrammatic cross section through the well is shown on Figure 3.4.

BW01 has a typical abstraction rate of around 375 m³/d from the Kingscourt Sandstone Formation. The source zone protection report says that the majority of the sandstone aquifer footprint is confined by the overlying low and moderate permeability subsoil deposits. It is mainly recharged at areas of bedrock outcrop and extreme vulnerability along the Kingscourt Fault scarp to the west of the borehole. This suggests that the borehole is not abstracting water from the area of the mine and the mine dewatering does not affect water levels within the well.

The isolation from the mining areas is further supported by the statement in the report that the sandstone aquifer appears to be *hydraulically isolated from the gypsum aquifer by the low permeability basal layer of the sandstone and upper strata of the gypsum. Where the two aquifers are juxtaposed by faulting, the gypsum appears to be sealed off by a low permeability "gouge" of marl.*

⁵ CCC, 2011^a. Cavan County Council. Establishment of groundwater source protection zones – Kingscourt Water Supply Scheme, Mullantra Borehole (May 2011).

Figure 3.4: Diagrammatic cross section through the Kingscourt Mullantra PWS (reproduced from CCC, 2011a)



The nature of the geology and presence of fault barriers suggests that BW01 is hydraulically isolated from any mining activities

Kingscourt Descart PWS

BW02 and BW03 are located around 3.5 km southeast of the study area. A diagrammatic cross section showing the wells is shown in Figure 3.5. Based on the source protection zone report⁶, the wells are drilled to depths of 19 and 91 m, respectively. Their static groundwater levels are at, or above, ground level (i.e. they are artesian).

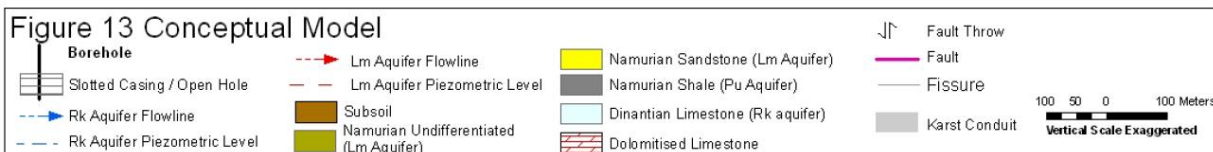
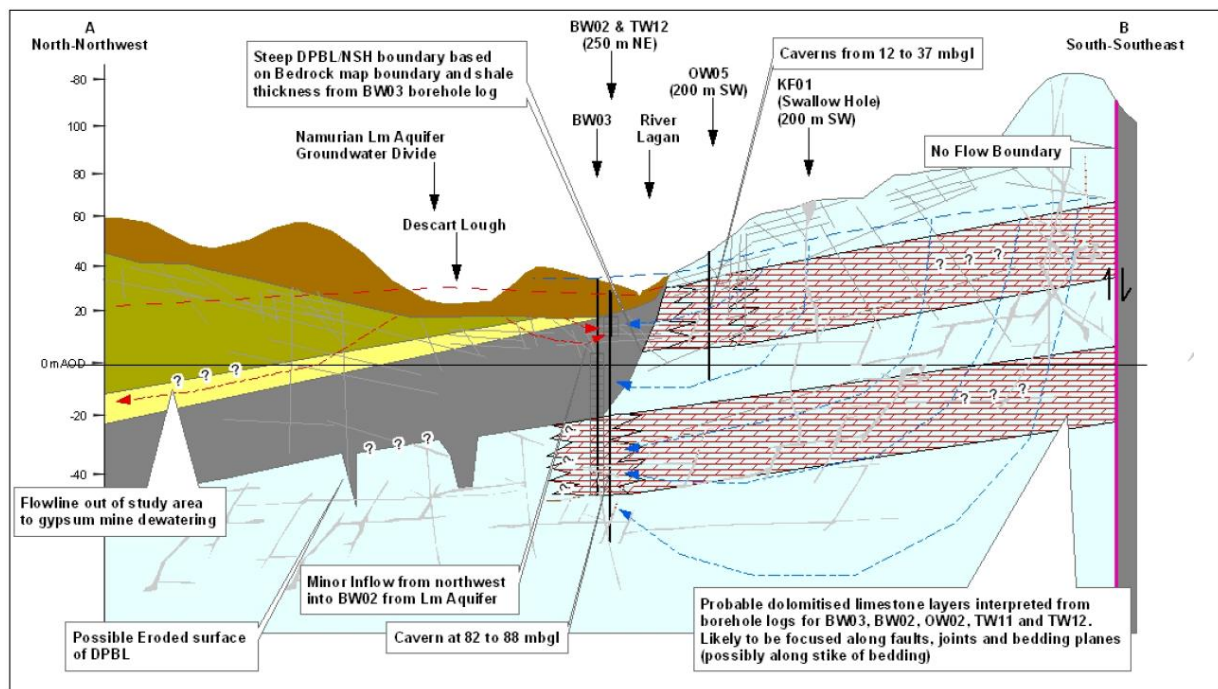
Pumping test results show that both wells have potential yields of around 1,000 m³/d or greater from the dolomitised Milverton Group limestone. The source protection zone report says that the limestone unit is karstified and mainly recharged at bedrock outcrop and through karst features on Barley Hill, and where the overlying subsoils are thin. Barley Hill is to the south of

⁶ CCC, 2011^b. Cavan County Council. Establishment of groundwater source protection zones – Kingscourt Water Supply Scheme, Descart Boreholes (April 2011).

the wells, so groundwater flow is northwards towards the wells and discharges in the Lagan River.

The nature of the geology and discussion in the source protection zone report suggests that the boreholes are not abstracting water from the mining area and are located within a hydraulically disconnected groundwater system. It therefore appears unlikely that any current or planned future mining activities could affect the wells.

Figure 3.5: Diagrammatic cross section through the Kingscourt Descart PWS (reproduced from CCC, 2011^b)



The nature of the geology is such that the wells are likely isolated from any mining activities

Carrickmacross PWS

The Monanny borehole and Nafferty spring and borehole are located over 6 km to the northeast of the study area. The supplies do not have source protection reports but the EPA states that Monanny borehole is 97 m deep and both supplies abstract water from karstified limestone (the Milverton Group). As outlined above, boreholes (and springs) of the Milverton Group do not abstract water from the mining area and are located within a hydraulically disconnected groundwater system.

3.3.2 Group water supply schemes

In addition to the public water supplies, there are three group water schemes (GWS) within 10 km of the study area (Figure 3.1).

- Magheraclone GWS sources its water from Greaghlon Lough, 6 km northeast of the site. The lough is underlain by low permeability tills and Castlerahan Formation which is a poorly productive bedrock aquifer based on GSI mapping. The mine is within a separate hydrogeological block and therefore does not have any hydraulic connection with the lough. Most of the properties in the vicinity of the mine which do not have private supplies are connected to the Magheraclone GWS water supply network.
- Meath Hill GWS is a groundwater source located 7 km to the southeast (beyond Kingscourt Descart PWS). The borehole is located within the Tobercolleen and Lucan Formation (Carboniferous limestone) which forms an isolated 'locally important' aquifer between the 'poor' Ardagh Shale Formation to the west and 'regionally important' Milverton Group to the north and west. This would suggest that there is no hydraulic connection with the mine.
- Killanny Reaghstown GWS abstracts groundwater from two boreholes in the regionally important Milverton Group aquifer around 7 km to the northeast of the site. As outlined in the source protection plan for the Kingscourt Descart PWS wells above, boreholes of the Milverton Group do not abstract water from the mining area and are located within a hydraulically disconnected groundwater system.

3.3.3 Domestic groundwater supplies

Based on a survey completed in September 2019, there are 23 third-party wells and groundwater sources within 500 m of Drumgoosat workings. Locations for nineteen of these have been surveyed and are shown in Figure 3.1. Locations with surveyed coordinates also have water level data available. A total of fourteen are listed as being in use but none are currently monitored regularly. Most are used to supply water to local housing and farms; eight are boreholes, eleven dug wells and four are springs. One publicly accessible healing spring is also recorded.

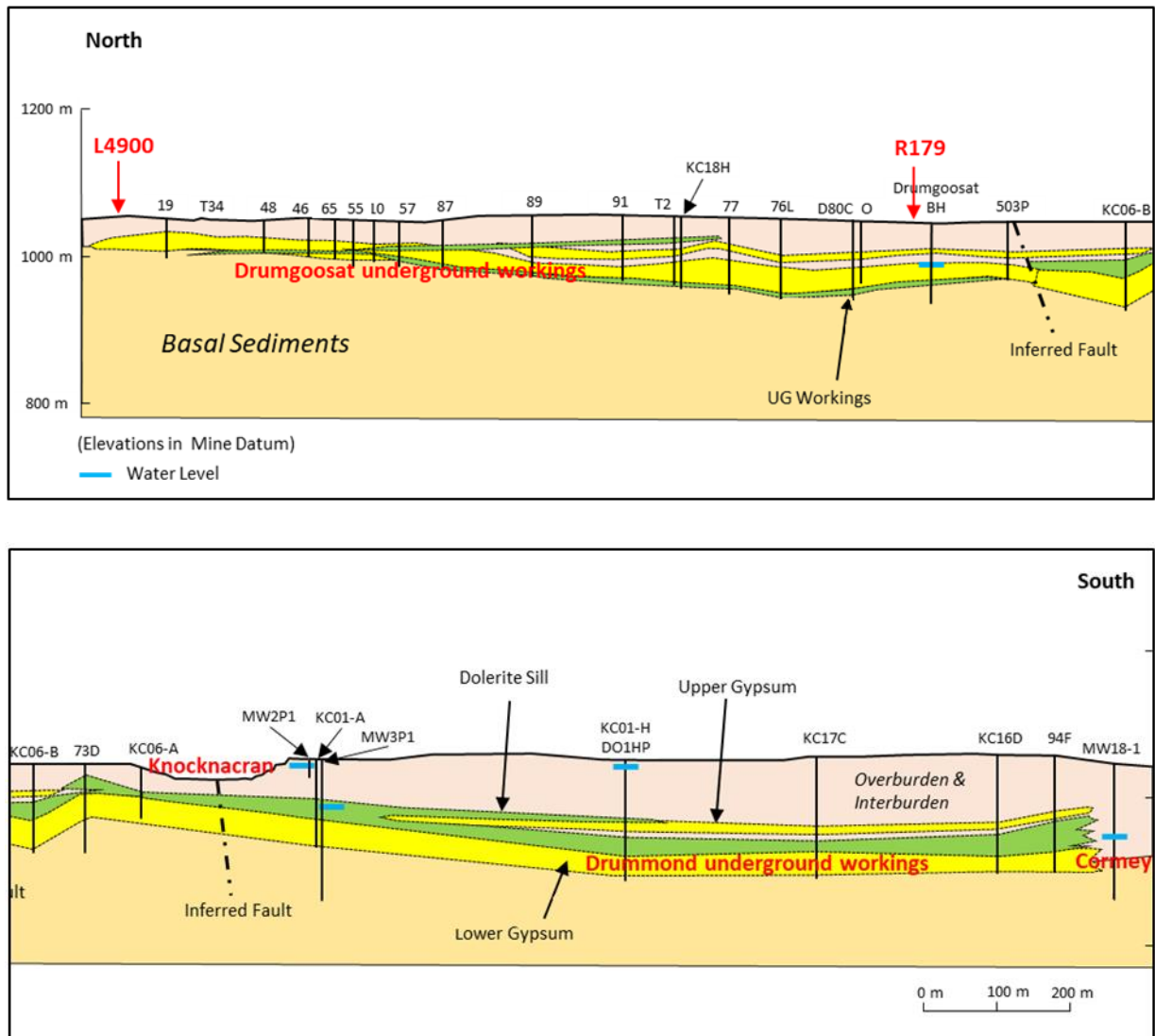
The majority of the known supply sources occur in the outcrop area of the Kingscourt Sandstone (to the west of the Kingscourt Fault) or to the east of the faults that define the eastern side of the graben. Only one of the supplies are located close to the mining areas or above the subcrop area of the Kingscourt Gypsum sequence.

3.3.4 Mine water storage

The decommissioned Drumgoosat underground mine reaches a maximum depth of around 100 mbgl to the north and northwest of the Knocknacran open cast (Figure 3.6). The underground workings have historically been used to store mine water as part of the water management plan for the Drummond underground mine and the Knocknacran open cast. Water

was stored during times of low flow in the River Bursk. Water is discharged when the flow rate in the river could assimilate the sulphate content of the mine water release to the river in line with the conditions in the EPA licence for the site.

Figure 3.6: Schematic North-South section through all mines. The figure shows the location of the R179 and L4900 roads



3.4 GROUNDWATER LEVELS

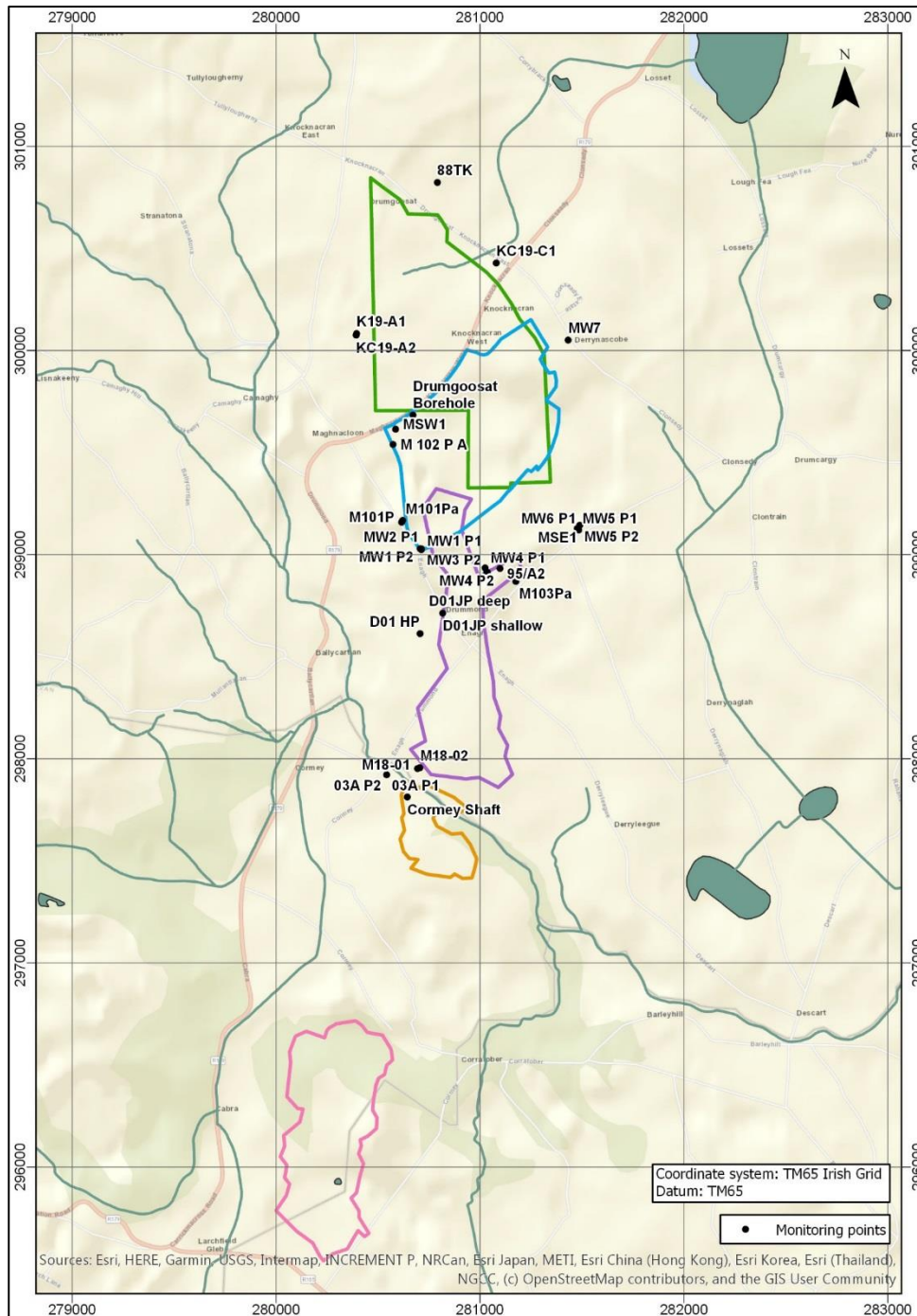
3.4.1 General

Groundwater level monitoring data have been compiled by Minerex and are available for a 38 year period (1981 and 2019). Data for the 29 wells with multiple years of data were analysed. The locations of the wells are shown in Figure 3.7. Of these:

- six wells are in “clay” superficial deposits (till);

- seventeen wells are in the Kingscourt Gypsum Formation (five in Upper Mudstone; four in Upper Gypsum; six in Middle Mudstone; two in Lower Gypsum; and none in Lower Mudstone); and
- six wells are in the Namurian Sandstone Formation, including the well drilled into the Drumgoosat underground workings to control water levels in the interconnected mine area.

Figure 3.7: Groundwater monitoring well locations



The wells are colour-coded by stratigraphic position by Minerex (Figure 3.8). Recent groundwater levels (May 2019) are shown on Figure 3.9 and in Table 3-1.

Table 3-2 shows water levels for monitoring points in the South Drummond area only. Groundwater hydrographs between January 2013 and June 2019 are shown in Figure 3.10 to Figure 3.15.

Figure 3.8: Groundwater monitoring well stratigraphical positions (Source: Minerex, 2019)

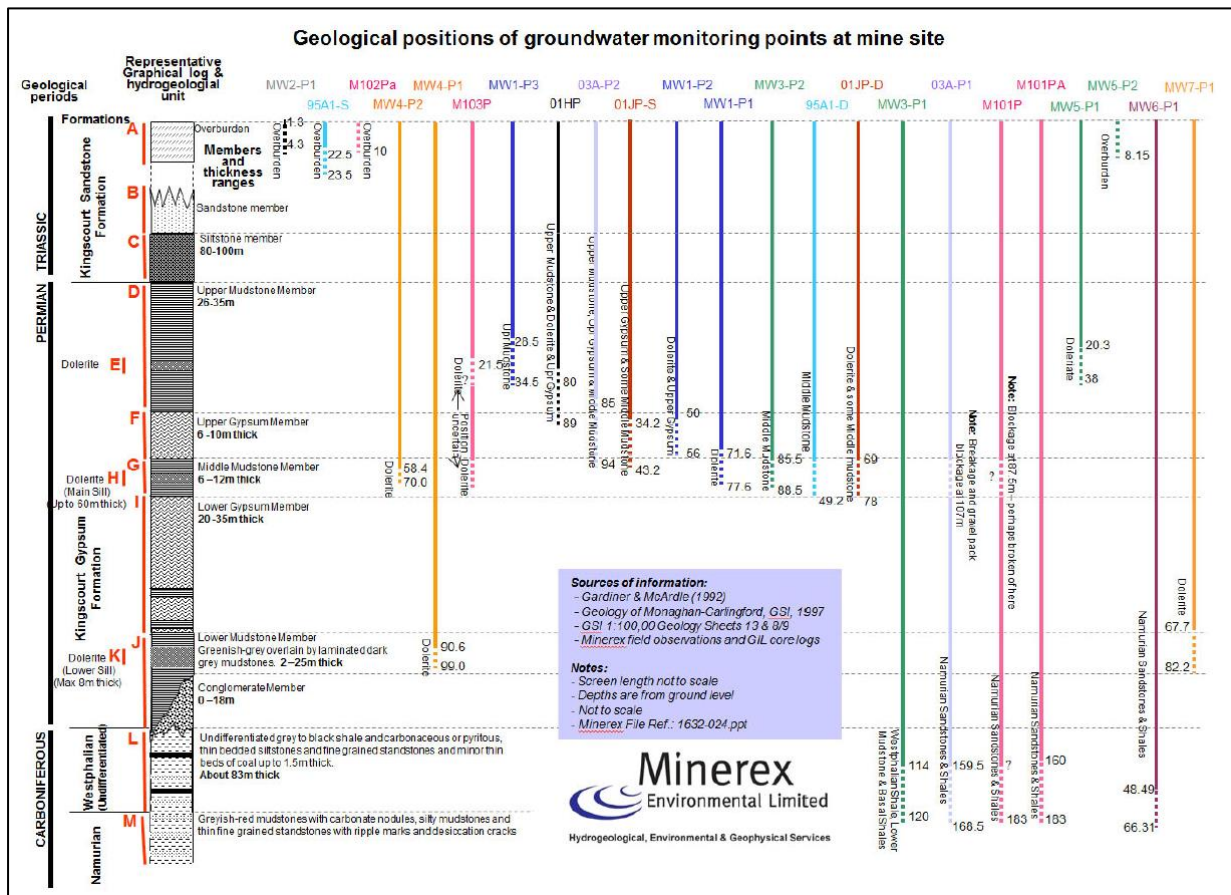


Figure 3.9: Currently recorded groundwater levels (November 2019)

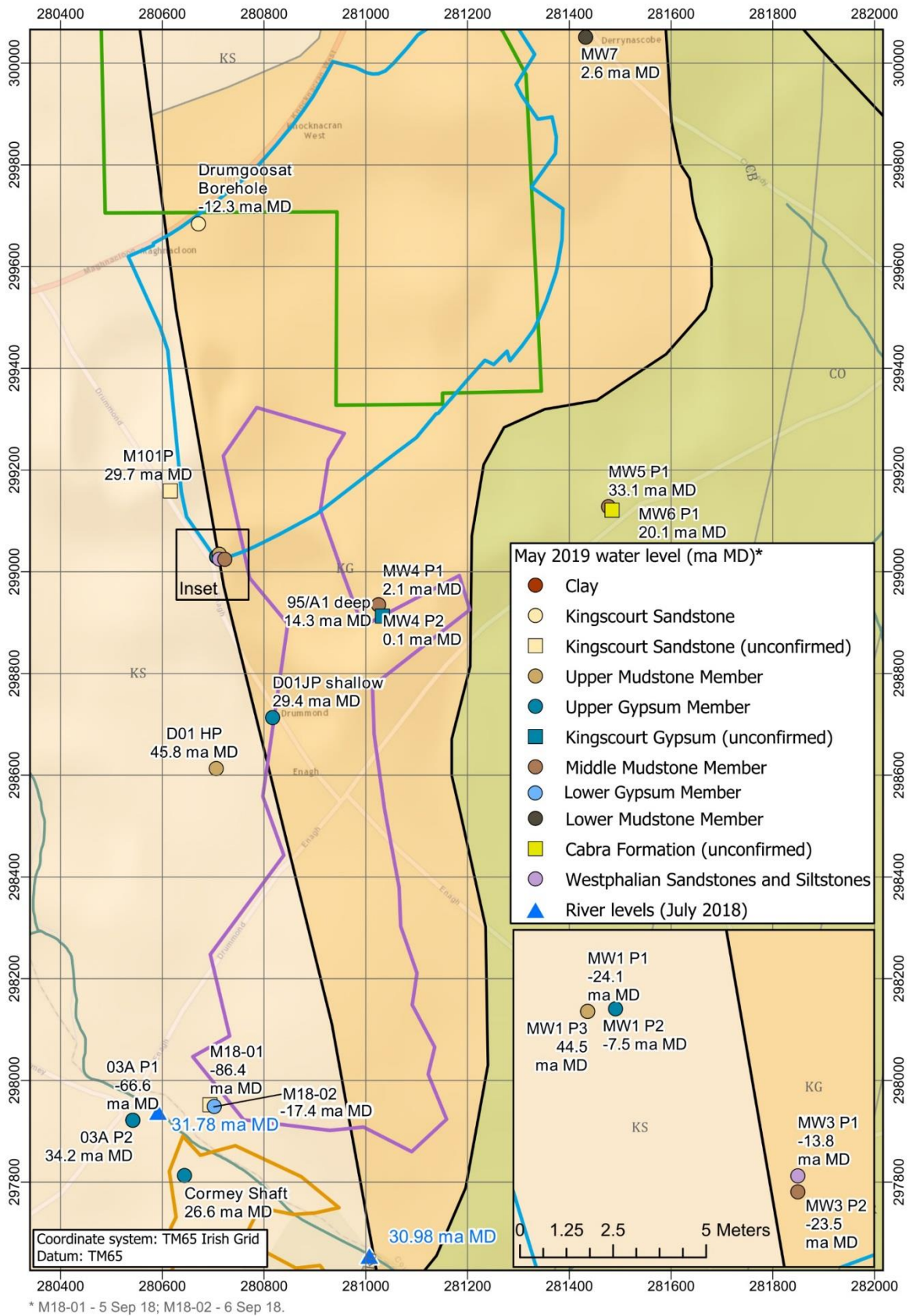


Table 3-1 Recent groundwater levels in all available monitoring wells

Monitoring Point	Hydrogeological Unit	Date	Water level elevation (maODM)	Inferred Drawdown from Baseline
1 H P	Upper Mudstone Member	01 May 19	45.8	0
1 J P Shallow	Upper Gypsum Member	01 May 19	29.4	33.0
1998 - Cormey Shaft	Upper Gypsum Member	01 May 19	26.6	5.0
95 A 1 Deep	Middle Mudstone Member	01 May 19	14.3	19.1
95 A 1 Shallow	Clay	01 May 19	36.4	0
Drumgoosat dewatering well	Kingscourt Sandstone	01 May 19	-12.3	-29.3
M 101 P	Kingscourt Sandstone	01 May 19	29.7	14.7
M 102 P A	Clay	01 May 19	39.2	0
MW 1 P 1	Middle Mudstone Member	01 May 19	-24.1	68.5
MW 1 P 2	Upper Gypsum Member	01 May 19	-7.5	51.9
MW 1 P 3	Upper Mudstone Member	01 May 19	44.5	0
MW 2 P 1	Clay	01 May 19	46.5	0
MW 3 P 1	Westphalian Sandstones and Siltstones	01 May 19	-13.8	58.2
MW 3 P 2	Middle Mudstone Member	01 May 19	-23.5	67.9
MW 4 P 1	Lower Mudstone Member	01 May 19	2.1	60.4
MW 4 P 2	Middle Mudstone Member	01 May 19	0.1	62.3
MW 5 P 1	Middle Mudstone Member	01 May 19	33.1	15.3
MW 5 P 2	Clay	01 May 19	50.3	0
MW 6 P 1	Cabra Formation	01 May 19	20.1	28.3
MW 7 P 1	Lower Mudstone Member	01 May 19	2.6	45.8
O3A P 2	Upper Gypsum Member	01 May 19	34.2	-2.8
MW 18 2	Upper Gypsum Member	06 Sep 18	-17.4	79.8
MW 18 1	Lower Gypsum Member	01 Sep 18	-86.4	148.8
O3A P 1	Namurian Sandstone	01 Sep 18	-66.6	100.0
Drummond E 4	Lower Gypsum	01 Aug 18	-79.6	77.0
Drummond E 7	Lower Gypsum	01 Aug 18	-70.7	68.1
1 J P Deep	Middle Mudstone Member	01 Apr 14	43.8	18.6
M 101 P A	Lower Mudstone Member	01 May 10	49.1	-11.7
M 102 P	Clay	01 Apr 09	39.2	-2.8
95 A		01 Nov 05	64.9	-2.5
96 A		01 Nov 05	75.8	-3.4
95 A 2	Clay	01 Oct 05	38.5	-11.1
M 103 P	Upper Mudstone Member	01 Aug 05	29.8	4.6
506 P	Upper Mudstone Member		31.6	-3.2
507 P	Upper Mudstone Member		30.4	-5.0

Table 3-2 Water levels for South Drummond area monitoring points

Monitoring Point	Hydrogeological Unit	Water level elevation (maODM)
River		31.8
O3A P2	Upper Gypsum Member	34.2
1998 – Cormey Shaft	Upper Gypsum Member	26.6
MW 18 2	Upper Gypsum Member	-17.4
O3A P 1	Namurian Sandstone	-66.6
MW 18 1	Lower Gypsum Member	-86.4

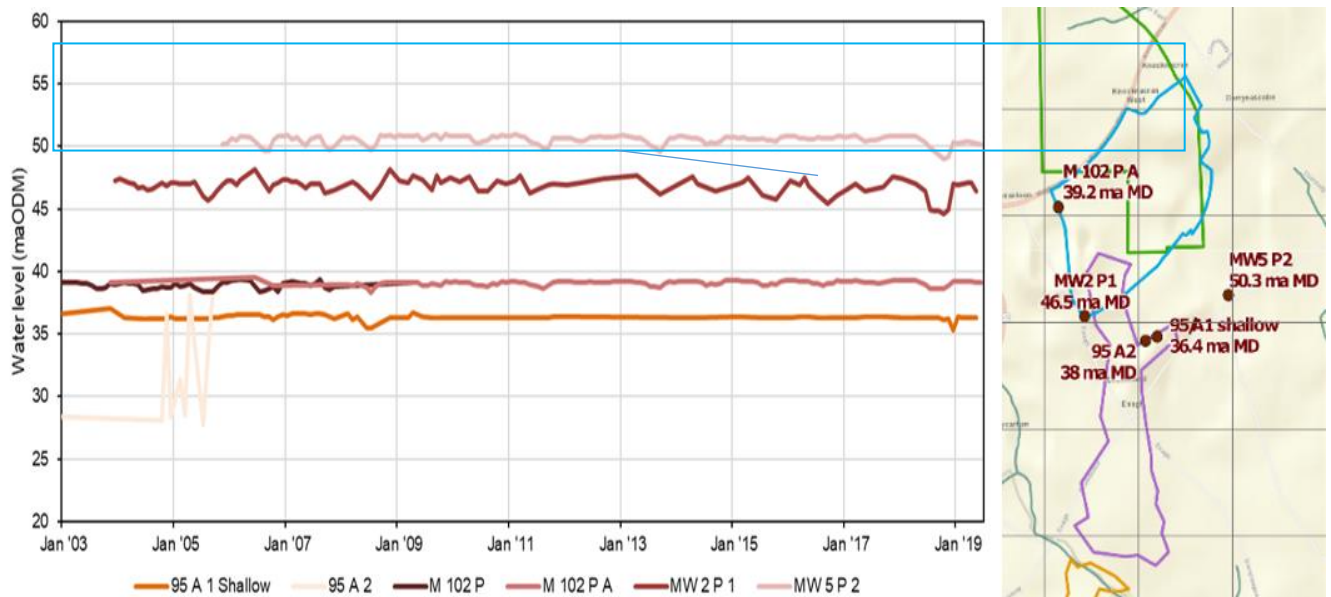
3.4.2 Superficial deposits

Figure 3.10 shows the hydrographs for the six wells believed to be representative of superficial deposits (mostly till). The observed water levels range between 28 maODM (95 A2) and 50 maODM (MW5 P2). The water elevation typically reflects the local topography and the elevation of the well collar. The depth to water in the wells is typically in the range of 0.5 to 2 m. All wells show a seasonal fluctuation, except for 95 A 1.

The largest seasonal fluctuation is typically seen in MW2 P1, located close to the northern margin of the Drummond underground mining area. This showed a water level reduction of about 3 m during the dry summer of 2018; recovering during the recharge period towards the end of the year. It does not appear to show any correlation with the recent increased inflows to the Drummond workings. There are no trends that would indicate long term drawdown or changes due to the mining operations.

As is seen in other mining districts in Ireland (and worldwide), the behaviour of water levels in superficial deposits tends to be mostly independent of conditions in the underlying bedrock formation. The data from the six wells in the study area are consistent with this. The underlying mine workings do not significantly affect the near-surface water balance in the superficial deposits. The seasonal fluctuation in MW2 P1 appears to be related to natural climatic cycles.

Figure 3.10: Hydrographs for wells thought to be screened in superficial deposits (till)



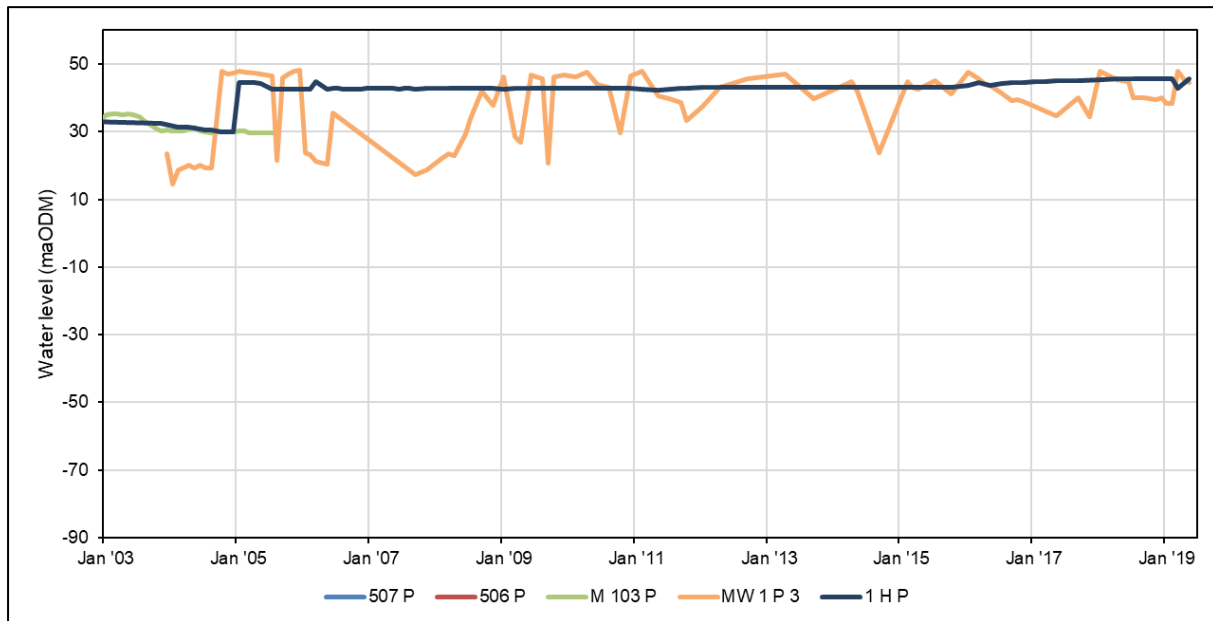
3.4.3 Kingscourt Gypsum Formation

Upper Mudstone Member

Monitoring data are available for three wells screened in the Upper Mudstone Member with records between January 2003 and June 2019 (Figure 3.11). Groundwater levels are above the inferred hydrogeological base level. There is no apparent influence of recent or historical mining activities.

The record for M103 P ceased in mid-2005 but closely matched 1HP when concurrent data were available. Levels in 1HP have typically remained around 43 maODM since January 2005 and have shown a slight increase in the recent years. MW1 P3 shows a much broader range in level than MW1 P3, which is screened in the same unit. The reported groundwater elevation shows significant fluctuation between 15 maODM and 50 maODM since 2003, with greatest peaks correlating to wet winter periods. It is not apparent why the early water levels fluctuate.

Figure 3.11: Hydrographs for wells screened in the Upper Mudstone Member



Upper Gypsum Member

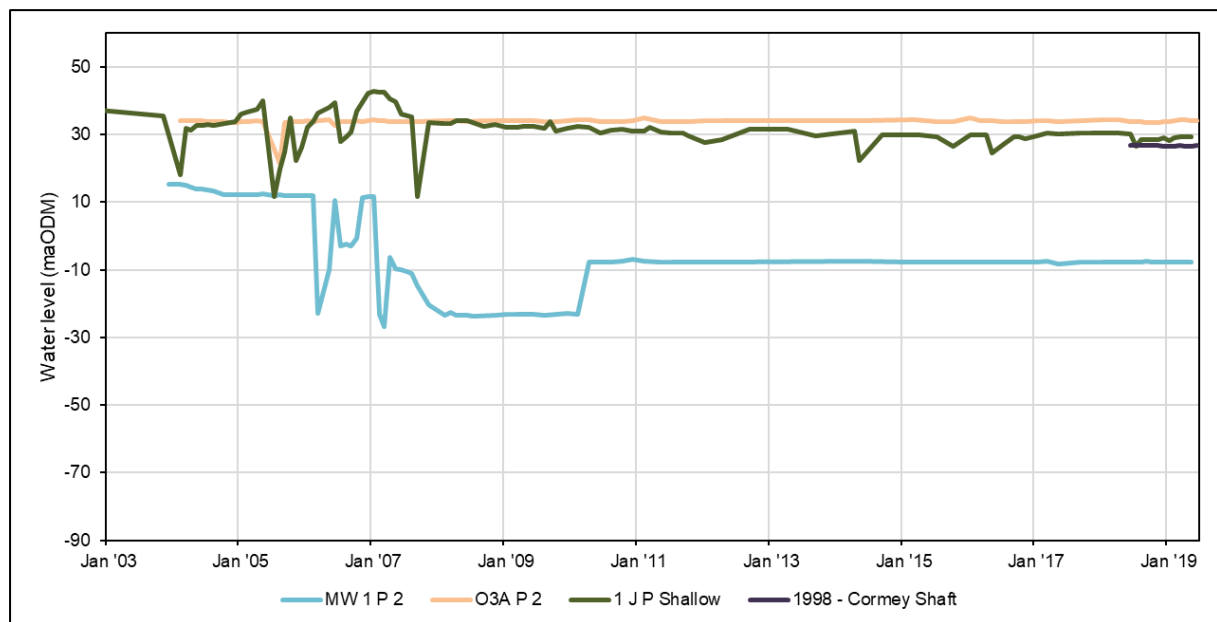
There are four observation wells monitoring the Upper Gypsum Member (Figure 3.12). These typically have water levels around 10 m lower than the Upper Mudstone Member wells. This suggests a downward hydraulic gradient and indicates that significant downward groundwater flow does not occur.

O3A P2 has remained stable since monitoring began, with the exception of a sharp drop in level in July 2009 which corresponds to a similar drop in 1J P Shallow. Overall levels in these two wells have been similar since 2009, but 1J P Shallow has decreased by approximately 4 m in that period and shows stronger fluctuations than O3A P2.

Groundwater levels observed in MW1 P2 are about 35 m lower than in the other Upper Gypsum Member wells. The level was recorded at 18 maODM when monitoring began in February 2004 in this well. The drawdown may have been a response to early underground development in Drummond. Further drawdown occurred during 2006 and early 2007. The reason for the reported recovery in 2010 and the stable water level since June 2010 (-8 maODM) is unclear, although it continues to be influenced by mining.

Monitoring data for the Cormey shaft have shown a slight downward trend since 2007 but the shaft appears to be mostly isolated from the Drummond underground mine. There was a drop of about 1 m which appears to be coincident with the increase in mine inflows in June 2018.

Figure 3.12: Hydrographs for wells screened in the Upper Gypsum Member

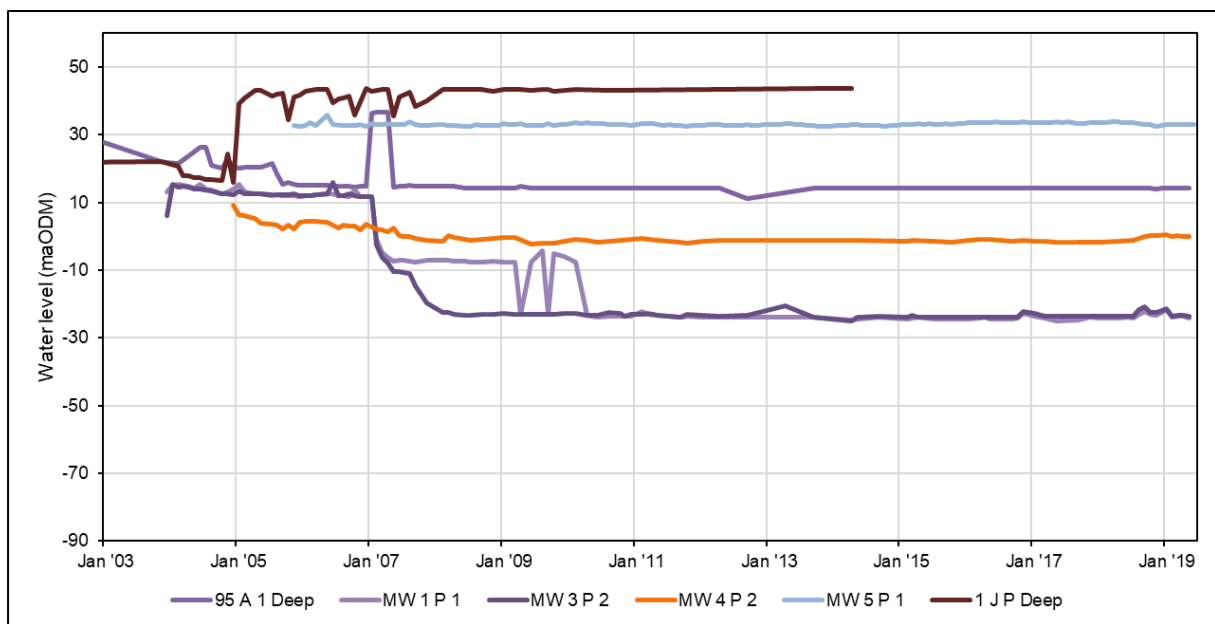


Middle Mudstone Member

Observation wells in the Middle Mudstone Member are shown in Figure 3.13. Overall, water levels show a much wider range than those seen in the upper units. This is due to proximity to mine workings and associated dewatering. All but two of the observation points (MW 5 P1 and 1 JP Deep) are below the hydrogeological base level. Key observations are as follows:

- Levels in MW5 P1 have remained stable at around 33 maODM since monitoring began in 2006 and do not appear to be impacted by mining;
- 1JP Deep increased from 22 maODM in November 2003 to 43 maODM in May 2005, where it has remained since;
- 95A1 Deep and MW4 P2 have shown similar trends, with levels declining gradually up until 2008 when they stabilised, and a slight rise in water level is seen in late 2018;
- M1 P1 and MW3 P2 have decreased in level by around 17 m and 35 m respectively, with the main drop occurring in January 2007 (consistent with MW 1 P2 in the upper gypsum and M 101 P in the Numurian – albeit a more subdued response);
- M1 P1 and MW3 P2 have approximately the same reported groundwater level of around -23 maODM since January 2007.

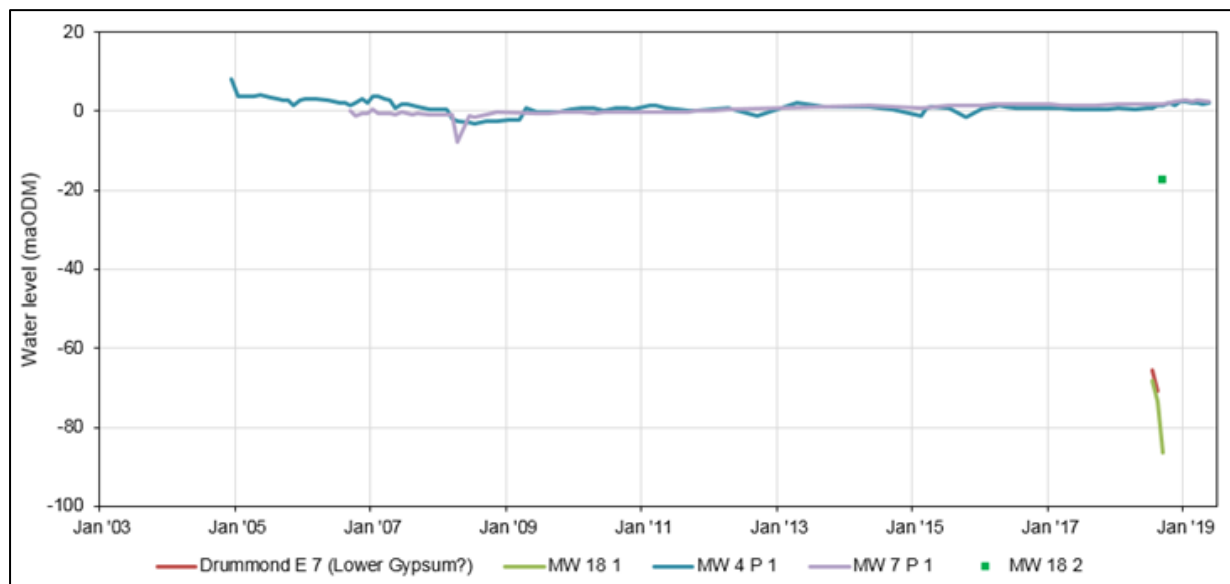
Figure 3.13: Hydrographs for wells screened in the Middle Mudstone Member (including dolerites)



Lower Gypsum Member

Observation wells in the Lower Gypsum Member (Figure 3.14) have shown little variation since monitoring started in about 2005. Reported water levels in MW4 P1 and MW7 P1 are very similar, but MW7 P1 fluctuates less than MW4 P1. Both wells have a reported water level of around 0 maODM which is significantly below the hydrogeological base level. However, neither well responds to the increase in Drummond Mine inflows in 2018.

Drummond E7 and MW18 2 are believed to be open in the Lower Gypsum member. The level in Drummond E7 is approximately -65 maODM and the single water level measurement for MW 18 2 was 17 maODM in September 2018. Borehole logs for MW 18 1 shows it is open in a faulted interval of the Lower Gypsum Member. The water level was between -70 and -90 maODM in late 2018.

Figure 3.14: Hydrographs for wells screened in the Lower Gypsum Member

3.4.4 Namurian sandstone and Westphalian shale

The Drumgoosat dewatering well is screened in Namurian sandstone. The monitoring data indicate that pumping maintained the water level at between -50 and -30 maODM until June 2018 (Figure 3.15), when water levels increased to around -10 maODM as a result of the increased inflow of water pumped from the Drummond Mine (see Section 4.3). The Drumgoosat dewatering well levels are approximately 80 m below the regional water levels reported for the Namurian sandstone, and the hydrograph shows a strong seasonal signature. Well levels have typically varied by around 10 m between seasons, but levels during the 2018 winter period exceeded those previously reported.

In addition to the Drumgoosat well, there are two observation wells screened in the Namurian sandstones (M101 P and MW6 P1). These are below their expected hydrogeological base level but show relatively little variation over the past 10 years (Figure 3.15). Between early January 2007 and January 2009, a decline in water level was observed in M101 P, from around 35 to 29 maODM. This response was not observed in MW6 P1, but was also seen in MW 3 P 1 which is screened in the Westphalian Shales.

Water levels in MW 3 P 1 (-10 to -20 maODM) are at least 30 m lower than the expected hydrogeological base level at that location, but remain relative stable from 2009 until early 2017, when a further reduction in level of around 3 m was observed. MW 3 P1 also shows a subdued response to the recent increase in water level in the Drumgoosat well.

Water levels in O3A P1 have shown little variation since monitoring started in about 2005 until the 6 month period between April 2018 and October 2018 when a steep drop from 30 maODM

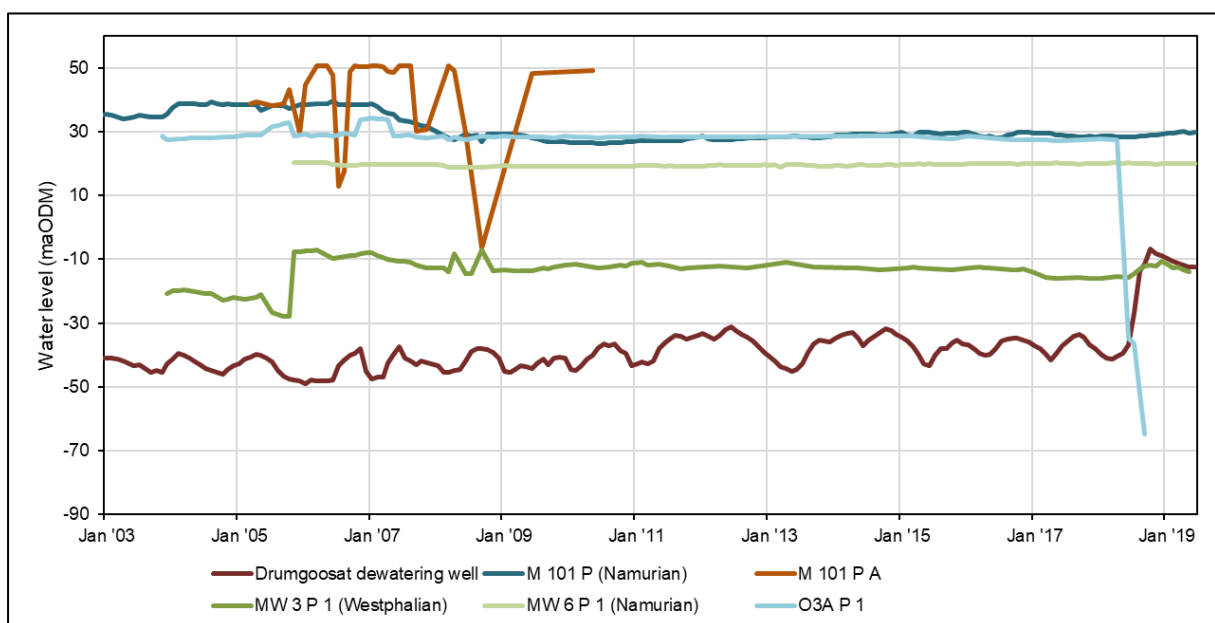
to -60 maODM occurred. This can be correlated with mining into a fracture zone associated with the June 2018 mine fault (see Section 4.3).

There are no further apparent correlations between the water levels in the dewatering well and water levels in the observation wells. It is inferred that all three observation wells have been influenced by historical mining to some degree, but only MW 3 P1 responds (by a minor amount) to recent mining activity.

Due to the hydraulic layering and poor connectivity of the geological units in the area, it is apparent that some lower units have become dewatered to variable degrees, while units above them remain unimpacted by mining. This is most notable with regards to the superficial deposits, but it also occurs in the bedrock due to the layering of the units with the Kingscourt Gypsum sequence and the presence of the dolerite sills.

Furthermore, below the Kingscourt Gypsum sequence, there are high groundwater levels in some of the underlying Namurian sandstone units compared to overlying gypsum sequence.

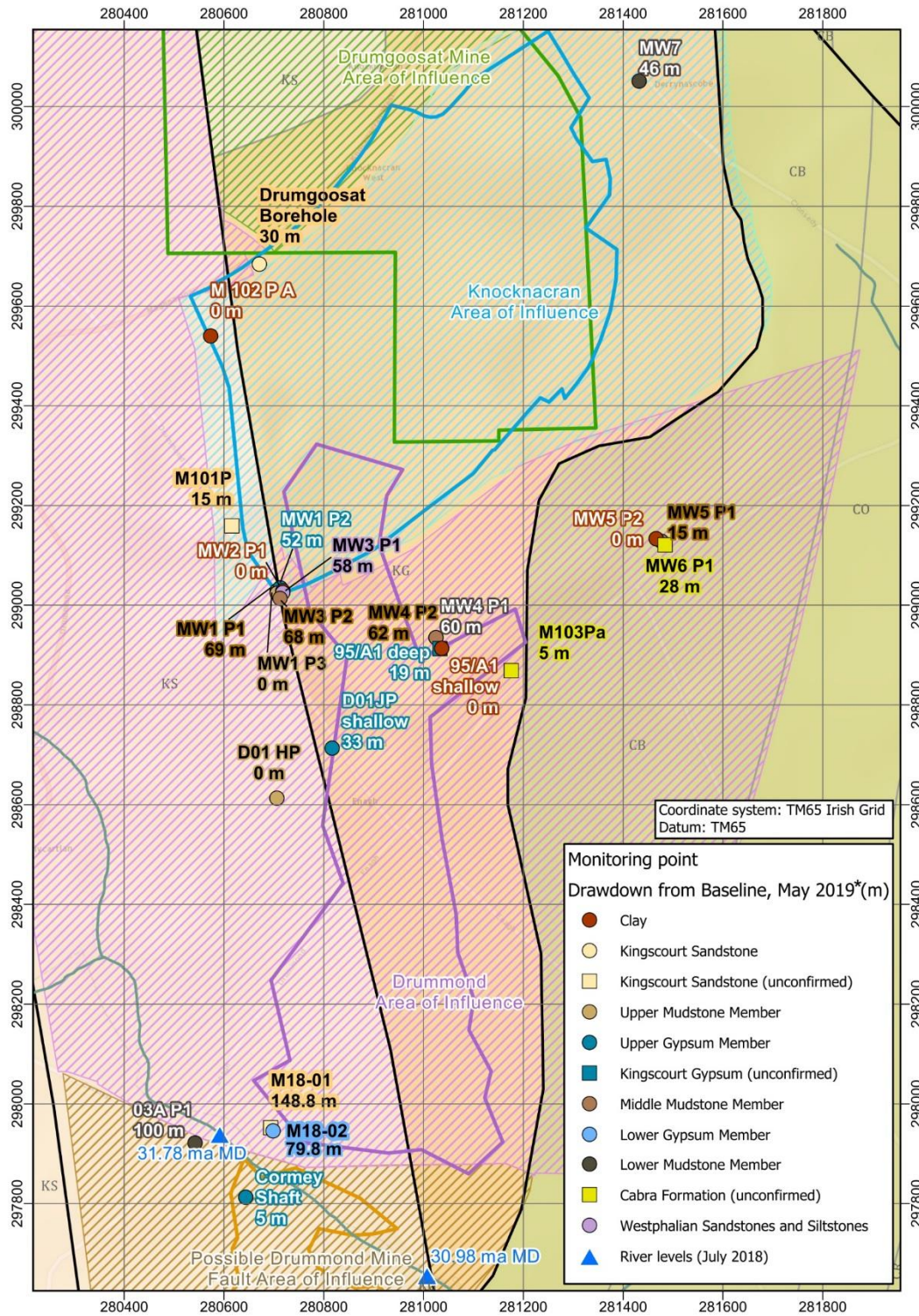
Figure 3.15: Hydrographs for wells screened in Namurian sandstone



3.4.5 Drawdown

Using the long-term water level records, the drawdown from original baseline for each monitoring well has been estimated as shown in Figure 3.16. Drawdown is greatest within the mudstone and gypsum members, as would be expected because these are the units where mine workings are present. There is some localised drawdown in the Kingscourt Sandstone and Namurian Sandstone units, some of which can be related to the penetration of the hydraulic barriers caused by the faults and lithological contacts (see Section 5.5).

Figure 3.16: Interpreted monitoring well drawdown from baseline conditions



* Drawdown calculated from water levels on the following dates: M18-01 - 5 Sep 18; M18-02 - 6 Sep 18.

Beneath the R179 and L4900 roads, about 70 m of drawdown has occurred within the Kingscourt Gypsum Formation as a result of historical mining and dewatering of the Drumgoosat Mine. Figure 4.5 shows the strata dip away from the R179. The interpreted pre-mining groundwater level was likely around 40 maODM below the alignment of the road. It appears that the pumping from Drumgoosat underground has maintained dewatered conditions beneath the roads. It is expected that pumping from the Knocknacran open cast and the Drumgoosat well will cause groundwater levels beneath the roads to remain low during the period of active operations. Any potential seasonal variation in groundwater level would be limited provided pumping from the workings is continuous.

All bedrock drawdown is relatively local to the mining areas. There is no indication of any regional-scale drawdown.

There is no apparent drawdown or influence of mining on the superficial deposits.

3.5 GROUNDWATER CHEMISTRY

The Minerex 2018 Annual Monitoring Report⁷ presents water quality plots for all monitoring wells to the end of 2018. The plots are included in Appendix A. The monitoring well locations and depths are presented in Figure 3.7 and Figure 3.8. In general terms, the groundwater of the area is near-neutral pH; with high chloride and sodium and moderate sulphate and calcium. Table 3-3 provides a summary of the sample results.

Each monitoring location tends to have at least one parameter which is an exception to these generalisations. There does not appear to be any correlation with regards to lithology, depth or location (except MW1 and MW3), suggesting that groundwater quality is localised and is primarily controlled by local flow conditions and the interaction of the specific combination of lithologies in that area.

Alkalinity is mostly high but is also variable between sampling stations. For samples that have high alkalinity, the sulphate and calcium are relatively low, suggesting that the water has not had significant residence time within any of the gypsum horizons. Samples that have high sulphate also tend to show high calcium (this is expected) and sodium which suggests the water has had contact with gypsum and other evaporite lithologies. The high pH values (> pH8) indicate an external influence, possibly cement from the well construction.

Any groundwater that comes into contact with gypsum will, in principle, cause gypsum to dissolve, provided the water is under saturated. The rate of dissolution is dependent on the extent of under saturation and also the pH of the water (lower pH = faster dissolution). Most

⁷ Minerex, 2019b. Annual Monitoring Report 2018 Rev 0, May 2019. Doc. Ref.:1632-2089.

groundwater samples from monitoring wells appear to be under saturated with respect to gypsum. Therefore, there is the potential for dissolution of gypsum to occur, even though the pH is typically neutral. Superficial groundwaters tend to have the lowest pH, so the greatest potential for dissolution is where these waters have contact with gypsum such as in the wall of the open cast or in the Upper Mudstone or Upper Gypsum members above the roof of the underground mining areas. However, most of the local superficial (till) deposits are of low permeability, so percolation rates are relatively low. There is more potential for on-going gypsum dissolution below natural or mining-induced surface depressions where infiltration and percolating water may become concentrated.

The ability for gypsum dissolution to cause mechanical changes to the formation is more likely to be a function of kinetics (physical movement) and not of thermodynamics (degree of under-saturation and pH). The kinematics of crystalline gypsum dissolution in Palaeozoic and Mesozoic rocks is typically slow and tends to be associated with water movement rather than thermodynamics. If flow through the wall rock or void space is sufficiently slow, gypsum will dissolve, reach equilibrium and then begin to re-precipitate.

The data show a significant change in groundwater quality of MW1-P3 as a result of the inflows related to the June 2018 mine fault. The water in the monitoring well goes from having relatively low concentrations of all parameters and elevated pH (unlike any other water type), to being similar to MW1-P1 and MW3-P2 (i.e. with relatively high sodium, calcium and sulphate). Reported values of calcium are 500-600 mg/l with 1,400-1,900 mg/l sulphate, showing near gypsum saturation. Recent samples from the inflow water from the mine fault show lower sulphate values and under saturation with respect to gypsum (Table 3-4).

Table 3-3 Summary of groundwater quality

Lithology	Unit	Well	pH	Alkalinity	Chloride	Sodium	Calcium	Sulphate	Comment
Dolerite	Lower Mudstone	MW4-P1	7 to 8	100 to 400	10 to 20	50 to 70	100 to 200	400 to 500	Comparable to M102-PA
Dolerite	Middle Mudstone	MW1-P1	7 to 8	100 to 400	40	50 to 70	500 to 600	1400 to 1900	Comparable to MW3-P2
Dolerite	Upper Mudstone	MW5-P1	7 to 8	400 to 1000	10 to 20	10 to 30	100	100 to 200	
Mudstone	Middle Mudstone	95A1-D	11 to 13	400 to 1000	10 to 20	10 to 30	Variable	Variable	
Mudstone	Middle Mudstone	MW3-P2	7 to 8	100 to 400	40	50 to 70	500 to 600	1400 to 1900	Comparable to MW1-P1
Mudstone	Upper Mudstone	MW1-P3	8 to 10	<50	10 to 20	10 to 30	<100	100 to 200	Pre-June 2018
			7 to 8	100 to 400	40	120	500 to 600	1400 to 1900	Post-June 2018
Till	Overburden	M102-PA	7 to 8	100 to 400	10 to 20	50 to 70	100 to 200	400 to 500	Comparable to MW4-P1
Till	Overburden	MW2-P1	6 to 7	500	60	10 to 30	200	100 to 200	
Till	Overburden	95A1-S	11 to 13	100 to 400	10 to 20	10 to 30	100 to 200	10	
Till	Overburden	MW5-P2	7 to 8	100 to 400	10 to 20	10 to 30	100	10	Comparable to MW6-P1
Mudstone & Gypsum	Upper Mudstone	01JP-S	7 to 8	400 to 1000	10 to 20	10 to 30	500 to 600	Erratic	
Sandstone	Namurian sandstones	MW6-P1	7 to 8	100 to 400	10 to 20	10 to 30	100	100 to 200	Comparable to MW5-P2
Sandstone	Namurian sandstones	MW3-P1	7 to 8	100 to 400	10 to 20	50 to 70	500 to 600	1400 to 1900	

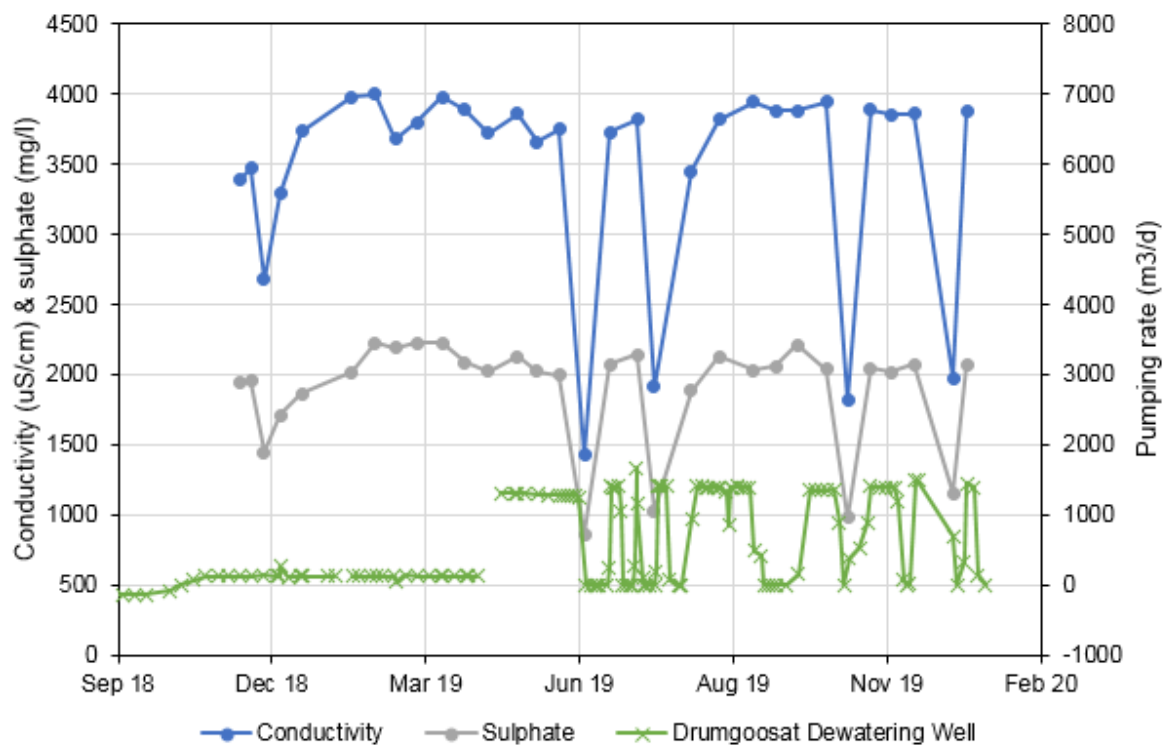
Note: higher than typical values are highlighted in orange and lower than typical in green.

Table 3-4 Sample results from the Drumgoosat well and the south mine inflow water

	No. of Samples	Sulphate (mg/l)			pH (pH units)			Conductivity (µS/cm)		
		Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Drumgoosat well	31	1900	863	2227	8	7.08	7.98	3482	1424	3995
Drummond south inflow	2	545	532	558	-	-	-	1331	1328	1333

Samples from the Drumgoosat well typically show near-saturation with respect to gypsum (Table 3-4) but with some samples showing lower parameter values (Figure 3.17). The lower values may be related to samples taken following the pumping of water into the well.

Figure 3.17: Time series plot of Drumgoosat well chemistry



Note: positive pumping rate indicates water pumped to lagoon, negative pumping rate indicates water pumped to workings.

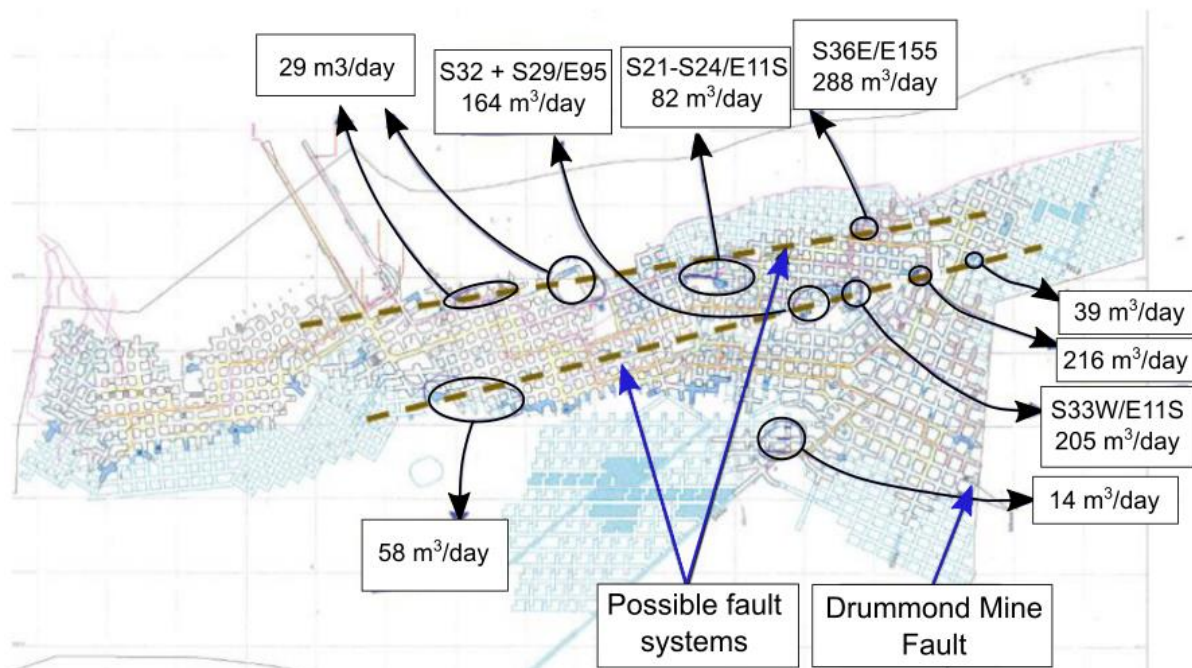
4. MINE WATER MANAGEMENT

4.1 INFLOW SOURCES

4.1.1 Drummond Mine

All inflows to the active Drummond Mine are derived from groundwater. Historical inflows were between 1,400 and 2,200 m³/d. Current inflows are a little over 2,000 m³/d, with about 50% of this derived from the 2018 mine fault zone. The remainder of the inflows are derived from joints and fracture zones, as mapped on Figure 4.1, with much of the hydraulic connection thought to be from the Upper Gypsum unit and/or the dolerite sill. There is a strong correlation between the mapped inflows and the position of inferred fault zones.

Figure 4.1: Sketch map showing inflows to the Drummond mine (November 2019)



4.1.2 Knocknacran open cast

Inflows to Knocknacran open cast mine are mostly derived from incident precipitation onto the pit walls and floor, with a minor amount of local groundwater inflow. Estimated sump pumping rates range between about 10 m³/d in September (groundwater flow only) and 950 m³/d in April (mostly surface water runoff).

The water in Knocknacran open cast is collected in a sump on the pit floor and is pumped up to the settlement lagoons. Mining and water management appears to be well executed, with plating of the bench faces to reduce erosion and piping (Figure 4.2).

Figure 4.2: Good surface runoff management practices at the Knocknacran open cast, including plating of the bench faces and drainage of the benches



4.1.3 Drumgoosat workings

Inflows to Drumgoosat workings are derived from groundwater, plus water pumped into the workings as part of the site water management strategy. Pumping records for the mine during active operations indicate groundwater inflows were low, but seasonally variable, between 20 m³/d in September to 870 m³/d in March.

The seasonal nature of the pumping records suggests that much of the water would likely have been derived from surface infiltration, potentially focused on natural or mining-induced surface depressions, and particularly in the central section of the mine where the Upper Gypsum and mine workings are within 50 m of the ground surface.

Additional groundwater is likely to have entered the workings from the north, along the strike of the Kingscourt Gypsum Formation.

4.2 PUMPING AND WATER MANAGEMENT

Groundwater inflow to Drummond Mine is routed to a central sump in the mine, from where it is pumped to the settlement lagoons. A bulkhead was installed following the inflow that occurred in June 2018 as a result of mining into the June 2018 mine fault (see Section 4.3.5). Water from behind the bulkhead is also routed to the central sump.

Water from Drumgoosat Mine is pumped from a borehole in the old mine workings up to the settlement lagoons.

SLR, 2019⁸ prepared the Drummond Mine Dewatering Plan (2019 to 2020). It includes surface water runoff from the areas around the above-ground infrastructure at the workshop, office and car park. The runoff is also directed to the settlement lagoons. Runoff around the workshop hard stand area is directed to a hydrocarbon separator and then to the settlement lagoons. The surface water volumes are small compared to the overall volume of water from the Drummond, Drumgoosat and Knocknacran mining areas.

The existing water management system collects the water from the various sources, and routes it through the treatment facility to the discharge point on the River Bursk. All waters from the site are treated in the settlement ponds for the removal of suspended solids. The water from the various sources at the site is relatively low in suspended solids so does not require significant settlement time (SLR, 2019⁸). There is no process water used at the site.

The water from the final settlement lagoon is pumped to the River Bursk via the infrastructure at MSE-1 located in the south eastern corner of the site (Figure 1.1). MSE-1 infrastructure comprises two large holding tanks, a v-notch weir for measuring discharge flow and continuous monitoring instrumentation for measurement of electrical conductivity (to allow the estimation of sulphate).

SGMI monitor the flow and electrical conductivity in the River Bursk in real time. The discharge of mine water is automatically adjusted depending on the available flow and assimilative capacity in the river. The discharge is controlled in order to ensure compliance with a sulphate value of 200 mg/L at a compliance point (CP1) in the river. CP1 is 70 m downstream of the discharge point (Figure 1.1).

Historically, SGMI has stored the excess mine water in Drumgoosat Mine when discharge to the River Bursk would have exceeded the CP1 compliance value. The mine workings provided a buffer for water storage when there was insufficient assimilative capacity in the River Bursk. Water was released during higher river flows when there is adequate assimilative capacity.

Following the subsidence event at Drumgoosat on the 23rd/24th September 2018, SGMI commenced the discharge of mine water directly to the existing settlement lagoons and the River Bursk as part of emergency measures which went into force on 28th September.

⁸ SLR, 2019. Drummond Mine Dewatering Plan (2019 to 2020) SLR Ref: 190311.501.00545.0004.

4.3 WATER BALANCE MODEL

4.3.1 Reported flows

Within the current mine water management system, three flows are recorded on a regular basis:

- 'Effluent monitoring' – daily monitoring of total mine site discharge from MSE-1 to the River Bursk [April 2004 to September 2019];
- 'Drummond pumping log' – spot flow meter readings of water pumped from Drummond underground to the surface lagoon (sum of BS2400 #2 Flowmeter from Ritz 8", Ritz pumps to Lagoon and #1 Sub from Ritz 8") including water from the June 2018 mine fault [January 2010 to November 2019];
- 'Drumgoosat pump' – spot flow meter readings of the well abstracting water from the Drumgoosat workings to the surface lagoon (negative numbers), or injecting water from the lagoon to the workings (positive numbers) [January 2018 to November 2019].

In addition to these flows, scanned paper records are available of pumping hours from Drumgoosat at various points in time between 1981 and 1992.

4.3.2 Estimated flows

The available flow records above were used to help support the development of a water balance model for estimating the following flows which are not recorded:

- June 2018 mine fault inflow;
- Additional lagoon water which reports to Drumgoosat workings;
- Drumgoosat groundwater inflow;
- Knocknacran groundwater inflow;
- Knocknacran and mine surface infrastructure area runoff.

The water balance includes:

Drumgoosat inflows

- Infiltration from above through superficial deposits
- Lateral groundwater flow within Kingscourt Gypsum from north
- Water pumped in from storage

Outflows from Drumgoosat

- Water pumped out of the dewatering well

Drummond inflows

- Infiltration from above through Upper Gypsum and Dolerite

- Lateral groundwater flow within Kingscourt Gypsum from south
- Inflow from the 2018 mine fault

Outflows from Drummond

- Water pumped out of the Central sump

Knocknacran inflows

- In-pit runoff due to incident precipitation on the pit walls
- Minor groundwater inflow from superficial deposits
- Lateral groundwater flow within Kingscourt Gypsum from south and south (currently none because of mines to north and south)

Outflows from Knocknacran

- Water pumped out from sump

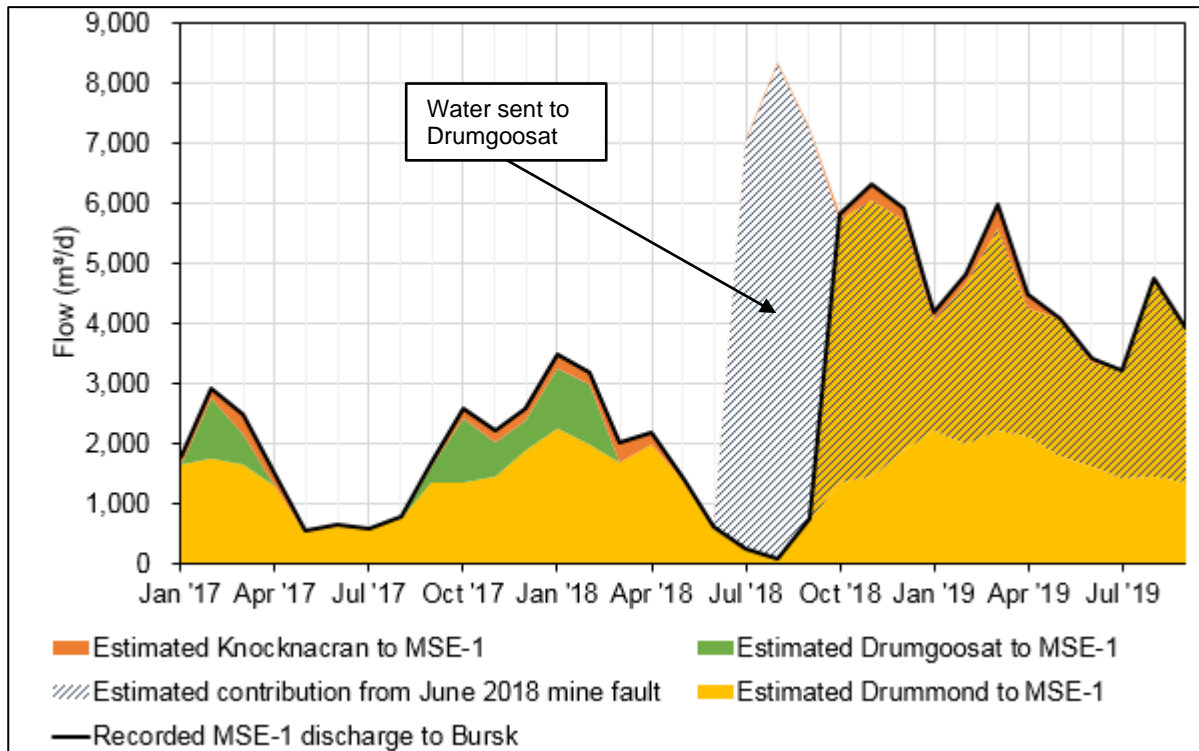
The monthly water balance is presented in Appendix B and the components of flow making up the MSE-1 discharge are shown in Figure 4.3. The following subsections describe the water balance for each of the mining areas.

4.3.3 Drumgoosat underground

Scanned copies of hand-written pumping hour records are available from the period when Drumgoosat was being mined. The record was not continuous but included dates between 1981 and 1992. 1991 provided the best record and had pump capacity estimates so flows could be derived from the pumping hours record. It showed that a total of 92,691 m³ was pumped from Drumgoosat between 9th January and 5th December 1991, giving an average flow of 281 m³/hr. However, flows were strongly seasonal ranging from 20 m³/d in September to 870 m³/d in March. This reflects the normal seasonal recharge pattern.

For the purposes of this study, and to take a conservative approach, it has been assumed that all water pumped was groundwater (i.e. no water service water was pumped back underground for drill rigs or dust suppression). The monthly total flows for Drumgoosat were used directly in the water balance model, with two thirds of the flow being attributed to the current Drumgoosat underground and one third to the Knocknacran open cast pit (which has mined into the southeast portion of the Drumgoosat workings). These flows are presented in Table 4-1.

Figure 4.3: Estimated mine water balance 2017 to 2019



Colour blocks show cumulative components of MSE-1 flow.

4.3.4 Drummond underground

Figure 4.1 shows that the dewatering rate from Drummond underground was seasonally variable between (1,400 and 2,200 m³/d) in 2017 and early 2018. These flows are consistent with the groundwater point-source inflow mapping (Figure 4.1) which indicates inflows of around 760 L/min (1,094 m³/d). The point source inflows appear to occur along linear features as indicated in Figure 4.1. This would be expected in this environment where faults act as barriers to groundwater flow (and in some cases flow may also be slightly enhanced parallel to their strike).

Additional inflows to the Drummond workings after June 2018 are not recorded directly or as part of the 'Drummond pumping log'. However, the Drummond flow record increases significantly from June 2018 reflecting the changing of the water management system to handle the new inflows. In general, there appears to be a slight incremental rise in groundwater inflows through late-2018 and early-2019, but continuing to display a seasonal variation. Estimated inflows between October 2018 and September 2019 (excluding June 2018 mine fault) are between 1,600 and 2,300 m³/d.

Table 4-1 Estimated groundwater inflows to the Drumgoosat Workings based on 1991 records

Month	1991 Drumgoosat pumping record (m ³ /month)	Estimated current Drumgoosat groundwater inflow (m ³ /month)	Estimated current Knocknacran groundwater inflow (m ³ /month)
January	11 351	7 567	3 784
February	10 885	7 257	3 628
March	26 786	17 857	8 929
April	17 037	11 358	5 679
May	1 437	958	479
June	1 879	1 253	626
July	1 426	950	475
August	1 511	1 007	504
September	672	448	224
October	8 240	5 494	2 747
November	14 101	9 401	4 700
December	12 726	8 484	4 242
Total (m³/yr)	108 049	72 033	36 016

4.3.5 Drummond south end inflow

A significant groundwater ingress to the Drummond Mine occurred on 21st June 2018 after the advancing development for the galleries encountered a fracture zone in the rock (Minerex⁹). Initially, the ingress was not apparent and remained unnoticed when the mine staff left the site in the evening. However, the inflow increased substantially during the night and the mine galleries were found partially flooded the next morning.

It was postulated that that the inflow increased from its initial low rate as a result of local-scale gypsum dissolution. However, a more plausible explanation may be flushing out of fault gouge material from the fault zone. The early water inflow to the mine from the ingress was estimated to be around 12,000 m³/d. After a number of weeks, this had reduced to around 4,000 m³/d. The current inflow at this location is now around 1,200 m³/d.

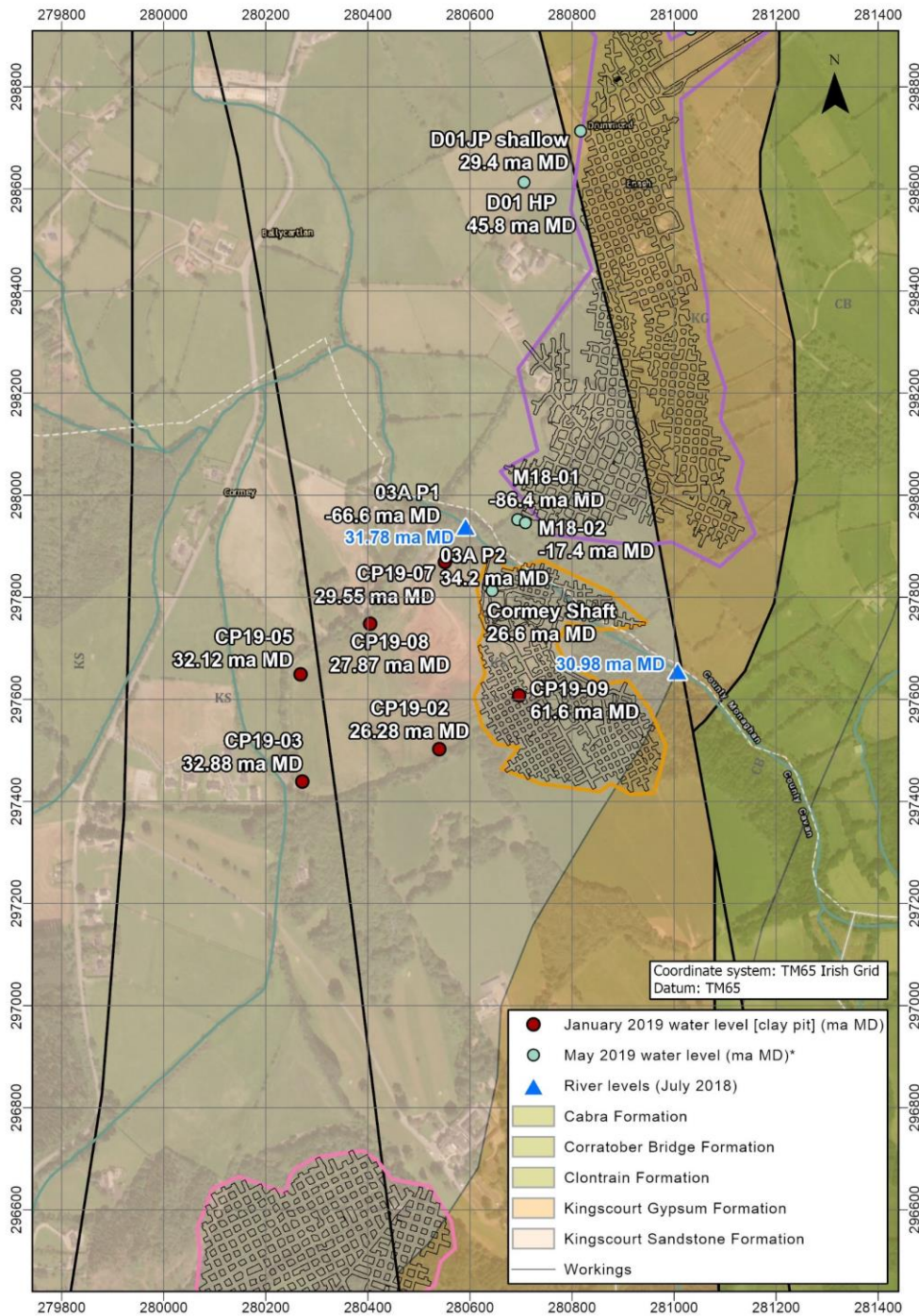
The inflow had a notable impact on monitoring well O3A P 1 (in the Lower Mudstone). The rapid change in water level suggests a limited source of groundwater storage in the locally interconnected fracture network. The reduced inflow rate in 2019 is likely because: (i) much of the groundwater storage has been discharged from the fault; and (ii) July is a seasonal low for

⁹ Minerex, 2019a. Drummond Mine Water Ingress: Assessment of Impact on Groundwater Resources - Rev 1, June 2019. Doc. Ref.: 1632-2093 (Rev 3).

recharge to the groundwater system (and so low groundwater inflow). Recent water samples show the inflow waters are under-saturated with respect to gypsum.

Figure 4.4 shows the current water levels in the area around the south end of the Drummond mine. The map includes available groundwater monitoring data, including the monitoring wells drilled around Cormey brick quarry, plus low flow river spot heights.

Figure 4.4: Current groundwater levels around the south end of Drummond mine



The map shows strongly depressed groundwater levels in M18-02 and 03A P1 due to the 2018 mine inflow, and also reduced water levels in M18-02. Water levels in the Cormey shaft, CP19-02, CP-19-07 and CP19-08 are about 3 to 5 m below the level of the river, indicating they are below their hydrogeology base level and effected by the mine workings or by local groundwater inflow to Cormey brick quarry. The water level in OPA P2 is slightly higher than the river, as are water levels in CP19-02 and CP19-05, which appear to occur to the west of a mapped fault zone.

Figures 4.5 and 4.6 show north-south and east-west cross sections through the south end of the Drummond mine area. The alignment of the cross sections is shown on Figure 4.7. The inferred north-south fault penetrated by the workings in June 2018 is shown on Figure 4.6. The low groundwater levels occur immediately to the west of the fault. The reported water level in MW18-02 appears to coincide with the level of the Upper Gypsum unit. It should be noted that the old Cormey mine workings are located within the Upper Gypsum unit which occurred within about 30 to 40 m below the level of the alluvium below the River Lagan. All the Drummond Mine workings are within the Lower Gypsum unit.

Figure 4.5: North-south cross section through the south end of Drummond mine

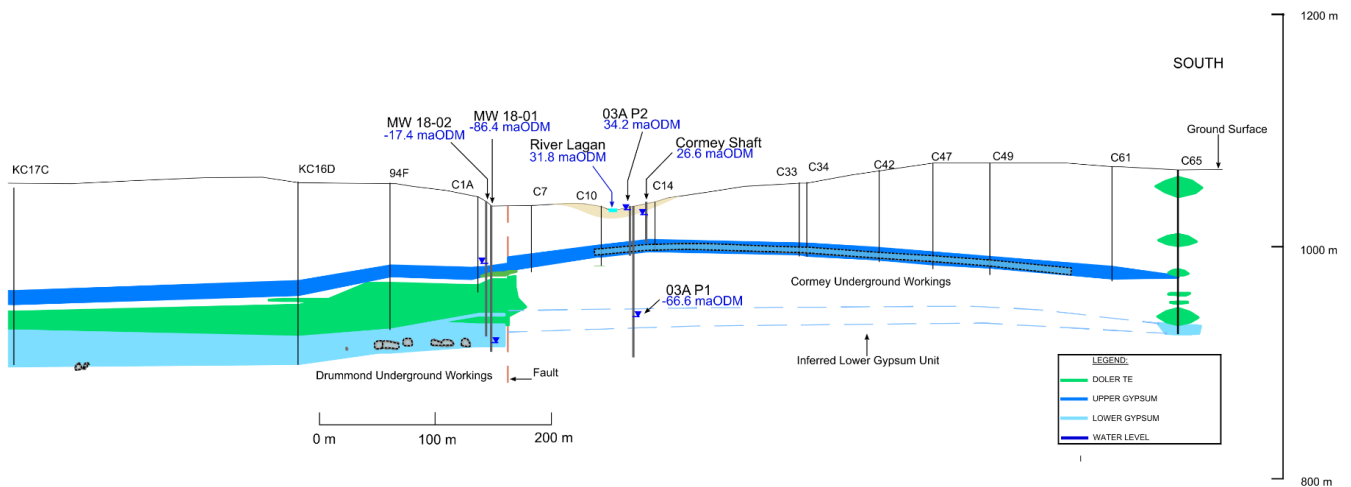


Figure 4.6: East-west cross section through the south end of Drummond mine

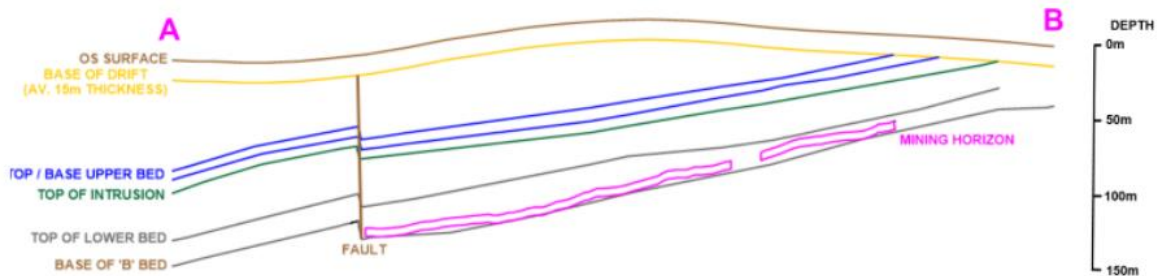
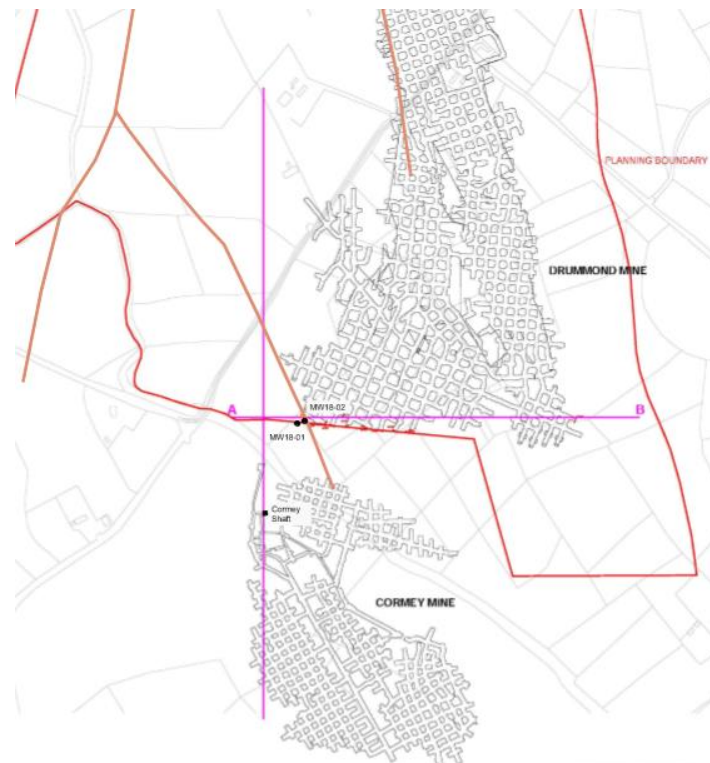


Figure 4.7: Location of the cross sections at the south end of Drummond mine



The following conclusions can be inferred from the available data:

- The area of high drawdown resulting from the Drummond 2018 inflow is localized and limited in aerial extent. The high drawdown area is potentially bounded to the west by sub-parallel north-south trending faults and bounded to the north and south by lithological contacts
- The Lower Gypsum is hydraulically isolated from the Upper Gypsum apart from locally around the fault zone. The Upper Gypsum unit remains saturated (or partially saturated) above the south end of the Drummond workings, below the River Lagan, and within the flooded Cormev workings.
- The superficial deposits around the river remain saturated, with groundwater levels similar to the surface water levels in the river
- The groundwater entering the south end of the Drummond mine likely follows a diffuse flow pathway, as follows:
 - Ultimately, the recharge is derived from the alluvium beneath the river.
 - There is likely a reasonably good hydraulic connection between the alluvium beneath the river and the Upper Gypsum unit (potentially occurring through a dolerite sill).
 - As the percolating water moves downwards through the Upper Gypsum unit, the levels of dissolved calcium and sulphate increase, but the water remains under saturated with respect to gypsum.

- The connection between the Upper Gypsum and the Lower Gypsum (and the Drummond Mine workings) is related to the fault (or the footwall of the fault) but remains relatively weak.

4.3.6 Knocknacran open cast

Water pumped from the Knocknacran open cast is not currently metered. Surface runoff to the sump has also been estimated based on the precipitation record of the site and assuming an average runoff coefficient of 0.3. This produces a runoff contribution of up to 20,000 m³/mon (650 m³/d) in the winter months. Based on the Drumgoosat groundwater inflow assessment shown in Table 4-1, the groundwater inflows to Knocknacran are estimated to be between 200 m³/month in September and 9,000 m³/month in April. However, the actual groundwater inflows may be lower than these estimates because of the relatively small recharge area.

5. CONCEPTUAL GROUNDWATER MODEL

5.1 SUMMARY OF MINE INFLOWS

Groundwater inflows to the existing underground workings are typically low. Inflows to the Drumgoosat mine are estimated to be seasonally between 20 and 870 m³/d. In the Drummond mine, inflows excluding water from the June 2018 mine fault are between 1,600 and 2,300 m³/d, with an additional 900 to 2,100 m³/d derived from the June 2018 mine fault.

5.2 RECHARGE

Precipitation records from 1990 to 2019 show that the site has an annual average precipitation of 955 mm. Dunsany synoptic station (45 km south of the site) has an annual average potential evapotranspiration of 515 mm (2016 to 2019). Assuming actual evapotranspiration is 95% of potential, the effective rainfall for the area is around 466 mm/yr.

The GSI national groundwater recharge map indicates that recharge within the footprint study area is typically 100 to 200 mm/yr. This represents 10 to 20% of mean annual precipitation and 22 to 42% of the effective rainfall, which is considered to be slightly high given the local topography, but is reasonable for planning purposes. It represents a conservative estimate for predicting on-going recharge to the underground mining areas.

5.3 NEAR-SURFACE WATER TABLE

The natural water table is typically within the range 0.5 to 2.0 mbgl across much of the mining area. Groundwater levels in the superficial deposits typically show a seasonal variation of less than 2 m (apart from well MW2 P1). The seasonal variation is due to recharge from October to

March (increasing levels) and limited recharge between April and September as groundwater is removed from the system through evapotranspiration and discharge to local ditches or small streams.

All superficial observation wells are above or very close to mine workings but there are no declining trends in any of the superficial groundwater monitoring points, which suggests that any leakage from the alluvium to the dewatered underground mining areas would represent only a small part of the near-surface water balance. Other underground mines in Ireland have not seen any noticeable change in the near-surface water balance of the superficial deposits caused by mining.

5.4 GROUNDWATER FLOW

Based on the available monitoring results, it can be inferred that the north-south strike of the stratigraphical contacts exerts a significant influence on groundwater flow. Most of the groundwater movement within the strata of the Kingscourt Gypsum Formation occurs under fracture flow conditions through structures (faults, or occasionally karst within the gypsum units) or within the dolerite sills which are thought to be locally altered and more potentially permeable than the surrounding gypsum and mudstone units.

The observed geological discontinuities within the strata means there is limited lateral or vertical groundwater flow within the Kingsland Gypsum Formation on a site scale. The layered nature of the strata impedes the downward flow of groundwater to the mine voids and creates strong vertical hydraulic gradients.

The north-south strike of many of the major faults helps to reinforce the groundwater compartmentalisation. The Kingscourt Gypsum Formation is located within the Kingscourt Outlier, which is a half-graben feature, approximately 1.2 km wide (east-west) and 12 km long (north-south). During mine dewatering, the boundaries of the half-graben have helped to localise the area of drawdown. The western limit of drawdown is a fault within the Kingscourt Sandstone Formation.

The geology information and available water level data suggest that the area of drawdown influence from the mining is anisotropic in a north-south direction. This is illustrated in Figure 3.16, where the relatively low groundwater inflow rates to Drumgoosat and Knocknacran produce highly localised areas of drawdown, primarily defined by north-south trending faults. Penetration of the June 2018 mine fault by mining extended the area of influence by a small amount to the south and west.

The groundwater inflows to the Drummond Mine are around an order of magnitude larger than Drumgoosat and Knocknacran combined due to the proximity of saturated alluvial deposits below River Lagan. The saturated alluvium crosses the north-south trending sub-crop areas of

the Kingscourt Gypsum units. The saturated alluvial deposits that underlie the river cause on-going recharge to the Upper Gypsum unit.

5.5 HYDROGEOLOGICAL BOUNDARIES

The total area of drawdown for Drumgoosat, Knocknacran and Drummond is estimated to be less than 4.5 km². The inferred hydrogeological boundaries are illustrated in Figure 3.16 and can be described as follows:

- Western boundary: a fault within the Kingscourt Sandstone Formation. Mine workings have not penetrated this fault. The area of drawdown is unlikely to extend beyond it.
- Northern boundary: the inferred geological interpretation shows the gypsum pinching out, which would support the relatively localised northward extent of the drawdown, potentially further constrained by a northwest-southeast trending fault mapped by the GSI. Current indications are that drawdown extends no more than about 0.5 km from the northern part of the workings.
- Eastern boundary: the graben-stepped faulting determines the maximum distance which any drawdown can extend to the east. Where mining into the Namurian Sandstone has occurred (Drummond and the southeast portion of Drumgoosat/Knocknacran), the area of drawdown may locally extend outside of the Kingscourt Gypsum Formation.
- Southern boundary: drawdown to the south appears to have been limited, potentially by offsets in the Kingscourt Gypsum strata. Recharge from the saturated alluvial deposits below the River Lagan also creates a recharge boundary between the Drummond Mine and the old Cormey workings.

Following the intersection of the fault by the underground development in the southwest part of the workings, the initial inflow was around 12,000 m³/d. The inflow has now reduced to around 1,200 m³/d. The inflow is sustained by recharge (as opposed to groundwater storage) which is ultimately derived from the alluvial deposits below the River Lagan, with the percolating water passing through the Upper Gypsum Unit and through a weak sub-vertical hydraulic connection into the Drummond Mine workings (Lower Gypsum unit).

There are a number of examples of underground mines in Ireland and elsewhere that have encountered additional groundwater inflows as a result of penetrating hydraulic boundaries caused by lithological contacts or faults. Groundwater levels in the surrounding bedrock units typically show very little variation until the hydrogeological boundary is penetrated. At Drummond, there was a rapid fall in water level in OPA P 1 level once mining had penetrated the hydrogeological boundary, indicating limited storage within the Lower Mudstone Member outside of the boundary. The slight fall in water level in the Cormey shaft monitoring point indicates re-equilibrium of the system as a result of the increased mine inflows.

5.6 IMPLICATIONS FOR THE R179 AND L4900 ROADS

Prior to June 1998, the groundwater level in the Kingscourt Gypsum beneath the R179 was about -30 maODM, which represents about 70 m of drawdown from its original pre-mining groundwater level. Pumping water into the Drumgoosat well following the June 2018 Drummond inflow event caused the water level beneath the road to rise to a maximum of about -5 maODM (995 mine level; Figure 5.1). Figure 5.2 shows the extent of inundation of the lower seam for water levels of -37 and -6 maODM. The current groundwater level beneath the road is about -15 maODM.

Figure 5.1: Water levels in the Drumgoosat workings from January 2018 to June 2019 (note that water levels on the y-axis are mine level – maODM plus 1,000 m)

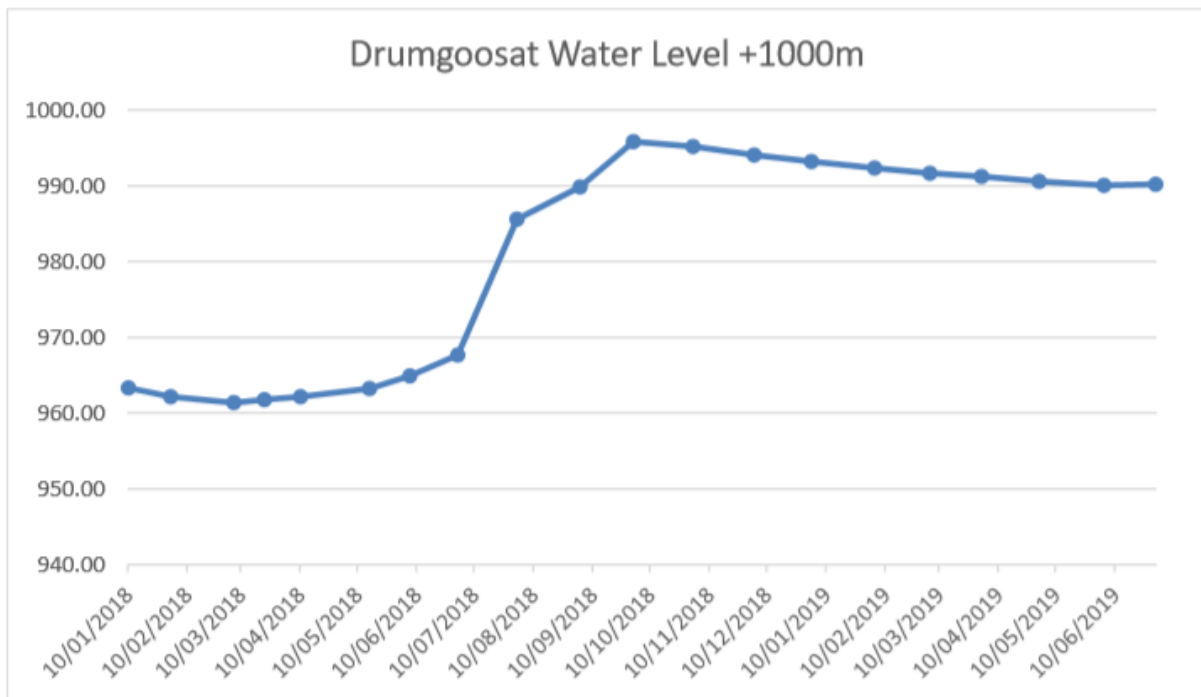
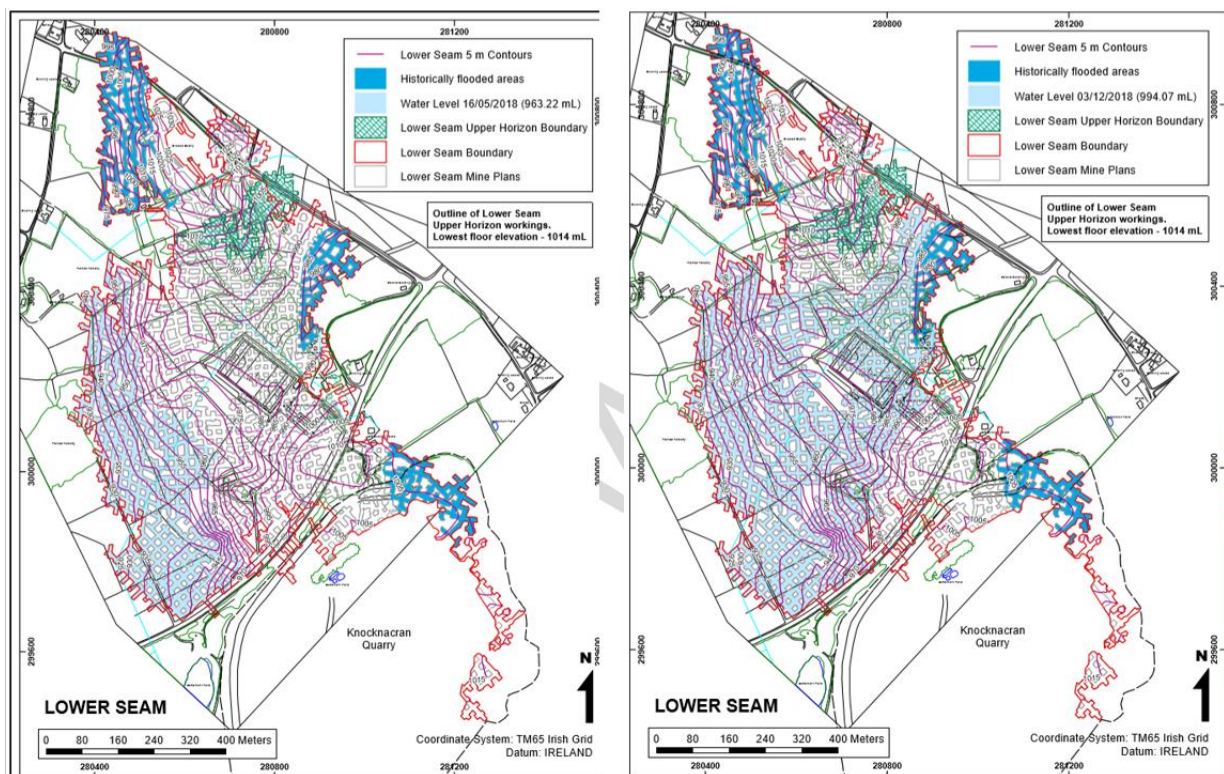


Figure 5.2: Extent of inundation in the Lower Seam close to the R179 with a water level of -37 maODM (left) and -6 maODM (right)



While mining is on-going in Knocknacran open cast and pumping from the Drumgoosat well is being continued, it can be expected that groundwater levels will remain at or below their current level beneath the R179 and L4900.

The available data indicate that seasonal fluctuations are unlikely to affect groundwater levels beneath the roads.

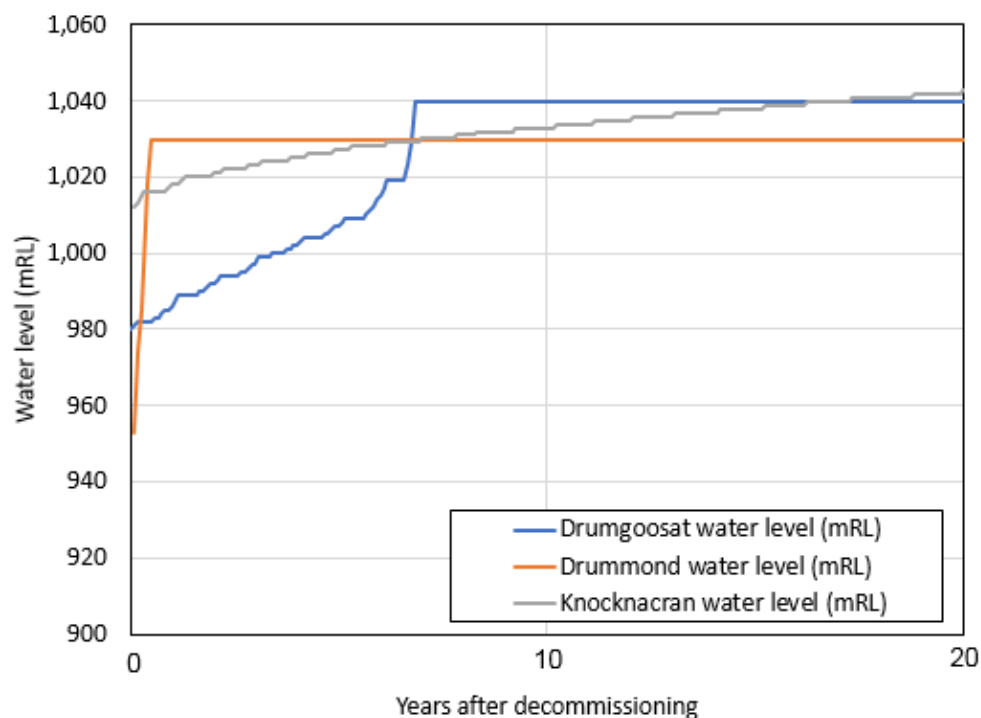
5.7 IMPLICATIONS FOR THE EVENTUAL CLOSURE OF THE SITE

Upon closure of the mine and final shut down of the pumping in Knocknacran, Drumgoosat and Drummond, a lake will form in the area of the Knocknacran open cast and all underground workings will flood. The rate of water level rise in lake will be controlled by the incident precipitation and runoff onto the area of the open cast and the groundwater interconnection with Drummond underground workings.

The water balance model has been used to make a preliminary prediction of the post mining rise in water levels. The model indicates that the Knocknacran lake will rise to about 44 maODM within a period of about 10-15 years following shut down of the pumps (Figure 5.3) and that the lake would create a small surface water overflow at the low point on its western margin. The actual rate of water level rise would depend on the climatic conditions and the amount of rainfall that occurred during the post-closure period.

Figure 5.3 also shows that flooding of the Drummond workings would occur much more rapidly than the lake because of the high rate and groundwater inflow and the low void space of the underground workings relative to the open cast void. The preliminary model indicates that the Drummond workings would flood to about the 33 maODM elevation within a year. There may be some groundwater transfer from the Drummond workings to the lake during the early period of recovery. Potential outflow from the lake to Drummond may also affect the timing of the final stages of the lake recovery, once the lake level rises above about 33 maODM.

Figure 5.3: Water balance model results showing post-mining water level recovery



The Drumgoosat underground is isolated from the Knocknacran open cast by backfill material placed against the North wall of the Knocknacran pit. The backfill will minimize the likelihood of groundwater outflow at the south end of Drumgoosat. Groundwater levels within the Upper and Lower Gypsum beneath the R179 and L4900 roads would initially rise at a slower rate than the lake, but the rate of water level rise would increase once the underground void space is totally flooded. The water level about the flooded workings would rise to above 40 maODM within about 4-6 years. Transfer of groundwater beneath the roads will be limited because of the presence of the backfill material. This will help limit the amount of future gypsum dissolution that can occur beneath the R179.

Final post-mining groundwater levels around Knocknacran are expected to be slightly higher than pre-mining. The final groundwater flow system across the site area can be expected to be similar to pre-mining. Groundwater recharge will occur due to rainfall and runoff on the lake and due to minor natural recharge above the flooded underground mines. Groundwater

discharge from the site will occur across the boundaries of the hydrogeological block defined in Section 5.5. Bulkheads are planned near the south end of the Drummond Mine to minimize the potential for outflow to occur across the fault zone in the southwest part of the workings.

6. SUMMARY AND ACTION PLAN

6.1 HYDROGEOLOGY

The principal control of the hydrogeology of the gypsum mining district is the north-south alignment of the geological strata. This is further enforced by the similar north-south trend of the main regional geological structures. The general low permeability nature of the strata within the Kingscourt Gypsum Formation means that groundwater inflows to the mining areas are mostly low.

The current study includes the inactive Drumgoosat underground, the active Knocknacran quarry (open cast) and the active Drummond underground mine. The available data indicate that all three mining areas are contained within a broad hydrogeological block. Although there are some internal boundaries to the block, the three mining areas appear to be hydrogeologically connected along the strike of the Kingscourt Gypsum Formation.

The hydrogeological block is bounded to the west by a fault within the Kingscourt Sandstone Formation, and to the east by the faults that form the eastern boundary of the half graben. Based on pumping records from the Drumgoosat underground, the extent of dewatering influence to the north appears to be limited, likely no more than 0.5 km to the north of the existing underground mine workings. The available geology data suggest that the gypsum strata may pinch out or become offset.

Saturated alluvial deposits of the River Lagan cross the north-south trending sub-crop of the Kingscourt Gypsum strata between the south end of the Drummond Mine and the historical (flooded) Cormey Mine. Recharge to Upper Mudstone and Upper Gypsum units from the alluvium created mining difficulties during Cormey operations (which mined the Upper Gypsum seam) and has led to higher inflows into the Drummond Mine than are observed at either Drumgoosat or Knocknacran.

6.2 POTENTIAL IMPACTS

All local public water supplies are located outside the boundaries of the hydrogeological block and are not affected by the mining operations. Source zones for the water supplies are remote from the mining areas.

There is no apparent influence of mining on the groundwater table in the superficial deposits that overlie the mine workings, except very locally around the Knocknacran open cast. This is consistent with observations around mining areas elsewhere in Ireland.

While mining is on-going in Knocknacran open cast and pumping from the Drumgoosat well is being continued, it can be expected that groundwater levels will remain low beneath the R179 and L4900 roads. There may be a minor seasonal variation in groundwater level, but this would be limited provided pumping from the workings is continuous. The available data indicate that seasonal fluctuations are unlikely to affect groundwater levels beneath the roads.

6.3 EVENTUAL SITE CLOSURE

When mining is completed in the Knocknacran open cast, and the pumps are shut down in the open cast sump and in the Drumgoosat dewatering well, a lake will begin to form in the area of the open cast. The rate of water level rise will be controlled by the incident precipitation and runoff onto the area of the open cast and the groundwater connection with the Drummond Mine.

The water balance model indicates that the Knocknacran lake will rise to about 44 maODM within a period of about 20-25 years following shut down of the pumps. Flooding of the Drummond workings to about the 33 maOAD elevation will occur within a year. The backfill material placed against the north wall of the Knocknacran pit will help prevent the possibility of groundwater outflow at the south end of Drumgoosat. The water level about the flooded workings would rise to above 40 maODM within about 4-6 years. Transfer of groundwater beneath the R179 and L4900 roads will be limited because of the presence of the backfill material. This will help limit the amount of future gypsum dissolution that can occur beneath the R179.

6.4 PLAN GOING FORWARD

6.4.1 Key issues

The current study has defined a number of key issues that require on-going monitoring. These are:

- The water level in the Drumgoosat workings
- The water balance of Knocknacran
- The inflow at the south end of the Drummond Mine
- Groundwater levels around the south end of Drummond

6.4.2 Monitoring plan

Going forward, the following needs to be considered for on-going monitoring:

- Continuation of daily monitoring of total mine site discharge from MSE-1 to the River Bursk
- Instantaneous and cumulative flow measurement of the water pumped from Drummond underground
- Instantaneous and cumulative flow measurement of the water pumped from the Drumgoosat well.
- Daily and cumulative flow measurement of the water pumped from the Knocknacran sump
- Daily (or continuous) water level measurements in the Drumgoosat well
- Daily (or continuous) water level measurements in the Cormey shaft
- Quarterly water level measurements in all current monitoring boreholes
- Quarterly water quality sampling of the water pumped from the Drumgoosat well
- Quarterly water quality sampling of the south Drummond inflow

6.4.3 Additional studies

An improved understanding is required to assess the interaction of the Eghagh bog with the mine area, including the swallow hole at Enagh. A walk-over survey of the area is planned for March 2020. A hydrogeology study will be scoped at that time. The study will consider the implications of closure and flooding of the Drummond Mine workings.

7. LIMITATIONS

Piteau Associates has exercised reasonable skill, care and diligence in obtaining, reviewing, analysing and interpreting the information acquired during this study, but makes no guarantees or warranties, expressed or implied, as to the completeness of the information contained in this report. Conclusions and recommendations provided in this report are based on the information available at the time of this assessment.

In preparing the recommendations contained herein, Piteau Associates has relied on information and interpretations provided by others. Piteau Associates is not responsible for any errors or omissions in this information. This report is comprised of text, tables, figures, photos and appendices, and all components must be read and interpreted in the context of the whole report. The report has been prepared for the sole use of Saint-Gobain Mining Ireland (Ltd.), and no representation of any kind is made to any other party.

Respectfully submitted,

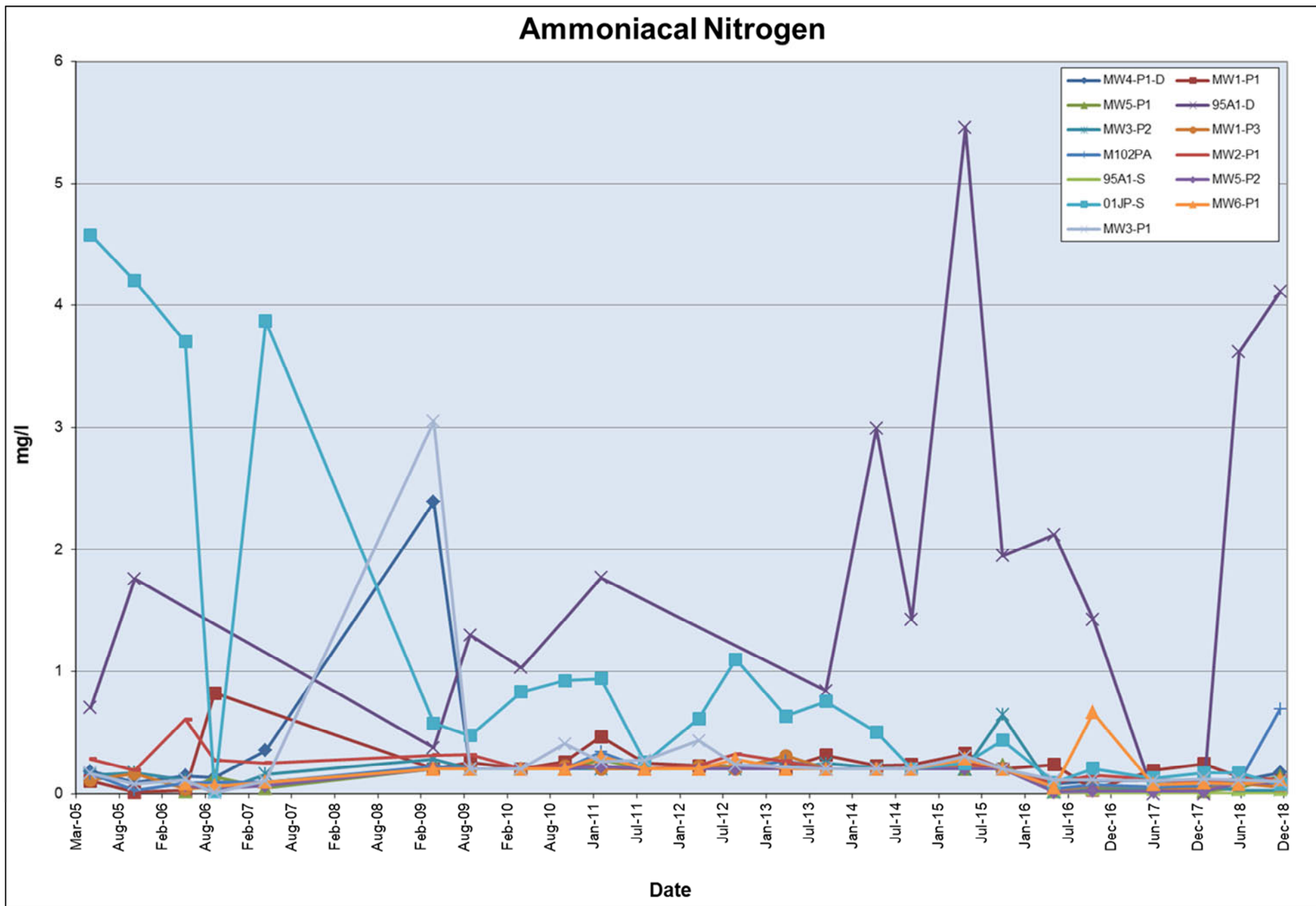
PITEAU ASSOCIATES.

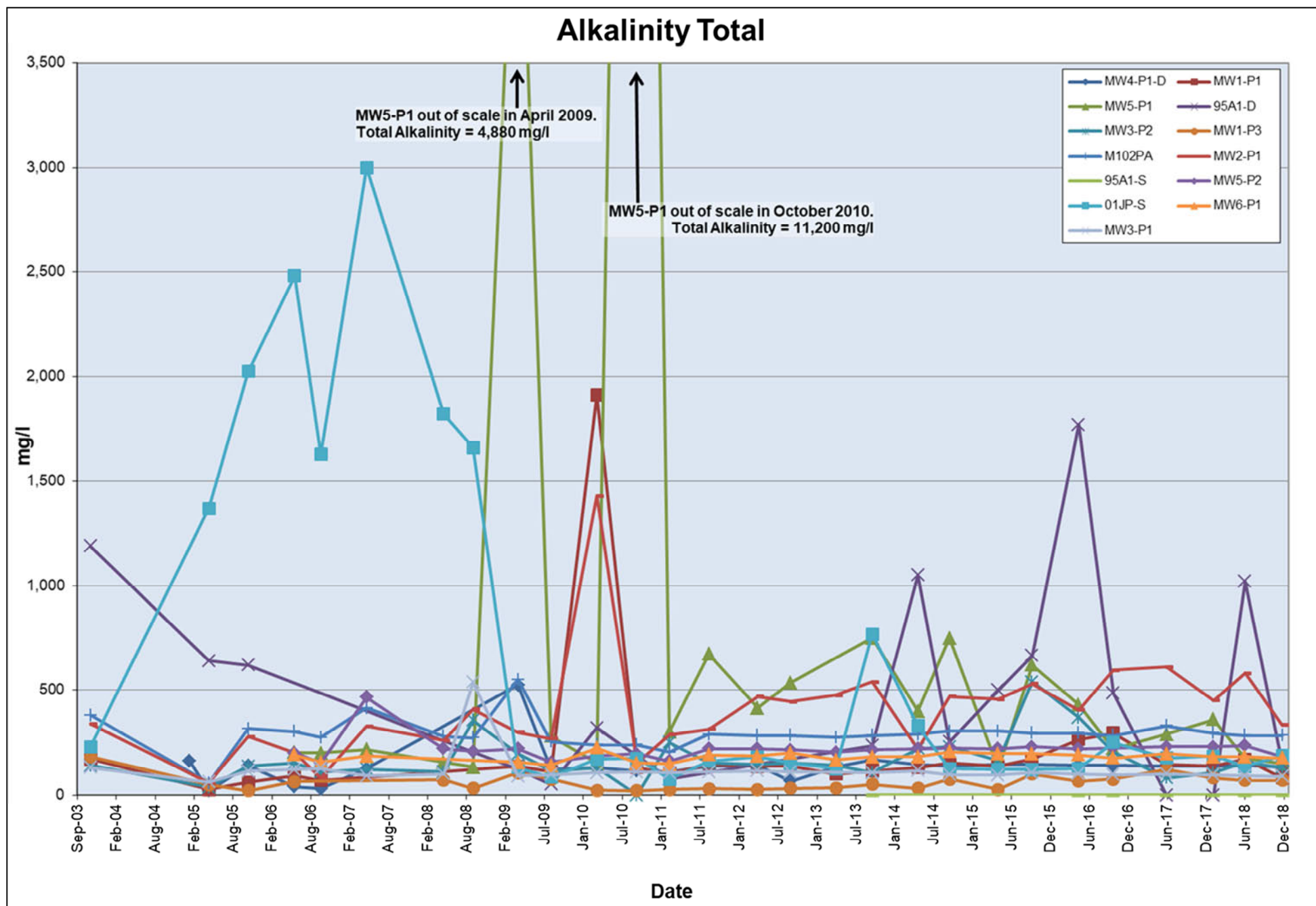
A handwritten signature in black ink, appearing to read 'Geoff Beale', with a long horizontal flourish extending to the right.

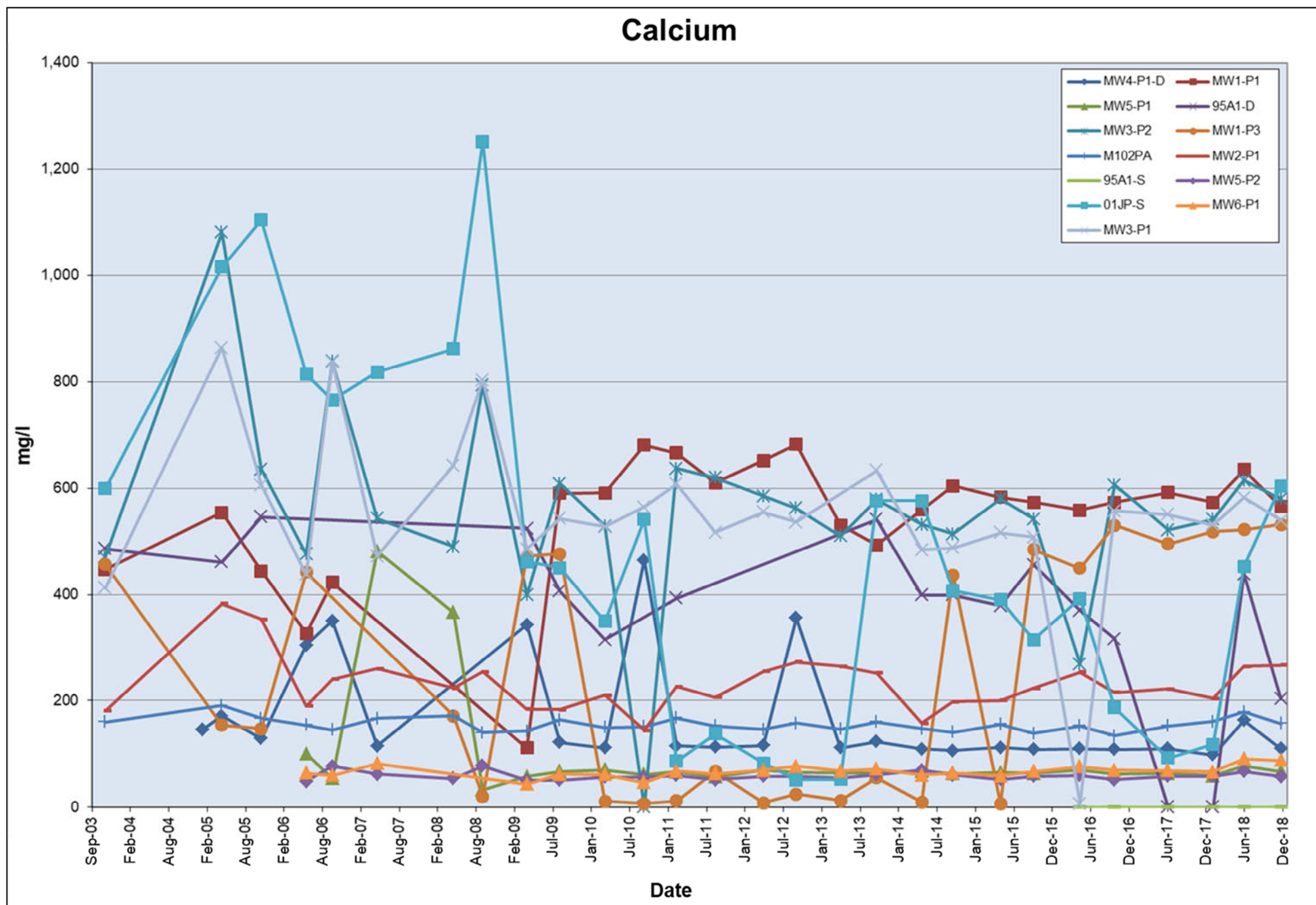
Geoff Beale
Principal

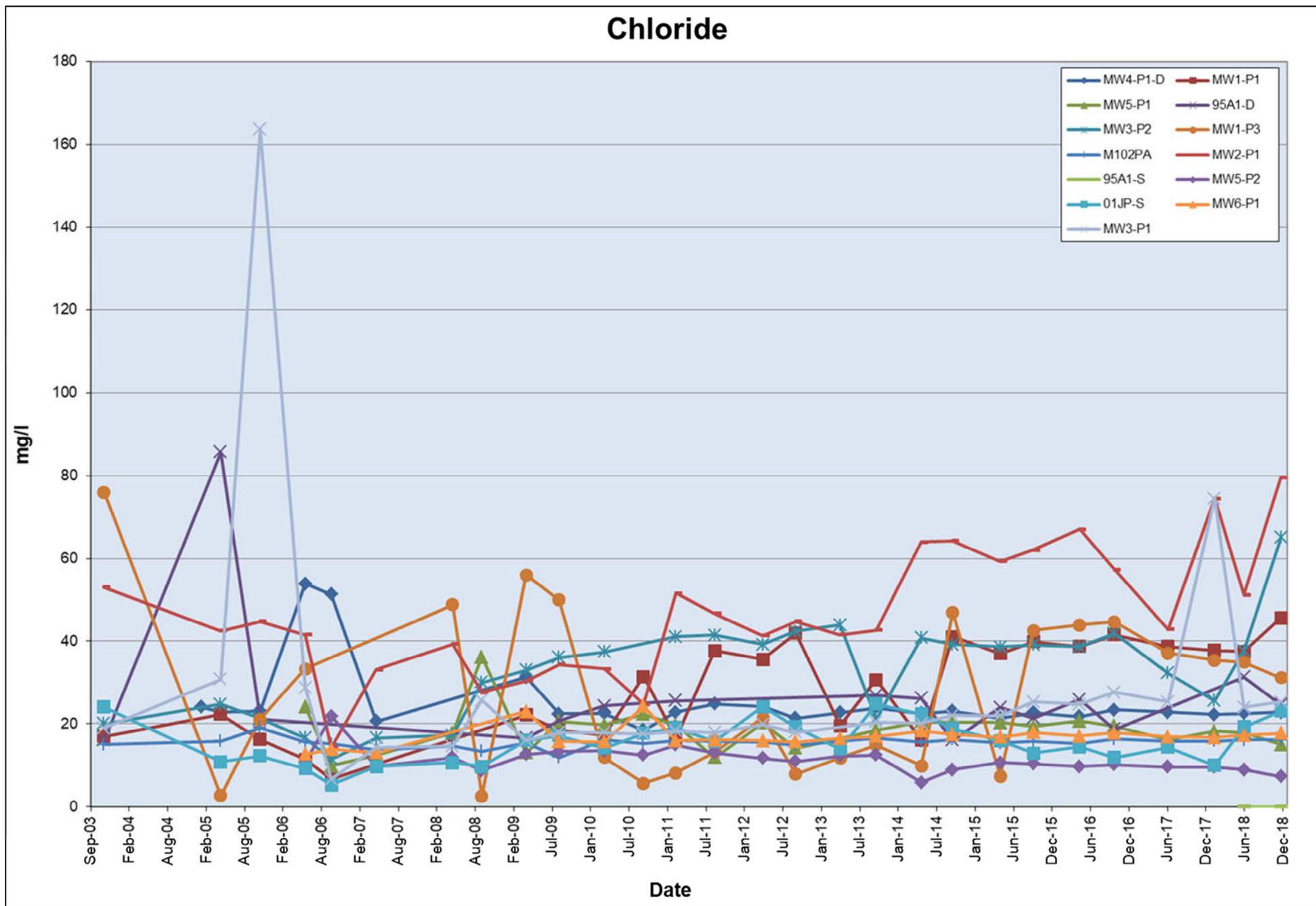
APPENDIX A

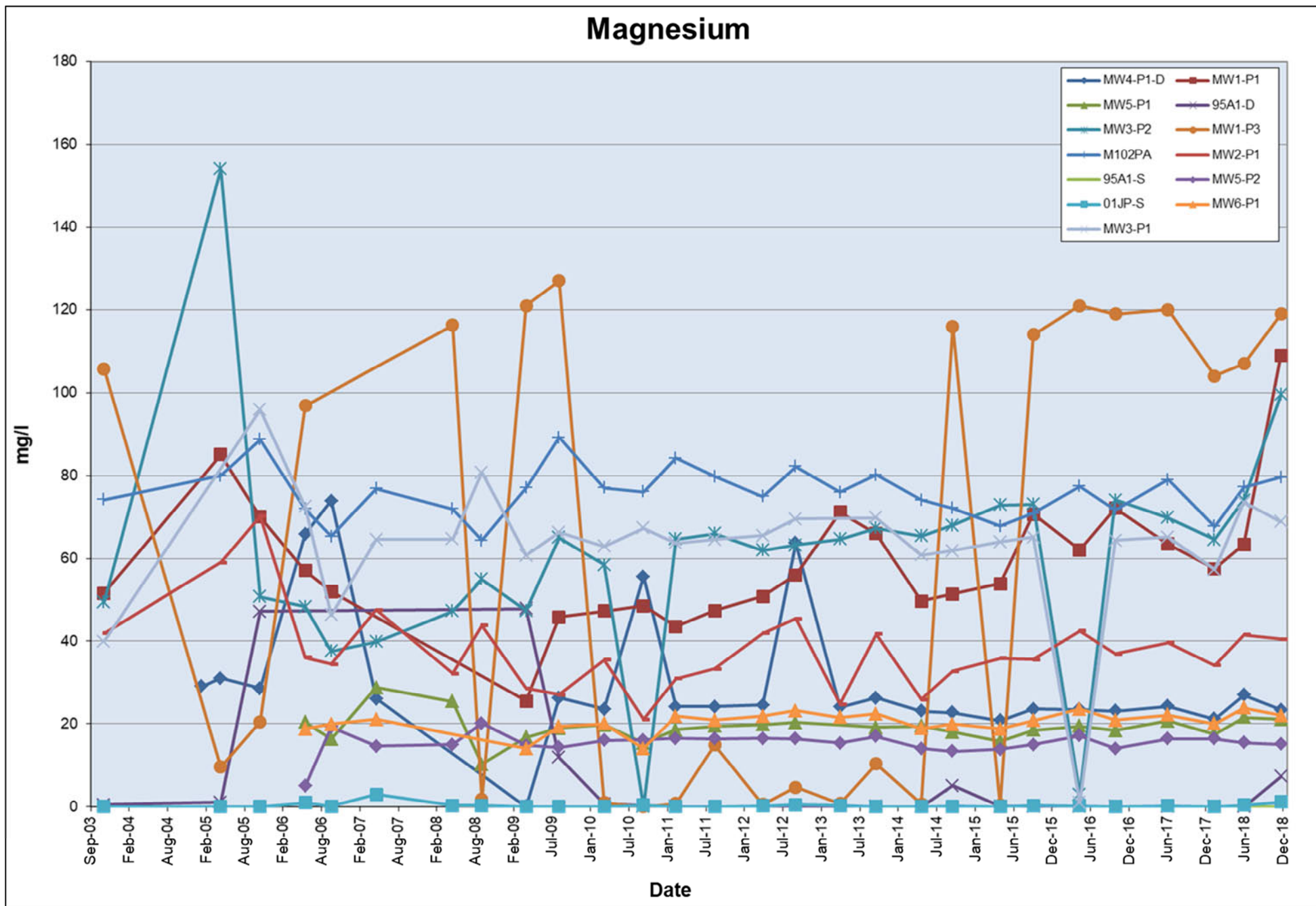
Minerex 2018 Annual Monitoring Report

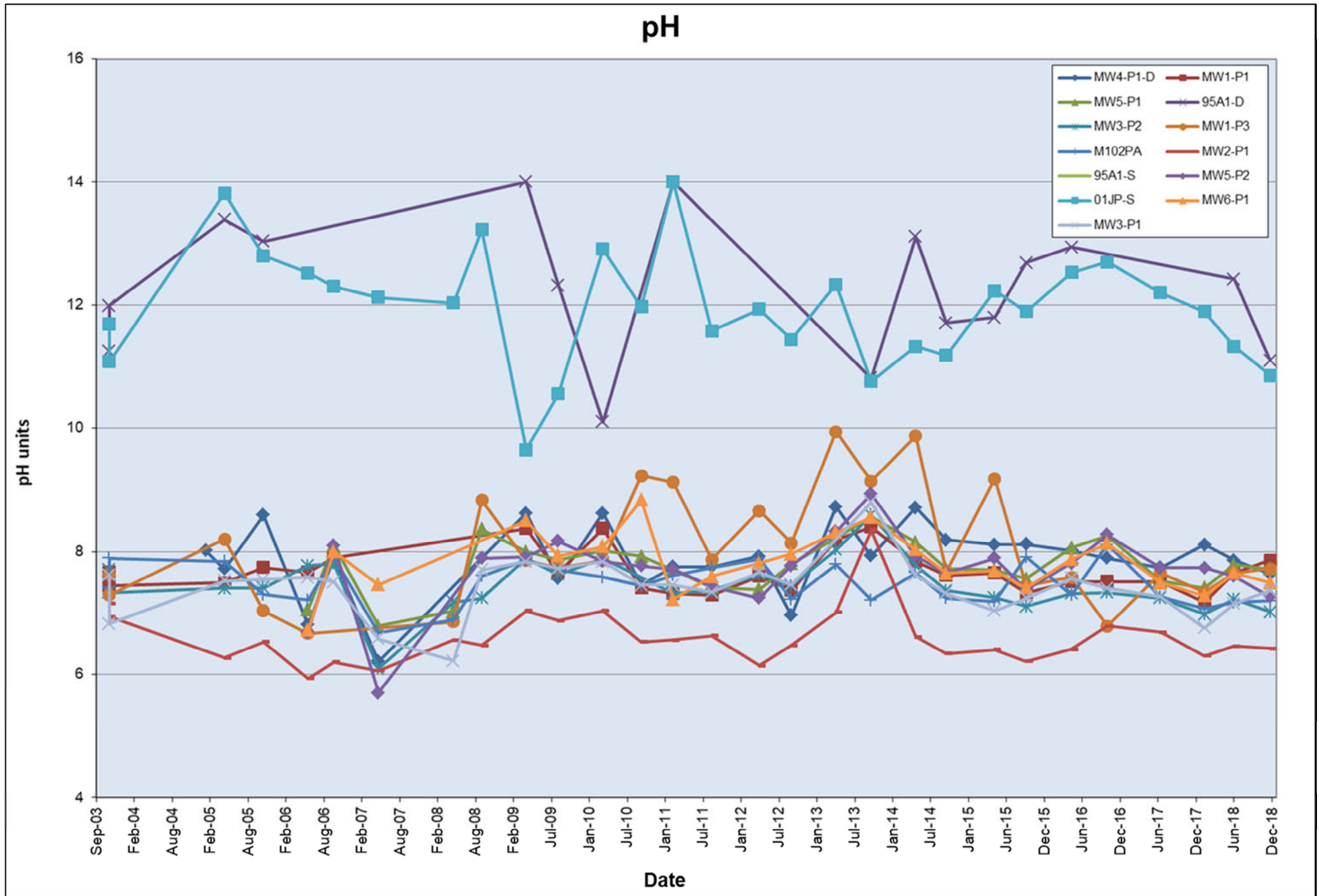


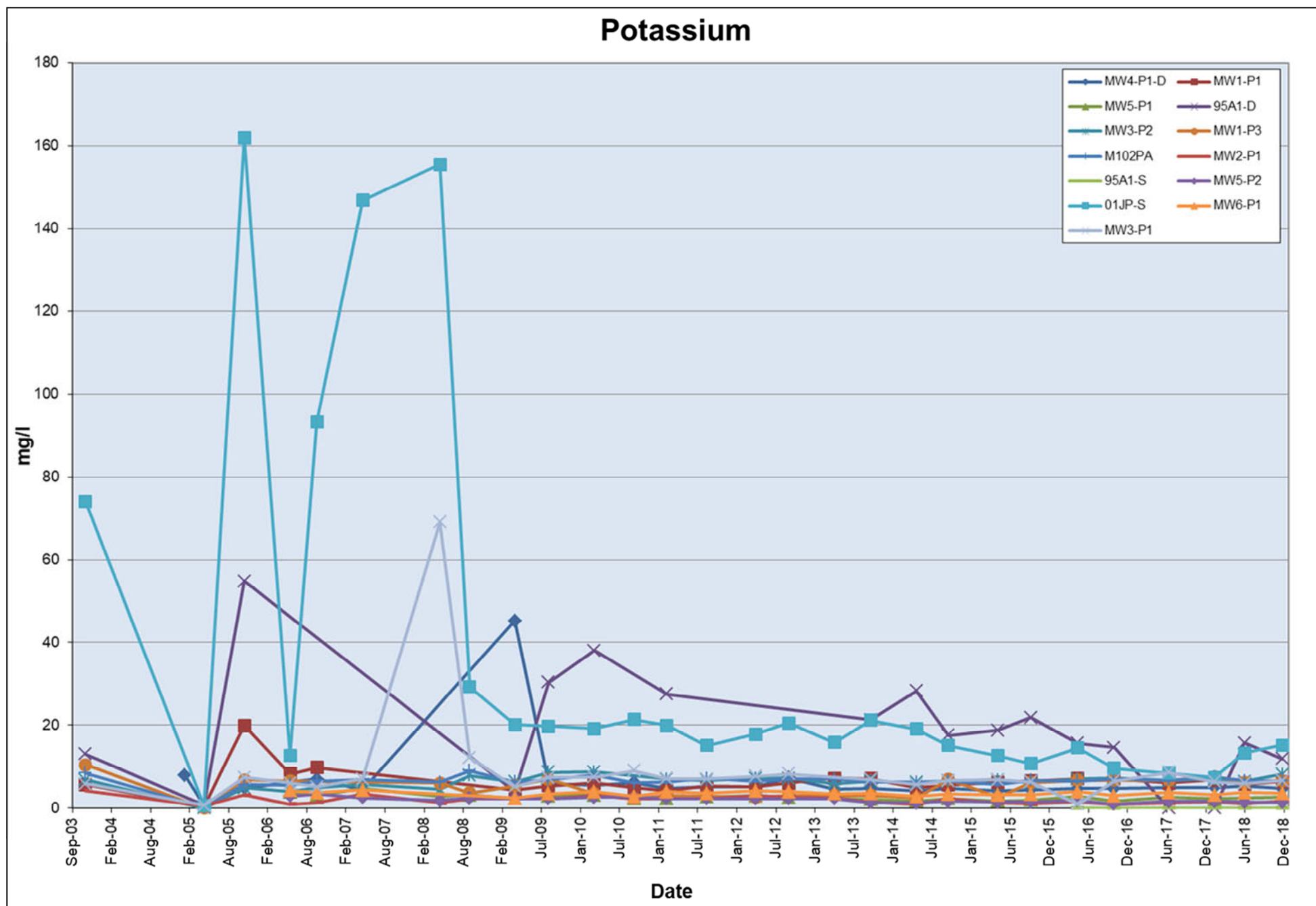


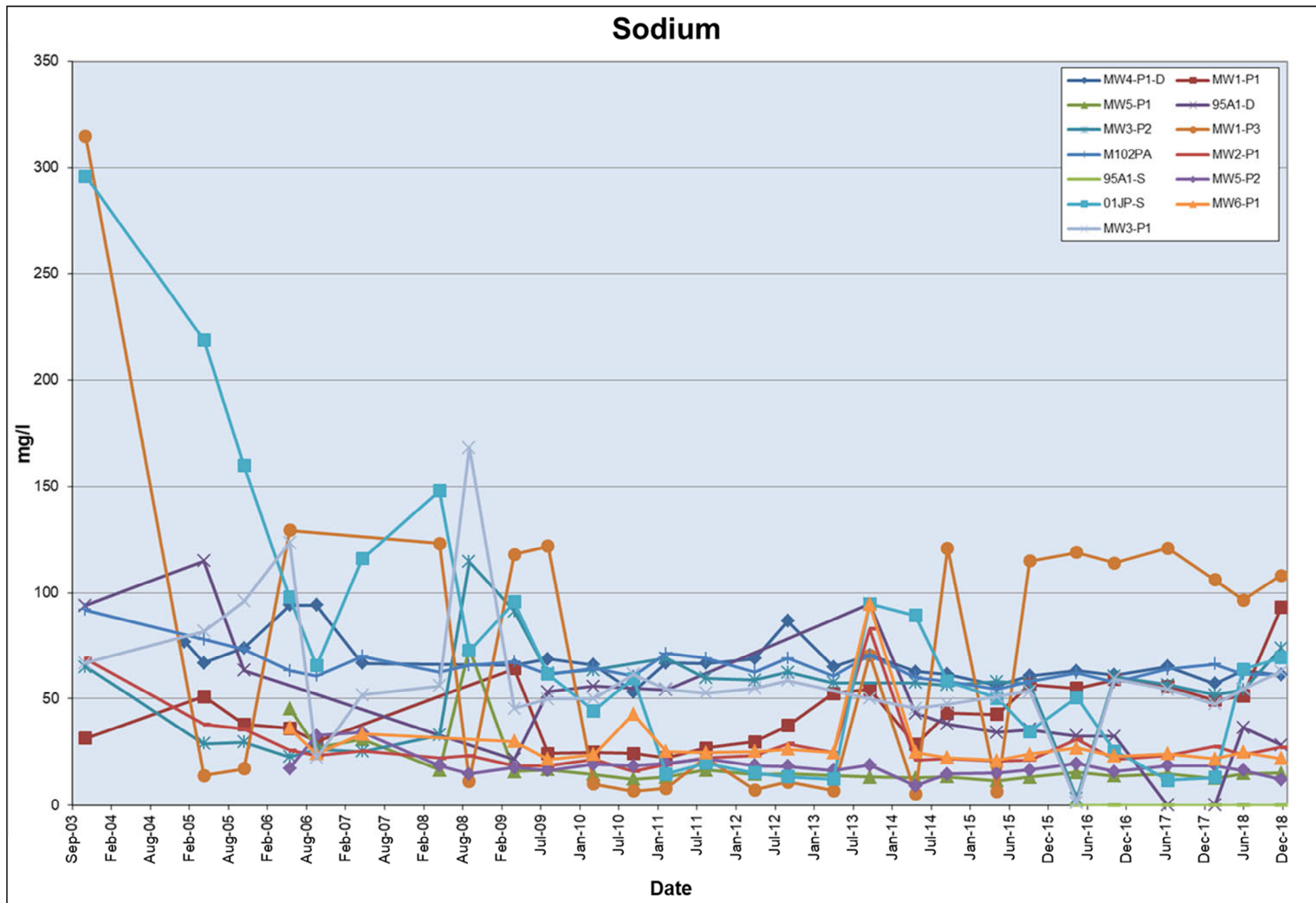


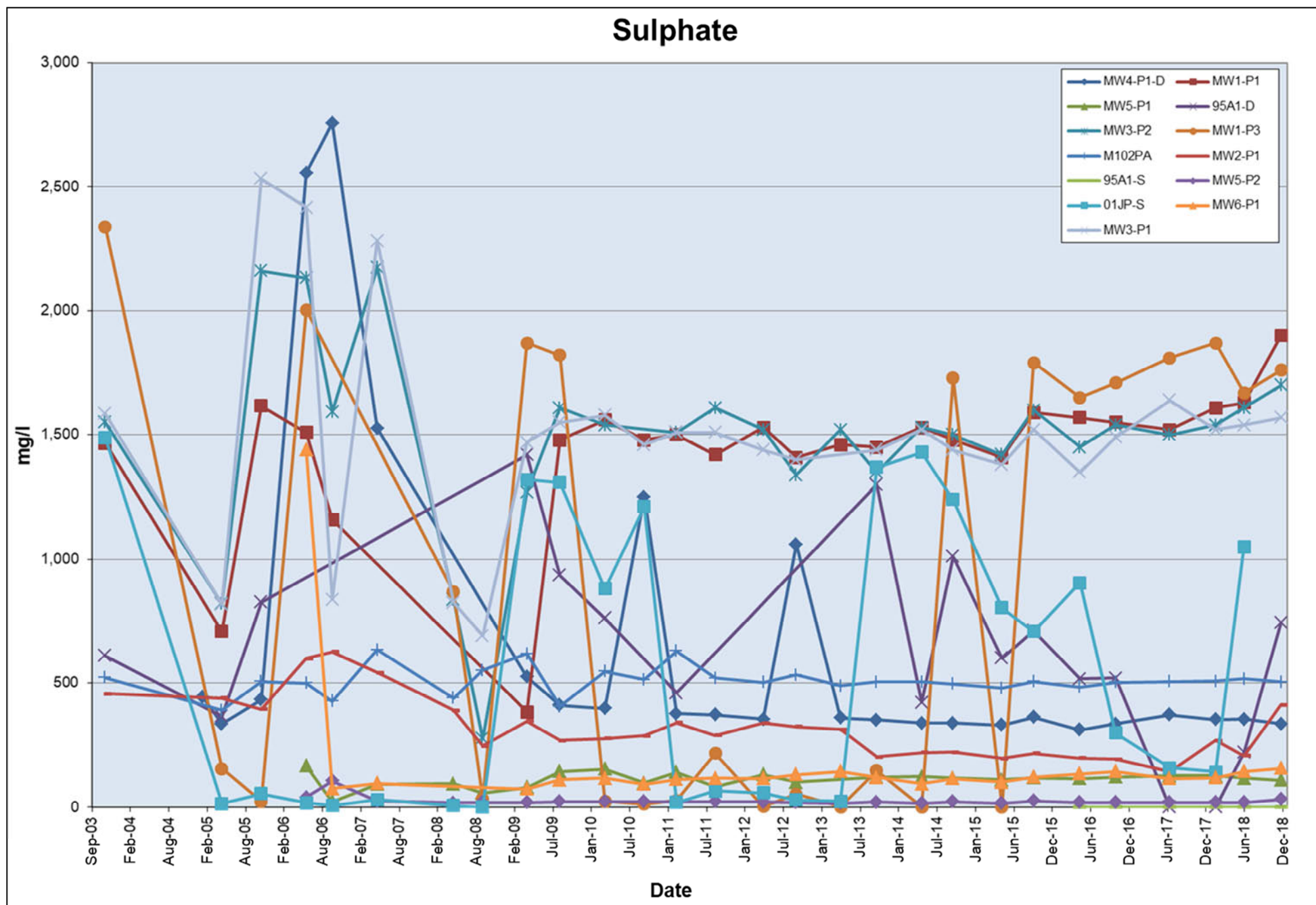












APPENDIX B

Preliminary mine site water balance 2017 to 2019

Month	m ³ /d															mm/d			mRL
	Recorded MSE-1 discharge to Bursk	Recorded Drummond to Lagoons	Estimated Drummond to MSE-1	Estimated contribution from June 2018 mine	Estimated contribution from June 2018 mine	Drumgoosat groundwater	Recorded Drumgoosat Well	Additional to Drumgoosat	Estimated Drumgoosat to MSE-1	Knocknacran groundwater	Knocknacran runoff	Estimated Knocknacran to MSE-1	Site runoff to MSE-1	Total Discharge	Precipitation	PET	Effective Ppt	Recorded water level	
Dec-16																		966.6	
Jan-17	1,776	1,876	1,636	0	0	244	0	241	0	122	18	140	0	1,776	0.0010	0.0003	0.0007	966.4	
Feb-17	2,927	1,736	1,736	0	0	259	0	-998	998	130	63	192	0	2,927	0.0028	0.0006	0.0023	965.5	
Mar-17	2,480	1,645	1,645	0	0	576	0	-497	497	288	50	338	0	2,480	0.0028	0.0010	0.0018	963.9	
Apr-17	1,479	1,921	1,290	0	0	379	0	631	0	189	0	189	0	1,479	0.0003	0.0016	0.0000	961.8	
May-17	535	1,608	520	0	0	31	0	1,088	0	15	0	15	0	535	0.0022	0.0026	0.0000	961.6	
Jun-17	650	1,611	613	0	0	42	0	998	0	21	16	37	0	650	0.0032	0.0027	0.0006	964.1	
Jul-17	589	1,422	563	0	0	31	0	859	0	15	11	26	0	589	0.0029	0.0027	0.0004	966.5	
Aug-17	786	1,459	754	0	0	32	0	705	0	16	16	32	0	786	0.0026	0.0021	0.0006	967.8	
Sep-17	1,686	1,343	1,343	0	0	15	0	-271	271	7	63	71	0	1,686	0.0037	0.0014	0.0023	969.1	
Oct-17	2,569	1,357	1,357	0	0	177	0	-1,058	1,058	89	66	154	0	2,569	0.0031	0.0008	0.0024	968.9	
Nov-17	2,210	1,442	1,442	0	0	313	0	-558	558	157	53	210	0	2,210	0.0022	0.0003	0.0019	967.3	
Dec-17	2,576	1,864	1,864	0	0	274	0	-513	513	137	61	198	0	2,576	0.0025	0.0003	0.0022	965.6	
Jan-18	3,477	2,220	2,255	0	0	234	34	-1,009	975	122	126	248	0	3,477	0.0050	0.0004	0.0046	963.8	
Feb-18	3,167	1,972	1,972	0	0	638	0	-1,019	1,019	130	47	176	0	3,167	0.0023	0.0006	0.0017	962.2	
Mar-18	2,005	2,228	1,673	0	0	366	0	555	0	288	44	332	0	2,005	0.0025	0.0009	0.0016	961.3	
Apr-18	2,163	2,115	1,974	0	0	32	0	141	0	189	6	195	0	2,163	0.0018	0.0017	0.0002	962.0	
May-18	1,405	1,788	1,389	0	0	40	0	399	0	15	0	15	0	1,405	0.0012	0.0026	0.0000	962.8	
Jun-18	600	1,991	579	0	0	32	0	1,412	0	21	0	21	0	600	0.0000	0.0035	0.0000	964.4	
Jul-18	245	7,017	230	0	6,787	32	0	6,787	0	15	0	15	0	245	0.0014	0.0031	0.0000	967.7	
Aug-18	92	8,311	64	0	8,246	14	0	8,246	0	16	11	28	0	92	0.0025	0.0022	0.0004	985.4	
Sep-18	729	7,226	718	0	6,508	183	0	6,508	0	7	4	11	0	729	0.0017	0.0016	0.0001	989.9	
Oct-18	5,817	6,411	1,357	4,363	0	303	59	691	0	89	8	97	0	1,453	0.0011	0.0009	0.0003	995.8	
Nov-18	6,319	5,303	1,442	4,613	0	283	137	0	0	157	107	263	0	1,706	0.0044	0.0005	0.0039	995.2	
Dec-18	5,928	4,843	1,864	3,845	0	234	144	0	0	137	83	219	0	2,083	0.0034	0.0004	0.0030	994.1	
Jan-19	4,174	4,136	2,220	1,818	0	576	112	98	0	122	14	136	0	2,357	0.0009	0.0004	0.0005	993.3	
Feb-19	4,801	4,446	1,972	2,666	0	406	124	0	0	130	33	163	0	2,135	0.0019	0.0007	0.0012	992.4	
Mar-19	5,963	4,750	2,228	3,337	0	31	131	0	0	288	110	398	0	2,626	0.0051	0.0011	0.0040	991.8	
Apr-19	4,465	4,013	2,115	2,133	0	42	884	0	0	189	42	27	0	2,331	0.0026	0.0017	0.0010	991.2	
May-19	4,095	3,901	1,788	2,291	0	31	1,292	0	0	15	0	15	0	1,803	0.0013	0.0023	0.0000	990.6	
Jun-19	3,407	3,449	1,611	1,747	0	34	399	91	0	21	28	49	0	1,660	0.0035	0.0026	0.0010	990.0	
Jul-19	3,222	3,440	1,422	1,779	0	14	449	239	0	15	6	21	0	1,443	0.0030	0.0029	0.0002	990.2	
Aug-19	4,739	3,663	1,459	3,257	0	177	1,171	0	0	16	6	23	0	1,482	0.0025	0.0024	0.0002	990.1	
Sep-19	3,912	3,968	1,343	2,557	0	313	588	68	0	7	4	12	0	1,355	0.0017	0.0016	0.0002	989.4	
Oct-19		3,661					891									0.0008		988.4	
Nov-19																		986.7	
Dec-19																			

Green = monitored value, orange = derived value

Appendix 2

Saint Gobain Insurance Document

To Whom It May Concern

30 June 2020

Dear Sir or Madam,

CONFIRMATION OF INSURANCE

Saint Gobain Limited including Saint-Gobain Construction Products (Mining) Limited

As requested by the above client, we are writing to confirm that we act as Insurance Brokers to the client and that we have arranged insurance(s) on its behalf as detailed below:

PUBLIC & PRODUCTS LIABILITY

LAYER	Primary
INSURER	Zurich Insurance plc
POLICY NUMBER	TBC
PERIOD OF INSURANCE	01 July 2020 to 30 June 2021 or any subsequent period for which the Company accepts payment for the renewal of this Policy
LIMIT OF INDEMNITY	EUR5,000,000 per claim and in the annual aggregate
CONDITIONS	Indemnity to Principals
EXCLUSIONS	RS5000 Product is excluded from cover

We have placed the insurance which is the subject of this letter after consultation with the client and based upon the client's instructions only. Terms of coverage, including limits and deductibles, are based upon information furnished to us by the client, which information we have not independently verified.

This letter is issued as a matter of information only and confers no right upon you other than those provided by the policy. This letter does not amend, extend or alter the coverage afforded by the policies described herein. Notwithstanding any requirement, term or condition of any contract or other document with respect to which this letter may be issued or pertain, the insurance afforded by the policy (policies) described herein is subject to all terms, conditions, limitations, exclusions and cancellation provisions and may also be subject to warranties. Limits shown may have been reduced by paid claims.

We express no view and assume no liability with respect to the solvency or future ability to pay of any of the insurance companies which have issued the insurance(s).



Chartered

Registered in England and Wales Number: 1507274
Registered Office: 1 Tower Place West, Tower Place, London EC3R 5BU.
Marsh Ltd is authorised and regulated by the Financial Conduct Authority for General Insurance Distribution and Credit Broking (Firm Reference No. 307511).
RM DES v4.0

We assume no obligation to advise yourselves of any developments regarding the insurance(s) subsequent to the date hereof. This letter is given on the condition that you forever waive any liability against us based upon the placement of the insurance(s) and/or the statements made herein with the exception only of wilful default, recklessness or fraud.

This letter may not be reproduced by you or used for any other purpose without our prior written consent.

This letter shall be governed by and shall be construed in accordance with English law.

Yours faithfully,

The image shows a handwritten signature in cursive that reads "L Palmer". To the right of the signature is a circular stamp. The stamp contains the word "MARSH" at the top and "LTD" at the bottom.

Marsh Ltd