Annual Environmental Monitoring Report for the TSF site at Tara Mines, 2024

Final

Boliden, Tara Mines

March 2025

Quality information

Prepared by	Checked by	Verified by	Approved by
Aline Moreau Consultant Hydrogeologist	Darragh Reilly Principal Hydrogeologist	Neil Mackenzie Technical Director	Jenny Rush Associate Hydrogeologist

Revision History

Revision	Revision date	Details	Authorized	Name	Position
0	04 March 2025	Draft	JR	Jenny Rush	Associate Hydrogeologist
1	12 March 2025	Final Draft	JR	Jenny Rush	Associate Hydrogeologist
2	24 March 2025	Final	JR	Jenny Rush	Associate Hydrogeologist

Distribution List

# Hard Copies	PDF Required	Association / Company Name

Prepared for:

Boliden Tara Mines

Prepared by:

Jenny Rush
Associate Hydrogeologist
E: Jenny.rush@aecom.com

AECOM Limited
Midpoint, Alencon Link
Basingstoke
Hampshire RG21 7PP
United Kingdom

T: +44(0)1256 310200
aecom.com

Table of Contents

Charts

Tables

1. Introduction

1.1 This report has been prepared to provide a review of the hydrogeological, hydrological and water quality monitoring data collected during 2024 at the tailings storage facility (TSF) at Tara Mines, Navan. The 2024 hydro-environmental data have been reviewed and compared with data collected since 2020 (5 years' worth of data), to identify changes and trends in the hydrogeological and water quality conditions.

1.2 The extraction and processing operations at the Tara Mines site and Randalstown TSF are subject to Industrial Emissions Licence (IEL) No. P0516-04. This report has been prepared to address Condition 6.21 of the licence, as follows:

> *"The licensee shall review and assess all hydrogeological monitoring and water quality monitoring results and report annually on compliance with the European Communities Environmental Objectives (Surface Water) Regulations 2009 as amended and European Communities Environmental Objectives (Groundwater) Regulations 2010 as amended. The report shall include trend assessments."*

Background

1.3 The Tara zinc-lead mine is situated 2 km west of Navan, County Meath, Ireland. Since 1977, part of the residue produced from processing the ore (known as tailings) has been pumped to the Randalstown TSF, some 2.8 km north of the mine site. Since 2019, Stage 6 of the TSF is being operated.

1.4 This report is the most recent in a series of review reports based on hydro-environmental monitoring data collected and supplied by Boliden Tara Mines DAC. The reports outlined below have provided background on the geology, hydrology, and hydrogeology of the TSF site, along with geological maps and graphs of the spatial variation of sulphate concentrations:

- Randalstown Tailings Facility - Stage IV: Hydro-environmental Monitoring Report (Knight Piésold, 1996).
- Randalstown Tailings Management Facility Stage V Raise to Embankment Environmental Impact Statement (EIS) (Tara Mines, 2009).
- Risk Screening and Technical Assessment Report for Randalstown Tailings Management Facility at Tara Mines (AECOM, 2015).
- TSF Stage 6 Extension – Hydrology & Hydrogeology Environmental Impact Assessment (AECOM, 2016).
- Remediation Action Plan for Randalstown Tailings Management Facility at Tara Mines (AECOM, 2021).
- Corrective Action Feasibility & Design Report for Tara Mines TSF (AECOM, 2022).
- Annual Environmental Monitoring Report for the TSF site at Tara Mines, 2023 (AECOM, 2024).
- Tailings Facility Embankment Buttress – EIAR Chapter 7: Hydrology and Hydrogeology (AECOM 2024).

2. Hydro-Environmental Monitoring

Mine water abstraction

2.1 The mine water abstraction data is presented in Charts 1 and 2 below and includes details of the annual rate and volume of water abstracted at the Main Mine / SWEX mine area (No 1 pumping station), abstraction point (APR02826) and the Nevinstown/ Liscarton/ Rathaldron mine area (1390L pumping station), abstraction point (APRAPR02827), as well as the annual rainfall.

2.2 In 2024, the abstraction volumes and rates in Nevinstown/ Liscarton/ Rathaldron mine area showed a decrease of approximately 25% from 2023, while the abstraction volumes and rates in the Main Mine / SWEX mine area showed a decrease of approximately 36% from 2023, representing the lowest abstraction volumes and rates compared to the previous years between 2015 to 2023.

2.3 These 2024 reductions groundwater abstractions were due to recent period from late 2023 through 2024 when Tara Mine was placed under Care and Maintenance, and pumping stations 7 and 8 in the Main Mine / SWEX areas were shut down and abstractions from the 1390L pumping station where reduced. BTM is currently preparing an application for an abstraction license for each of this abstraction points, in line with Water Environment Act 2022 and Licensing Regulations 2024.

Chart 1: Annual volume of groundwater abstraction at the Tara Mine

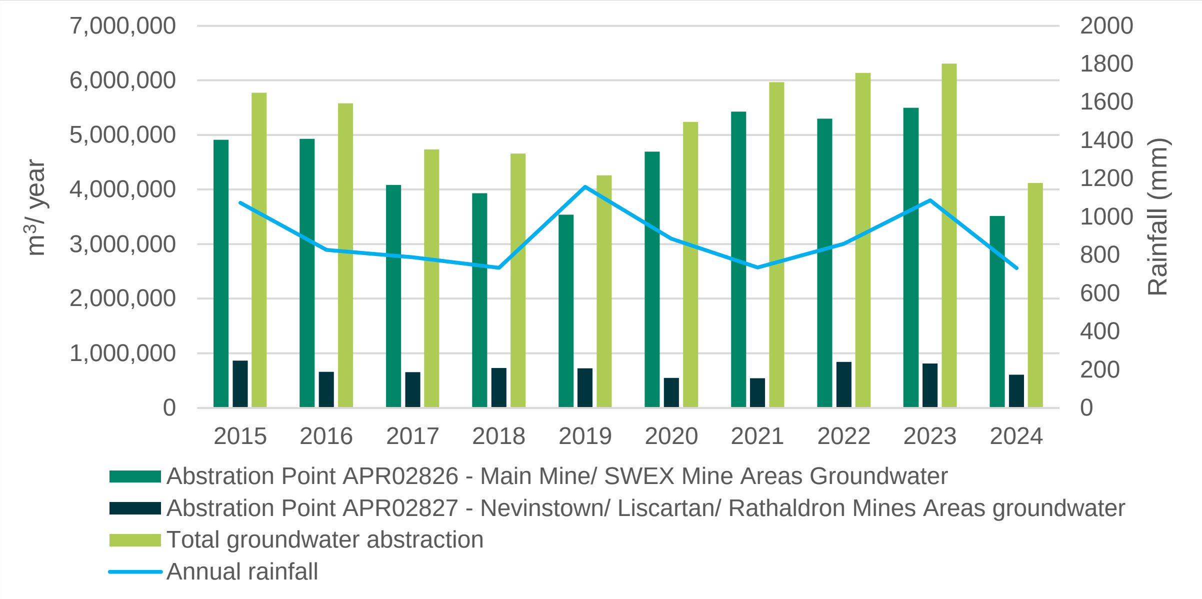
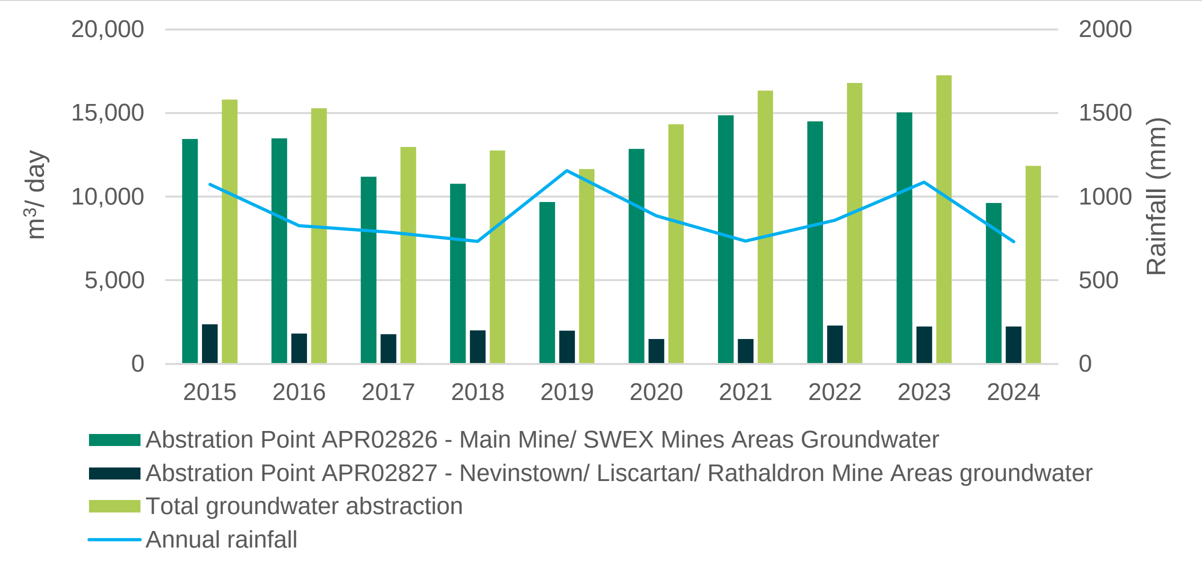


Chart 2: Annual rate of groundwater abstraction at the Tara Mine



Development of the monitoring system

2.4 The TSF monitoring system has been operating since 1996 to collect relevant water quality data at strategic locations in the immediate area. The system aims to act as an advance warning system for any potential pollution incidents to local landowners or water users and to ensure compliance with the IEL and the Water Framework Directive (WFD).

2.5 The potential for localised contamination of groundwater in the vicinity of the TSF has been consistently monitored through the collection and analysis of spot samples from an extensive network of sampling points, in accordance with IEL P0516-04. Sulphate is the main water quality parameter associated with contamination from the TSF and is used as the key parameter for evaluating water quality trends. Therefore, emphasis is placed in this report on the observed concentrations of sulphate.

Location of sampling points

2.6 The locations of groundwater and surface water monitoring points currently in use are presented in Figure 2.1 and Figure 2.2, respectively. The original monitoring network evolved and expanded as works took place in the area, with additional sampling points introduced to ensure a comprehensive understanding of all potential pollution locations.

2.7 A summary of monitoring points and abbreviations used in this report are listed in Table 2-1 below.Table

Table 2-1. Summary of monitoring points and abbreviations

Abbreviation	Description	No. of monitoring points
ICP	Interceptor channel monitoring points:	12
	Water quality monitoring point (ICP1.E, ICP1.W, ICP6, S6_IC1)	4
	Water level monitoring point VNW1, VNW2, VNW3, VNW4, VNW5, VNW6, VNW7, VNW8.	8
OB	Overburden monitoring points:	18
	Piezometer at level 2 – in overburden deposits (OB1-P2, OB2 (dry since July 2024), OB3, OB4-P2, OB5 (dry since September 2024), OB6, OB7, OB10, OB11 (dry since July 2024), OB12, OB13, OB20, OB21, OB22, OB24 (inaccessible since July 2024 due to crop in the field), OB25, OB26, OB27)	
BR	Piezometer at level 1 – in bedrock (OB4-P1)	18
	Bedrock monitoring point (OB1-P1 (blocked 2023 – not monitored in 2024), BR1 (water too deep since September 2024 to sample), BR2, BR3, BR4, BR5, BR6, BR9, BR10, BR14, BR15 (blocked – not monitored in 2024), BR16, BR23, BR24 (inaccessible since July 2024 due to crop in the field), BR25, BR26, BR27)	
R	Domestic well monitoring point (9R (dry – not monitored in 2024), 10R, 12R, 17R, 18R, 22R, 23R, 28R, 29R, 30R, 32R, 35R)	12
GR	Bedrock monitoring points (GR1 and GR2)	2
T	Surface water monitoring points:	13
	Yellow River (T8, T13)	
	Simonstown Stream (T12, T14, T15 (Blake's stream diverted and now enters Simonstown))	
	River Blackwater (T4, T7, T11)	
	Duog Stream (T10 (dry since August 2024))	
	River Boyne (T5, T0A – downstream of Tara Mines effluent discharge point, T0B, T6 – upstream of Tara Mines effluent discharge point)	

Groundwater monitoring

2.8 Groundwater chemistry has been determined from the collection and analysis of samples taken from domestic wells and piezometers at up to 45 locations. The groundwater encountered is characterised as generally being of "bicarbonate type", with calcium and bicarbonate as the major ions, and is typical of water in a limestone bedrock aquifer (Figure 2.1).

2.9 The existing groundwater monitoring system in the TSF area involves:

- Monthly sampling of groundwater from overburden (OB) and bedrock monitoring boreholes (BR and GR), totalling 34 piezometers (landowners have refused access at two sites).
- Quarterly sampling of groundwater from up to 12 domestic wells, depending on accessibility.

Surface water monitoring

2.10 Surface water chemistry is determined from the collection and analysis of samples taken from rivers, streams, and water from the interceptor channel at up to 17 locations (Figure 2.2).

2.11 The existing surface water monitoring system in the TSF area involves:

- Monthly sampling of surface water from rivers and streams at up to 13 locations. These locations are on the River Boyne, River Blackwater, Yellow River and Simonstown and Duog Streams (the River Blackwater is the only watercourse in the immediate area used for abstraction of potable water supplies).
- Monthly sampling of water from the interceptor channel (ICP) at up to 4 locations. The interceptor channel is part of the TSF dam and collects water from the internal drainage system within the embankment of the TSF, horizontal seepage from the TSF, local runoff and groundwater.

Sampling analysis and frequency

2.12 The sampling frequency of groundwater and surface water for physical and chemical parameters (including metals), as required by IEL P0516-04 is summarised in Table 2-2 below. The schedule of parameters includes all chemicals of potential concern, and no new chemicals of concern have been identified to date.

Table 2-2. Summary of analysed parameter and frequency

Parameter	Units	Overburden boreholes**	Bedrock boreholes**	Domestic wells	Interceptor channel	River & streams
pH	pH units	Monthly	Monthly	Quarterly	Monthly	Monthly
Temperature	°C	Monthly	Monthly	Quarterly	Monthly	Monthly
Electrical Conductivity	(µS/cm)	Monthly	Monthly	Quarterly	Monthly	Monthly
Total Hardness as $CaCO_3$	mg/l	-	-	-	-	Monthly
Alkalinity as $CaCO_3$	mg/l	-	-	-	-	Monthly
Suspended Solids	mg/l	-	-	-	Monthly	Monthly
Dissolved Oxygen	mg/l	Monthly	Monthly	Quarterly	-	Monthly
Ammonia (NH_4-N)	mg/l	Quarterly	Quarterly	Quarterly	-	Monthly
Chloride as Cl	mg/l	Quarterly	Quarterly	Quarterly	-	Quarterly
Nitrate as NO_3	mg/l	Quarterly	Quarterly	Quarterly	-	Monthly
Nitrite as N	mg/l	Quarterly	Quarterly	Quarterly	-	-
Phosphate as P	mg/l	Quarterly	Quarterly	Quarterly	-	Quarterly
Aluminium	mg/l	Monthly	Monthly	Quarterly	Quarterly	Quarterly
Antimony	mg/l	-	-	-	-	Quarterly
Arsenic	mg/l	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Cadmium	mg/l	-	-	-	Quarterly	Quarterly

Parameter	Units	Overburden boreholes**	Bedrock boreholes**	Domestic wells	Interceptor channel	River & streams
Chromium	mg/l	-	-	-	-	Quarterly
Copper	mg/l	-	-	-	Quarterly	Quarterly
Cobalt	mg/l	-	-	-	Quarterly	Quarterly
Cyanide	mg/l	-	-	-	Quarterly	Quarterly
Iron	mg/l	Monthly	Monthly	Quarterly	Quarterly	Quarterly
Lead	mg/l	Monthly	Monthly	Quarterly	Quarterly	Monthly
Manganese	mg/l	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Magnesium*	mg/l	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Mercury	mg/l	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Nickel	mg/l	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Potassium	mg/l	Quarterly	Quarterly	Quarterly	-	-
Sodium	mg/l	Quarterly	Quarterly	Quarterly	-	Quarterly
Sulphate*	mg/l	Monthly	Monthly	Quarterly	Monthly	Monthly
Zinc	mg/l	Monthly	Monthly	Quarterly	Quarterly	Monthly

** Schedule C.7 Groundwater Monitoring of IEL P0516-04 requires that samples from OB4-P2, OB13 and BR4 be analysed for magnesium and sulphate monthly. This requirement follows on from the setting out of compliance points, trigger values and intervention values for the Chemicals of Potential Concern (COPCs) at the TSF, sulphate and magnesium, in AECOM's Risk Screening and Technical Assessment report (2015). This assessment of compliance points has now been reviewed to include OB20, BR14 and T8 (on the Yellow River), as set out in the Remediation Action Plan for Tailings Management Facility at Tara Mines (AECOM, 2021); IEL P0516-04 is currently under review to reflect this.*

*** The frequency of monitoring at the following boreholes is proposed to be reduced from monthly to quarterly, as sulphate concentrations at these locations have remained stable and below the threshold value since monitoring began – OB10, OB22, OB24, OB25, BR10, BR16, BR23, BR24 and BR25. This request was submitted to the Environmental Protection Agency (EPA) in the Memo - EPA Audit Response, dated 19th December 2024 (LR089592).*

Screening criteria

2.13 Water quality is evaluated in the context of current legislative requirements for Ireland, in particular the European Water Framework Directive (2000/60/EC) (WFD). As part of the WFD implementation process, EU Member States are required to set or review their national water quality standards, considering groundwater-surface water interaction and potential ecological impacts. The Competent Authority responsible for reviewing water quality standards in Ireland is the Environmental Protection Agency (EPA).

2.14 The following regulations give effect to the Water Framework Directive in Ireland:

- EC Environmental Objectives (Groundwater) (Amendment) Regulations S.I. No. 366 of 2016, which came into force on 15th July 2016 to amend EC Environmental Objectives (Groundwater) Amendment Regulations S.I. No. 389 of 2011 and S.I. No. 9 of 2010.
- EC Environmental Objectives (Surface Waters) Regulations S.I. No. 272 of 2009, which came into operation on 30 July 2009 to give effect to the Water Framework Directive including the environmental quality standards of Directive 2008/105/EC and further effect to the Dangerous Substances Directive (2006/11/EC).
- EU Environmental Objectives (Surface Waters) Regulations S.I. No. 386 of 2015, which came into force on 15th September 2015.

- EU Environmental Objectives (Surface Waters) (Amendment) Regulations S.I. No. 77 of 2019, which came into force on 12th March 2019 to amend EC Environmental Objectives (Surface Waters) Amendment Regulations S.I. No. 327 of 2012 and S.I. No. 272 of 2009.
- EC Environmental Objectives (Surface Waters) (Amendment) Regulations S.I. No. 659 of 2021, which came into force on 7th December 2021 to amend EC Environmental Objectives (Surface Waters) Amendment Regulations S.I. No. 272 of 2009.
- EC Environmental Objectives (Surface Waters) (Amendment) Regulations S.I. No. 288 of 2022, which came into force on 17th June 2022 to amend EC Environmental Objectives (Surface Waters) Amendment Regulations S.I. No. 272 of 2009.
- European Union (Drinking Water) Regulations S.I. No. 99 of 2023, which came into force on 10th March 2023.

2.15 The groundwater threshold values set by the EC Environmental Objectives (Groundwater) Regulations are the most stringent guideline values and therefore these values were included in the assessment of the monitoring data for 2010 onwards. Although these guideline values were established for the protection of groundwater, they are considered appropriate for the protection of surface waters influenced by groundwater, such as at the TSF.

2.16 Where there is no threshold value, the most stringent alternative is used as summarised in the Table 2-3 below. The most stringent alternatives for all monitored parameters are Interim Guideline Values (IGVs), which were set to assist in the characterisation of groundwater bodies. However, there is no groundwater threshold value or IGV for antimony; therefore, the EU (Drinking Water) Regulations 2023 (S.I. No. 99 of 2023) value has been used. The applicable groundwater threshold values, the IGVs or drinking water standards, are henceforth referred to as “guideline values” or “GTV” on the figures.

Table 2-3. Guideline values for groundwater and surface water

Parameter	Threshold value*	IGV**	Drinking Water Regulations***
Aluminium (mg/l)	0.15	-	0.2
Ammoniacal Nitrogen (NH_4-N) (mg/l)	0.065	-	0.38
Antimony (mg/l)	-	-	0.01
Arsenic (mg/l)	0.0075	-	0.01
Cadmium (mg/l)	-	0.005	0.005
Calcium (mg/l)	-	200	-
Chromium (mg/l)	0.0375	-	0.025
Cobalt (mg/l)	-	-	-
Copper (mg/l)	-	0.03	2
Chloride (mg/l)	24	-	250
Cyanide (mg/l)	-	0.01	0.05
Electrical Conductivity (µS/cm)	800	1,000	2,500
Iron (mg/l)	-	0.2	0.2
Lead (mg/l)	0.0075	-	0.005
Magnesium (mg/l)	-	50	-
Manganese (µg/l)	-	50	50
Mercury (mg/l)	0.00075	-	0.001
Nickel (mg/l)	-	0.02	0.02
Nitrate as NO_3 (mg/l)	37.5	-	50
Nitrite as NO_2 (mg/l)	0.375	-	0.5

Parameter	Threshold value*	IGV**	Drinking Water Regulations***
Orthophosphate (mg/l)	-	0.03	-
pH (pH units)	-	≥6.5 to ≤9.5	-
Phosphorus (MRP-P) (mg/l)	0.035	-	-
Potassium (mg/l)	-	5	-
Sodium (mg/l)	-	150	200
Sulphate (mg/l)	187.5	-	250
Sulphide (mg/l)	-	-	-
Temperature (ºC)	-	25	-
Total hardness ($CaCO_3$)	-	200	-
Uranium (mg/l)	-	0.009	0.03
Zinc (µg/l)	75	-	-

** Threshold Value: EC Environmental Objectives (Groundwater) (Amendment) Regulations Threshold Value, 2016 (S.I. No. 366 of 2016)*
*** Interim Guideline Values: Towards Setting Guideline Values for the Protection of Groundwater in Ireland*
**** EU (Drinking Water) Regulations 2023 (S.I. No. 99 of 2023)*
Note: All values are for hardness >100 mg/l

3. Data presentation

Sulphate

3.1 Sulphate is used as the key parameter for assessing seepage from the TSF. The 2024 monitoring data is presented in graphical format, along with data collected since 2020 (5 years' worth of data), as follows:

- Figure 4.1 - Groundwater sulphate concentrations in the overburden.
- Figure 4.2 – Average groundwater sulphate concentrations in the overburden and 5-year trend.
- Figure 4.3 - Groundwater sulphate concentrations in bedrock.
- Figure 4.4 – Average groundwater sulphate concentrations in bedrock and 5-year trend.
- Figure 4.5 - Annual average sulphate concentrations in overburden at each monitoring location and 5-year trend.
- Figure 4.6 - Annual average sulphate concentrations in bedrock at each monitoring location and 5-year trend.
- Figure 4.7 - Number of exceedances of the trigger value for sulphate in the last 5 years.
- Figure 4.8 - Sulphate concentration contours in overburden.
- Figure 4.9 – Sulphate concentration contour in bedrock.
- Figure 4.10 - Sulphate concentrations in domestic wells.
- Figure 4.11 - Average sulphate concentrations in domestic wells and 5-year trend.
- Figure 4.12 - Sulphate concentrations in surface water.
- Figure 4.13 - Average sulphate concentrations in surface water and 5-year trend.
- Figure 4.14 – Sulphate concentrations in the interceptor channel.
- Figure 4.15 – Average sulphate concentrations in the interceptor channel and 5-year trend.

3.2 Sulphate concentrations are discussed in Section 4.

Other substances

3.3 All water quality monitoring data has been reviewed and any notably high values in excess of background levels or environmental guidelines are discussed in the following sections. In previous years elevated concentrations of manganese, potassium, ammonia, and magnesium have been detected at various times in various locations; however, concentrations of nickel and aluminium continue to remain below the guideline value and have been excluded from the Appendices in this report.

3.4 Appendices A-E contain graphs for these substances as summarised in Table 3-1 below.

Table 3-1. Summary of graphs in Appendices A-E

Data included	Manganese	Ammoniacal Nitrogen (NH_4-N)	Magnesium	Zinc	Potassium
Interceptor channel	A1	B1	C1	D1	-
Overburden	A2	B2	C2	D2	E1
Bedrock	A3	B3	C3	D3	E2
Domestic Wells	A4	B4	C4	D4	E3
Surface Water	A5	B5	C5	D5	-

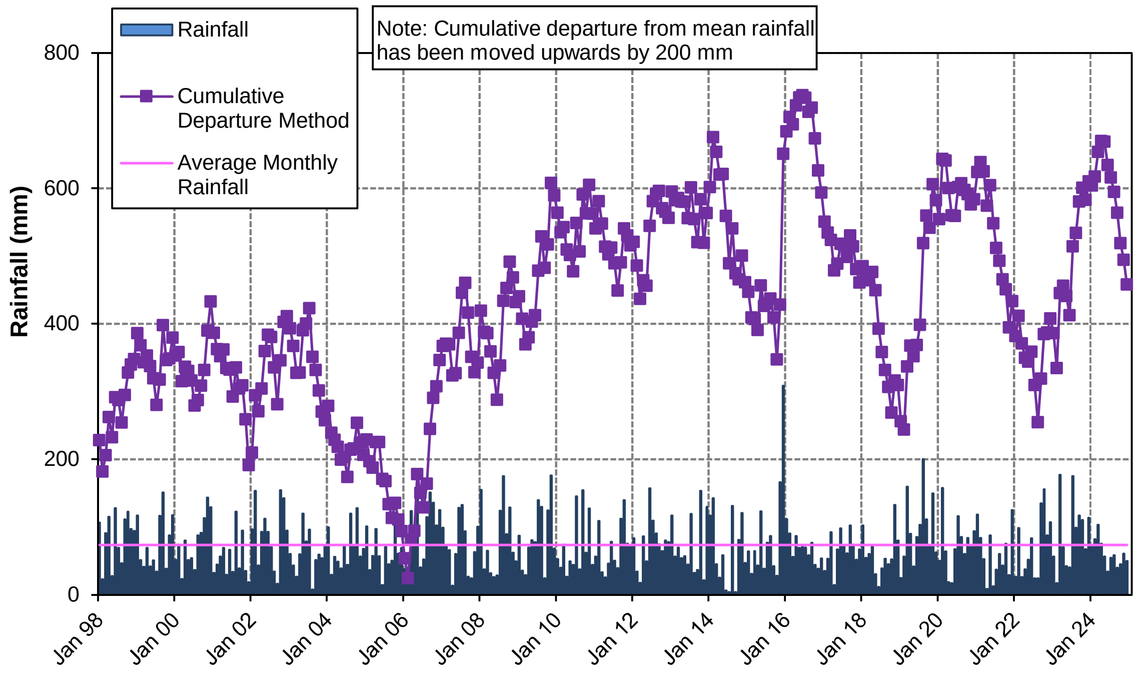
4. Hydro-Environmental Monitoring Results

Rainfall

4.1 A long-term record of rainfall from the rain gauge at Tara Mines has been used which includes daily rainfall data from 1987 to 2024. The location of the rain gauge station is shown in Figure 2.2. As of 1st October 2013, rainfall data has been sourced from an automatic meteorological station located at Randalstown which records from midnight to midnight.

4.2 The annual rainfall for 2024 was 731 mm. The average annual rainfall recorded between 1987 and 2024 is 882 mm. The cumulative departure from average rainfall method shows that monthly rainfall in 2024 increased and decreased monthly with no clear pattern emerging (see Chart 3 below).

Chart 3. Rainfall data for Tara Mines (1997 to 2024)



Groundwater monitoring data

Sulphate concentrations

4.3 Sulphate concentrations in the overburden and bedrock boreholes for 2019-2024 are shown graphically in Figures 4.1 and 4.3. Figures 4.2 and 4.4 present the average sulphate concentrations and the trends in the data for overburden and bedrock monitoring boreholes respectively. Table 4-1 below summarises the average sulphate concentrations measured in boreholes and piezometers at 34 sampling locations for 2024 and the historic average sulphate concentrations. The red text indicates where sulphate concentrations have exceeded the GTV.

Table 4-1. Average sulphate concentrations in observation boreholes

Sampling point	Sulphate concentrations (mg/l)					
	Average 2020	Average 2021	Average 2022	Average 2023	Average 2024	Start of record
Bedrock						
OB1-P1	734	428	-	-	-	1996
OB4-P1	598	875	791	632	703	1996
BR1	350	279	399	344	294	1996
BR2	107	114	114	124	90	1996
BR3	52	38	41	47	32	1996
BR4	94	96	90	105	68	1999
BR5	37	15	21	18	15	1999
BR6	43	28	50	25	24	1999
BR9	39	31	39	20	26	1999
BR10	28	26	25	19	19	1999
BR14	1,554	1,507	1,627	1,507	1,401	2014
BR15	131	100	145	99	-	2014

Sampling point	Sulphate concentrations (mg/l)					
	Average 2020	Average 2021	Average 2022	Average 2023	Average 2024	Start of record
BR16	35	34	44	18	5	2014
BR23	31	43	39	40	39	2016
BR24	33	27	26	25	14	2016
BR25	32	31	41	30	28	2016
BR26	140	95	90	71	63	2018
BR27	1,407	1,323	1,346	1,358	1,309	2018
GR1	52	51	53	26	36	1996
GR2	174	191	142	85	63	2018
Overburden						
OB1-P2	379	492	-	479	-	1996
OB2	601	427	487	317	240	1996
OB3	622	771	1,194	322	130	1996
OB4-P2	1,013	1,168	1,123	829	928	1996
OB5	117	125	276	135	56	1996
OB6	162	210	225	46	57	1999
OB7	27	19	57	22	14	1999
OB10	48	41	39	30	23	2014
OB11	108	124	114	90	61	1999
OB12	175	124	175	183	108	1999
OB13	45	48	138	56	27	1999
OB20	1,355	1,413	1,402	1,168	1,286	2014
OB21	177	196	196	-	-	2014
OB22	27	28	28	23	28	2014
OB24	37	30	31	28	16	2016
OB25	43	34	49	46	38	2016
OB26	123	152	160	186	88	2018
OB27	672	718	850	630	749	2018

4.4 Figures 4.5 and 4.6 present the annual average sulphate concentrations for each monitoring boreholes in the overburden and in bedrock for the last 5 years, and associated trends for those locations where annual average sulphate concentrations exceed the GTV. All the datasets show a reducing or stable trend in annual average sulphate concentrations over the last 5 years, with the exception of at OB27 where annual average concentrations fluctuate but monthly concentrations show a reducing trend.

4.5 Figure 4.7 presents the number of exceedances of the trigger value for sulphate in the overburden and bedrock per year for the last 5 years. There have been no exceedances of the trigger value in 2024.

4.6 The following are the key points relating to the average sulphate concentrations in groundwater surrounding the TSF in 2024:

- In general, average sulphate concentrations continue to be higher in the overburden than in the bedrock sampling locations. Also, average sulphate concentrations continue to be highest in the overburden to the west and southwest of the TSF, as evidenced by concentrations at OB3, OB4-P2, OB20 and OB27. In 2024, while the average values at locations to the south of the TSF have decreased since 2023, the average values have increased at locations to the west. The reduction in mine water abstraction, particularly from the Main Mine / SWEX areas (No1 Pumping station) and consequent reduction in tailing water discharge at the TSF in late 2023 and 2024, is likely to have have contributed to this reduction in sulphate concentrations to the south of the TSF.

- Of those overburden monitoring points with data for 2024, most points show a decrease in average sulphate concentrations compared to 2023. Maximum concentrations at OB20, the overburden compliance point, and at OB4-P2 remain below the trigger level of 1,600mg/l. There is no apparent spatial pattern of increase or decrease in average sulphate concentrations relative to the TSF.
- Of those bedrock monitoring points with data for 2024, most points show a decrease in average sulphate concentrations compared to 2023, including at BR14, the bedrock compliance point. Maximum concentrations at BR14 remain below the trigger level of 1,600mg/l. Again, there is no apparent spatial pattern of increase or decrease in average sulphate concentrations relative to the TSF.
- The average sulphate concentrations show a steady overall decreasing trend in the 5 years' worth of data in both overburden and bedrock boreholes (see Figures 4.2 and 4.4).

Comparison with natural background sulphate concentrations

4.7 The following are the key points relating to the average sulphate concentrations in groundwater surrounding the TSF over time:

- Sulphate concentrations in OB7 and OB24, and BR10 and BR24 are likely to represent natural background concentrations in the overburden and bedrock respectively. With exception of OB7, these boreholes are located up hydraulic gradient of the TSF. The range of annual average sulphate concentrations measured between 1996 and 2024 at OB7 and OB24 is 10 to 68 mg/l and at BR10 and BR24 is 10 to 72 mg/l, which remain below the guideline value. The range in bedrock corresponds well with the median Natural Background Level (NBL) reported for sulphate of 11 mg/l (EPA, 2008).
- Sulphate concentrations in the overburden are elevated above natural background conditions to the south of the TSF as far east as OB12 and as far west as OB20 and at least as far south as OB11 (the most southerly monitoring point). Sulphate concentrations in bedrock are elevated above natural background concentrations to the south of the TSF at least as far as the most westerly monitoring point BR14 and as far the most southerly monitoring point BR4. This area corresponds approximately with the extent of the Meath Formation or 'Pale Beds' bedrock geology in the direction of regional groundwater flow.
- Elevated sulphate concentrations to the south of the TSF are thought to be exacerbated by mine dewatering, where bedrock groundwater levels are drawdown below overburden groundwater levels and a downward vertical hydraulic gradient is established, permitting elevated sulphate concentrations in the overburden to move downwards into the bedrock aquifer. Elevated sulphate concentrations are thought to be spatially limited by the heterogeneous nature of the overburden and by bedrock lithology and faulting. Groundwater levels are further discussed in the sections below.
- Figure 4.8 shows the average sulphate concentrations recorded in overburden boreholes in 2024 and an approximate contour of where these average sulphate concentrations met the guideline value for sulphate of 187.5 mg/l. The contours suggest that conditions have remained relatively stable since late 2022, when the area over which sulphate concentrations exceed the GTV is modelled to have decreased from previous years.
- This pattern is most likely influenced by the fragmented bedrock geology here and the presence of faults. However, at the request of the EPA, this additional plot of average sulphate concentrations in bedrock and contour lines has been prepared and included in Figure 4.9. The contour lines suggest that conditions have remained stable since late 2020, when the area over which sulphate concentrations exceed the GTV is modelled to have decreased from previous years.
- The borehole log for BR1 shows Argillaceous Limestones and Calcareous Sandstones associated with the Meath Formation or 'Pale Beds', whilst the borehole log for BR3 shows shales, sandstones and conglomerates associated with the Carboniferous Old Red Sandstone or 'Red Beds' at the base of the Navan Group. This suggests that the variation in bedrock geology influences average sulphate concentrations, and that bedrock concentrations here are not dominated by the downward vertical movement of overburden groundwater, but rather background bedrock concentrations within this bedrock unit.

Metals and other major ions

4.8 All water quality data for groundwater monitoring boreholes in 2024 has been reviewed in line with relevant water quality standards, as discussed in Section 2. In previous years, the assessment has focused on manganese, ammonia, magnesium, zinc, and potassium, as there were known instances of guidelines being exceeded for these parameters. This format has been maintained in this report and Appendices A-E show the concentrations over time for each of these parameters, including the latest data from 2024.

- **Manganese** concentrations in groundwater in 2024 generally exceeded the guideline value of 50 µg/l (Appendix A.2 and A.3). Concentrations increased slightly in terms of the annual average concentration in 2024 compared to 2023. Annual manganese concentrations in groundwater averaged 862 µg/l in 2020 followed by 869 µg/l in 2021, 880 µg/l in 2022, 778 µg/l in 2023, and 818 µg/l in 2024. There is evidence from historical data that manganese occurs naturally in groundwater within the catchment.
- **Ammoniacal Nitrogen** concentrations in groundwater in 2024 generally remained below the limit of detection of 0.06 mg/l, but where detected, concentrations exceeded the guideline value of 0.065 mg/l (Appendix B.2 and B.3). Concentrations increased slightly in terms of the annual average concentration in 2024. Annual ammoniacal nitrogen concentrations in groundwater averaged 0.46 mg/l in 2020 followed by 0.36 mg/l in 2021, 0.65 mg/l in 2022, 0.36 mg/l in 2023 and 0.43 mg/l in 2024. Concentrations recorded at BR06 in November 2024 are the highest on record.
- **Magnesium** concentrations in groundwater in 2024 generally remained below the guideline value of 50 mg/l, except for concentrations at OB20, OB27, OB04P2, BR14, OB04P1 and BR27 on at least one occasion (Appendix C.2 and C.3). A concentration of 113 mg/l of magnesium was recorded in September at point BR27, the highest concentration ever recorded for this point. Concentrations decreased slightly in terms of the annual average concentration in 2024. In 2020, annual magnesium concentrations in groundwater averaged 37.4 mg/l, 39.7 mg/l in 2021, 39.5 mg/l in 2022, 37.0 mg/l in 2023 and 35.1 mg/l in 2024.
- **Zinc** concentrations in groundwater in 2024 generally remained below the guideline value of 75 µg/l, except for concentrations at OB2, OB20, BR2, BR6, BR14 and BR23 on at least one sampling occasion (Appendix D.2 and D.3). Overall, zinc concentrations decreased slightly in terms of the annual average in 2024. In 2020, annual zinc concentrations in groundwater averaged 48 µg/l, 38.1 µg/l in 2021, 47 µg/l in 2022, 39.6 µg/l in 2023 and 31.2 µg/l in 2024.
- **Potassium** concentrations in groundwater in 2024 remained below the guideline value of 5 mg/l, except for concentrations at OB20, OB22, OB26, OB4P1, BR6, BR14, BR16 and BR26 (Appendix E.1 and E.2). Concentrations have decreased in terms of the annual average concentration in 2024. In 2020, annual potassium concentrations in groundwater averaged 8.4 mg/l, 8.7 mg/l in 2021, 7.4 mg/l in 2022, 6.9mg/l in 2023 and 5.3 mg/l in 2024. The spatial distribution of potassium means that the source is unlikely to be the TSF and may be from agricultural activity.
- **Electrical conductivity** readings in groundwater exceeded the guideline value of 800 µS/cm at most of the groundwater sampling locations at some point in 2024. However, unlike 2023, almost half of the sampling points had an annual average below the guideline value.
- **Nitrate** concentrations in groundwater generally remain below the guideline value of 37.5 mg/l except for BR25, GR2, OB13 and OB25 on at least one sampling occasion. According to the EPA's Pollution Impact Potential Nitrate (PIP-N) mapping, there are some high-ranking areas (Rank 1-3) to the south, southwest and northeast of the TSF, where these boreholes are located. These are areas where there is a source of nitrate from agricultural areas and the land is susceptible to losses.

4.9 The following additional parameters demonstrated minor exceedances of guideline values on some occasions in groundwater during 2024: arsenic, chloride, iron, nickel, nitrite, and orthophosphate. All other parameters tested for in groundwater met the relevant guideline values in the 2024 data.

Domestic well monitoring data

4.10 Historically, 18 domestic wells have been monitored, with 4 of these wells, 8R, 31R, 33R and 34R, being decommissioned in 2003, 2022, 2012 and 2004, respectively. Only 3 of the 15 domestic wells are currently in use: 10R, 18R and 29R, with only 10R used for potable purposes (Figure 2.1). In 2024, only 11 domestic wells were monitored (9R dry, no access to 27R and 12R).

Sulphate concentrations

4.11 Sulphate concentrations in the monitored domestic wells for 2020-2024 are shown in Figure 4.10. There were no exceedances of the guideline value in 2024.

4.12 Figure 4.11 presents the average sulphate concentrations and the trend in the data. The average sulphate concentrations met the guideline value of 187.5 mg/l at all sampling locations and there is a downward trend in the dataset (2020-2024)

Metals and other major ions

4.13 Results of the other parameters analysed are presented below. Appendices A-E shows the concentrations over time for each of these parameters and include the latest data from 2024.

- **Manganese** concentrations in the domestic wells in 2024 generally remained below the threshold value of 50 µg/l, except for concentrations at 28R and 32R on one sampling occasion (Appendix A.4). The 2024 annual average for domestic wells cannot be compared with previous years because most of the measurements were below the detection threshold. In 2020, annual manganese concentrations averaged 118 µg/l, followed by 119 µg/l in 2021, 63 µg/l in 2022, 45µg/l in 2023 and 15 µg/l in 2024. The elevated annual average concentration in 2020 and 2021 was driven up by anomalously high results at 35R in December 2020 and 17R in July 2021. There is evidence from historical data that manganese occurs naturally in groundwater in the area. There is no elevated concentration at 35R in 2024.
- **Ammoniacal Nitrogen** concentrations in domestic wells in 2024 generally remained below the limit of detection of 0.41 mg/l, which is above the guideline value of 0.065 mg/l (Appendix B.4).
- **Magnesium** concentrations in the domestic wells in 2024 remained below the guideline value of 50 mg/l (Appendix C.4).
- **Zinc** concentrations in the domestic wells in 2024 remained below the guideline value of 75 µg/l(Appendix D.4).
- **Potassium** concentrations in the domestic wells in 2024 generally exceeded the guideline value of 5 mg/l (Appendix E.3) and have decreased slightly in terms of the annual average. In 2020, annual potassium concentrations averaged 8.3 mg/l, followed by 8.6 mg/l in 2021, 7.8 mg/l in 2022, 8.4 mg/l in 2023 and 8.2 mg/l in 2024. The spatial distribution of potassium means that the source is unlikely to be the TSF and may be from agricultural activity.
- **Nitrate** concentrations generally remain below the guideline value of 37.5 mg/l in 2023 except for 12R and 22R on one and two occasions respectively.

4.14 The following additional parameters demonstrated minor exceedances of guideline values in domestic wells during 2024: chloride and orthophosphate. No other parameters exhibited elevated concentrations or indicated cause for concern.

Surface water monitoring data

Sulphate concentrations

4.15 Sulphate concentrations in the monitored surface water locations for 2020-2024 are shown in in Figure 4.12. There were no exceedances of the guideline value of 187.5 mg/l in any of the collected samples in 2024. Figure 4.13 presents the average sulphate concentrations and the trend in the data. There is a downward trend in the dataset (2020-2024).

Metals and other major ions

4.16 Results of the other parameters analysed are presented below. Potassium monitoring is no longer required as part of the IEL conditions. Appendices A-D show the concentrations over time for manganese, ammonia/ammoniacal nitrogen, magnesium, and zinc, and include the latest data from 2024.

- **Manganese** concentrations in surface water in 2023 generally remained below the guideline of 50 µg/l, except for concentrations at T0A, T0B, T10 and T6 in January and T13 in July (Appendix A.5). Concentrations showed a slight increase in terms of the annual average concentrations in 2024 compared with 2023. In 2020, annual manganese concentrations in surface water averaged 19 µg/l, followed by 27 µg/l in 2021, 25 µg/l in 2022, 24 µg/l in 2023 and 29 µg/l in 2024. There is evidence from historical data that manganese occurs naturally in surface water in the area.
- **Ammoniacal Nitrogen** concentrations in surface water in 2024 generally remained below the limit of detection of 0.06-0.08 mg/l, but where detected, concentrations exceeded the guideline value of 0.065 mg/l. Exceedances occurred at T4, T8, T11, T13, T14 and T14 on one occasion and T7 on two sampling occasions only (Appendix B.5).
- **Magnesium** concentrations in surface water in 2024 remained below the guideline value of 50 mg/l (Appendix C.5).
- **Zinc** concentrations in surface water in 2024 remained below the guideline value of 75 µg/l (Appendix D.5).
- **Total Hardness** concentrations in surface water in 2024 exceeded the guideline value of 200 mg/l at all of the monitoring locations on at least one occasion, with an annual average of 259 mg/l. Readings in surface water were notably lower than those taken at the interceptor channel.
- **Nitrate** concentrations in surface water in 2024 generally remained below the guideline value of 37.5 mg/l at all of the monitoring locations, with the exception of T6 and T15 on one sampling occasion.

4.17 The following additional parameters demonstrated minor exceedances of guideline values on some occasions in surface water during 2024: chloride, electrical conductivity, mercury (at T11 on one occasion only), pH (at T11 on one occasion only) and phosphate. All other parameters analysed in surface waters met the relevant guideline values for 2024 data. There are no relevant guideline values for cobalt and silver.

Interceptor channel monitoring data

4.18 The interceptor channel is part of the TSF dam and collects water from the internal drainage system within the embankment of the TSF, horizontal seepage from the TSF, local runoff and groundwater. The results of monitoring here reflect water quality in the TSF, and the water is pumped back into the active stage of the tailings dam. Re-grading and piping of the perimeter interceptor channel to the west and south of Stage 3, adjacent to the Yellow River, took place in 2023.

Sulphate concentrations

4.19 Monthly sulphate concentrations for all 4 monitoring points in the interceptor channel for 2020-2024 are presented in Figure 4.14. Concentrations in the channel generally have not met the guideline value (187.5 mg/l), which is as expected, given the nature of the intercepted waters. Figure 4.15 presents the average sulphate concentrations and the trend in the data. There is a downward trend in the dataset (2020-2024).

4.20 Table 4-2 summarises the average annual sulphate concentrations at the sampling points for 2020-2024, together with the maximum concentrations measured in 2024. Average sulphate concentrations at most sampling points have increased in 2024 compared to 2023 but remain below values observed in and prior to 2021.

Table 4-2. Average sulphate concentrations in interceptor channel

Sampling point	Average sulphate concentrations (mg/l)					Maximum sulphate concentration (mg/l)
	2020	2021	2022	2023	2024	2024
ICP1.E	529	607	428	431	506	692
ICP1.W	737	827	602	772	808	1,055
ICP3	682	733	617	676	-	-
ICP6	485	543	428	394	498	779
S6_IC1	610	568	-	347	412	585
All samples	609	660	518	501	545	1,055

Metals and other major ions

4.21 All the water quality data for the interceptor channel in 2024 has been reviewed and compared with the relevant guidelines, as discussed in Section 2. Appendices A-D show the concentrations over time for manganese, total ammonia/ ammoniacal nitrogen, magnesium and zinc and include the latest data from 2024.

- **Manganese** concentrations in the interceptor channel in 2024 generally exceeded the guideline value of 50 µg/l. Concentrations increased in terms of the annual average concentrations in 2024 compared to 2023, from 298 to 373 µg/l (Appendix A.1).
- **Ammoniacal Nitrogen** concentrations in the interceptor channel, where detected, exceeded the guideline value of 0.065 mg/l. Concentrations in 2024 are slightly higher than in 2023 but remain below those in and prior to 2020 (Appendix B.1).
- **Magnesium** concentrations in the interceptor channel in 2024 exceeded the guideline value of 50 mg/l at least at one sampling occasion for each monitoring point. Concentrations have decreased in terms of the annual average in 2024 compared to 2024, from 53.7 to 50.5 mg/l (Appendix C.1).
- **Zinc** concentrations in the interceptor channel in 2024 exceeded the guideline value of 75 µg/l for ICP1E and ICP6. However, concentrations increased slightly in terms of the annual average concentration in 2024 compared to 2023, from 121 to 125 µg/l (Appendix D.1).
- **Electrical Conductivity** readings within the interceptor channel in 2024 exceeded the guideline value of 800 µS/cm on all of the sampling occasions, with an annual average of 1,494 µS/cm. Readings in the interceptor channel were notably higher than other surface water courses included in the monitoring programme.
- **Total Hardness** concentrations in the interceptor channel in 2024 exceeded the guideline value of 200 mg/l in all samples, with an annual average of 596 mg/l. Readings in the interceptor channel were notably higher than other surface water courses included in the monitoring programme.
- **Antimony** concentrations remained below the Drinking Water Regulations of 0.01 mg/l at all the interceptor channel monitoring locations, except for S6_IC1 on most sampling occasion.
- **Chloride** concentrations exceeded the guideline value of 24 mg/l in all the interceptor channel monitoring locations on most sampling occasion.
- **Calcium** concentrations exceeded the IGV of 200 mg/l in all the interceptor channel monitoring locations on at least one monitoring occasion.

4.22 Given the nature of the intercepted water, it would be expected that elevated concentrations are detected at times. In addition to the above exceedances, nitrate (at S6_IC1 on one occasion) demonstrated a minor exceedances of guideline values in the interceptor channel during 2024. All other parameters analysed in surface waters met the relevant guideline values for 2024 data. There are no relevant guideline values for cobalt and silver.

Trigger and intervention levels

4.23 As part of the *Risk Screening and Technical Assessment Report for Randalstown Tailings Management Facility at Tara Mines* (AECOM, 2015), compliance points and intervention and trigger values were set. The compliance points were set at OB4-P2 for overburden and the Yellow River; OB13 for overburden and the River Blackwater; and BR4 for bedrock.

4.24 As part of the *Remediation Action Plan for Randalstown Tailings Management Facility at Tara Mines* (AECOM, 2021), these points and values were reviewed and revised. The compliance points are set at OB13, OB20, BR14 and T8 for the River Blackwater receptor, and at BR14 for the bedrock aquifer receptor. The revised trigger and intervention values are set out for BR14 and T8 in Table 4-3 below.

4.25 Sulphate concentrations at T8 did not exceed the trigger or intervention values in 2024. Sulphate concentrations at BR14 did not exceed the trigger or intervention values in 2024, but remains close to the trigger value of 1,600 mg/l, with the highest concentration reaching 1,401 mg/l.

4.26 Magnesium concentrations at BR14 remained below the trigger value of 185 mg/l on all four sampling occasions in 2024. The average concentration at BR14 for 2024 is 175 mg/l, with the highest concentrations reaching a concentration of 184 mg/l.

Table 4-3. Trigger and intervention values

Water quality parameter	Receptor	Compliance point	Guideline value (mg/l)	Intervention value (mg/l)	Trigger value (mg/l)
Sulphate (mg/l)	River Blackwater	OB13, OB20, BR14, T8	187.5*	None set for groundwater 250 (at T8)	None set for groundwater 187.5 (at T8)
	Bedrock aquifer	BR14	187.5*	2,000	1,600
Magnesium (mg/l)	River Blackwater	OB13, OB20, BR14, T8	50	None set	None set
	Bedrock aquifer	BR14	50	230	185

** For comparison with annual average concentration*

Water levels

Groundwater levels

4.27 There are a total of 17 bedrock boreholes and 17 overburden boreholes within the TSF monitoring network where groundwater levels are currently monitored monthly. Groundwater levels have been monitored around the TSF since 1997. The groundwater hydrographs for overburden and bedrock are plotted in Figures 4.16 and 4.17 to illustrate trends in groundwater levels over the last 5 years. In addition, a groundwater contour map has been prepared, which shows overburden and bedrock groundwater levels contoured and the overburden and bedrock geology. The maps are included in Figures 4.18 and 4.19. The contours are plotted using groundwater level data taken in November 2024.

4.28 The following are the key points relating to these groundwater levels:

- Groundwater levels in the overburden and bedrock are generally between 0.25 m and 18.65 m below ground level (at BR1).
- The dominant flow direction in the overburden is towards the southwest, where the seepage collection system may be influencing groundwater levels. The dominant flow direction in bedrock is towards the south, where abstraction for mine dewatering appears to be influencing groundwater levels, within the ‘Pale Beds’ or Meath Formation (see Figure 4.19). The influence of dewatering on groundwater levels has reduced significantly during and since the Care and Maintenance shut down, between mid-2023 and end of 2024.
- Groundwater hydrographs show seasonal fluctuations in groundwater levels around the TSF in response to rainfall events. The magnitude of groundwater level fluctuation generally varies between 0.5 m and 3.5 m depending on the geology and location. The overburden monitoring point showing the highest fluctuation in 2024 was OB12, located to the southern boundary of the TSF, and showing a

fluctuation across the year of approximately 3.9 m. The bedrock monitoring point showing the highest fluctuation in 2024 was BR01, located to the south of the TSF, and showing a fluctuation across the year of approximately 10.3 m, followed closely by BR04 and BR05. These boreholes are located within the mapped Meath Formation or Pale Beds.

4.29 Overall, groundwater levels have remained relatively stable since 2015. In 2019, groundwater levels in boreholes located to the south of the TSF started to show an overall rising trend. The location of these boreholes corresponds approximately with the extent of the Meath Formation or Pale Beds in the direction of regional groundwater flow. The Pale Beds host the bulk of the Navan Orebody and are subject to dewatering. The rising trend observed in these boreholes is most likely as a result of the recent plugging/ decommissioning of exploration holes in the Nevinstown area.

Comparison between groundwater levels in overburden and in bedrock

4.30 Where groundwater levels show a continued declining trend, groundwater hydrographs for coupled boreholes (or pairs of boreholes) around the TSF are plotted (Figure 4.20) to compare overburden and bedrock groundwater levels. The following are the key points relating to the comparison of water levels in the overburden and in bedrock:

- Water levels within the bedrock at BR5 are up to 3 m higher than in the overburden at OB12 throughout 2024. Where water levels in the bedrock are higher than in overburden, there is an upward head gradient and little potential for vertical seepage downwards from the interceptor channel into the overburden.
- Water levels within the overburden at OB2 are up to 6.5 m higher than in the bedrock at BR1 throughout 2024 and previous years. Where water levels in the overburden are higher than in bedrock, there is a downward head gradient allowing the potential for vertical seepage downwards.
- Water levels within the overburden and bedrock at OB5 and BR2 are similar, with the head gradient fluctuating throughout 2024.

4.31 Groundwater levels in November 2024 are shown in groundwater contour plots in Figures 4.18 and 4.19. The groundwater levels show influence of lower rainfall in 2024 (82% of the LTA rainfall) in overburden and bedrock, and possible influence of dewatering at the Tara Mines (albeit reduced in 2024 at 65% of 2023 abstraction volumes) in bedrock, at BR1, BR2, BR4 and BR5.

Water levels in interceptor channel

4.32 The TSF consists of an impoundment (the tailings pond) contained by earth-built embankment walls (the tailings dam). The walls and foundations are constructed from the Quaternary glacial till which underlies the site to reduce the potential amount of seepage from the overburden material (tailings) into groundwater and adjacent surface watercourses.

4.33 An interceptor channel close to the base of the dam captures runoff and underdrainage from the dam. Tailings water collected in the interceptor channel is then pumped back up to the TSF (tailings pond) from one pump with automated level controls, at the south of the interceptor channel/ dam. By returning tailings water back to the TSF, a closed water cycle system operates which helps to protect the local water environment.

4.34 However, the occurrence of elevated sulphate concentrations in groundwater in the immediate vicinity of the TSF suggests that there is a small amount of seepage occurring from the tailings into groundwater. The interceptor channel may be an intermittent source of seepage when adjacent groundwater levels drop below the base of the interceptor channel. Therefore, maintaining water levels in the interceptor channel below adjacent groundwater levels is key to limiting the occurrence of seepage into the groundwater environment.

4.35 Re-grading and piping of the perimeter interceptor channel to the west and south of Stage 3, adjacent to the Yellow River has taken place in 2023. This is where previous attempts at re-grading the channel was thwarted by bedrock close to the surface and a high-water table. To overcome these issues, this area of the channel was piped and backfilled with drainage stone. The re-grading and piping of the perimeter interceptor channel is considered to have the potential to reduce the occurrence of seepage into the groundwater environment. In 2024, the average sulphate concentrations in the interceptor channel have increased slightly compared to 2023 but remain below values observed in and prior to 2021.

4.36 All options have been examined for controlling water levels within the interceptor channel, with the outcome provided in AECOM's *Corrective Action Feasibility & Design Report* for the Environmental Protection Agency.

4.37 During the re-grading and piping works, the historic monitoring locations on the interceptor channel – VNW 108, VNW 800, VNW 1600, VNW 3025, VNW 3610 and VNW 4045 – were decommissioned in December 2022, and eight (no. 8) new monitoring locations commissioned in July 2023 - VNW1, VNW2, VNW3, VNW4, VNW5, VNW6, VNW7 and VNW8 – where weekly water levels are collected. These are presented in Figure 2.2.

4.38 The water levels in the interceptor channel are controlled by pumping from the channel and remain constant apart from some response to rainfall events. The water level in the interceptor channel remained between 1566.3 and 1577.6 m above mine datum (AMD), consistent with previous years (Figure 4.21).

Comparison between groundwater levels in overburden and water levels in interceptor channel

4.39 The water level records are plotted in Figure 4.21 to compare water levels in the interceptor channel and overburden and thus understand the effectiveness of the interceptor channel in collecting the seepage from TSF. The following are the key points relating to the comparison of water levels in the overburden and in the interceptor channel:

- Figure 4.21 shows that water levels at interceptor channel monitoring points VNW1 and VNW8 remain above groundwater levels in the overburden at nearby boreholes OB25 and OB27 respectively. These water levels suggest that there is a downward hydraulic gradient at these locations and the potential for vertical seepage downwards from the interceptor channel into the overburden.
- Water levels at interceptor monitoring points VNW2, VNW3, VNW5, VNW6, VNW7 remain below groundwater levels in the overburden at adjacent boreholes OB24, OB10 and OB22, OB2 and OB27 respectively (see colour coded 'pairs' in Figure 4.21). These water levels suggest that there is an upward hydraulic gradient at these locations and little potential for vertical seepage downwards from the interceptor channel into the overburden. Water levels at VNW4 are similar to groundwater levels in OB5 in the first half of the year. Then, groundwater levels in OB5 have decreased from May and water levels VNW4 remained stable for the rest of the year.

5. Conclusions and recommendations

Conclusions

5.1 The on-going monitoring of the hydrogeological and hydrological environment at the Randalstown TSF is providing sufficient data to assess the effects of seepage from the TSF into the local environment. Based on the on-going monitoring, the following comments/ conclusions can be made:

- The EU (Drinking Water Supply) Regulations, EC Environmental Objectives (Groundwater) Regulations, EC Environmental Objectives (Surface Water) Regulations and interim guideline values for groundwater were used as guideline values for comparison with measured concentrations in groundwater and in surface water.
- Sulphate continues to be used as the key indicator parameter for monitoring seepage from the TSF and concentrations in groundwater continue to be generally higher in the overburden than in the bedrock.
- Historic water level monitoring in the interceptor channel suggested that there is a downward head gradient out of the interceptor channel and potential for vertical seepage downwards into the overburden at some locations, which may be the source of contamination in groundwater in the overburden and subsequently in bedrock.
- In 2024:

- Overall, sulphate concentrations in the interceptor channel have increased by approximately 8%, compared to 2023, but remain below values observed in and prior to 2021.
- Sulphate concentrations in groundwater have continued to remain highest in the overburden and to the south and southwest of the TSF close to and along the channel of the Yellow River.
- Average sulphate concentrations have remained below the guideline value in most overburden and bedrock boreholes. The majority of overburden and bedrock boreholes show a decrease in average sulphate concentrations in 2024, compared to 2023.
- The trigger and intervention value for sulphate was not exceeded at compliance points T8 and BR14 and the trigger value for magnesium was not exceeded at compliance point BR14.
- Sulphate concentrations in domestic wells and surface water in the area have remained below the guideline value.
- Contouring of the available average sulphate concentrations recorded at overburden and bedrock boreholes in 2024 shows that conditions have remained relatively stable since 2022 and 2020 respectively. The area over which sulphate concentrations exceed the GTV is modelled to have decreased compared with previous years.
- In groundwater, concentrations of other parameters such as ammoniacal nitrogen, magnesium, manganese, nitrate, potassium and zinc, have exceeded the guideline values, and on occasions, arsenic, chloride, iron, nickel, nitrite, and orthophosphate.
- In surface water, concentrations of other parameters such as ammoniacal nitrogen, manganese and total hardness have exceeded the guideline values, and on occasions chloride, electrical conductivity, mercury (at T11 only), pH (at T11 only) and phosphate.
- In addition to sulphate, the interceptor channel is characterised by elevated concentrations of ammoniacal nitrogen, calcium, chloride, electrical conductivity, hardness, magnesium, manganese, and zinc, and on occasions, antimony (at S6_IC1 only) and nitrate (at S6_IC1 only).
- Groundwater levels to the south and southeast of the TSF appear to show some local influence of the seepage capture pumping system in the overburden, and possible influence of abstraction for mine dewatering at Tara Mines in the bedrock. In 2024, groundwater levels in OB12 were up to 3 m lower than in corresponding bedrock borehole BR5, resulting in little potential for vertical seepage downwards here, while groundwater levels in OB2 were up to 6.5 m higher than in the corresponding bedrock borehole BR1, resulting in the potential for vertical seepage downwards here.
- As a result of the Care and Maintenance shut down in 2024 and reduction in mine dewatering in the Main Mine / SWEX areas, the mine water abstraction volume and rates were much lower than in previous years.

Recommendations

5.2 The interceptor channel provides an effective means of limiting the release of sulphate rich water into the local environment, as demonstrated by the generally higher sulphate content of samples taken from the channel compared with the lower values in the groundwater. After mid-2007, the situation started to change as a result of change in hydraulic conditions around the TSF due to mine dewatering, and groundwater sulphate concentrations started to increase slightly to the south of the TSF.

- It is recommended that the future mine dewatering strategy is reviewed and that groundwater levels are predicted so that the historical and potential future of effects of dewatering on groundwater levels and contaminant migration at the TMF may be evaluated.
- It is recommended that the monitoring strategy is continued, and comparisons are made with monitoring results from the previous 5 years' worth of data, as well as with relevant guideline values, so that trends can be observed, and comparison made against trigger and intervention values.
- It is recommended that concentrations recorded at OB4-P1, OB4-P2 and BR14 (where sulphate concentrations are highest) to the southwest and at BR14 and T8 (compliance points) should continue to be observed for future, potential increases and exceedance of trigger or intervention values.
- It is recommended that regular clearance of vegetation in the interceptor channel is carried out. A high level of maintenance of this channel will ensure its effectiveness, keep water levels low and closer to

adjacent groundwater levels, and reduce the risk of seepage, channel blockage, local infilling, or pump malfunction.

- It is recommended that new monitoring boreholes be installed in the overburden and bedrock in nearfield to the north and northwest of the TSF to delineate the limit of potential sulphate migration in these areas.

5.3 The following table summarises the recommendations provided in the *Annual Environmental Monitoring Report 2021* and the implementation plan.

Table 5-1. Recommendations and implementation plan

No.	Recommendation	Implementation plan
1	It is recommended that the **mine dewatering strategy** is reviewed and that groundwater levels are predicted so that the historical and potential future of effects of dewatering can be evaluated.	The mine dewatering strategy will be reviewed as part of the AECOM's *Corrective Action Feasibility & Design Report* for the Environmental Protection Agency. In addition, a review of groundwater levels corresponding with the highest sulphate concentrations will be undertaken. If appropriate and required, trigger and intervention groundwater levels could be set at compliance points to the south of the TSF.
2	It is recommended that the **monitoring strategy** is continued, and comparisons are made with monitoring results from the previous 5 years' worth of data, as well as with relevant guideline values, so that trends can be observed, and comparison made against trigger and intervention values.	The licensee will continue to comply with the requirements of IEL P516-04 with regards to the monitoring strategy. Annual reporting will include the results from the previous 5 years' worth of data, comparison with relevant guideline values and trigger and intervention values, and observation of trends.
3	It is recommended that **concentrations recorded at T8 and at BR14** to the southwest should continue to be observed for future increases and exceedance of trigger or intervention values.	The licensee will continue to comply with the requirements of IEL P516-04 with regards to monitoring of the compliance points. Annual reporting on concentrations recorded at BR14 and T8 will include the results from the previous 5 years' worth of data, comparison with relevant guideline values and trigger and intervention values, and observation of trends.
4	It is recommended that **regular clearance of vegetation** in the interceptor channel is carried out. A high level of maintenance of this channel will ensure its effectiveness and reduce the risk of channel blockage, local infilling, or pump malfunction.	The licensee has established a regular maintenance programme for the interceptor channel. This plan consists of: • Weekly visual inspections; and • Regular vegetation cutting and clearance.
5.	It is recommended that **new monitoring boreholes** be installed in the overburden to the north and northwest of the TSF to delineate the limit of sulphate exceedances. (no access to lands in this area-not Tara owned).	The licensee will install new monitoring boreholes.

6. References

a. Knight Piésold, 1996. Randalstown Tailings Facility – Stage IV Environmental Impact Statement: Technical Appendix 1 – Hydrology and Hydrogeology

b. Tara Mines, 2009. Randalstown Tailings Facility - Stage V Raise. Environmental Impact Statement

c. Environmental Protection Agency (2008), Water quality in Ireland 2004-2006

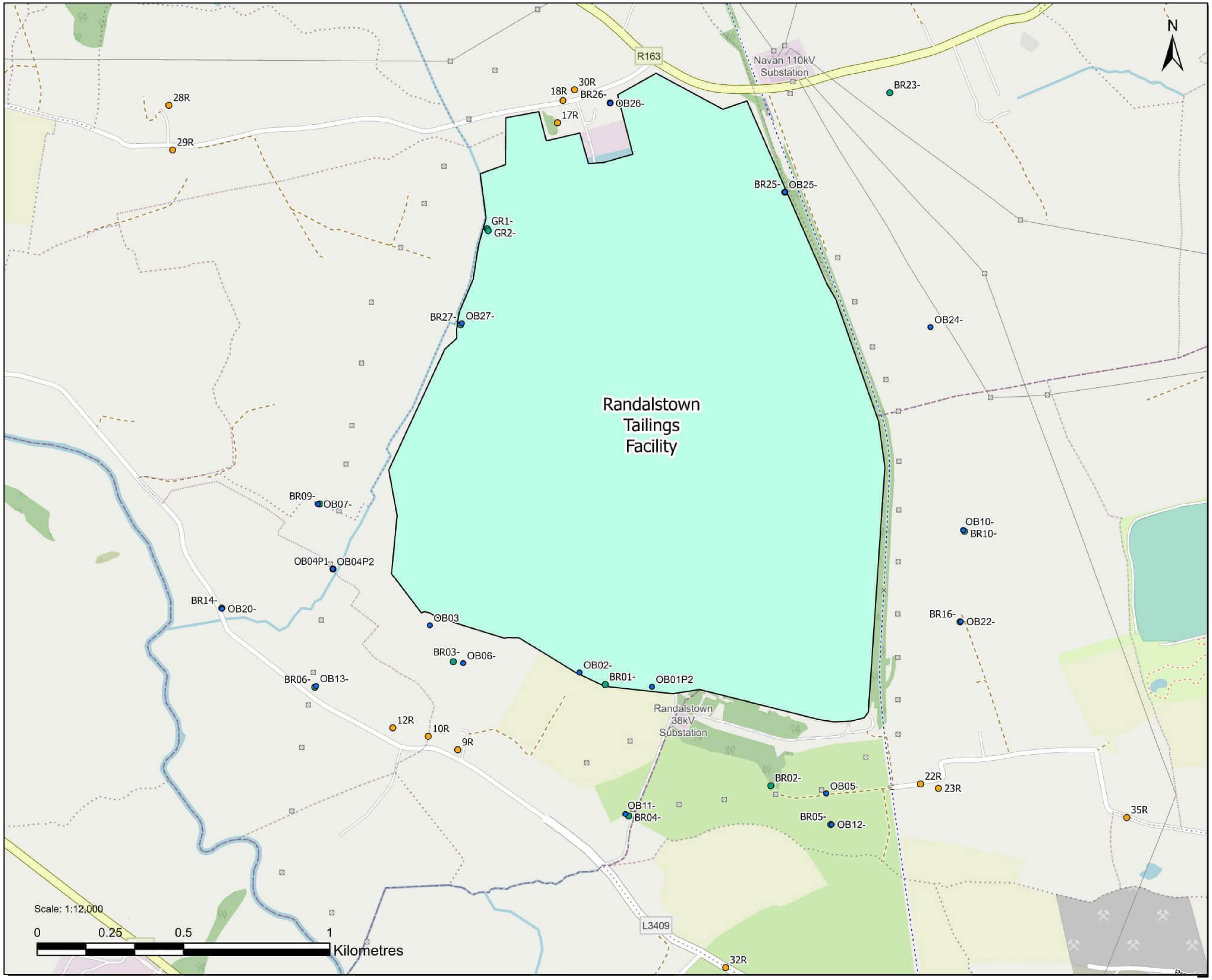
d. AECOM, 2015. Risk Screening and Technical Assessment Report for Randalstown Tailings Management Facility at Tara Mines.

e. EPA, 2011, Towards Setting Guideline Values for the Protection of Groundwater in Ireland, Interim Report.

f. AECOM, 2021. Remediation Action Plan for Randalstown Tailings Management Facility at Tara Mines. Final.

g. AECOM, 2022. Corrective Action Feasibility & Design Report for Tara Mines TSF.

Revision: 1 Drawn: AM Checked: JR Approved: JR Date: 2025-03-24



Filename: C:\Users\jenny.rush\AECOM\UK Water Env Projects - 60628825 Tara Mines Boliden 2020\400_TECH\434 GIS\ArcGIS Pro\Layout\60628825 Tara Mines Version 2.aprx

AECOM

PROJECT

Randalstown Tailings Storage Facility

CLIENT

Boliden Tara Mines

CONSULTANT

AECOM Limited
Midpoint, Alencon Link,
Basingstoke, Hampshire,
RG21 7PP
www.aecom.com

LEGEND

- Overburden Monitoring Borehole
- Bedrock Monitoring Borehole
- Domestic wells
- Tara Mines

CREDITS

Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

ISSUE PURPOSE

ANNUAL MONITORING REPORT

PROJECT NUMBER

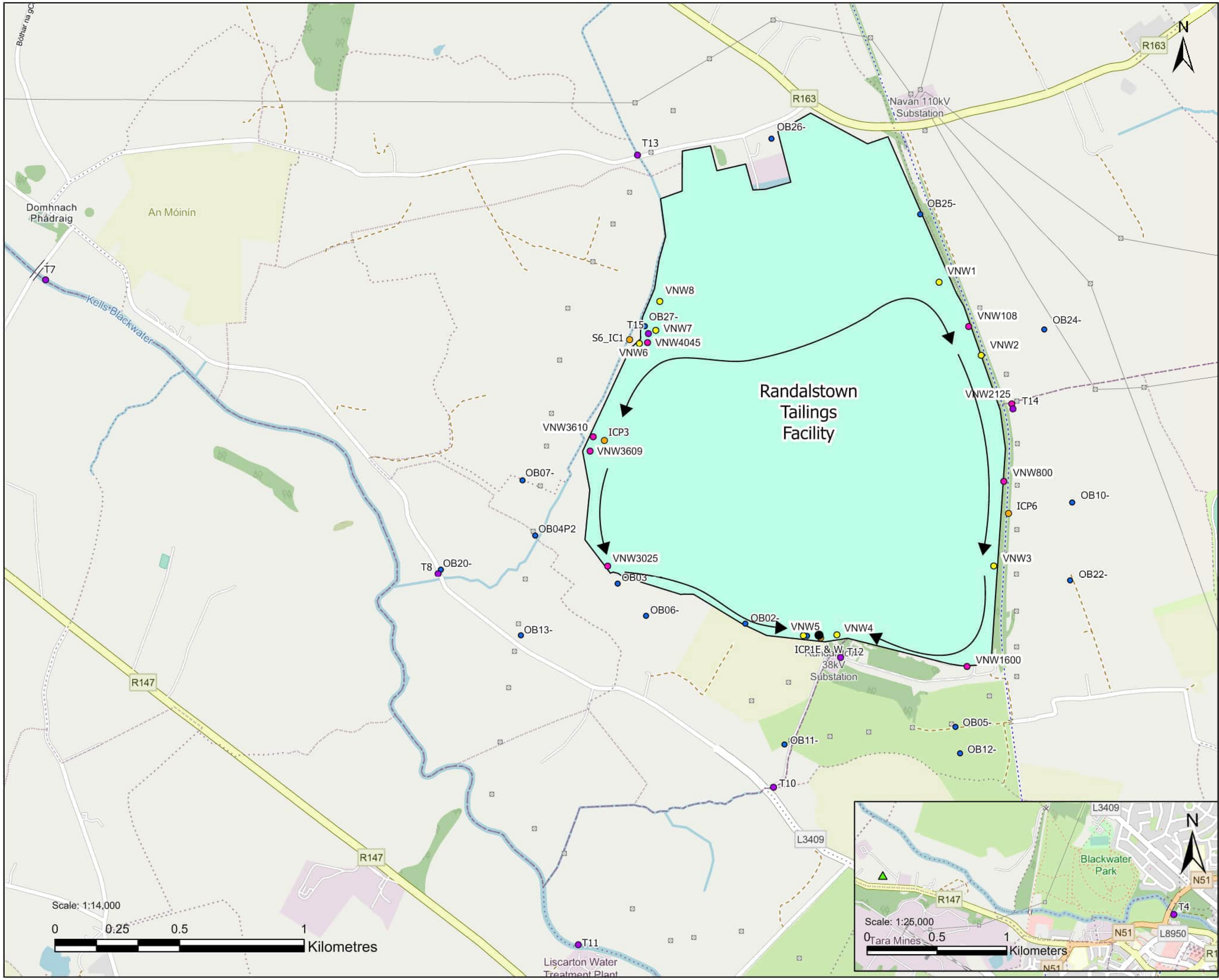
60628825

FIGURE TITLE

Groundwater monitoring locations

FIGURE NUMBER

Figure 2.1



AECOM

PROJECT

Randalstown Tailings Storage Facility

CLIENT

Boliden Tara Mines

CONSULTANT

AECOM Limited
Midpoint, Alencon Link,
Basingstoke, Hampshire,
RG21 7PP
www.aecom.com

LEGEND

- Rain Gauge
- Surface Water Locations
- Current VNW Locations
- Overburden Monitoring Borehole
- Old VNW Locations
- ICP Locations
- Tara Mines
- Pump
- Flow Direction

CREDITS

Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

ISSUE PURPOSE

ANNUAL MONITORING REPORT

PROJECT NUMBER

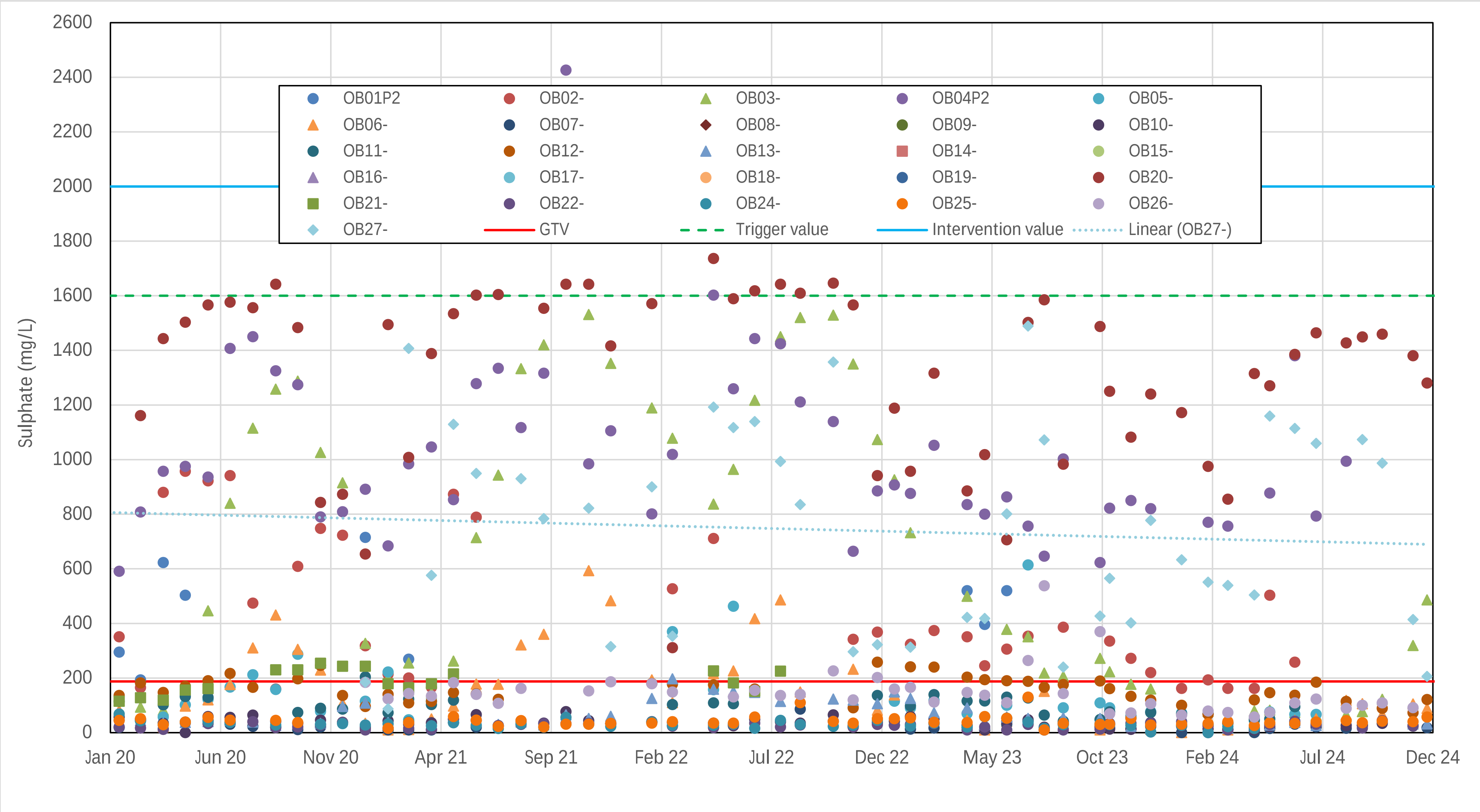
60628825

FIGURE TITLE

Surface water monitoring locations

FIGURE NUMBER

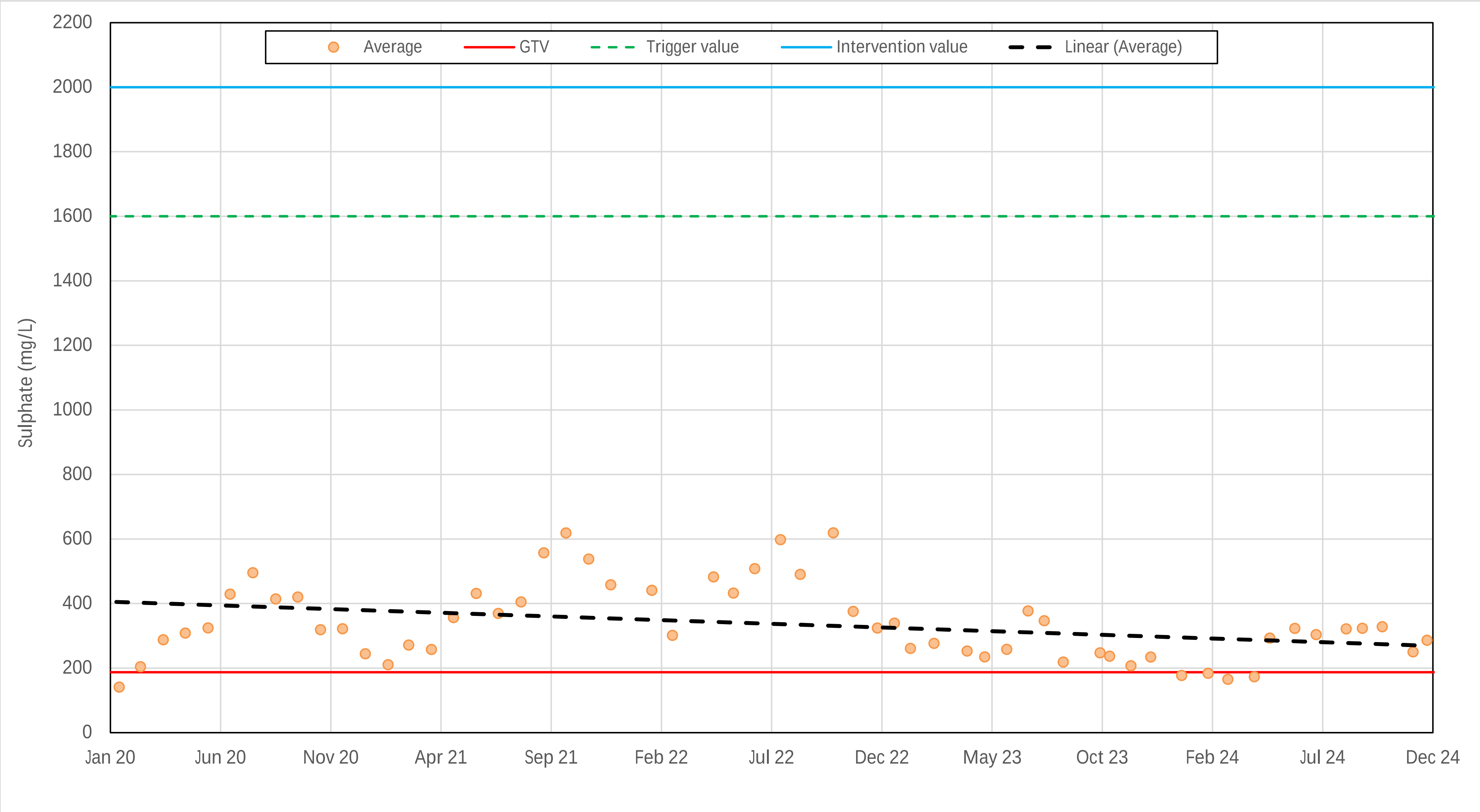
Figure 2.2



Client: Boliden_TaraMines_DAC

Site: Tara Mines

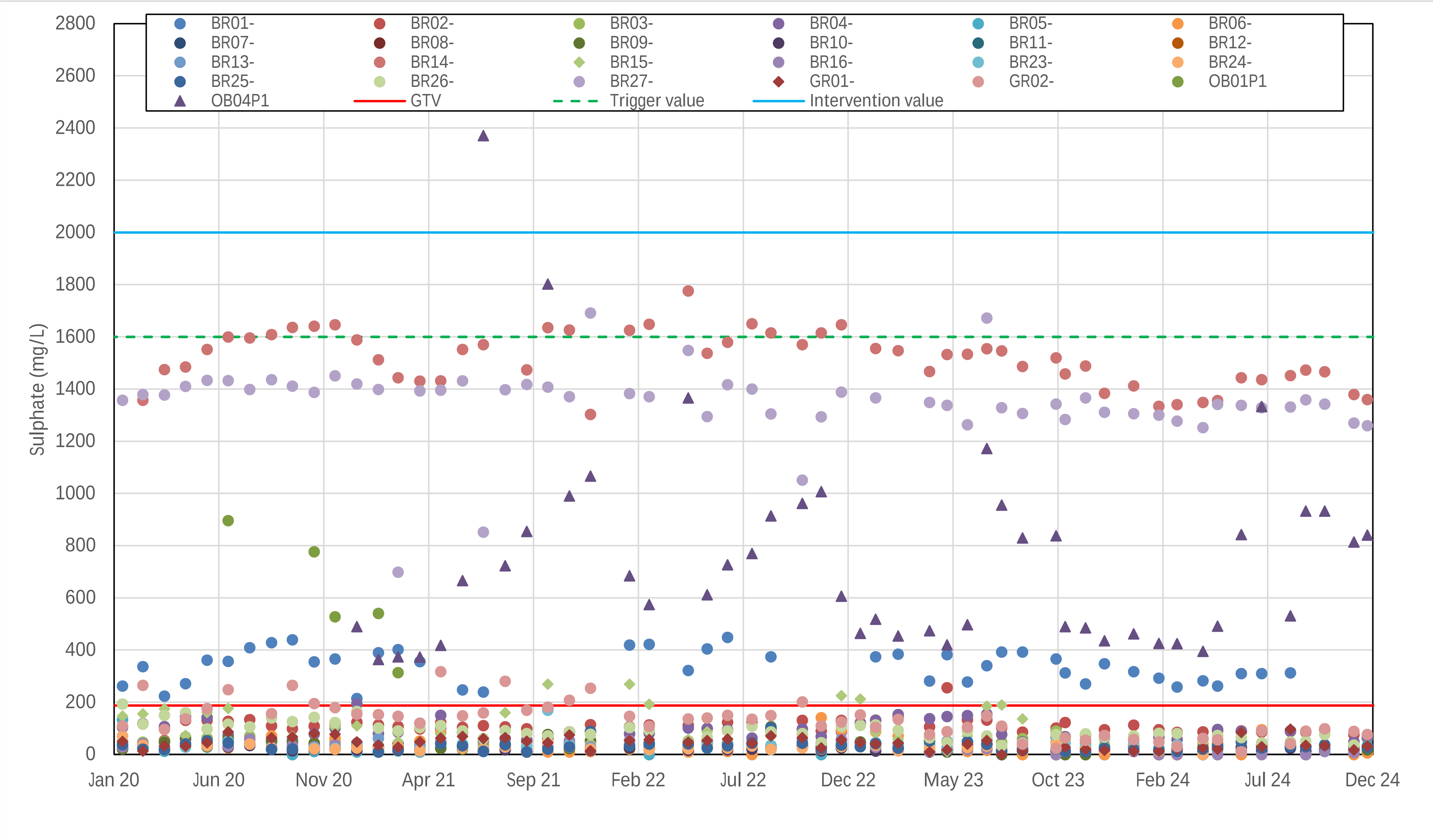
Figure 4.1 Groundwater sulphate concentrations in the overburden



Client: Boliden_TaraMines_DAC

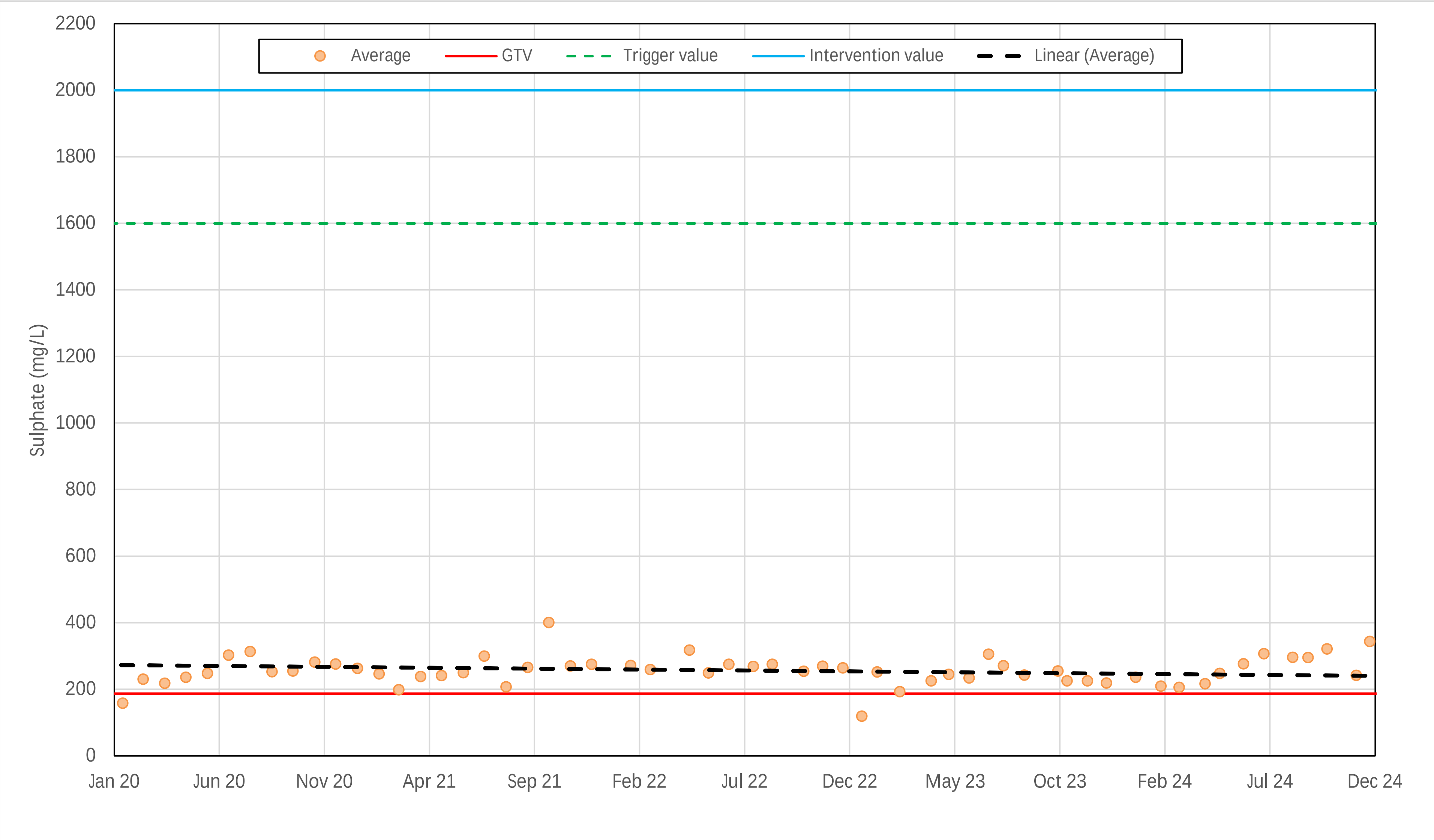
Site: Tara Mines

Figure 4.2 Average groundwater sulphate concentrations in the overburden and 5-year trend



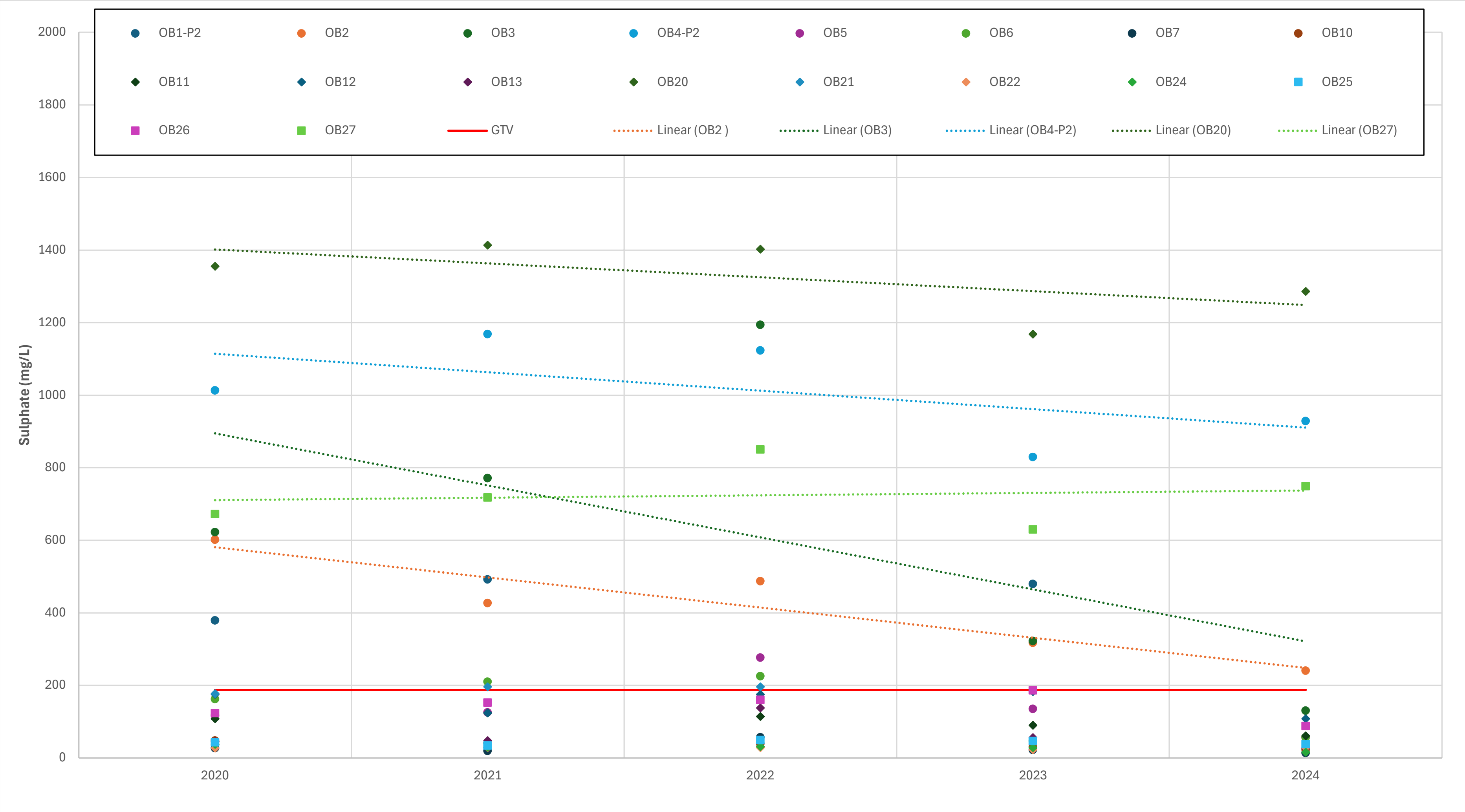
Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Figure 4.3 Groundwater sulphate concentrations in bedrock



Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Figure 4.4 Average groundwater sulphate concentrations in bedrock and 5-year trend



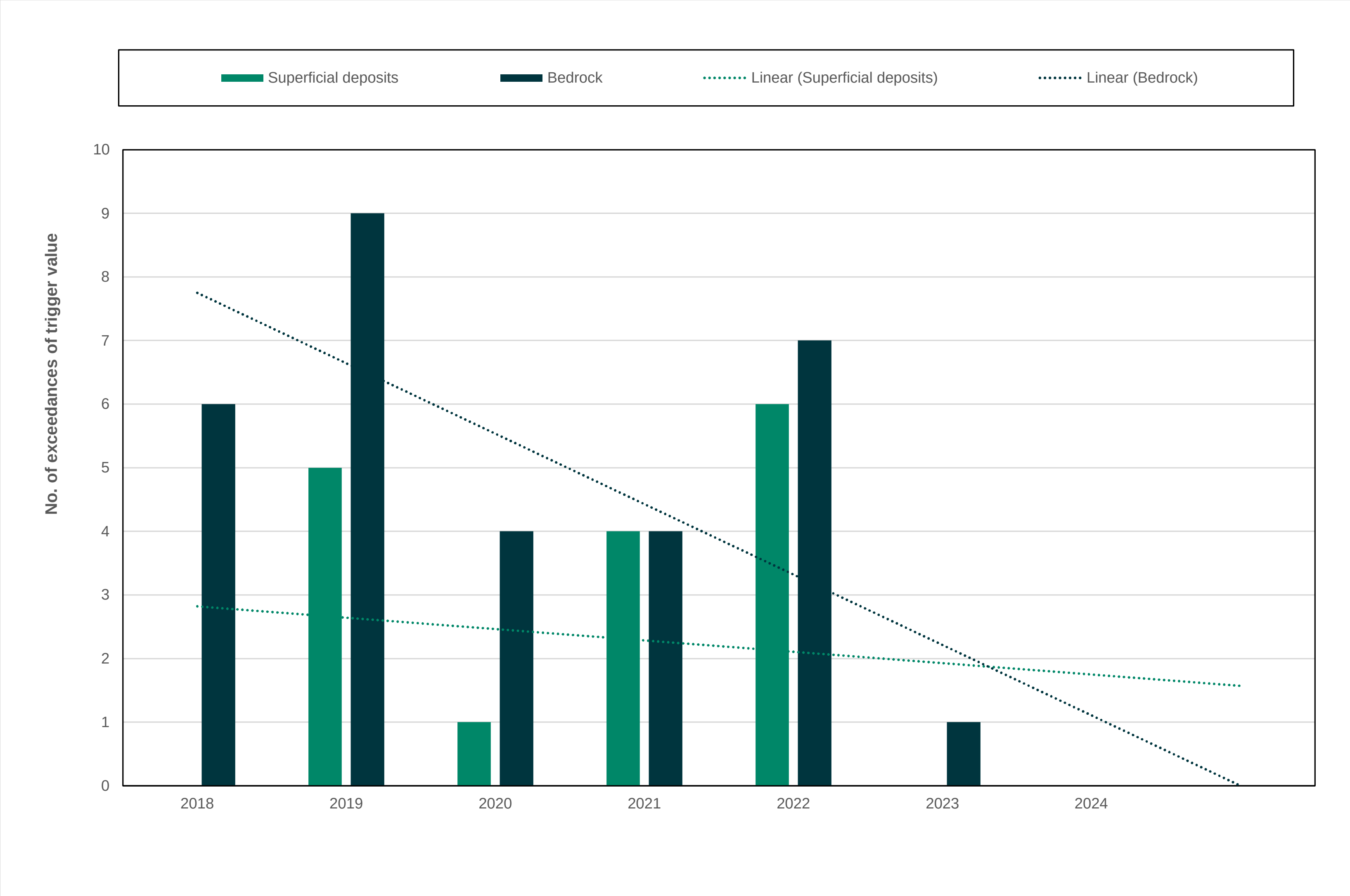
Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Figure 4.5 Annual average sulphate concentrations in overburden at each monitoring location and 5-year trend

Client: Boliden_TaraMines_DAC

Site: Tara Mines

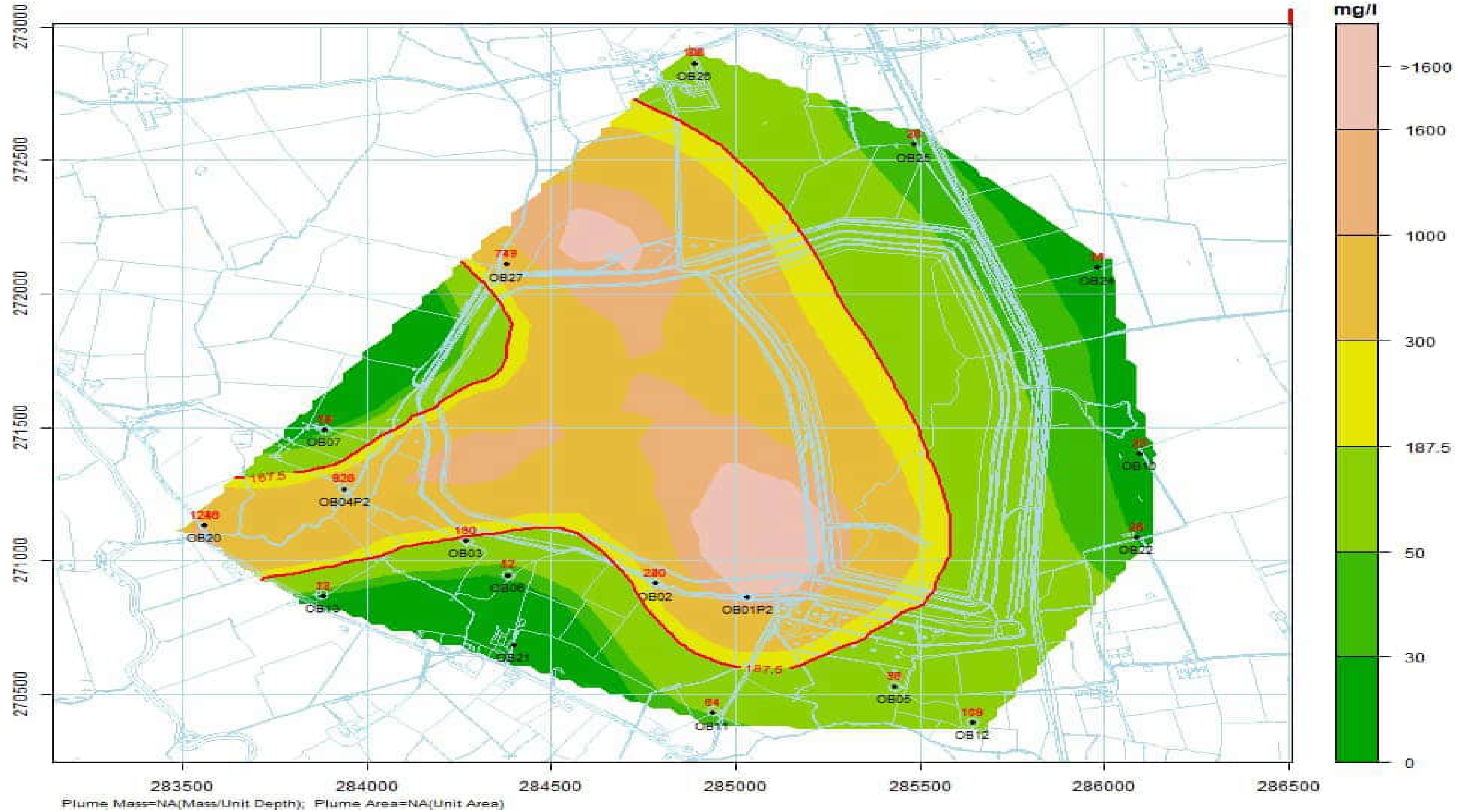
Figure 4.6 Annual average sulphate concentrations in bedrock at each monitoring location and 5-year trend



Client: Boliden_TaraMines_DAC

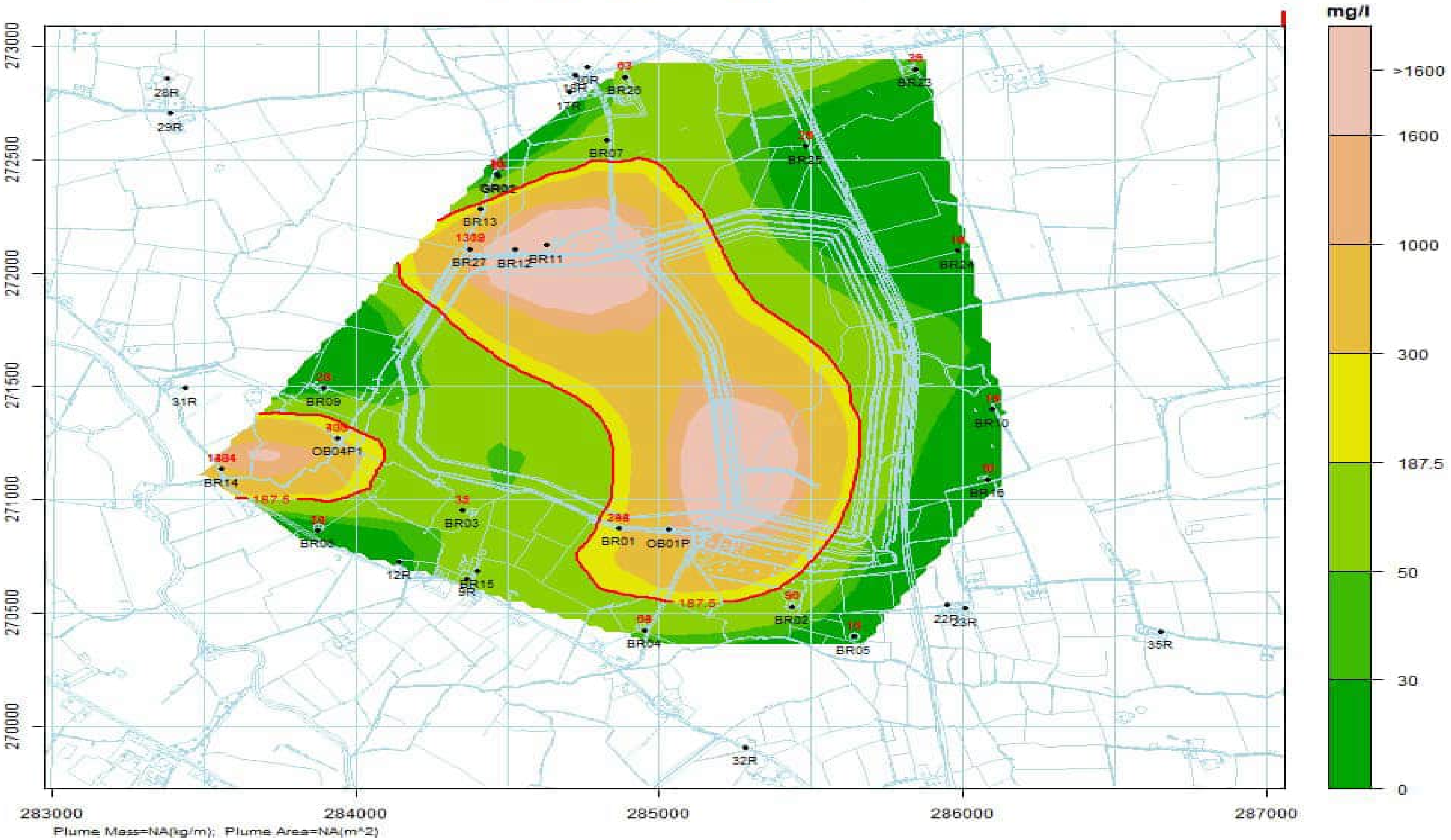
Site: Tara Mines

Figure 4.7 No. of exceedances of the trigger value for sulphate in the last 7 years



Client: Boliden_TaraMines_DAC **Site: Tara Mines**

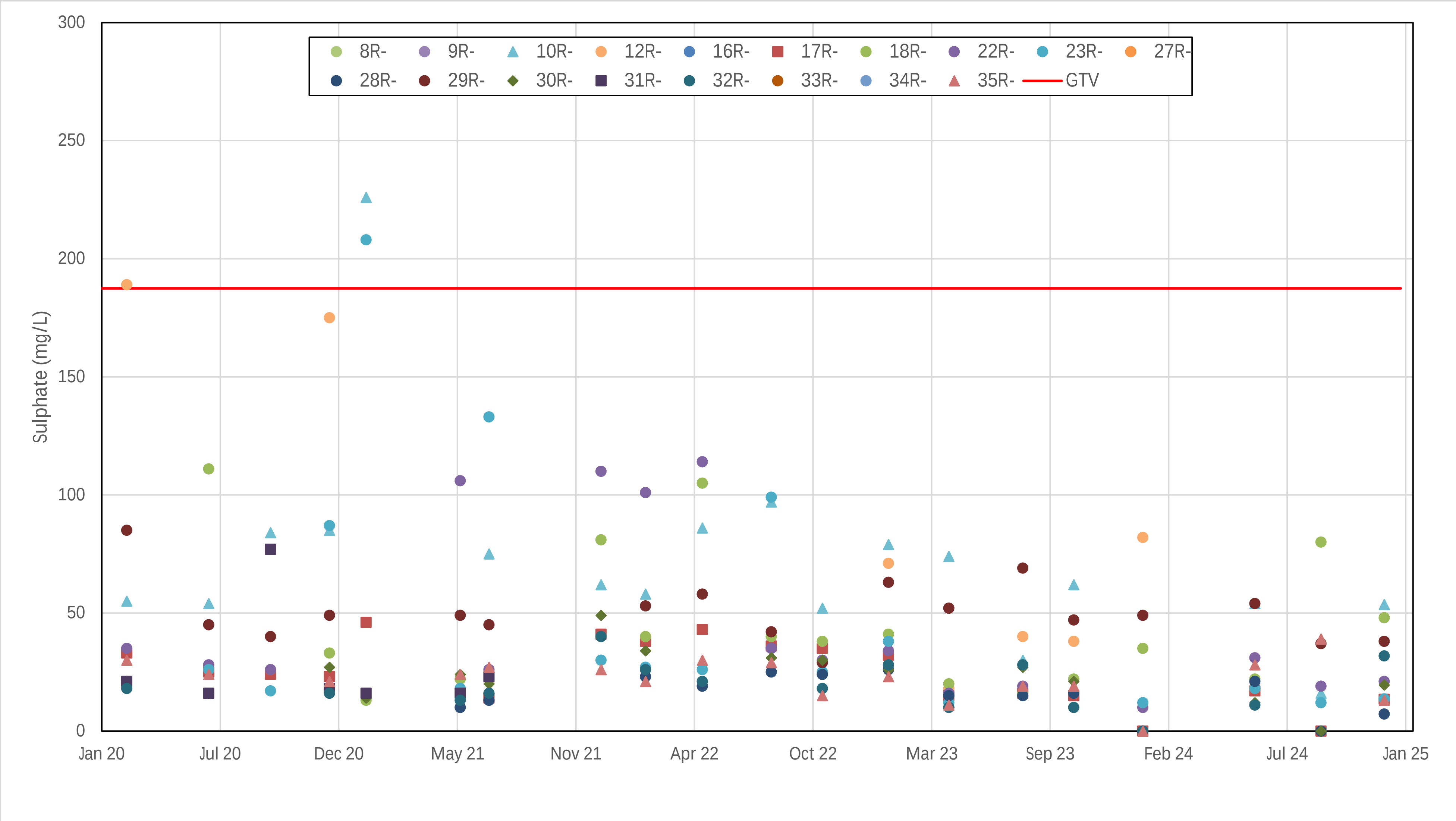
Figure 4.8 Average sulphate concentrations in overburden boreholes in 2024



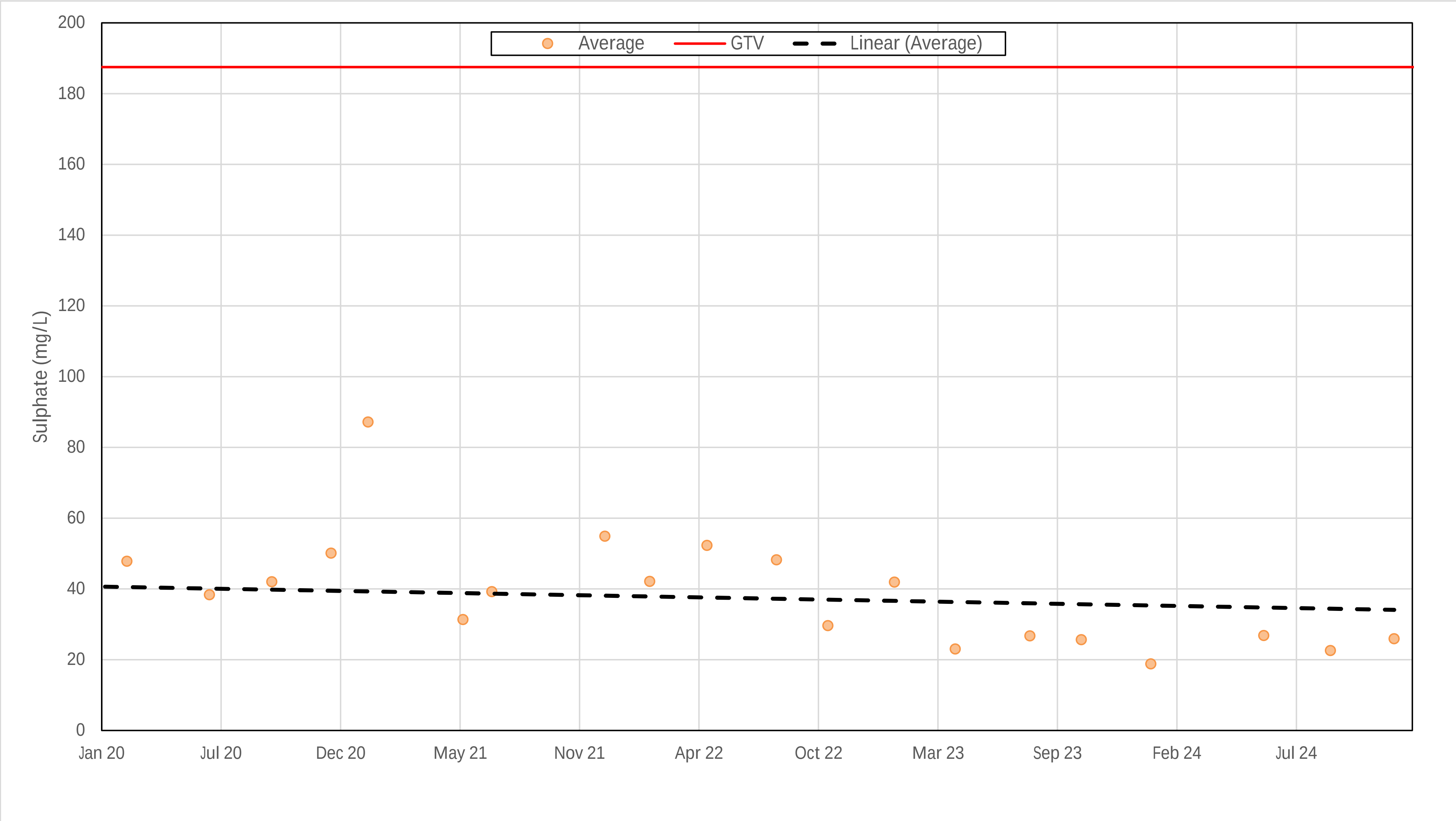
Client: Boliden_TaraMines_DAC

Site: Tara Mines

Figure 4.9 Average sulphate concentrations in bedrock boreholes in 2024

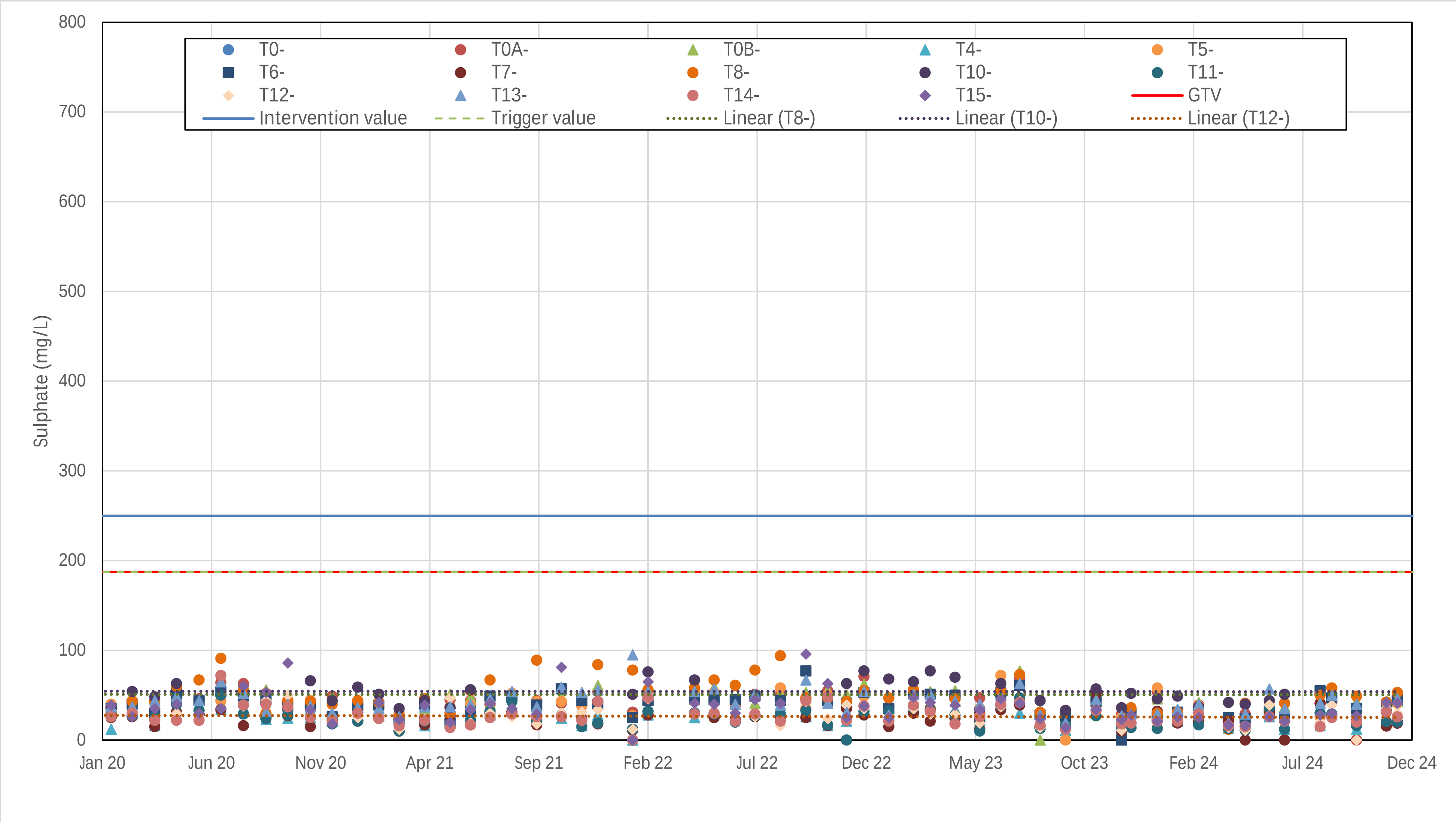


Client: Boliden_TaraMines_DAC **Site: Tara Mines** **Figure 4.10 Sulphate concentrations in domestic wells**



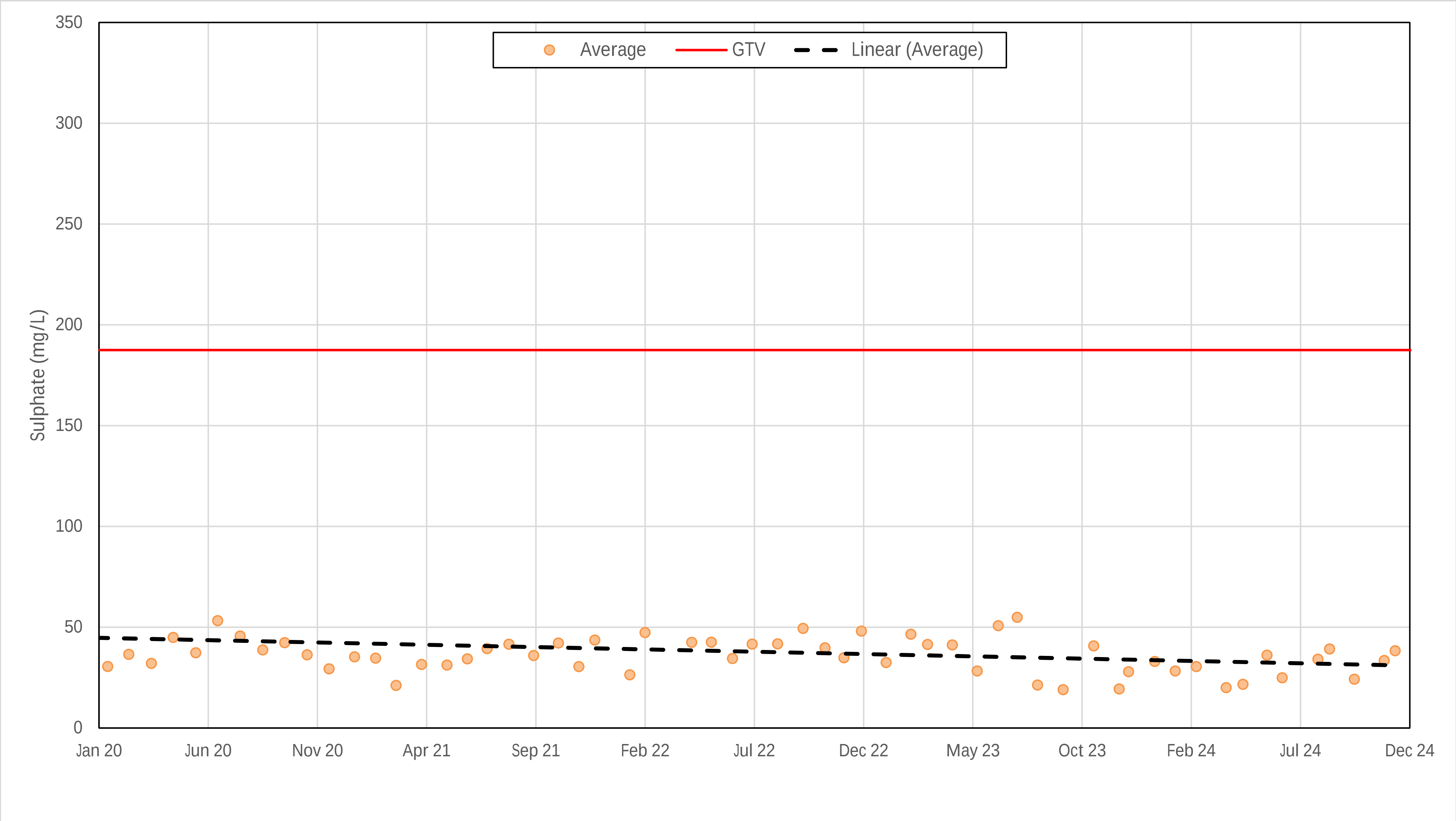
Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Figure 4.11 Average sulphate concentrations in domestic wells and 5-year trend

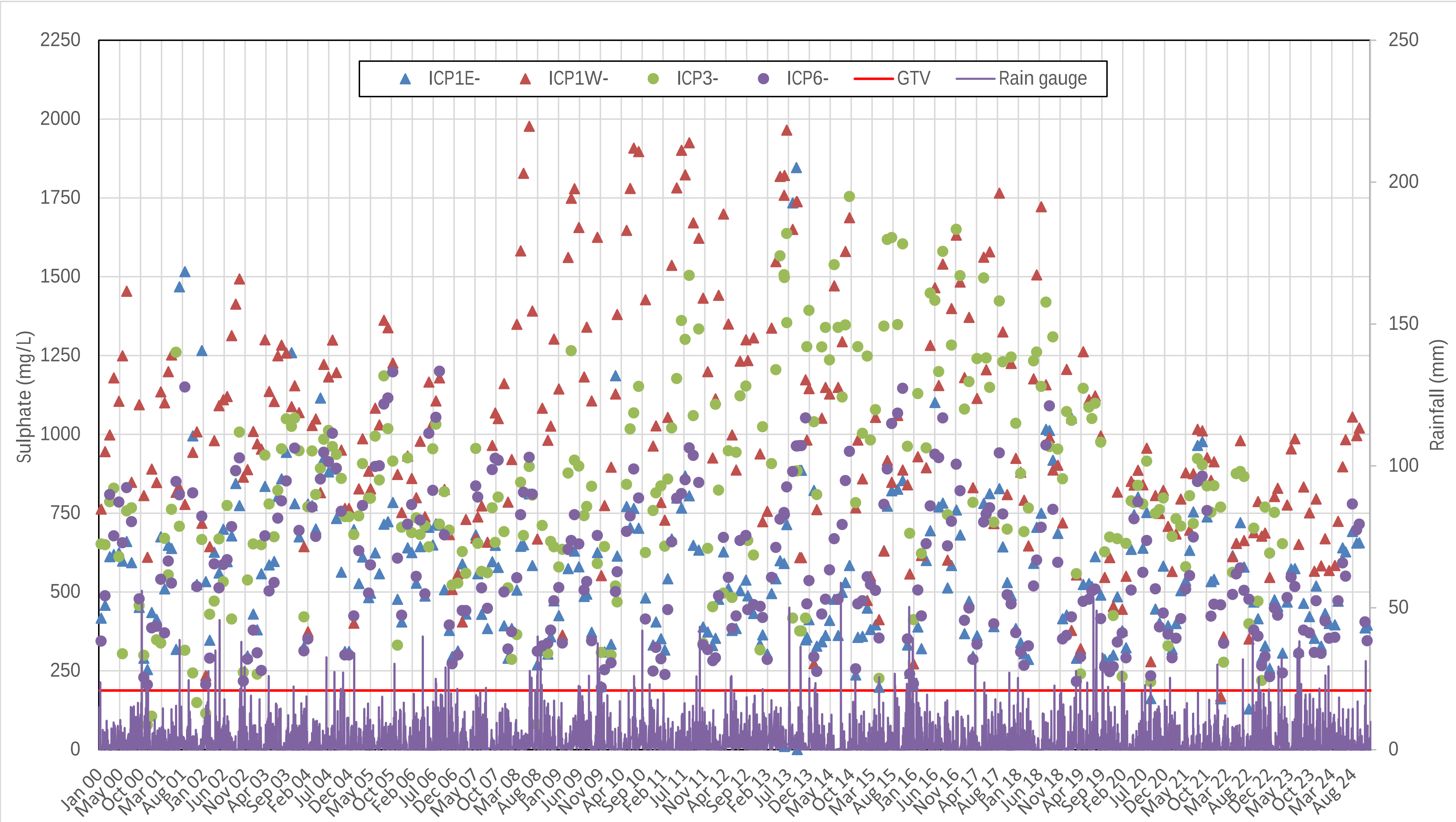


Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Figure 4.12 Sulphate concentrations in surface water

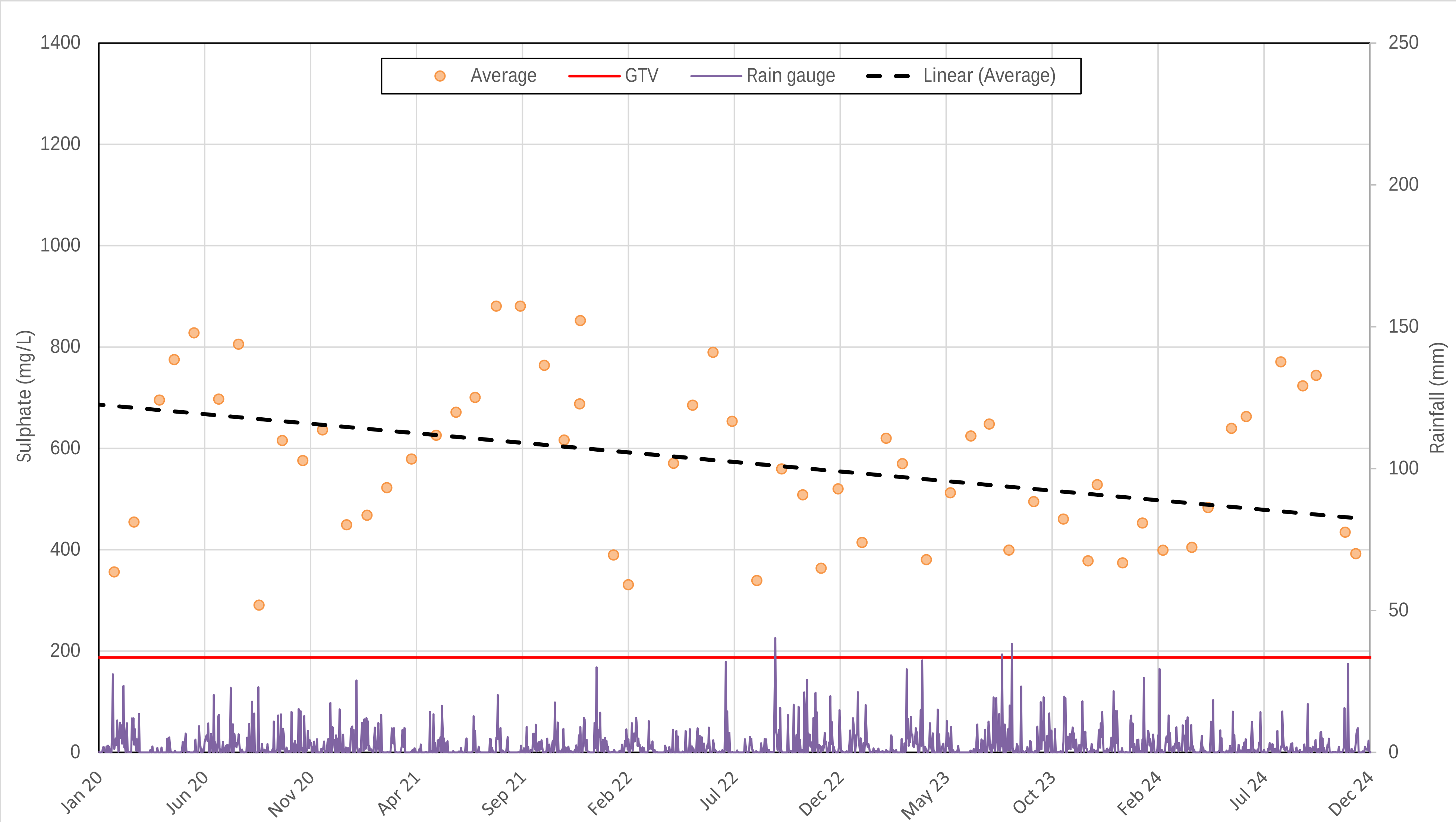


Client: Boliden_TaraMines_DAC **Site: Tara Mines** **Figure 4.13 Average sulphate concentrations in surface water and 5-year trend**



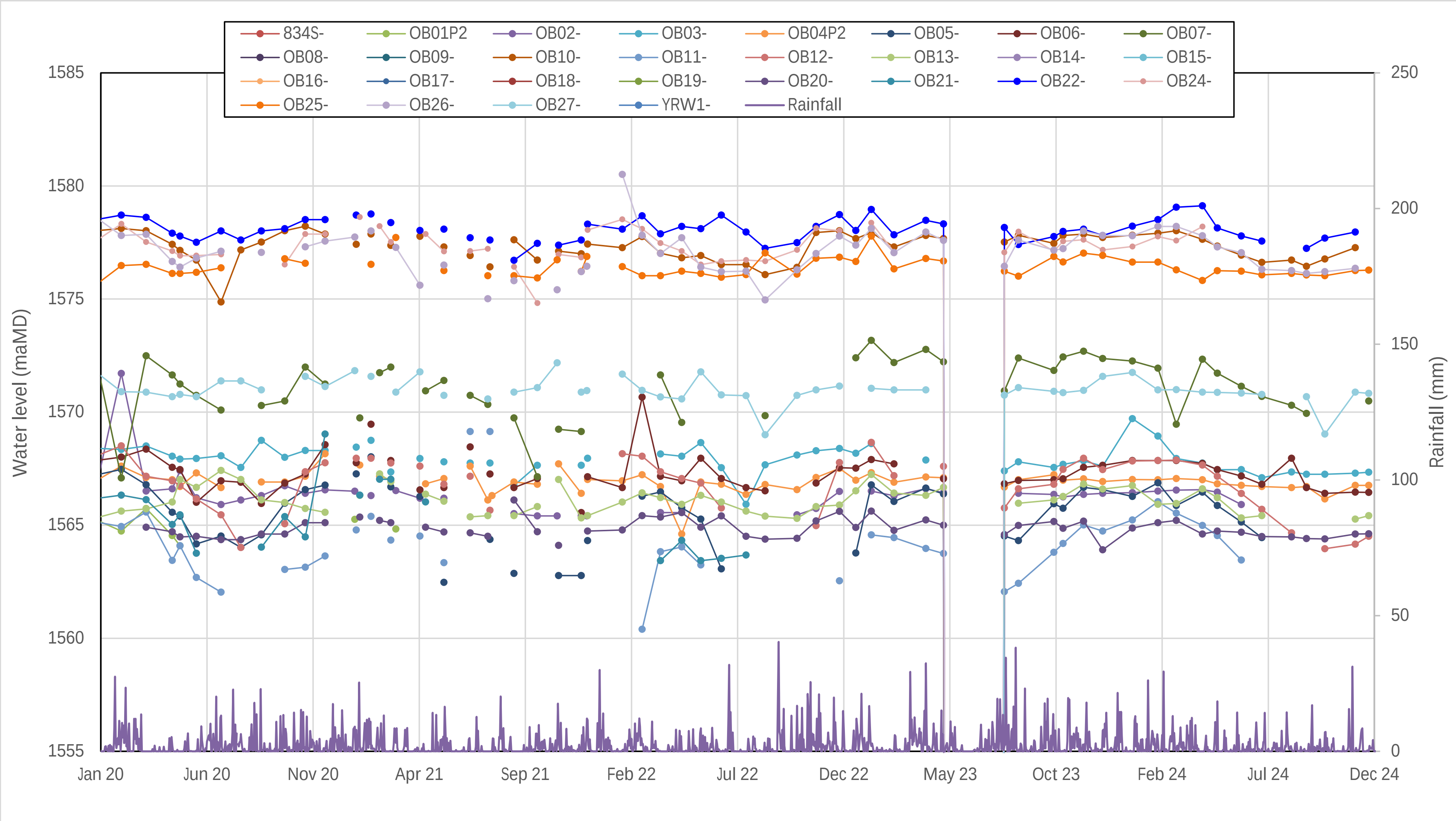
Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Figure 4.14 Sulphate concentrations in the interceptor channel

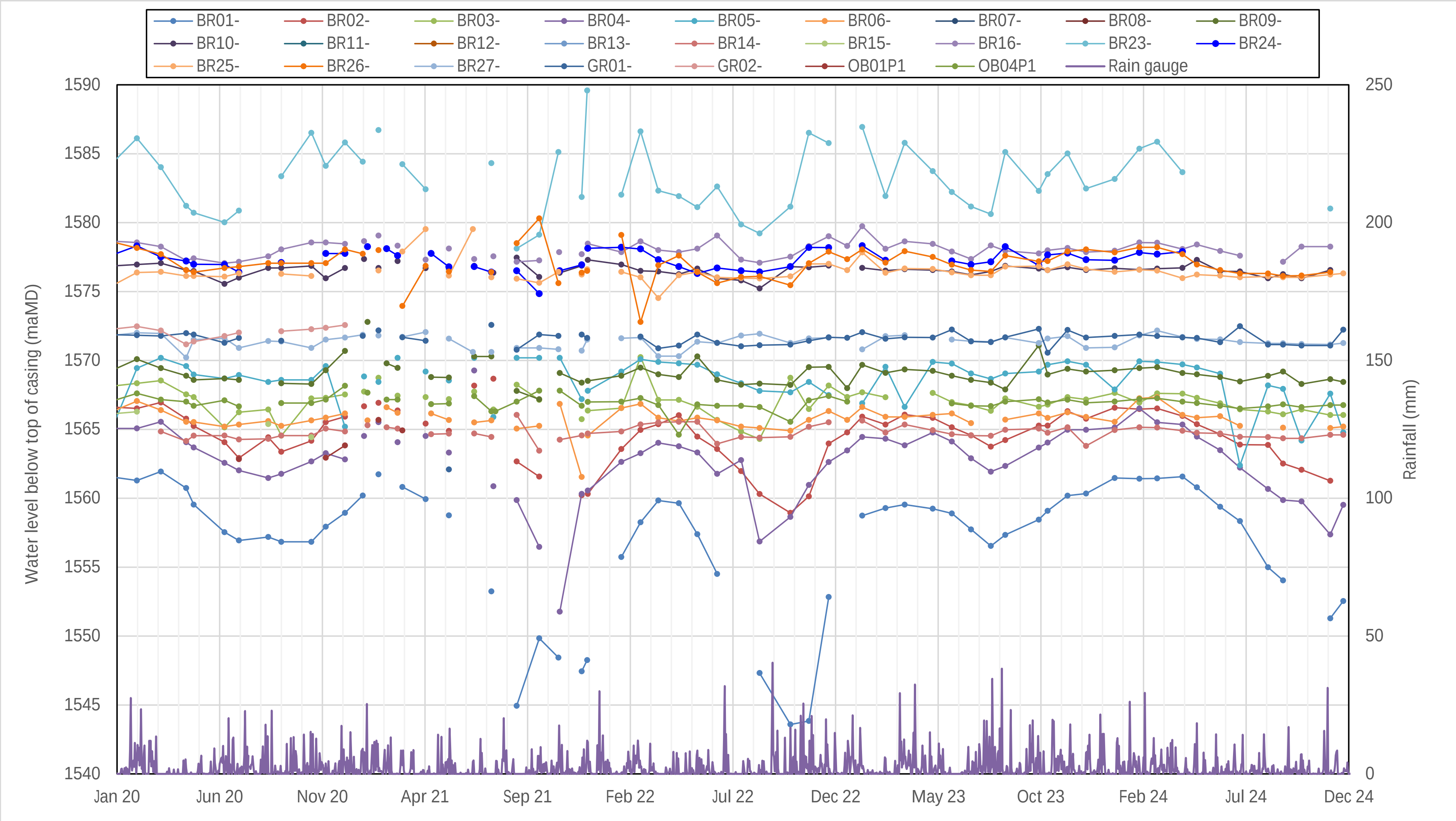


Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Figure 4.15 Average sulphate concentrations in the interceptor channel and 5-year trend



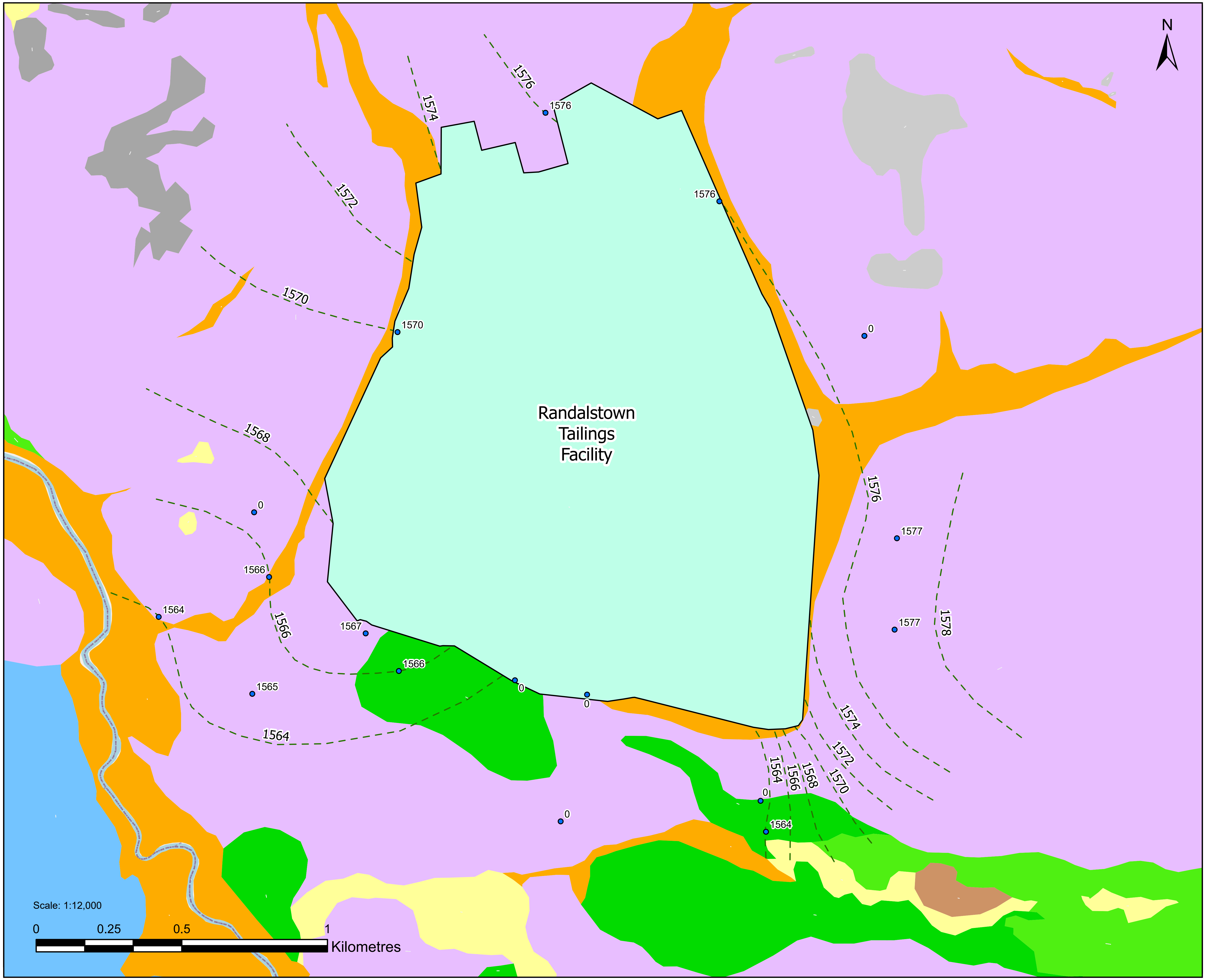
Client: Boliden_TaraMines_DAC **Site: Tara Mines** **Figure 4.16 Groundwater level hydrograph for overburden boreholes**



Client: Boliden_TaraMines_DAC

Site: Tara Mines

Figure 4.17 Groundwater level hydrograph for bedrock boreholes



Revision: 2 Drawn: AM Checked: JR Approved: JR Date: 2025-03-25

Filename: C:\Users\MoreauA\OneDrive - AECOM\60628825 Tara Mines Boliden 2020400_TECH434 GIS\ArcGIS ProLayout\60628825 Tara Mines Version 2.aprx

AECOM

PROJECT

Randalstown Tailings Storage Facility

CLIENT

Boliden Tara Mines

CONSULTANT

AECOM Limited
Midpoint, Alencon Link,
Basingstoke, Hampshire,
RG21 7PP
www.aecom.com

LEGEND

Legend

- Superficial Deposits Monitoring Borehole
- Tara Mines
- 2024-11 OB GWL
- Alluvium
- Cut over raised peat
- Gravels derived from Lower Paleozoic sandstones and shales
- Gravels derived from Limestones
- Kartsified bedrock outcrop or subcrop
- Lacustrine sediments
- Bedrock outcrop or subcrop
- Till derived from Lower Palaeozoic sandstones and shales
- Till derived from limestones

CREDITS

Map data © OpenStreetMap contributors, Microsoft, Facebook, Google, Esri Community Maps contributors, Map layer by Esri

ISSUE PURPOSE

ANNUAL MONITORING REPORT

PROJECT NUMBER

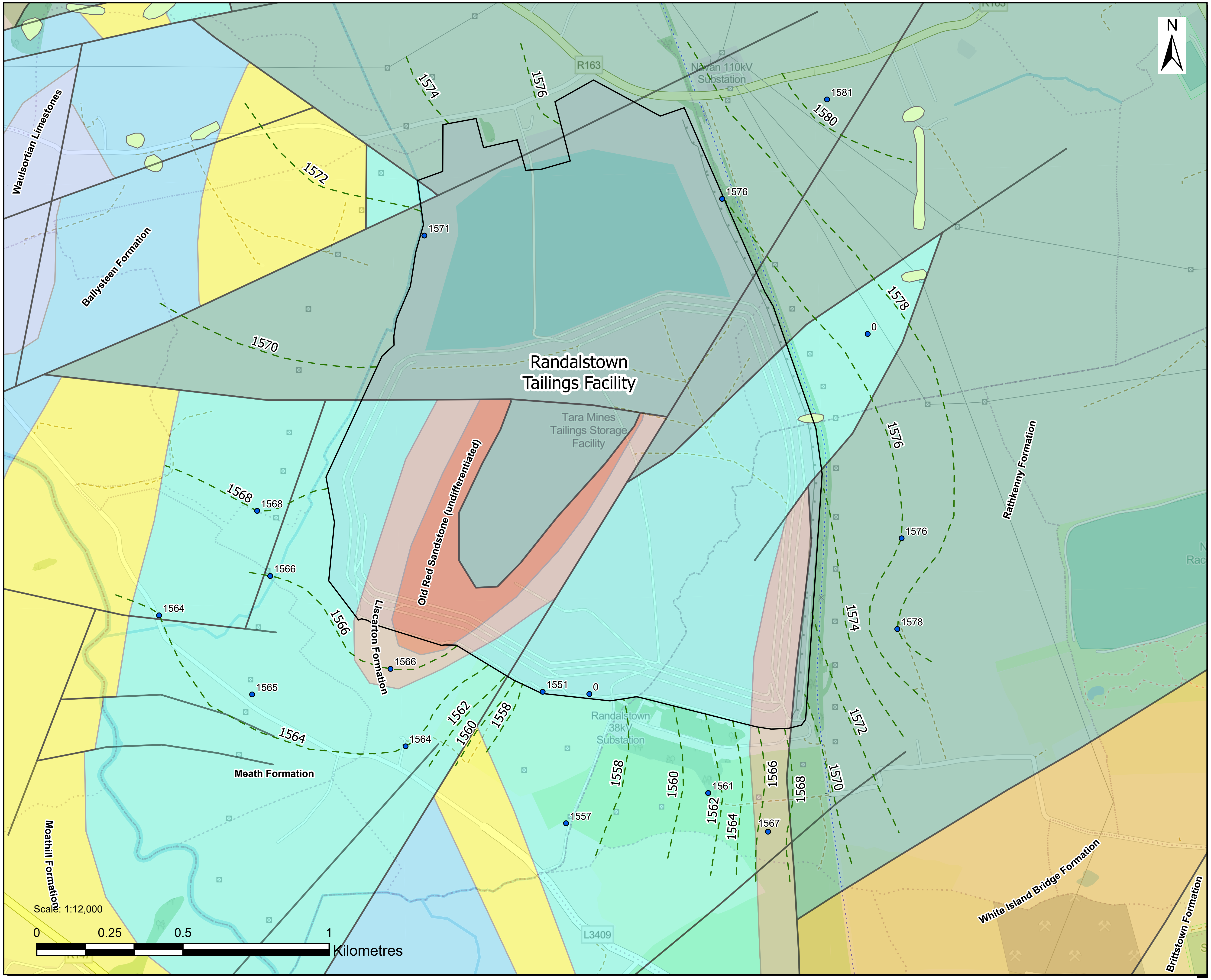
60628825

FIGURE TITLE

Overburden groundwater level contours (November 2024)

FIGURE NUMBER

Figure 4.18



Revision: 0 Drawn: LT Checked: JR Approved: JR Date: 2025-03-04

Filename: C:\Users\MoreauA\OneDrive - AECOM\60628825 Tara Mines Boliden 2020400_TECH434 GIS\ArcGIS Pro\Layout\60628825 Tara Mines Version 2.aprx

AECOM

PROJECT
Randalstown Tailings Storage Facility

CLIENT
Boliden Tara Mines

CONSULTANT
AECOM Limited
Midpoint, Alencon Link,
Basingstoke, Hampshire,
RG21 7PP
www.aecom.com

LEGEND

Legend

- Bedrock Monitoring Borehole
- Tara Mines
- 2024-11 BR GWL

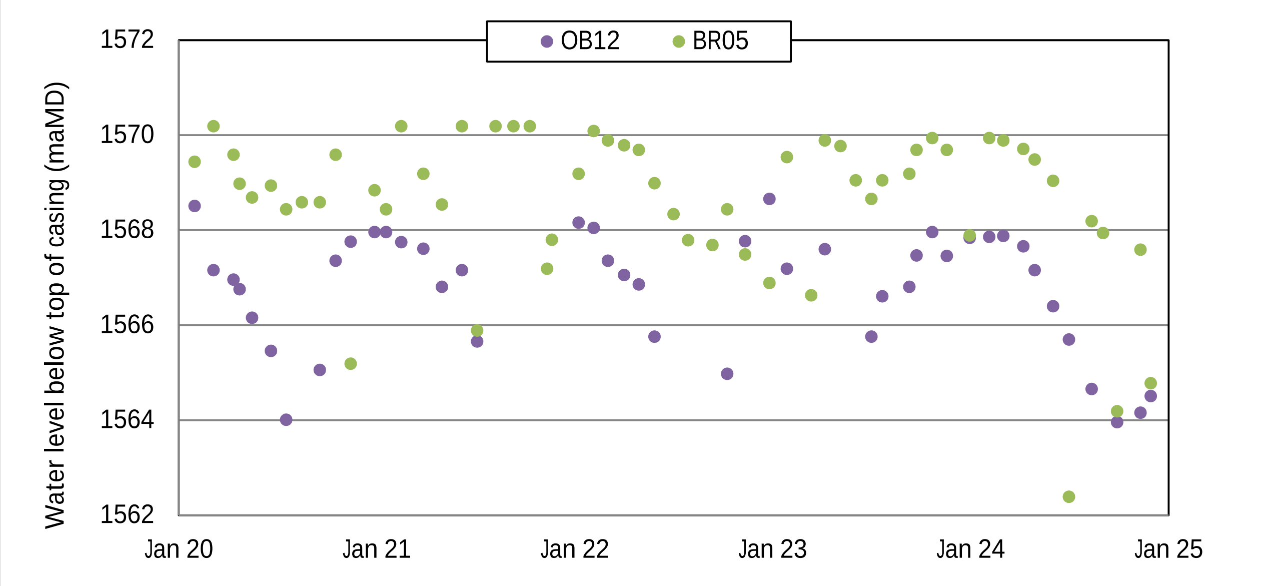
CREDITS
Map data © OpenStreetMap contributors, Microsoft, Facebook, Google, Esri Community Maps contributors, Map layer by Esri

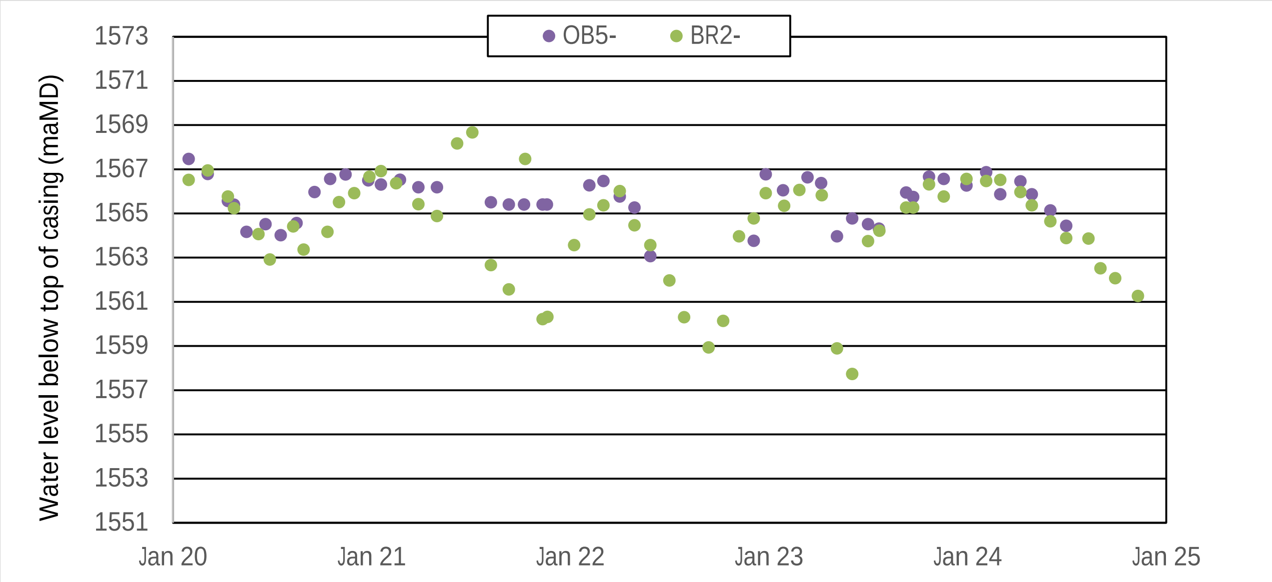
ISSUE PURPOSE
ANNUAL MONITORING REPORT

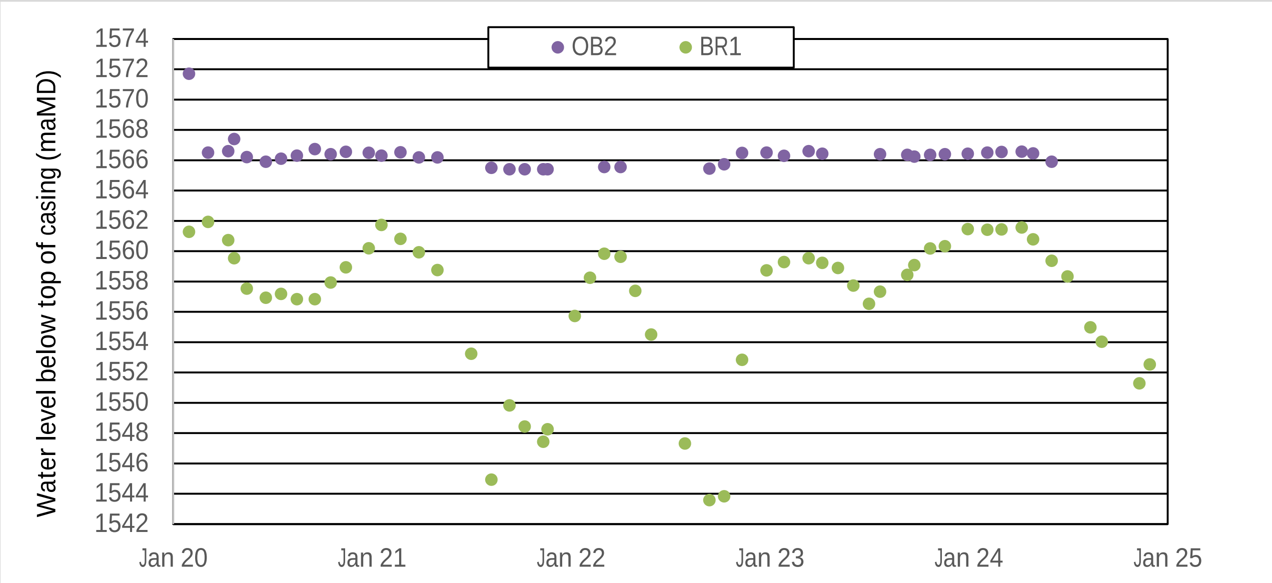
PROJECT NUMBER
60628825

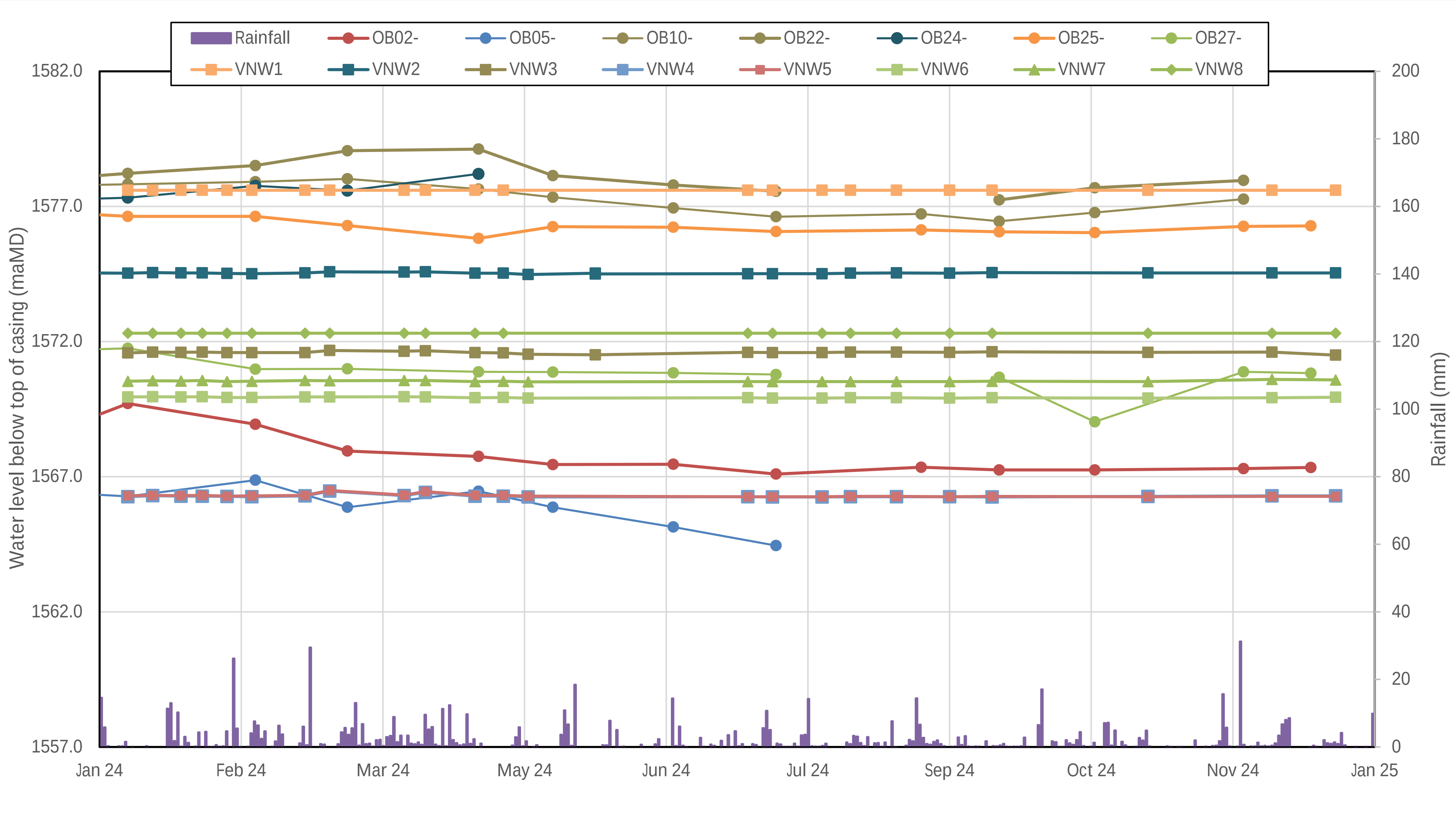
FIGURE TITLE
Bedrock groundwater level contours (November 2024)

FIGURE NUMBER
Figure 4.19


OB12
BR05
Water level below top of casing (maMD)
1572
1570
1568
1566
1564
1562
Jan 20
Jan 21
Jan 22
Jan 23
Jan 24
Jan 25


OB5-
BR2-
Water level below top of casing (maMD)
1573
1571
1569
1567
1565
1563
1561
1559
1557
1555
1553
1551
Jan 20
Jan 21
Jan 22
Jan 23
Jan 24
Jan 25

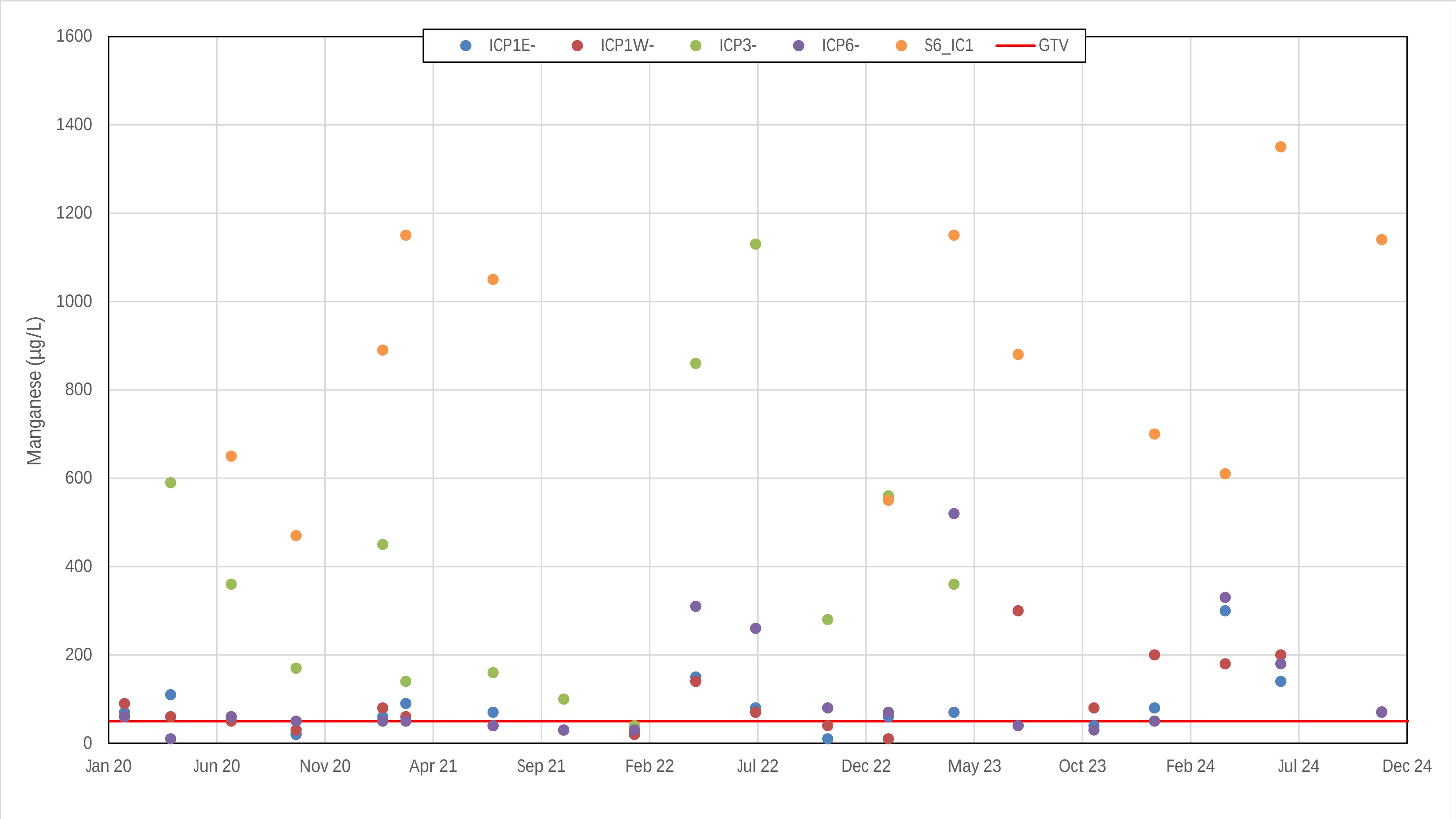

OB2
BR1
Water level below top of casing (maMD)
1574
1572
1570
1568
1566
1564
1562
1560
1558
1556
1554
1552
1550
1548
1546
1544
1542
Jan 20
Jan 21
Jan 22
Jan 23
Jan 24
Jan 25



Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Figure 4.21 Comparison of interceptor channel and overburden water levels

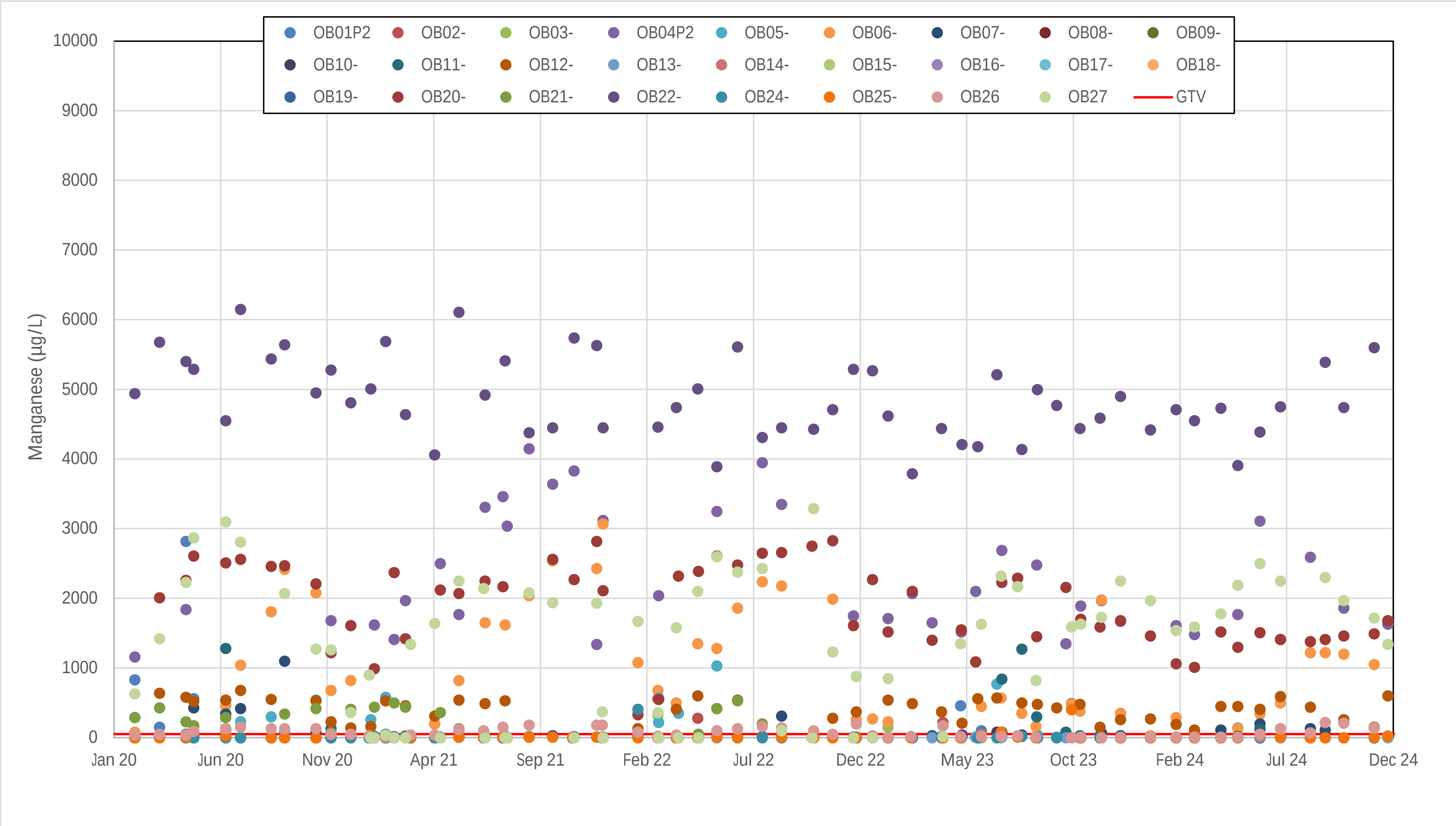
Appendix A Manganese



Client: Boliden_TaraMines_DAC

Site: Tara Mines

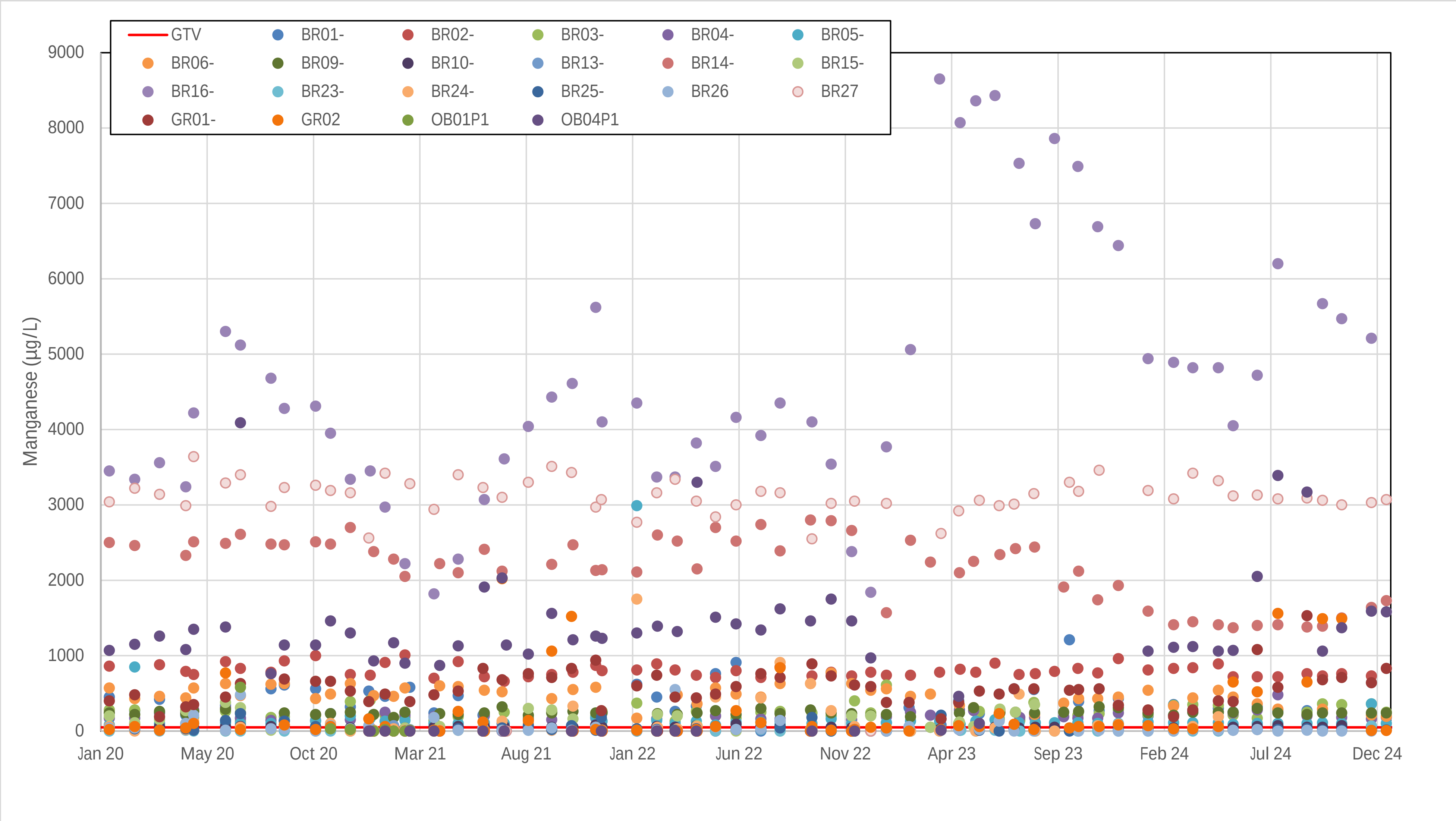
Appendix A.1 Manganese concentrations in the interceptor channel



Client: Boliden_TaraMines_DAC

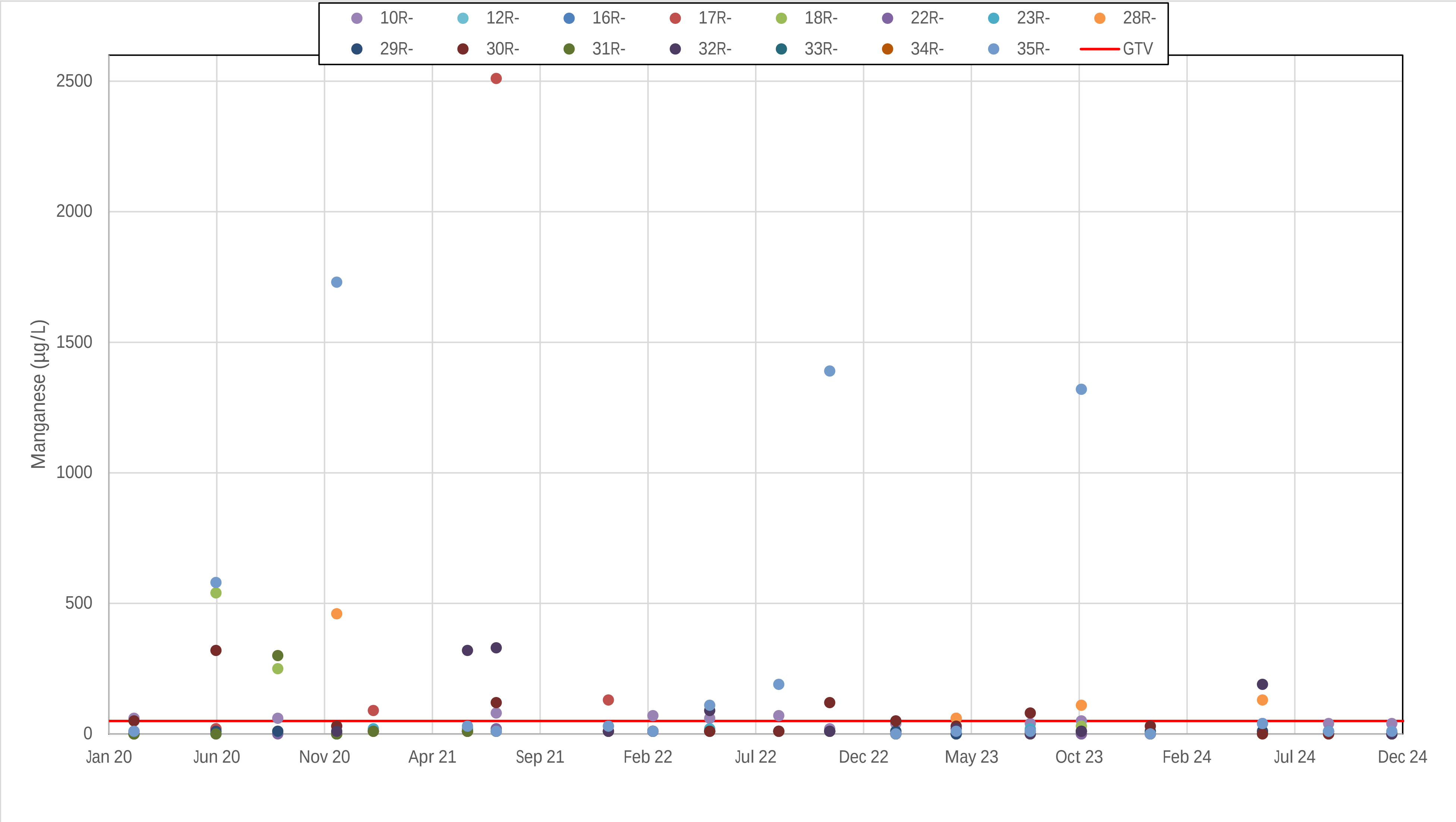
Site: Tara Mines

Appendix A.2 Manganese concentrations in overburden boreholes

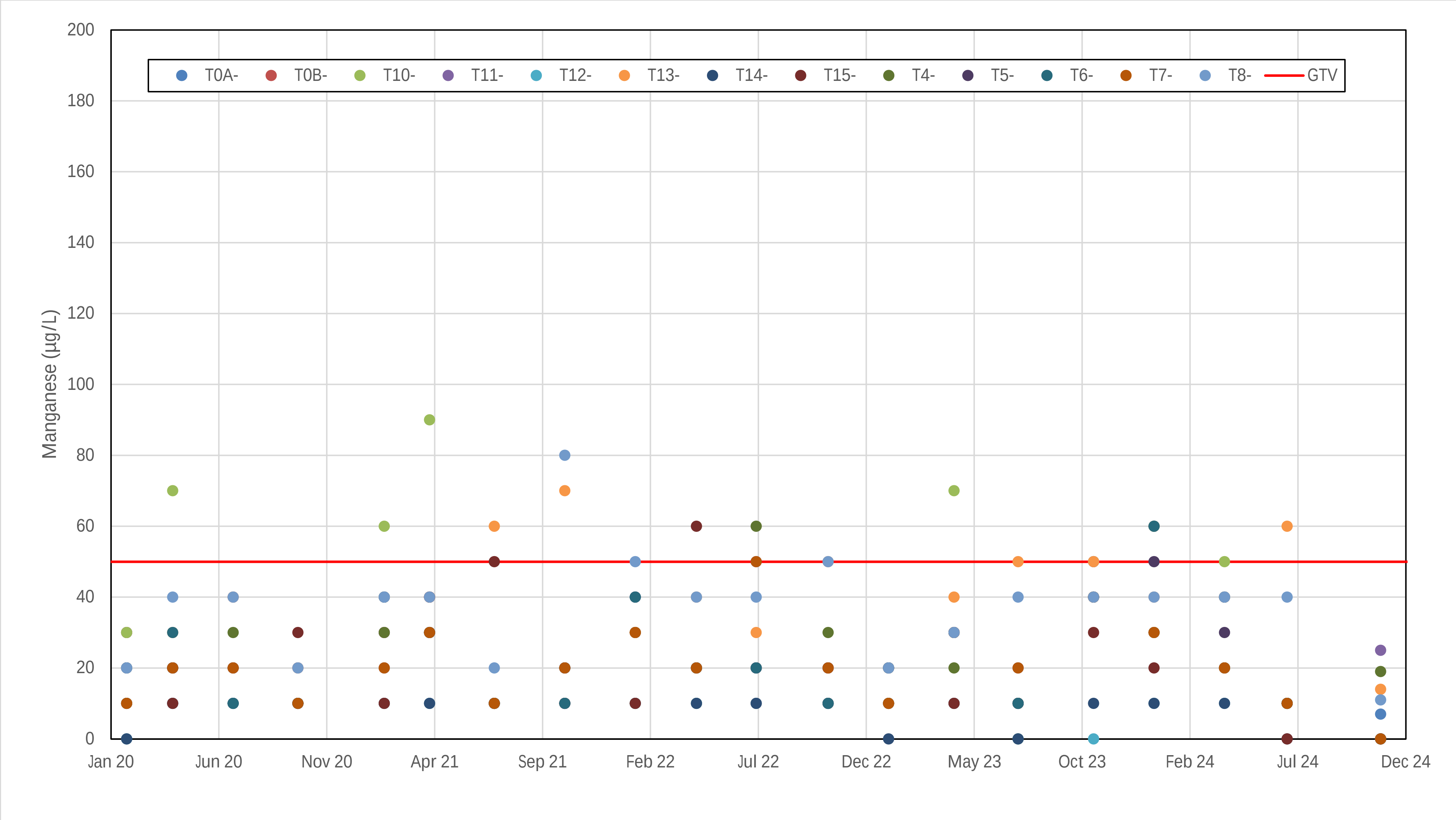


Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Appendix A.3 Manganese concentrations in bedrock boreholes



Client: Boliden_TaraMines_DAC **Site: Tara Mines** **Appendix A.4 Manganese concentrations in domestic wells**

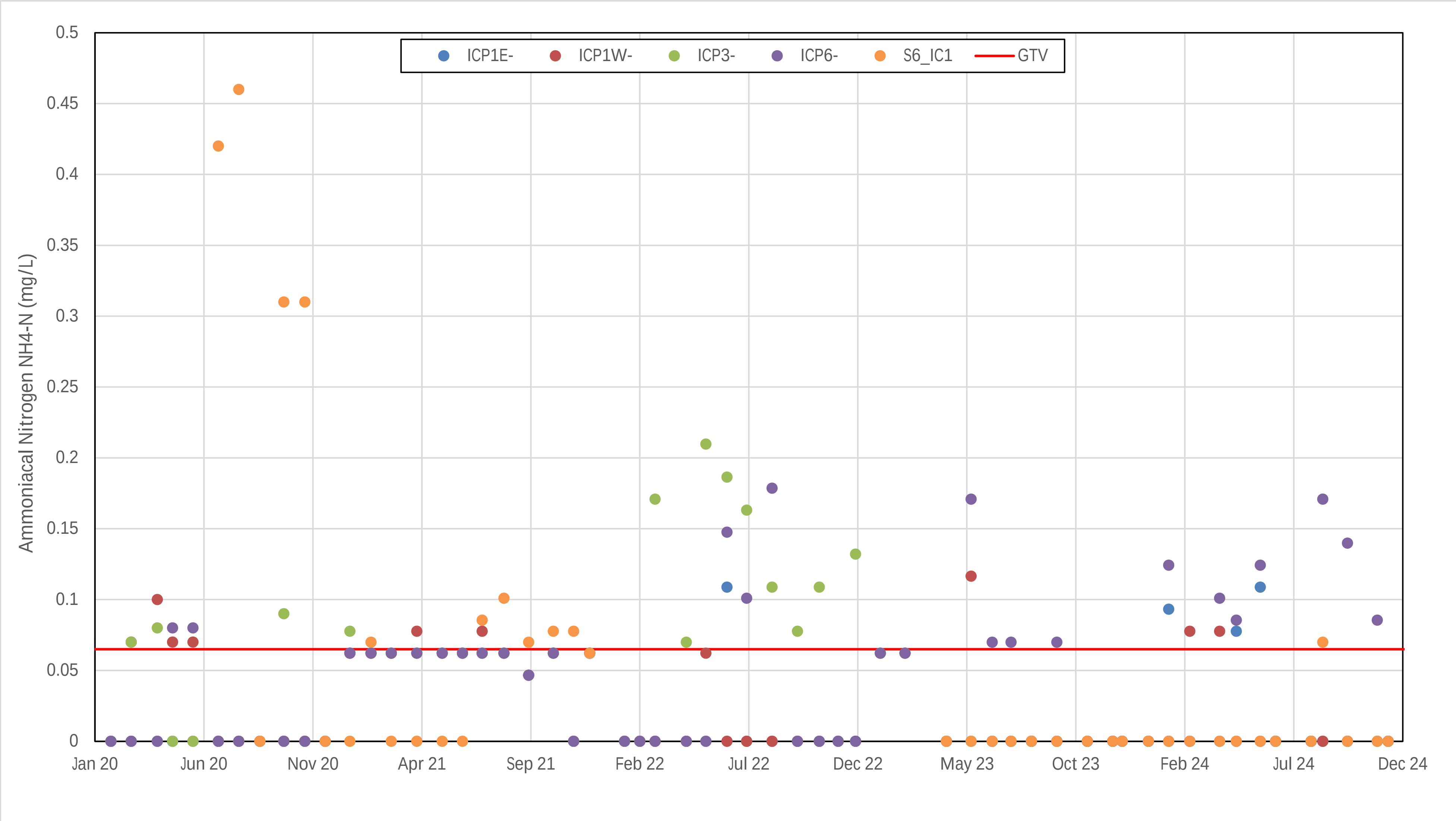


Client: Boliden_TaraMines_DAC

Site: Tara Mines

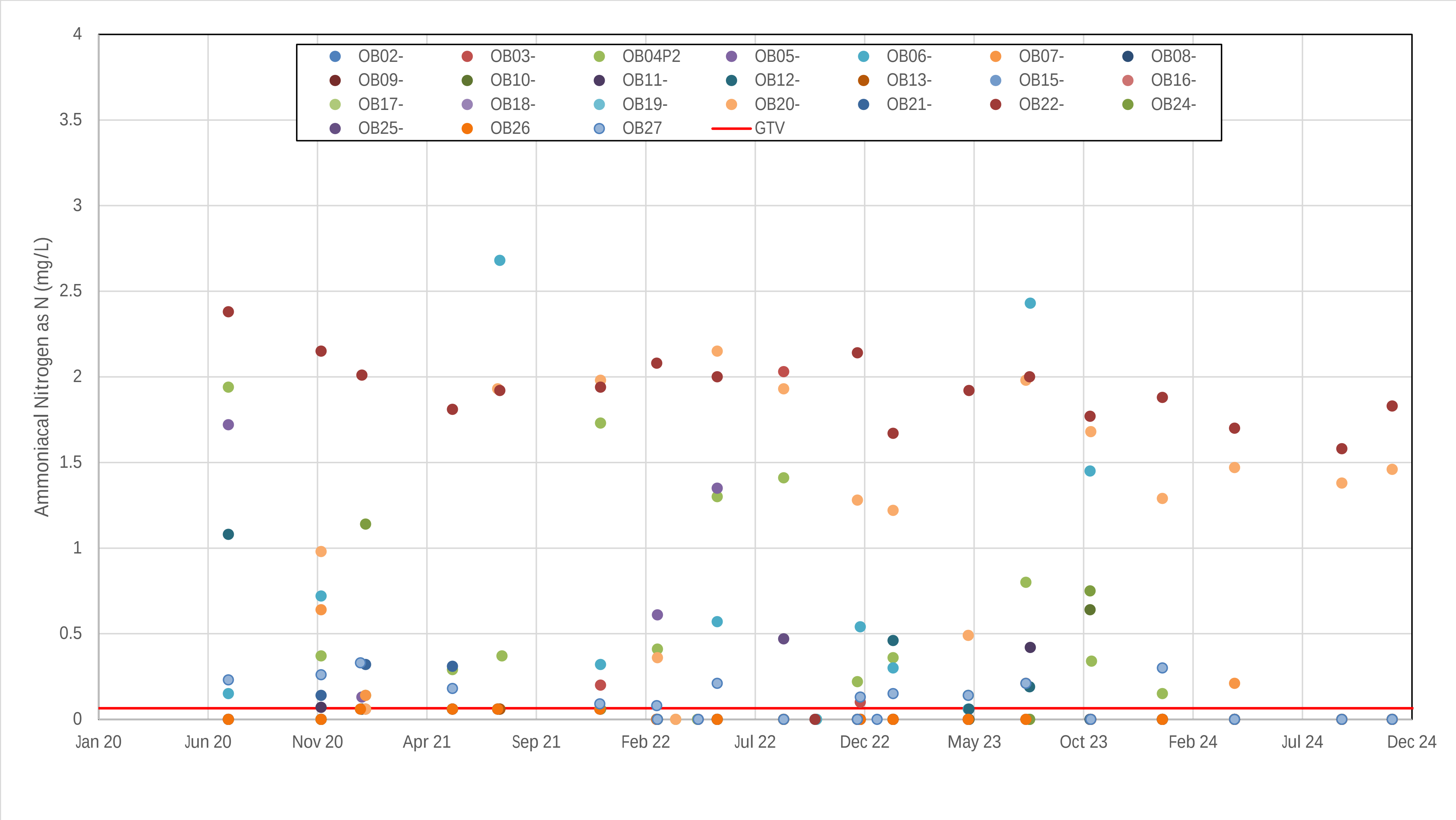
Appendix A.5 Manganese concentrations in surface water

Appendix B Ammoniacal Nitrogen NH_4 as N



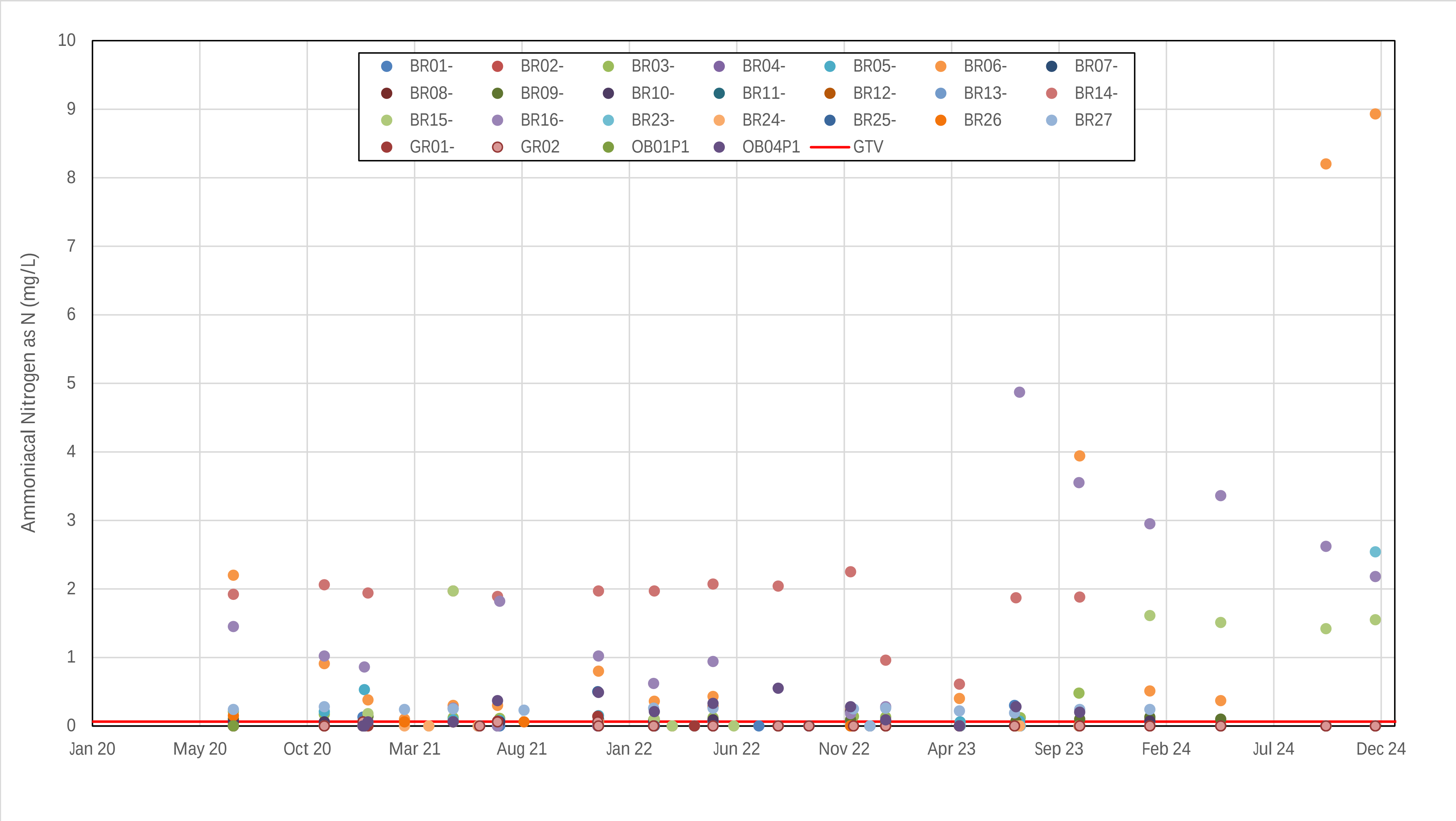
Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Appendix B.1 Ammoniacal Nitrogen concentrations in the interceptor channel



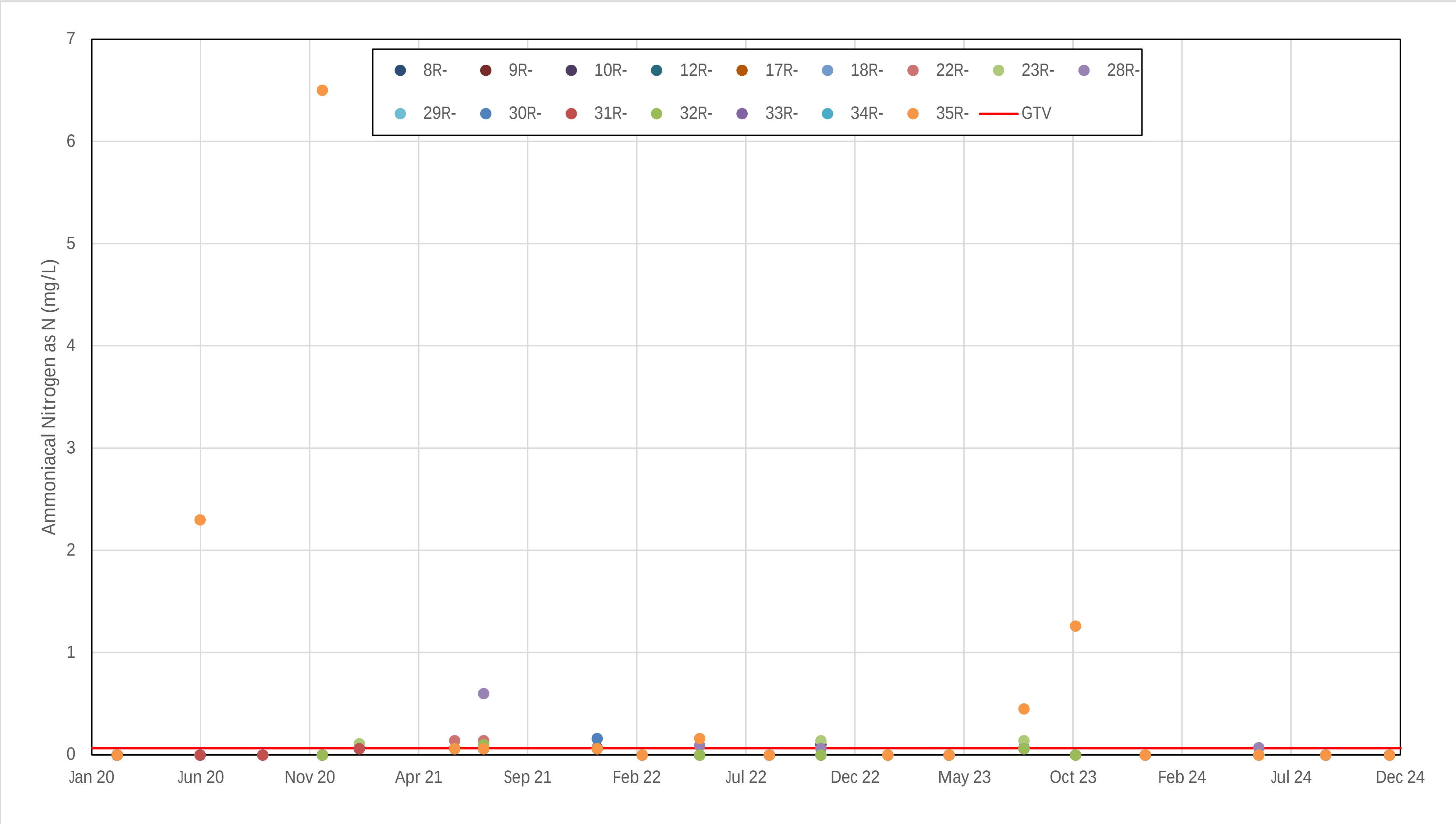
Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Appendix B.2 Ammoniacal Nitrogen in overburden boreholes

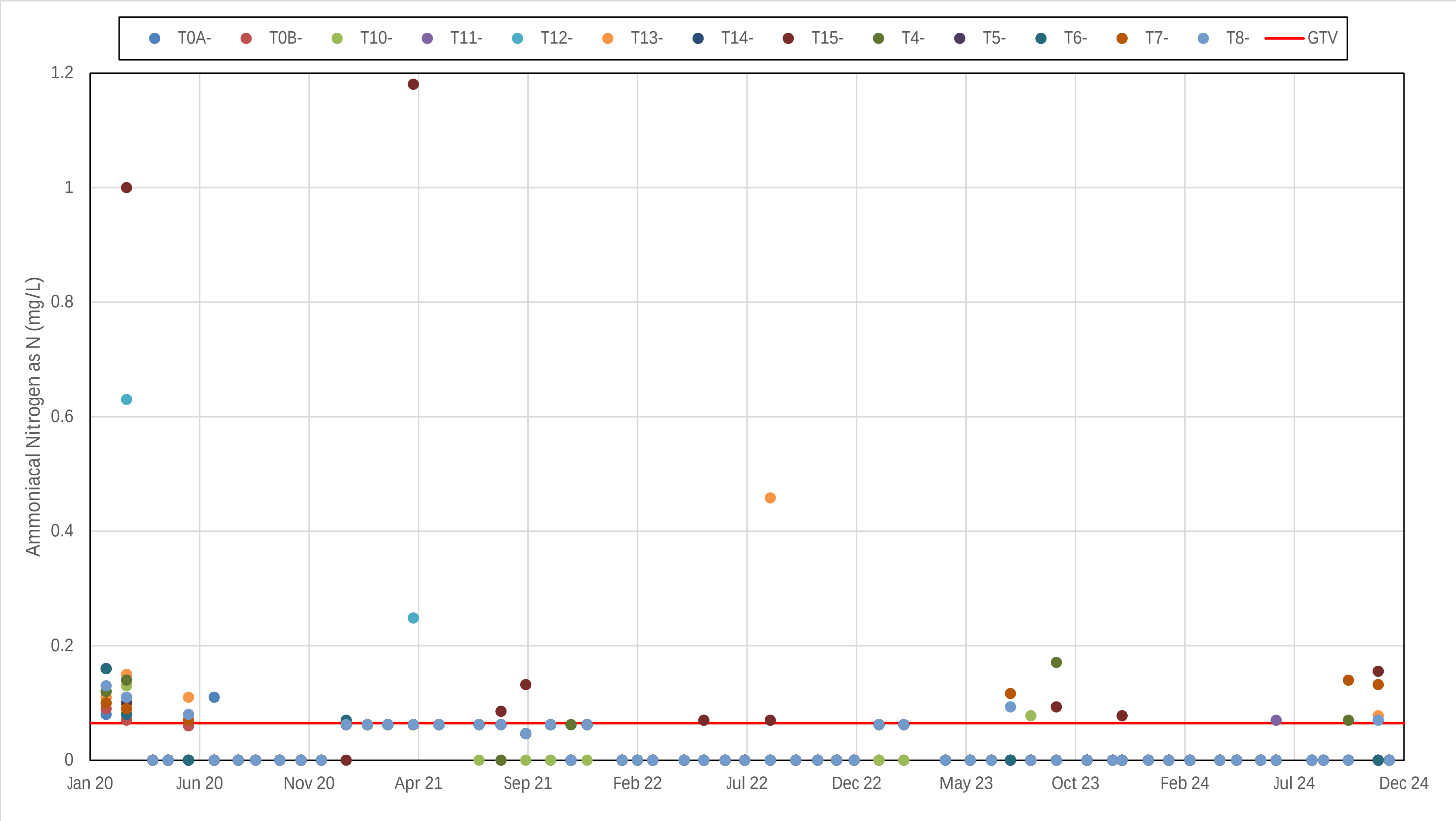


Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Appendix B.3 Ammoniacal Nitrogen in bedrock boreholes

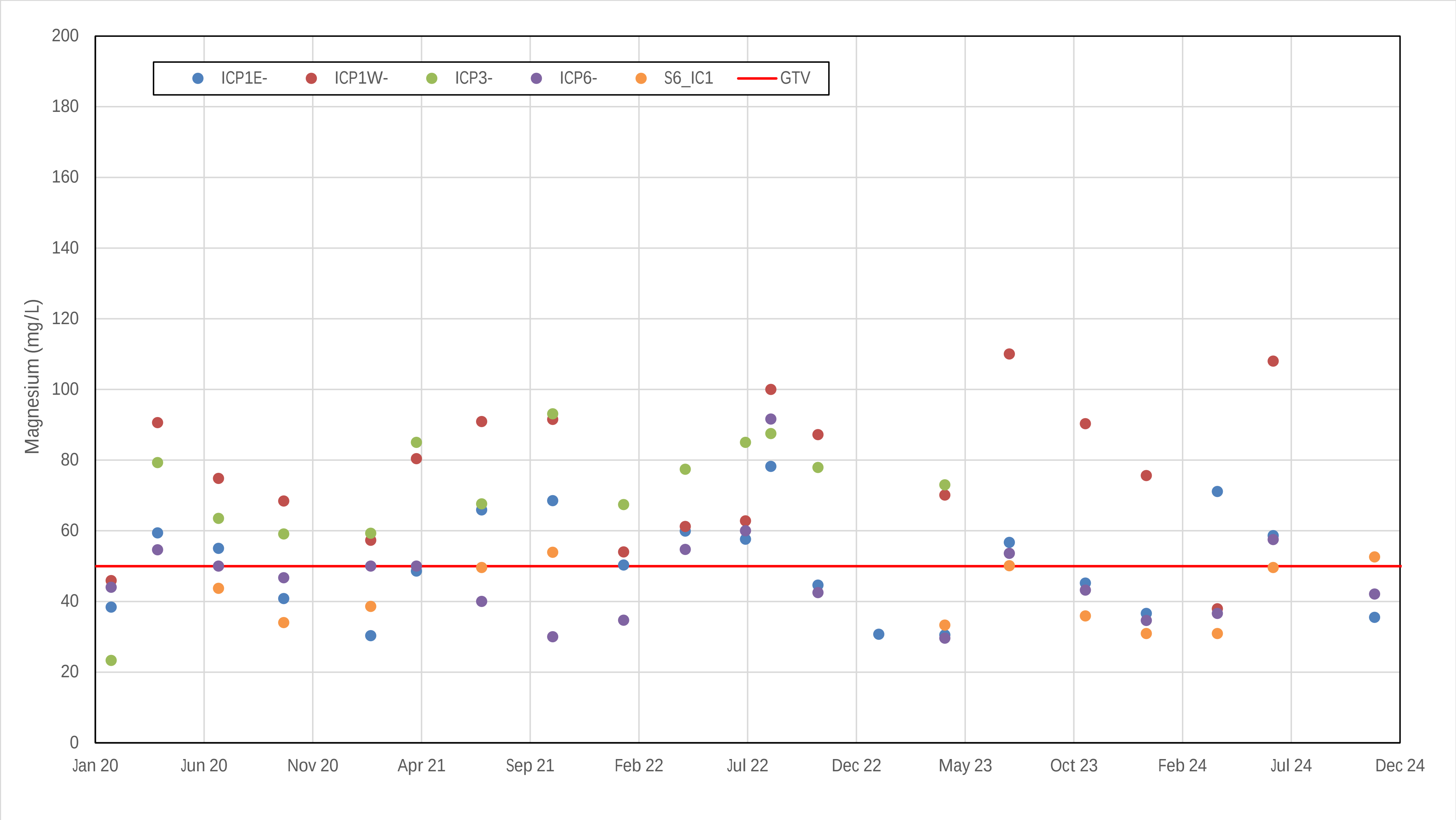


Client: Boliden_TaraMines_DAC **Site: Tara Mines** **Appendix B.4 Ammoniacal Nitrogen in domestic wells**



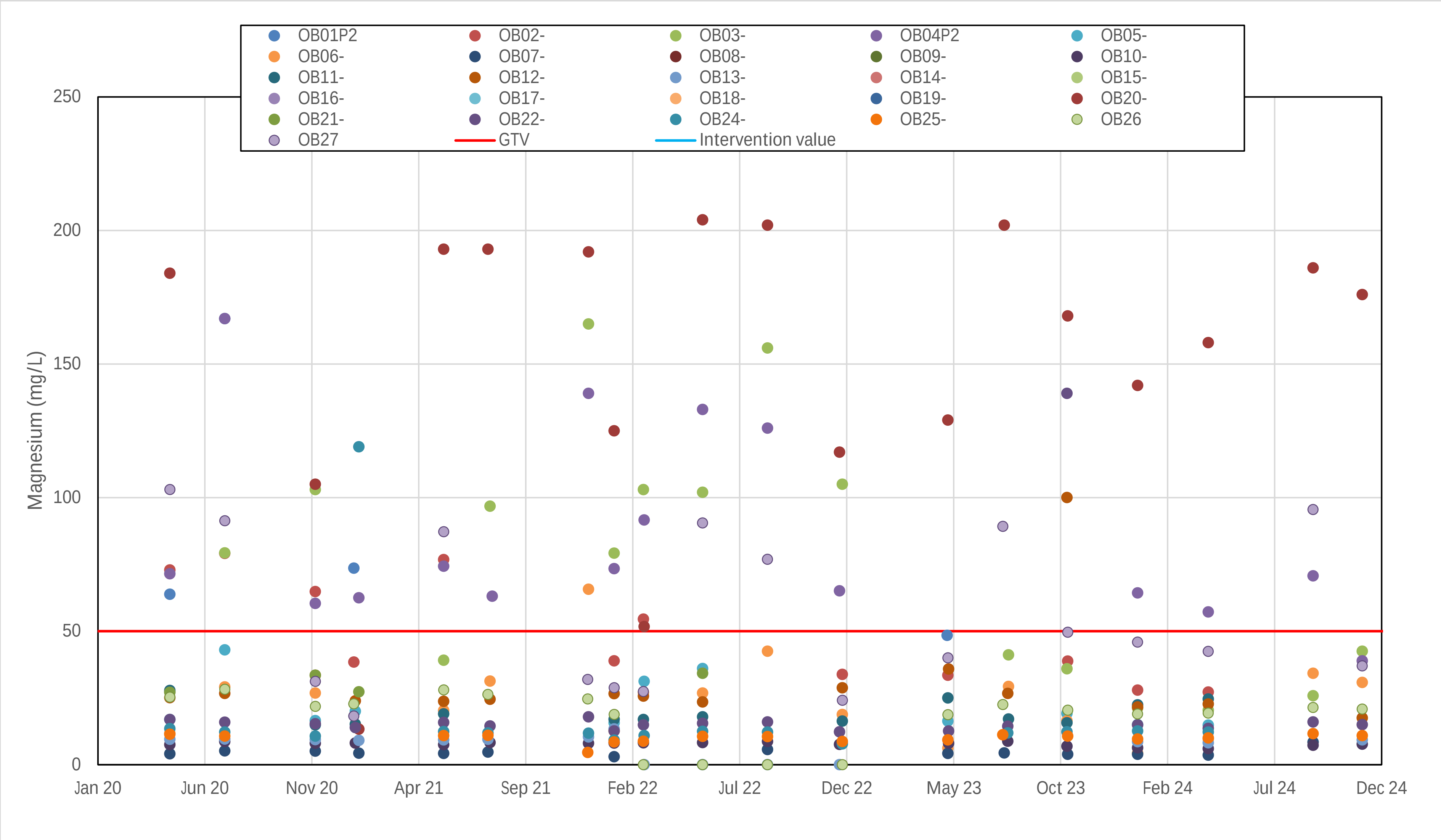
Client: Boliden_TaraMines_DAC **Site: Tara Mines** **Appendix B.5 Ammoniacal Nitrogen in surface water**

Appendix C Magnesium



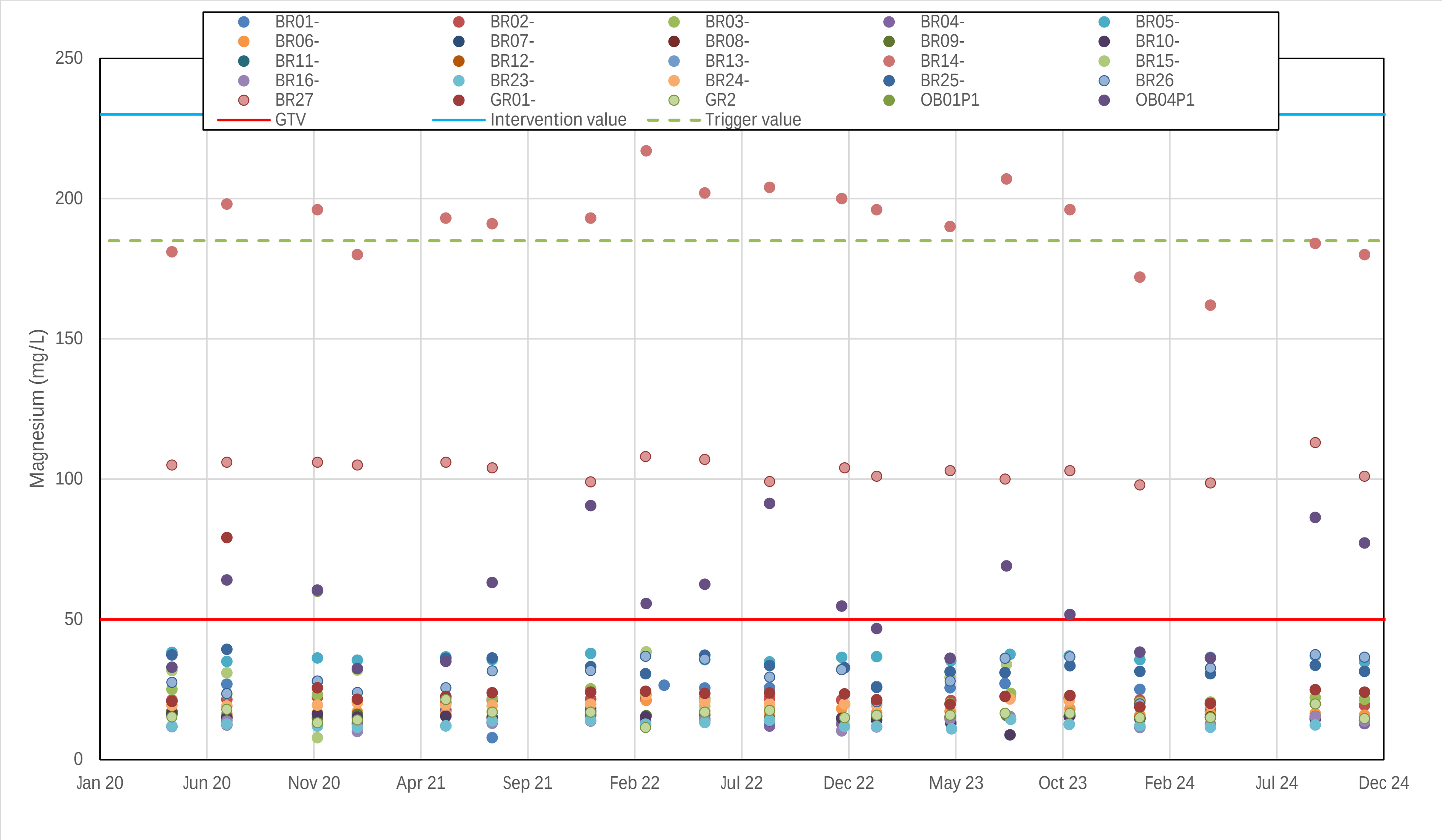
Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Appendix C.1 Magnesium concentrations in the interceptor channel



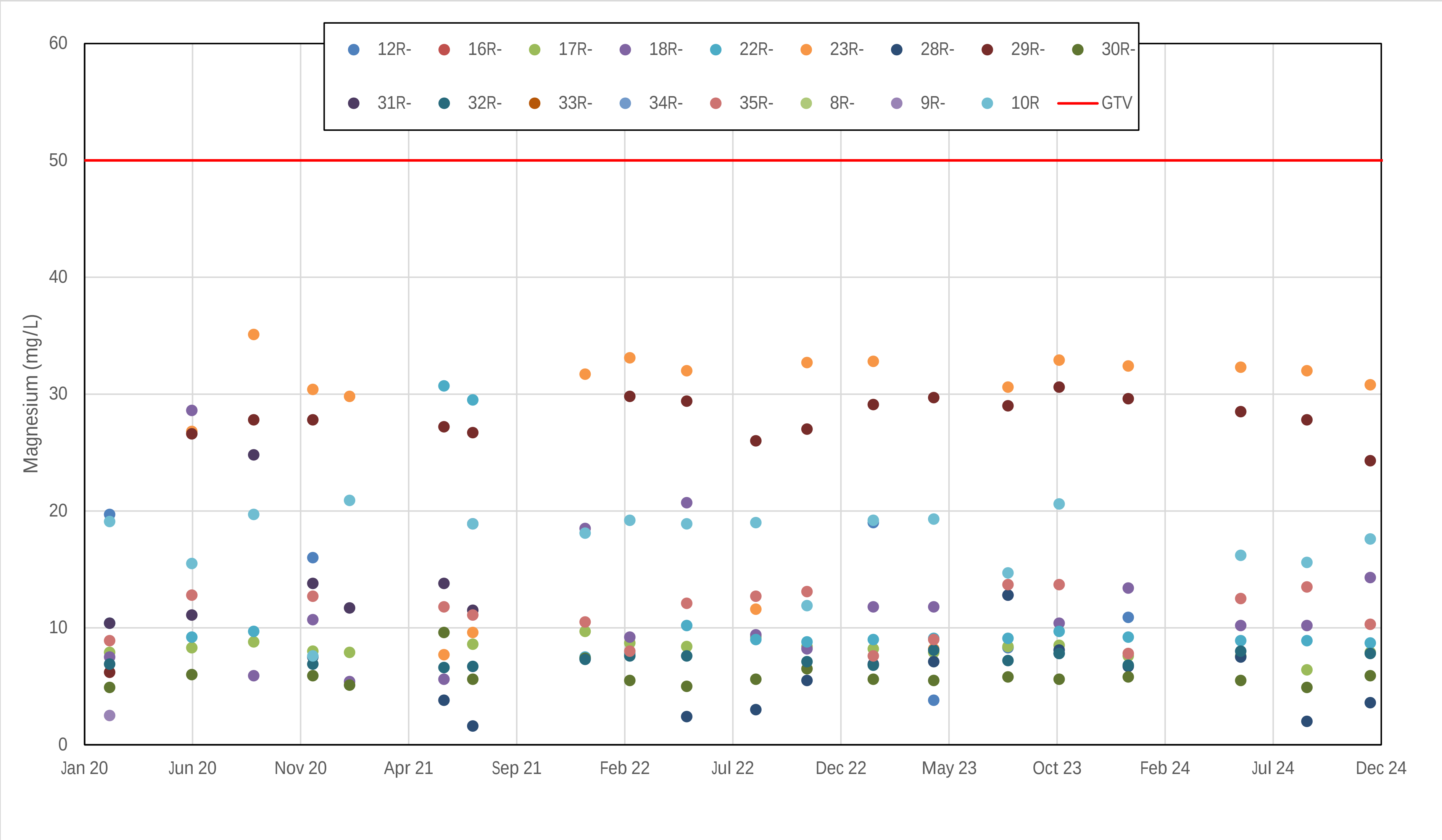
Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Appendix C.2 Magnesium concentrations in overburden boreholes



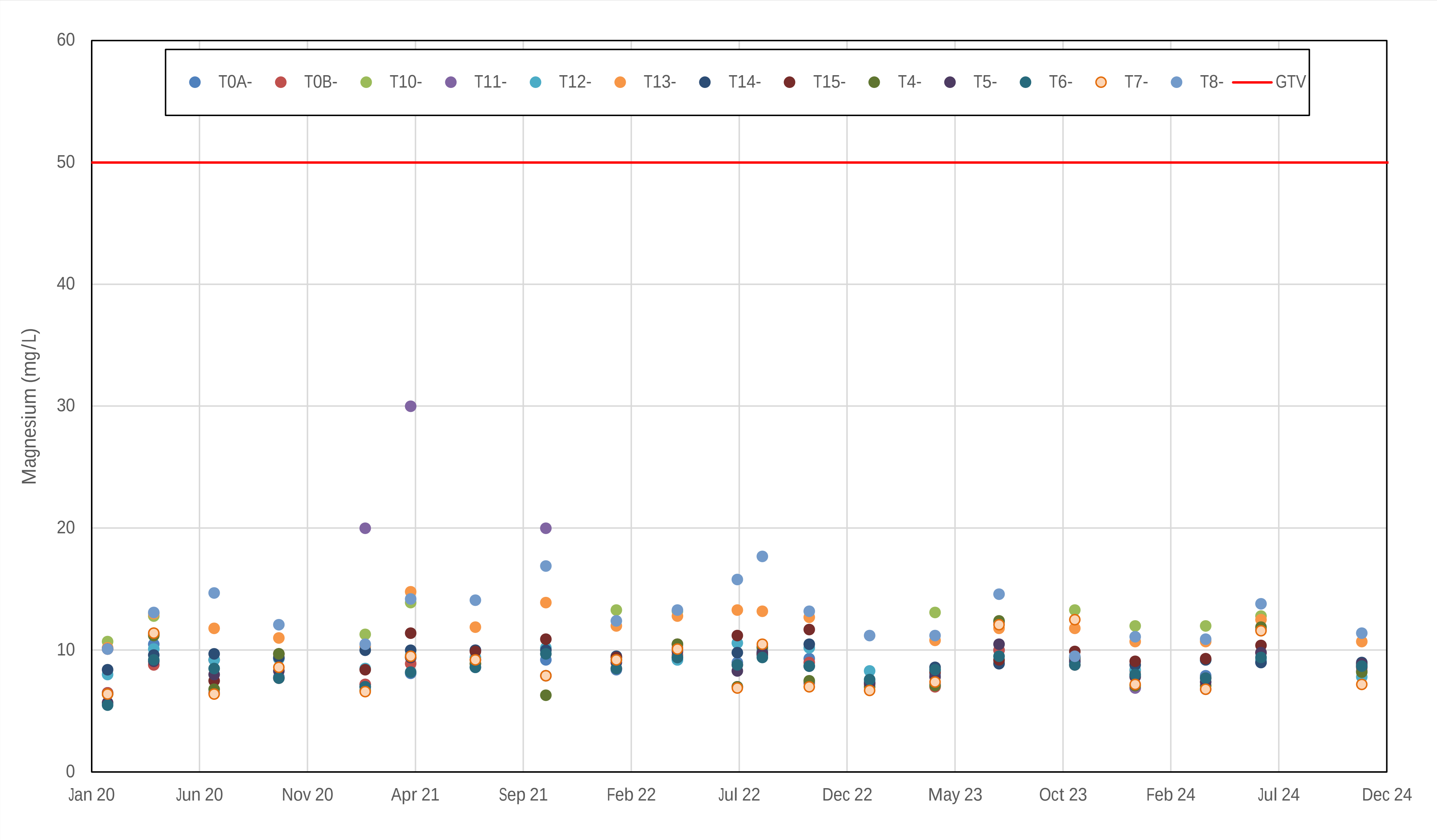
Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Appendix C.3 Magnesium concentrations in bedrock boreholes



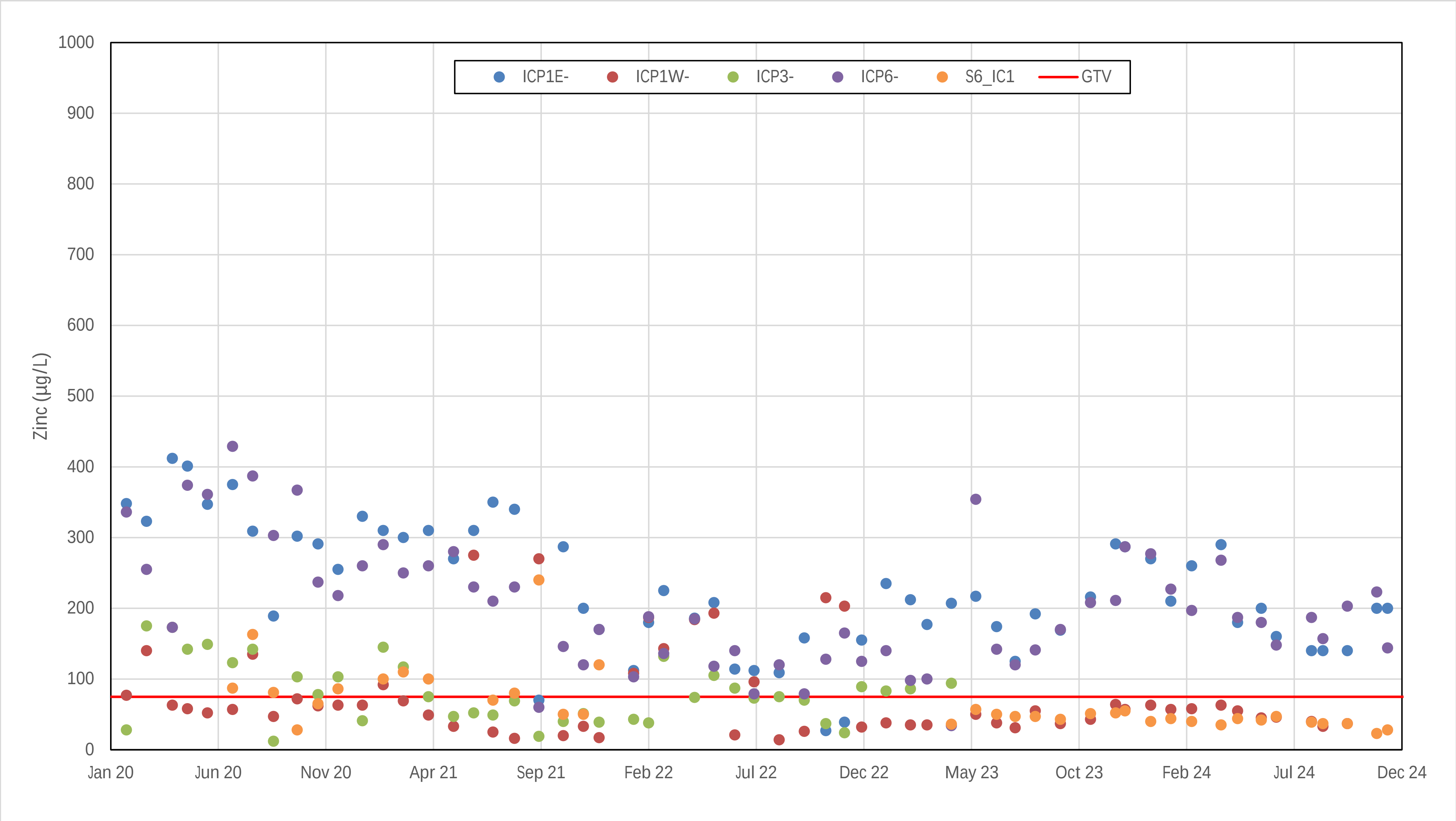
Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Appendix C.4 Magnesium concentrations in domestic wells



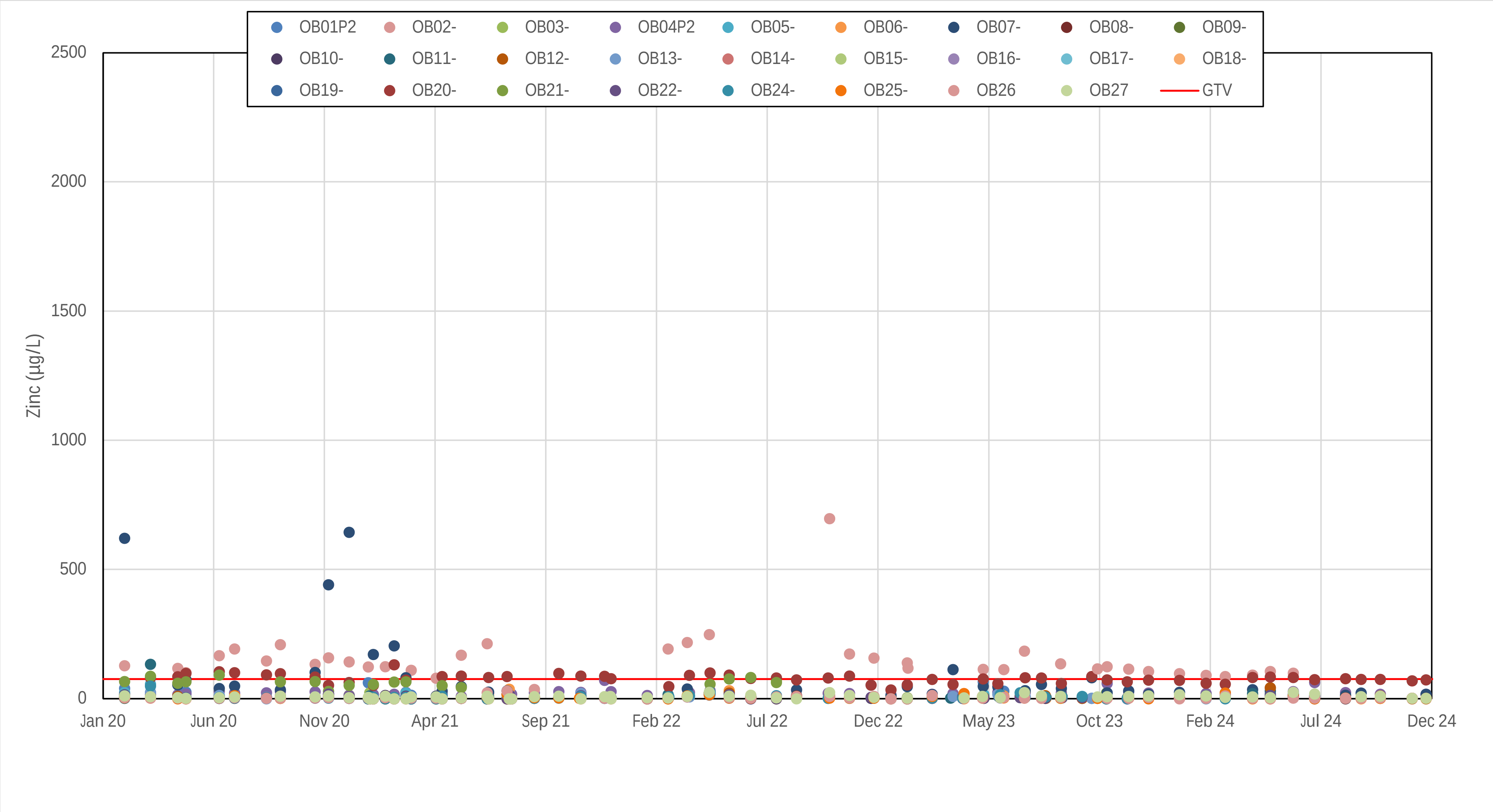
Client: Boliden_TaraMines_DAC **Site: Tara Mines** **Appendix C.5 Magnesium concentrations in surface water**

Appendix D Zinc



Client: Boliden_TaraMines_DAC **Site: Tara Mines**

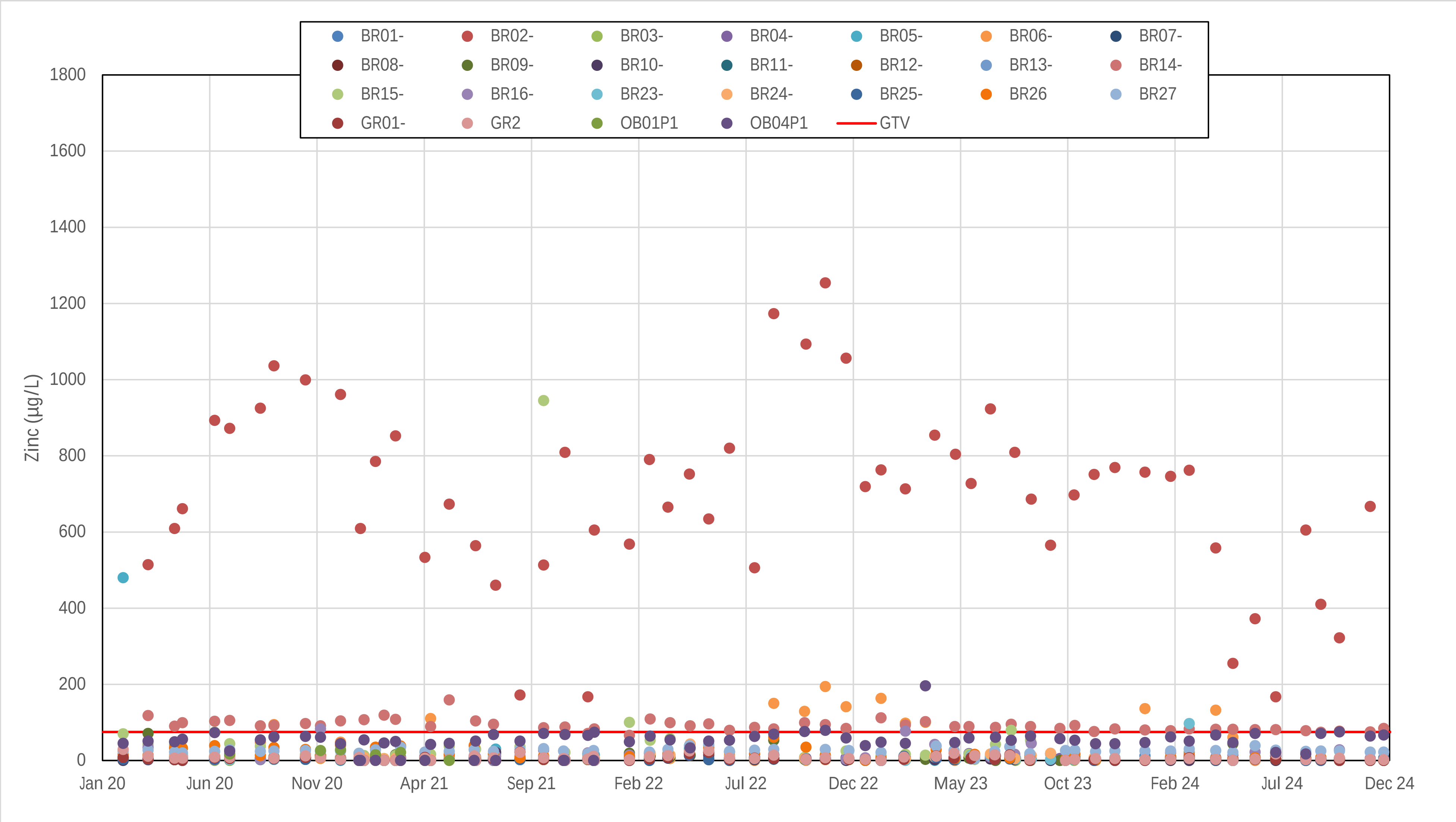
Appendix D.1 Zinc concentrations in the interceptor channel



Client: Boliden_TaraMines_DAC

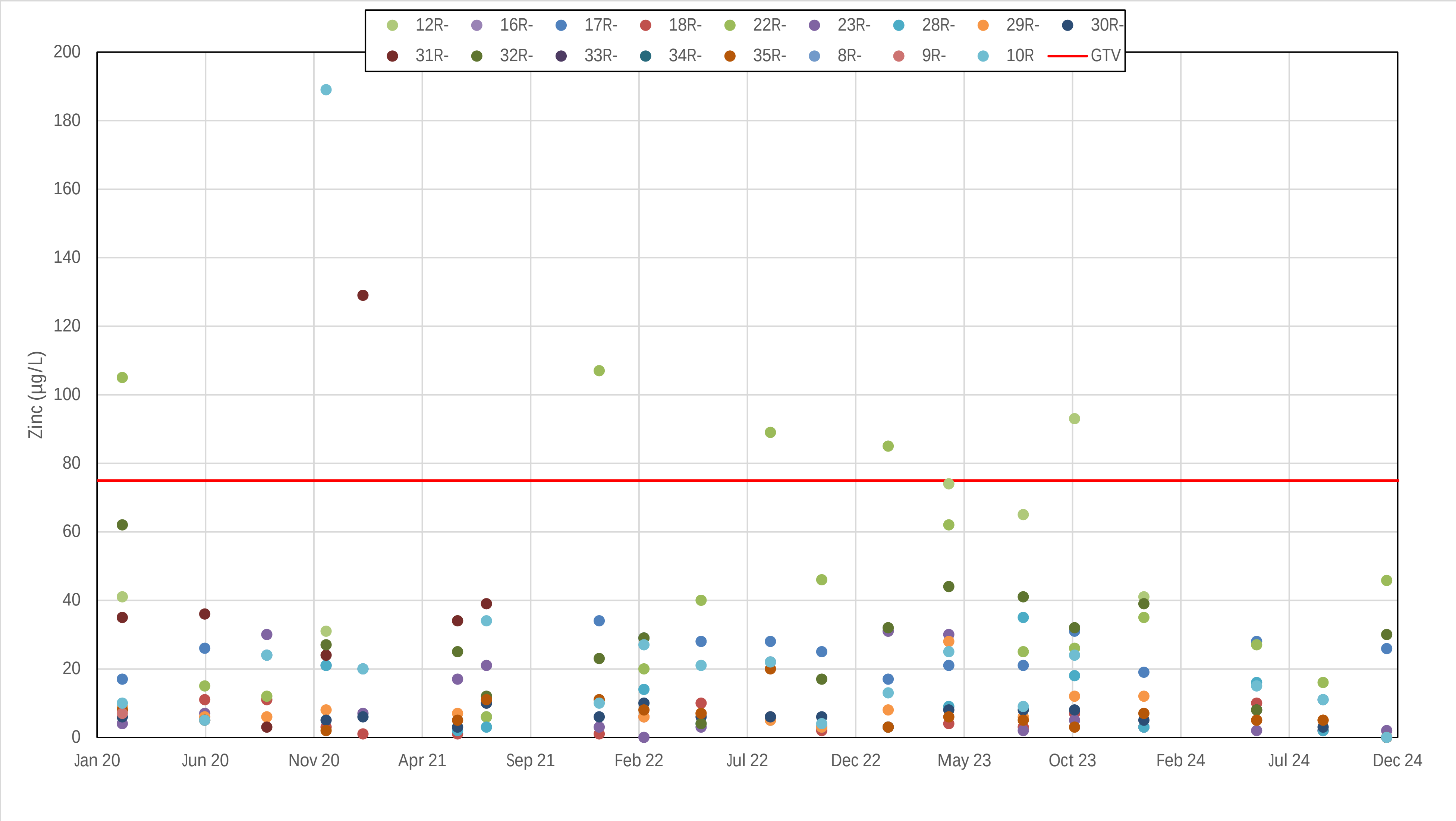
Site: Tara Mines

Appendix D.2 Zinc concentrations in overburden boreholes

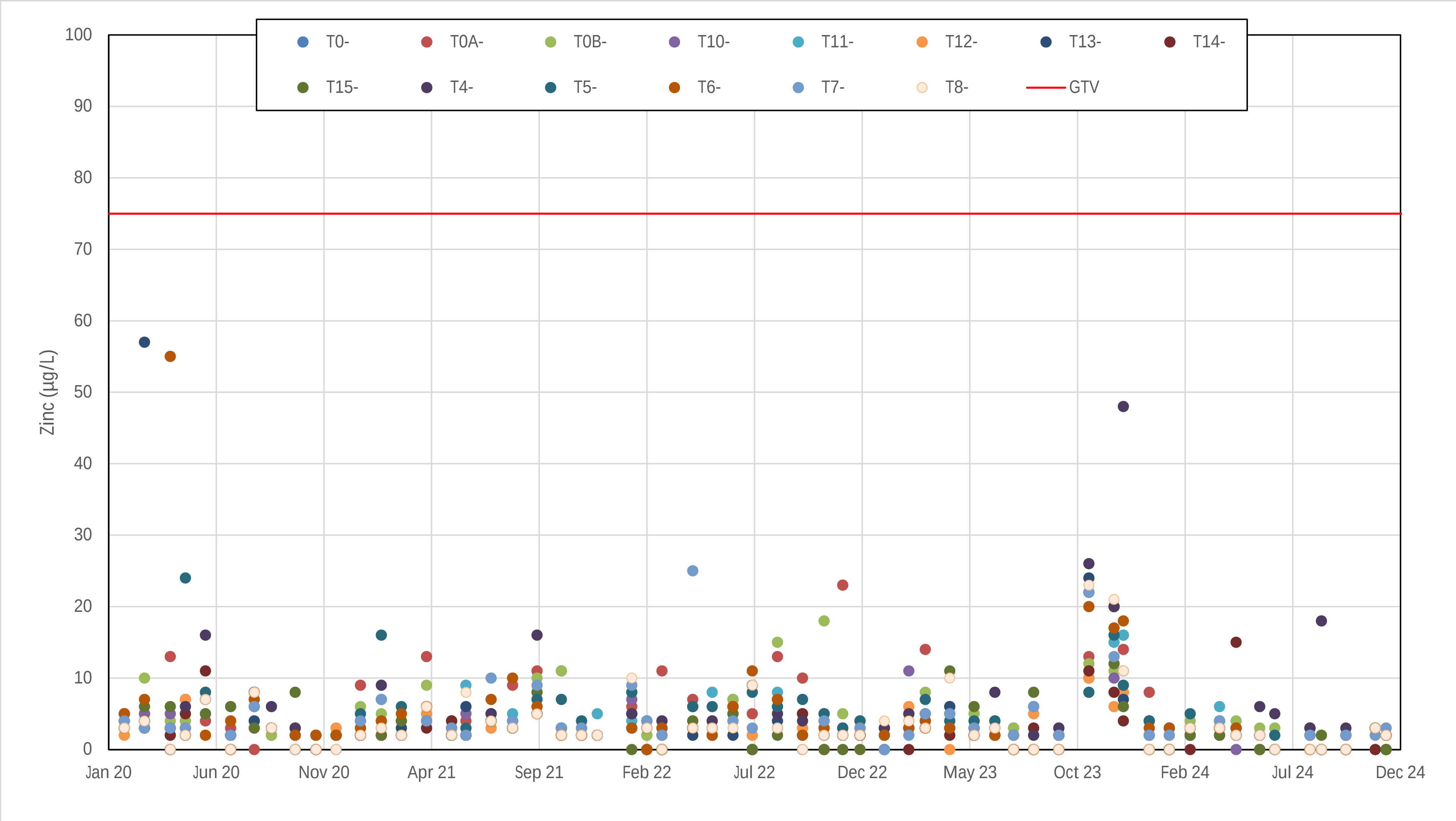


Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Appendix D.3 Zinc concentrations in bedrock boreholes

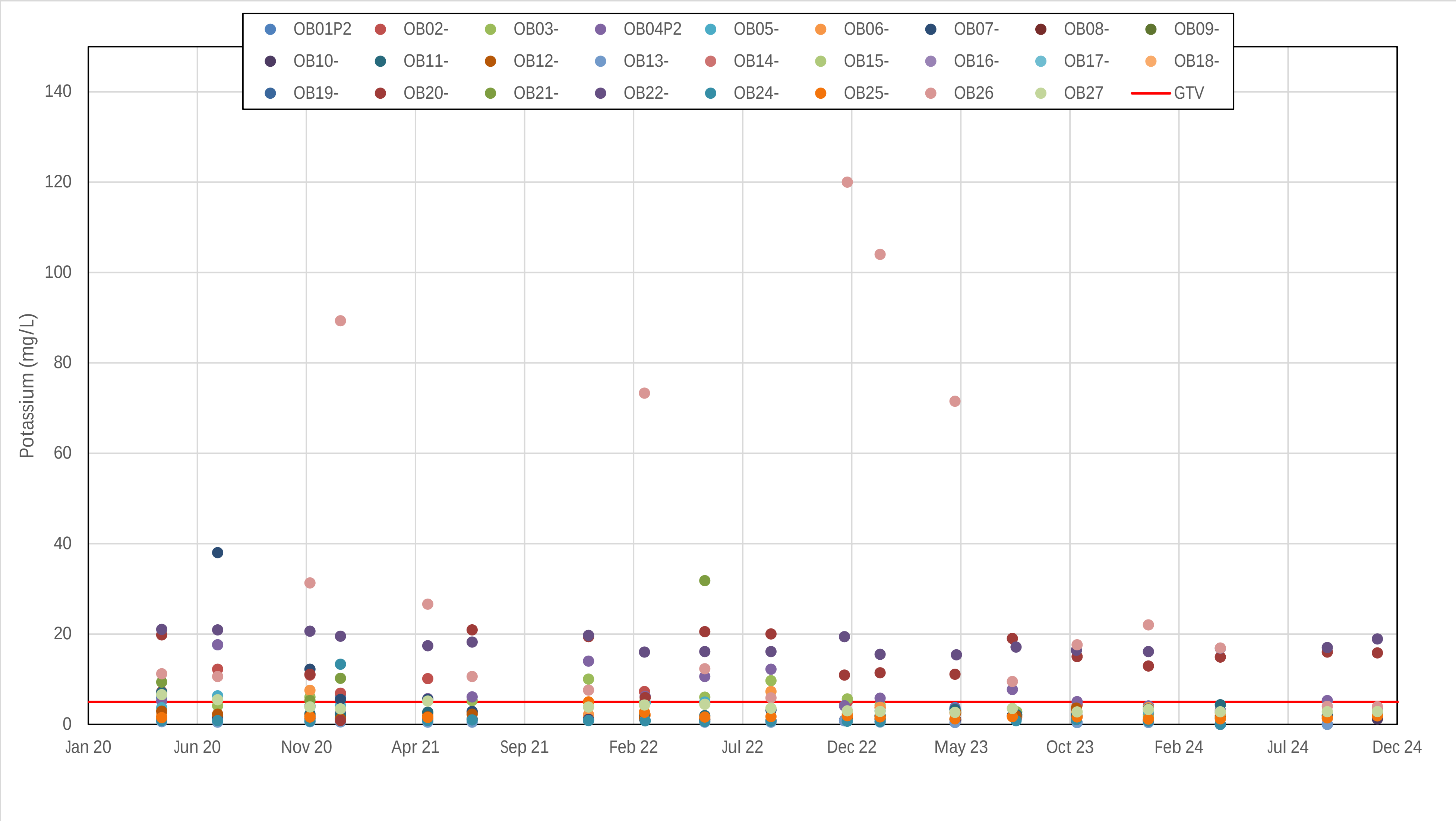


Client: Boliden_TaraMines_DAC **Site: Tara Mines** **Appendix D.4 Zinc concentrations in domestic wells**



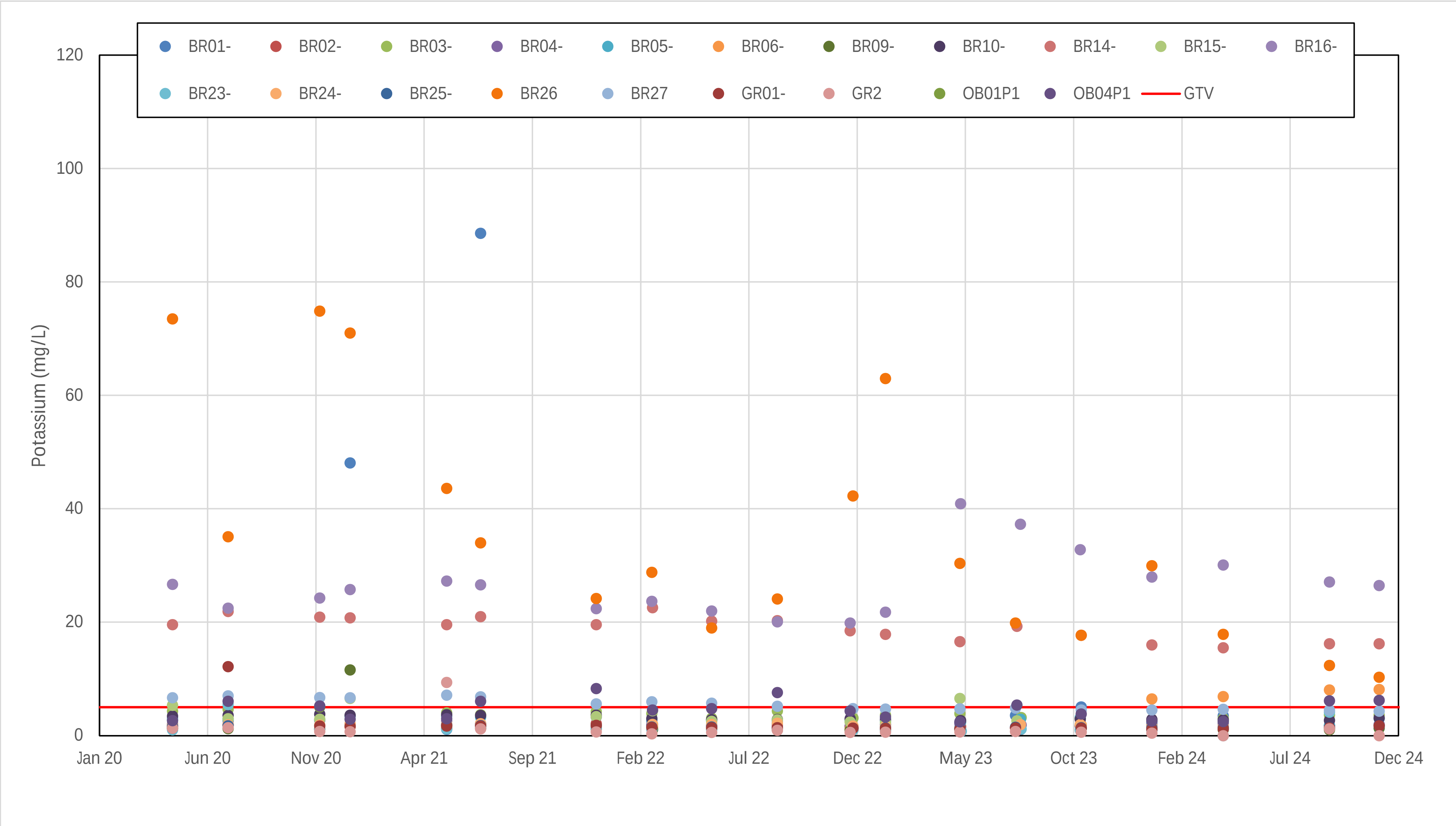
Client: Boliden_TaraMines_DAC **Site: Tara Mines** **Appendix D.5 Zinc concentrations in surface water**

Appendix E Potassium

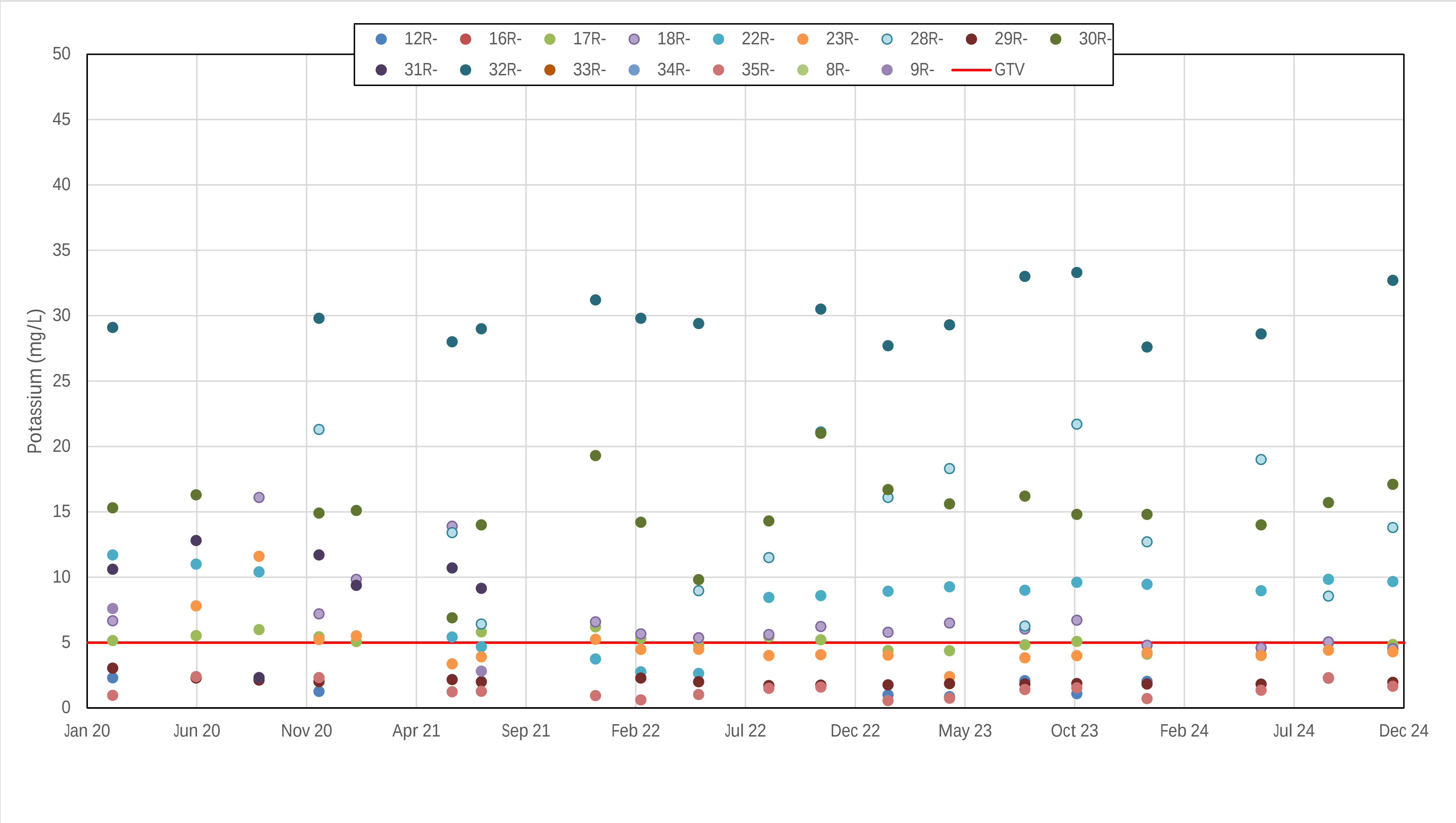


Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Appendix E.1 Potassium concentrations in overburden boreholes



Client: Boliden_TaraMines_DAC **Site: Tara Mines** **Appendix E.2 Potassium concentrations in bedrock boreholes**



Client: Boliden_TaraMines_DAC **Site: Tara Mines**

Appendix E.3 Potassium concentrations in domestic wells

aecom.com