Remediation Action Plan for Tailings Management Facility at Tara Mines

Boliden Tara Mines

Project number: 60628825

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1. Introduction

1.1 Overview

A Remediation Action Plan (RAP) is required to be put in place to address the groundwater contamination around the Tailings Management Facility (TMF) at Tara Mines, and to fulfil Condition 6.20.1 of IEL P519-04 (Ref. 1), as follows:

The licensee shall develop and implement to the satisfaction of the Agency a remediation action plan for groundwater contamination at the TMF. The licensee shall report annually on the progress of the remediation action plan as part of the AER.

This requirement follows on from the setting out of a remedial strategy including compliance points, trigger values and intervention values for the Chemicals of Potential Concern (COPCs) at the TMF, sulphate and magnesium, in AECOM's *Risk Screening and Technical Assessment* report (Ref. 2). It is understood that the RAP should review and develop this remedial strategy, and also provide other potential remedial actions that could be taken in the long-term. This is a live document and the remedial strategy, as well as the conceptual model, will be reviewed and updated on an annual basis.

1.2 Background

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 TMF, some 3 km north of the mine site. Since 2015, Stage 5A (east) of the TMF is being filled.

This report has been prepared to fulfil the requirement for a RAP at the TMF, and draws on the following reports, which provide background on the geology, hydrology and hydrogeology of the TMF site, along with geological maps and graphs of the spatial variation of sulphate concentrations:

- Knight Piésold, 1996. Randalstown Tailings Facility - Stage IV: Hydro-environmental Monitoring Report (Ref. 3);
- Tara Mines, 2009. Randalstown Tailings Management Facility Stage V Raise to Embankment Environmental Impact Statement (EIS) (Ref. 4);
- AECOM, 2016. TMF Stage 6 Extension – Hydrology & Hydrogeology Environmental Impact Assessment (Ref. 5);
- AECOM, 2019. Annual Hydro-environmental Monitoring Report (Ref. 6); and
- Schlumberger, 2015. Tara Mines: Assessment of Groundwater Conditions around the Tailing Management Facility (Ref. 7).

1.3 Objectives

The objectives of this report are to:

- Undertake a review of the 2015 remedial strategy for the TMF as outlined in AECOM's *Risk Screening and Technical Assessment* report (Ref. 2);
- Review, and redefine where appropriate, the compliance points, trigger values and intervention values;
- Define what actions are to be taken following an exceedance of the trigger and intervention values; and
- Identify any other appropriate measures to prevent deterioration, to limit pollution trends and to protect, enhance and/ or restore affected water bodies (both groundwater bodies and surface water bodies, where affected via groundwater pathways).

2. Conceptual model

The conceptual model for the TMF site is informed by geological logs for the monitoring boreholes onsite, by groundwater and surface water quality data, and by groundwater and interceptor channel level data. The conceptual model is outlined below and illustrated in Figure 1.

Sources:

- The chemicals of potential concern (COPCs) at the TMF site are sulphate and magnesium. The tailings water is known to be naturally high in sulphate, and to a lesser extent magnesium, and elevated concentrations of these chemicals have been recorded in groundwater in the immediate vicinity of the TMF and documented for many years.
- The source of elevated sulphate and magnesium is the current and historic seepage of tailings water from the TMF and the surrounding interceptor channel. The interceptor channel is likely to be an intermittent source, with seepage occurring when adjacent groundwater levels drop below the base of the channel.

Pathways:

- There is a pathway for seepage from the TMF and surrounding interceptor channel to enter shallow groundwater where the more permeable superficial deposits directly underlie or are adjacent to the TMF and the interceptor channel, and when the vertical or lateral hydraulic gradients allow.
- There is a pathway for seepage to enter the Yellow River and the River Blackwater as baseflow, moving laterally as shallow groundwater flow within the channels of alluvial deposits associated with the rivers, and to a lesser degree within the discontinuous lenses of sand and gravel immediately to the south of the TMF.
- There is a pathway for shallow groundwater to move vertically downwards entering bedrock, where the more permeable superficial deposits directly overlie permeable bedrock, when the vertical hydraulic gradients allow and where bedrock faulting is present.
- Within bedrock, there is a pathway for deep groundwater to move laterally via fractures and fissures in the direction of regional groundwater flow, i.e. to the south towards the River Blackwater, where it is used for potable water supply. The structural geology to the south of the TMF appears to have some control over the movement of sulphate-rich groundwater in the direction of flow.

Receptors:

- The receptors with the potential to be affected by seepage from the TMF are the locally important bedrock aquifer, protected for its current and future use, and the River Blackwater, protected for its designation as a Special Area of Conservation (SAC) and Special Protected Area (SPA).
- The locally important bedrock aquifer consists of the Meath, Liscarton and Old Red Sandstone formations, which underlie part of the TMF and the area to the south and west. These formations form part of the Athboy groundwater body, which was classified as being of Good Water Framework Directive (WFD) status in 2015 (Ref. 10). This groundwater body has been designated a drinking water supply body. There is one groundwater abstraction used for potable water supply from this aquifer located between the TMF and the River Blackwater, 10R installed in 2017. Sulphate concentrations at this location remain well below the Groundwater Threshold Value (GTV) of 187.5mg/l.
- The superficial deposits at the TMF are not classified as an aquifer.

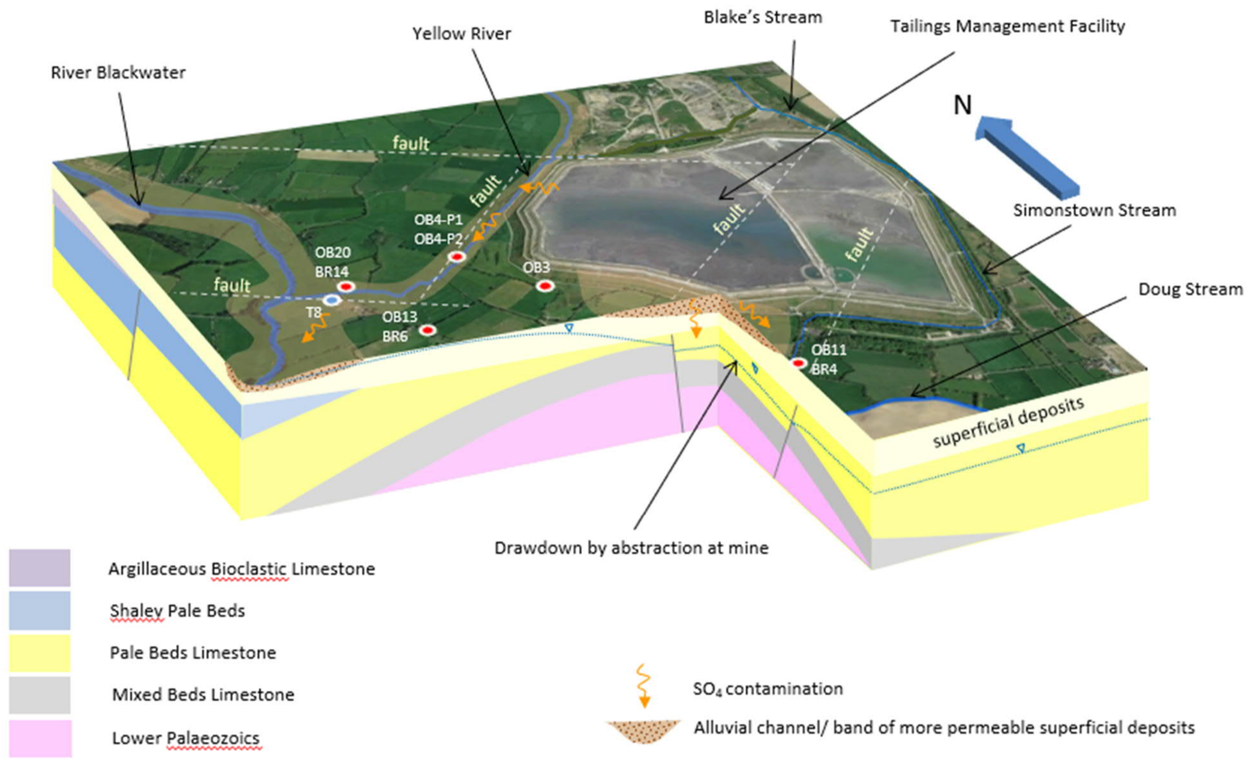

Figure 1: Conceptual model of TMF site

3. Monitored Natural Attenuation

3.1 Background

Following the screening of risk at the TMF undertaken as part of AECOM's *Risk Screening and Technical Assessment* (Ref. 2), it was concluded that the seepage from the TMF could be classified as a direct discharge (i.e. where and when groundwater levels fluctuate below water levels in the interceptor channel and seepage is in direct contact with the groundwater table) and represented a moderate risk activity warranting a Tier 2 assessment (Ref. 8).

This level of assessment required the prediction of an impact on groundwater quality, which was undertaken as part of the AECOM's *Risk Screening and Technical Assessment* report, for sulphate and magnesium. A programme of Monitored Natural Attenuation (MNA) was established, and groundwater compliance points and intervention/ trigger values were set, for the purpose of protecting groundwater and surface water receptors.

This is the preferred remedial option for the TMF, whilst it is in operation. This option is considered to be appropriate to the conditions at the TMF, and to meet industry performance criteria, as set out below in italics (Ref. 12), as a viable remedial option, for the following reasons:

- That the MNA *"will be effective in protecting receptors throughout the duration of the monitoring period (and beyond)":*
    - o The setting of receptor-specific intervention/ triggers values means that an increase in risk to these receptors will be apparent and that appropriate and immediate action can be taken (see below).
- That *"there will be no significant expansion of the "plume" into uncontaminated groundwater"*;
    - o The area in which average sulphate concentrations met the guideline value for sulphate is contoured on an annual basis (see AECOM's *Annual Environmental Monitoring Report for the TMF site at Tara Mines, 2019* (Ref. 7). This has shown no significant expansion over the last 5 years.
- That the existing *"monitoring network must be adequate to demonstrate that natural attenuation is occurring according to expectations"*:
    - o The existing monitoring network is backed by a robust conceptual model of the TMF which relies upon eleven years of water quality data, borehole logs and groundwater level data. The setting of compliance points where concentrations are highest is considered to best protect the receptors and to highlight any increase in risk (see below). It is expected that there will be no significant expansion of the "plume" into uncontaminated groundwater over time. This has been shown to be the case for at least the last 5 years.
- That the *"remedial objectives will be achieved within a reasonable time frame, which will typically be no more than one generation or 30 years, and will not be excessively long compared with other viable remedial options"*:
    - o The remedial objectives during operation are to ensure that the area of elevated sulphate in groundwater does not expand significantly and that sulphate concentrations remain below the GTV and drinking water standard in surface water. The remedial objectives following closure will be different and are outlined in the TMF closure plan (Ref. 9).

3.2 Compliance points

3.2.1 Groundwater

The bedrock aquifer that underlies the TMF site, including its current and future use, is the key groundwater receptor. The pathways for seepage inputs to potentially reach and move in deep groundwater are the downward movement of shallow groundwater, where the more permeable superficial deposits directly overlie permeable bedrock, when the vertical hydraulic gradients allow and where bedrock faulting is present; and the lateral movement of deep groundwater via fractures and fissures in the direction of regional groundwater flow.

No compliance point was previously set for the protection of the bedrock aquifer (Ref. 2). The reason for this was that there are no EPA monitoring boreholes located within 10km from the TMF, used to assess the groundwater body status, at which a compliance point could be set.

However, following a review of the water quality data and trends since 2015 (Ref. 6), this RAP proposes that a compliance point for the protection of the bedrock aquifer be set at BR14, for the following reasons:

- BR14 is capturing the highest concentrations of sulphate and magnesium leaving the TMF site in the direction of the River Blackwater;
- BR14 is located downgradient of the TMF and approximately 150m upstream of where the Yellow River enters the River Blackwater; and
- BR14 is located immediately adjacent to the Yellow River and within the alluvial, and possibly weathered rockhead, channel associated with this watercourse.

3.2.2 Surface water

The River Blackwater is the key surface water receptor at the TMF site. The pathways for seepage inputs to potentially reach the River Blackwater are surface water flow in the Yellow River, which receives seepages directly from the TMF, and as groundwater contributions or baseflow from the channel of alluvial deposits associated with the Yellow River, and to a lesser degree from the discontinuous lenses of sand and gravel immediately to the south of the TMF.

A compliance point was previously set at OB13, located approximately midway between the TMF and the River Blackwater, for the protection of the surface water (Ref. 2).

This RAP proposes that OB20 also be set as a compliance point for the protection of surface water, (as noted in AECOM's *Annual Environmental Monitoring Report for the TMF site at Tara Mines, 2019*) for the following reasons:

- OB20 is capturing the highest concentrations of sulphate and magnesium leaving the TMF site in the direction of the River Blackwater;
- OB20 is located downgradient of the TMF and approximately 150m upstream of where the Yellow River enters the River Blackwater; and
- OB20 is located immediately adjacent to the Yellow River and within the alluvial channel associated with this watercourse.

3.3 Intervention values

"Intervention" values are defined where the level of risk to water quality at the receptors is unacceptable, i.e. there is a non-compliance, and immediate action is required.

3.3.1 Sulphate

Groundwater:

- No intervention value for sulphate was previously set for the protection of the bedrock aquifer, for the same reasons as for the setting of a compliance point (Ref. 2).
- Following a review of the water quality data and trends since 2015 (Ref. 6), this RAP proposes that an intervention value of 2,000mg/l (set for the protection of surface water) be set for the protection of groundwater also [1]. This value has yet to be exceeded at any monitoring points to the south or southwest of the TMF and would indicate an increased risk to the bedrock aquifer.

Surface water:

- An intervention value for sulphate of 2,000mg/l <u>in groundwater</u> was previously set for the protection of the River Blackwater.
- Following a review of the water quality data and trends since 2015, this RAP proposes that this value is replaced by an intervention value of 250mg/l (the drinking water standard) <u>in surface water</u> be set at T8 in

[1] A review of the remedial targets methodology was undertaken for the purposes of setting an intervention/ trigger value for the protection of groundwater. However, due to the homogeneity of the subsurface and the discontinuous pattern of sulphate concentrations at distance from the TMF, the use of recognised statistical methods was deemed more appropriate in this instance. Using a method which relies on Reg (an estimate of value from simple linear regression parameters) + 2SE (standard error for the regression coefficient), an intervention value of 1,940mg/l was estimated. This correlates well with the intervention value set for the protection of surface water of 2,000mg/l.

the Yellow River, for the protection of the River Blackwater as a source of potable supplies, for the following reasons:

  - o Despite continued elevated sulphate concentrations in groundwater at OB20 and OB14, there have been no exceedances of the Groundwater Threshold Value (GTV) (187.5mg/l), Drinking Water Standard (250mg/l) at T8, the adjacent surface water monitoring point on the Yellow River.
  - o This indicates that there is significant assimilative capacity within the Yellow River which is more than sufficient to dilute sulphate concentrations in direct and indirect seepage inputs from the TMF to levels below the GTV, before it reaches the River Blackwater.
  - o This also suggests that the risk posed by seepage inputs to the River Blackwater is very low, and that the intervention value for sulphate in groundwater is not a useful value against which to assess the risk to surface water.

- Should the results of monitoring reach the value of 250mg/l at T8, this would be the point at which to take action, as it has yet to be exceeded at this location and would indicate an increased risk to the abstraction on the main channel of the River Blackwater.

3.3.2 Magnesium

Groundwater:

- No intervention value for magnesium was previously set for the protection of the bedrock aquifer, for the same reasons as for the setting of a compliance point (Ref. 2).
- Following a review of the water quality data and trends since 2015, this RAP proposes that an intervention value of 230mg/l be set for the protection of groundwater [2]. This value has yet to be exceeded at any monitoring points to the south or southwest of the TMF and would indicate an increased risk to the bedrock aquifer.

Surface water:

- An intervention value for magnesium of 100mg/l in groundwater was previously set for the protection of the River Blackwater. This value was set at twice the Interim Guideline Value (IGV) and was arbitrary.
- Following a review of the water quality data and trends since 2015, it is apparent that this value has been exceeded on numerous occasions since 2015 and therefore is no longer appropriate.
- The IGV for magnesium was set based on the historic Irish Drinking Water Regulations 1988 (S.I. no. 81 of 1988). No maximum admissible concentration (MAC) for magnesium has been included in subsequent iterations of Drinking Water Regulations, nor in the World Health Organisation (WHO) *Guidelines for Drinking-water Quality* (Ref. 11). Therefore, there is no sensible value at which to set an intervention value for magnesium in groundwater or in surface water for the protection of the River Blackwater.

3.4 Trigger values

"Trigger" values are defined where the level of risk to water quality is currently acceptable but may need to be monitored more closely due to rising trends and are designed to provide an alert of a potential future non-compliance at the compliance points and hence at the receptors.

3.4.1 Sulphate

Groundwater:

- No trigger value for sulphate was previously set for the protection of the bedrock aquifer, for the same reasons as provided above.
- Following a review of the water quality data and trends since 2015, this RAP proposes that an intervention value of 1,600mg/l be set for the protection of groundwater [3]. While this value has been exceeded at OB20 and BR14, it has not been exceeded elsewhere to the south and southwest of the TMF, i.e. in the direction of groundwater flow. The setting of a trigger value of 1,600mg/l for sulphate in groundwater is considered an appropriate point at which to review water quality trends.

[2] This value was estimated using the available water quality data and the recognised statistical method of Reg + 2SE.
[3] This value was estimated using the available water quality data and the recognised statistical method of Reg + 2SE.

Surface water:

- A trigger value for sulphate of 1,000mg/l in groundwater was previously set for the protection of the River Blackwater. This value was set at half the intervention value and was arbitrary.
- Following a review of the water quality data and trends since 2015, this RAP proposes that this value is replaced by an intervention value of 187.5mg/l (the GTV) in surface water be set at T8 in the Yellow River, for the protection of the River Blackwater as a source of potable supplies, for the following reasons:
    - Sulphate concentrations in groundwater at OB20 and OB14 have exceeded 1,000mg/l, but without any associated exceedances of the Groundwater Threshold Value (GTV), intervention value or trigger value at T8, the adjacent surface water monitoring point on the Yellow River.
    - This suggests that there is sufficient flow in this watercourse to dilute the sulphate concentrations in direct and indirect seepage inputs from the TMF to levels below the GTV, before it reaches the River Blackwater.
    - This also suggests that the risk posed by seepage inputs to the River Blackwater is very low, and that the trigger value for sulphate in groundwater is not a useful value against which to assess the risk to surface water.
- Should the results of monitoring reach the value of 187.5mg/l at T8, this would be the point at which to review water quality trends.

3.4.2 Magnesium

Groundwater:

- No trigger value for magnesium was previously set for the protection of the bedrock aquifer, for the same reasons as provide above.
- Following a review of the water quality data and trends since 2015, this RAP proposes that a trigger value of 185mg/l be set for the protection of groundwater [4]. This value has yet to be exceeded at any monitoring points to the south or southwest of the TMF and would indicate an increased risk to the bedrock aquifer.

Surface water:

- A trigger value for magnesium of 50mg/l in groundwater was previously set for the protection of the River Blackwater. This value was set at half the intervention value and was arbitrary.
- Following a review of the water quality data and trends since 2015, it is apparent that this value has been exceeded on numerous occasions since 2015 and therefore is no longer appropriate.
- The IGV for magnesium was set based on the historic Irish Drinking Water Regulations 1988 (S.I. no. 81 of 1988). No maximum admissible concentration (MAC) for magnesium has been included in subsequent iterations of Drinking Water Regulations, nor in the World Health Organisation (WHO) *Guidelines for Drinking-water Quality* (Ref. 11). Therefore, there is no sensible value at which to set a trigger value for magnesium in groundwater or in surface water for the protection of the River Blackwater.

3.5 Summary

The following table summarises the proposed compliance points, intervention values and trigger values.

Table 3-1 Proposed compliance points, intervention values and trigger values

Receptor	Compliance point/s	Intervention value	Trigger value
Groundwater	BR14	Sulphate: 2,000mg/l Magnesium: 230mg/l	Sulphate: 1,600mg/l Magnesium: 185mg/l
River Blackwater	OB13 OB20 T8	None set for groundwater Sulphate: 250mg/l at T8 Magnesium: none set	None set for groundwater Sulphate: 187.5mg/l at T8 Magnesium: none set

[4] This value was estimated using the available water quality data and the recognised statistical method of Reg + 2SE.

3.6 Actions if exceedances

3.6.1 Concentrations exceeding trigger value

The following actions should follow an event where measured concentrations exceed the trigger value:

- Investigate the circumstances under which the sample was obtained;
- Check the field water quality parameters to establish whether they too were outside the baseline conditions;
- Check with laboratory whether their methods were compromised or failed to meet standards with respect of time to undertake analysis, excessive turbidity in samples etc.;
- Repeat analysis of sample should sufficient sample remain, and this is appropriate for the determinands with exceedances;
- Schedule and undertake repeat sampling if repeat analysis of the existing sample is not possible. Schedule the analysis to be undertaken with a shorter turn-around time than the routine samples;
- Check with the field operative/s whether there have been any changes in the sampling methodology, site conditions and antecedent water levels at the monitoring location;
- If the results of repeat sampling or analysis lie within the expected baseline range, no further action is required;
- Otherwise:
  - Collate the information from the previous actions;
  - Review the statistical information for the COPC;
  - Consider whether, in the light of additional sampling that has been undertaken prior to the trigger exceedance, that the trigger value has been defined appropriately. Propose alternative trigger value for agreement with EPA; and
  - If the previous investigations have not established the cause of the exceedance is a “once-off” event, increase the monitoring frequency from monthly to fortnightly.

3.6.2 Concentrations exceeding intervention value

The following actions should follow an event where measured concentrations exceed the intervention value:

- Investigate the circumstances under which the sample was obtained;
- Check the field water quality parameters to establish whether they too were outside the baseline conditions;
- Check with laboratory whether their methods were compromised or failed to meet standards with respect of time to undertake analysis, excessive turbidity in samples etc.;
- Repeat analysis of sample should sufficient sample remain, and this is appropriate for the determinands with exceedances;
- Schedule and undertake repeat sampling if repeat analysis of the existing sample is not possible. Schedule the analysis to be undertaken with a shorter turn-around time than the routine samples;
- Check with the field operative/s whether there have been any changes in the sampling methodology, site conditions and antecedent water levels at the monitoring location;
- If the results of repeat sampling or analysis lie within the expected baseline range, no further action is required;
- Otherwise:
  - Collate the information from the previous actions;
  - Review the statistical information for the COPC;
  - Consider whether, in the light of additional sampling that has been undertaken prior to the intervention exceedance, that the intervention value has been defined appropriately. Propose alternative intervention concentration for agreement with EPA;

- If the previous investigations have not established the cause of the exceedance is a "once-off" event, increase the monitoring frequency to weekly. This should continue until the full circumstances of the occurrence have been reported and an agreed revision to the monitoring schedule is agreed between New Boliden and the EPA; and
- Additional actions and changes to activities may be proposed or instructed by the EPA.

4. Remediation alternatives

4.1 Introduction

The current programme of MNA is the preferred remedial option for the TMF, whilst it is in operation. However, one of the objectives of this RAP is to provide other potential remedial actions that could be taken in the long-term. These actions are outlined below and include ongoing maintenance of the interceptor channel, grouting of drill holes at the mine site, installation of an Integrated Constructed Wetland at the TMF site and installation of a grout curtain at the TMF site.

4.2 Maintenance of interceptor channel

4.2.1 Overview

The TMF 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.

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 TMF (tailings pond) from one pump with automated level controls, at the south of the interceptor channel/ dam. By returning tailings water back to the TMF, a closed water cycle system operates which helps to protect the local water environment.

However, the occurrence of elevated sulphate concentrations in groundwater in the immediate vicinity of the TMF suggests that there is a small amount of seepage occurring from the tailings into groundwater. The interceptor channel is likely to be an intermittent source, with seepage occurring when adjacent groundwater levels drop below the base of the interceptor channel.

Regular maintenance of the interceptor channel would help to keep the water levels low and closer to adjacent groundwater levels, thereby reducing the likelihood of seepage occurring. This should consist of:

- Keeping it clear of vegetation; and
- Dredging the build-up of silt.

4.2.2 Benefits

The benefits of maintaining the interceptor channel would be:

- Reduction in sulphate-rich seepage entering groundwater, and ultimately surface water;
- Ensure compliance with IE licence conditions; and
- Achieve the full effectiveness of the closed water cycle system.

4.3 Grouting/ plugging at mine site

4.3.1 Overview

In AECOM's *Risk Screening and Technical Assessment* report (Ref. 2), it was identified that the trend in sulphate and magnesium concentrations in groundwater surrounding the TMF is likely to be influenced by dewatering at the mine site to the south. Abstraction for dewatering has created a cone of depression and is likely to be accelerating the natural migration of sulphate-rich groundwater from the TMF in the direction of flow, i.e. to the south and southwest.

It was also identified that natural background sulphate concentrations in groundwater at the TMF are likely to be influenced by dewatering at the mine site. The lowering of the water table is likely to be increasing the natural processes of dissolution and oxidation of pyrite minerals that occur in the underlying Pale Beds, driving up natural background sulphate concentrations.

Abstraction for dewatering at the mine site increased between 2015 and 2018, due to an uncontrolled inflow of groundwater into the Nevinstown area of the mine. The increase in abstraction corresponds well with the apparent decline in groundwater levels in bedrock monitoring boreholes to the south of the TMF – most notably BR01, BR02 and BR04 (Figure 2 below). This inflow was plugged in 2018 and additionally, all exploration surface drill holes are now plugged from top to bottom.

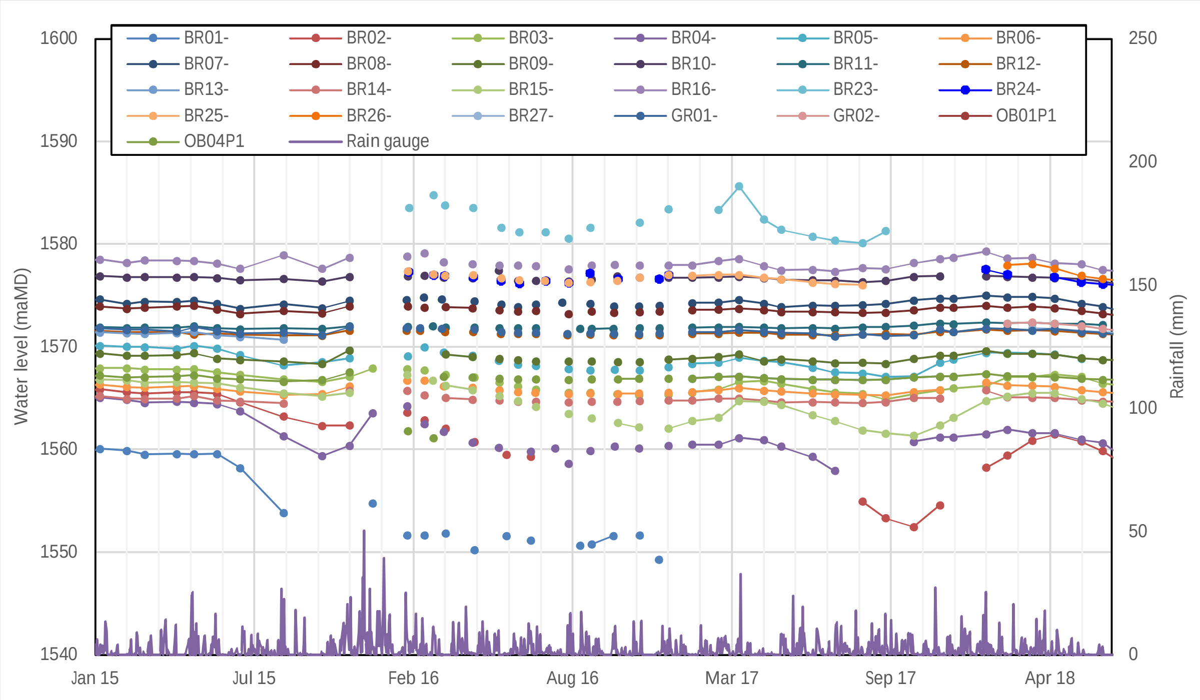

Figure 2: Groundwater levels in bedrock monitoring boreholes at the TMF site (Jan. 2015 to June 2019)

The impact of these actions on groundwater levels in the vicinity of the TMF site are apparent. The water table in bedrock monitoring boreholes to the south of the TMF site have risen by up to 10m, while the water table at the mine site has risen by about 60-70m. It is anticipated that the continued plugging of inflows and drill holes will slow the migration of sulphate-rich groundwater from the TMF site southwards and reduce the natural processes of dissolution and oxidation of pyrite minerals, and therefore natural background sulphate concentrations. Upon closure and the re-watering of the mine, this influence on groundwater levels will be significantly diminished.

4.3.2 Benefits

The benefits of continual plugging of drill holes and encountered flows would be to:

- Maintain the water table to avoid the accelerated migration of sulphate-rich groundwater from the TMF; and
- Ensure compliance with discharge licence/ permit conditions.

4.4 Integrated Constructed Wetland at TMF site

4.4.1 Overview

The use of Integrated Constructed Wetlands (ICWs) has been investigated for a range of water treatment options at Tara Mines, including post-closure treatment of runoff from the TMF. Indeed, the Closure Plan for the TMF involves the use of a spillway system connected to the interceptor channel, which would divert water to a wetland area. This would be for the purposes of water treatment prior to discharge into the River Blackwater, via a pipeline, downstream of the Liscartan water treatment works. There would be an overflow route to the Simonstown Stream at times of high flow when dilution is adequate for discharge without treatment.

ICW systems implement a free surface water flow approach, with dense helophyte vegetation, through a multi-cellular design which is made based on site-specific characteristics. ICW systems have shallow water depths (typically 100-250mm deep) and densely vegetated with appropriate native, emergent plant species to intercept and enhance the treatment of the through-flowing water (Ref. 9).

The primary vegetation types used in ICWs are emergent plant species (helophytes) that grow through and above the water column. They provide a support structure for the highly functional biofilms and microbe biodiversity within the wetlands functional zones. The majority of the vegetation is open to the atmosphere, which facilitates the interception of precipitation and conversely allows for massive water loss through evapotranspiration, both of which reduces water through-flow. They have specially adapted tissues that facilitate oxygen storage and its transportation from the leaves through the stem to the roots (Ref. 9).

The current design for the closure ICW consists of five ponds planted with a mixture of sedges, reeds, rushes and cattalls. The ponds would be constructed into low permeability material with any sand and gravel material encountered removed and replaced with glacial till. It is anticipated that the ICW will offer up to 80% removal of metals and around 70% removal of sulphate in the tailings water (Ref. 9).

The closure ICW system would not discharge to the River Blackwater until discharge parameters were met. Until such a time, the water would be recycled to the mine site for reuse or discharged to the River Boyne under the conditions of the current site licence.

A meso-scale experiment has already been undertaken at the TMF site, followed by a larger pilot-scale study, the results of which are proving favourable and in keeping with the removal rates anticipated by the Closure Plan for sulphates and metals.

4.4.2 Benefits

The benefits of installing an operational ICW at the TMF would be to:

- Reduction of sulphate and metal concentrations in discharge entering the River Blackwater;
- Ensure compliance with discharge licence/ permit conditions; and
- Achieve the full effectiveness of the closed water cycle system.

4.5 Grout curtain at TMF site

4.5.1 Overview

A grout curtain is a barrier that can protect the foundation of a dam from seepage and can be installed during dam construction or retrospectively. It usually consists of a row of vertically drilled overlapping holes filled with pressurized grout. Typical grouting materials include hydraulic cements, clays, bentonite, and silicates. The success of a grout curtain in protecting the local water environment will depend on the site suitability, geological setting and the conceptual site model. The impacts of installing a grout curtain at the base of the dam along the south of the TMF to limit seepage would need to be modelled and an assessment of site suitability undertaken.

4.5.2 Benefits

The benefits of installing a grout curtain at the TMF could be to:

- Control seepage from the TMF dam and limit the migration of sulphate-rich groundwater from the TMF; and
- Ensure compliance with discharge licence/ permit conditions.

5. Conclusions

The current programme of MNA is the preferred remedial option for the TMF, whilst it is in operation. This option is considered to be appropriate to manage the risks posed by the seepage of sulphate-rich tailings water at the TMF site into groundwater, and ultimately surface water in the short to medium-term. It is also considered to meet industry performance criteria as a viable remedial option.

The revised compliance points, and trigger and intervention values are also considered to provide the most appropriate points at which to review water quality trends and at which to take action, both spatially and temporally. An outline of what actions to be taken, should the intervention values be exceeded, are also provided.

A series of remediation alternatives have been outlined, including maintenance of the interceptor channel, grouting of drill holes at the mine site, installation of an ICW and installation of a grout curtain at the base of the TMF dam. A remedial options assessment should be being undertaken to provide further clarify on the most viable and achievable long-term options at the TMF site, in addition to those measures already outlined in the TMF Closure Plan (Ref. 9).

This is a live document and the remedial strategy, as well as the conceptual model of the TMF, will be reviewed and updated on an annual basis.

6. References

1. Industrial Emissions Licence (IEL) P519-04.
2. URS (incorporating AECOM), 2015. Risk Screening and Technical Assessment Report for Randalstown Tailings Management Facility at Tara Mines.
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