BOLIDEN TARA MINES DAC

Environmental Liabilities Risk Assessment

BTM Environmental Dept, 2020

NEW BOLIDEN

CONTENTS

Document History

Revision Number	Issue Date	Author	Reason For Revision
Rev 1	May 2002	Knight Piésold Limited	Original
Rev 2	November 2013	PM Group	Review after Licence update
Rev 3	August 2018	PM Group	Review after Licence update
Rev 4	April 2021	BTM/Golder	Review after agency consultation

1.0 Introduction

Boliden Tara Mines DAC. (BTM), Europe's largest zinc-lead mine located at Navan, Co. Meath. The facility consists of an aboveground ore processing facility on a footprint of approx. 70 hectares, an aboveground tailing management facility (approx. 280 hectares) and the underground mine.

The local surface water environment consists of the River Blackwater located a distance varying from approx. 180m and 400 to the north of the aboveground facility and the River Boyne, located approx. 1.4km to the east of the aboveground facility. The facility drains to the River Boyne.

The Navan ore body lies between 50 and 1,000 metres below the surface. The ore body rises to the surface to the northeast and dips in a southwest direction as it extends for approx. 6.5km. The mineable ore thickness ranges from 5 to 80 metres, with the thicker ore predominant in the eastern section. The ore body extends over an area of 6.5km by 1.5km, and the combination of a gently sloped ore body, together with a large geographical area, requires a mining method that utilises mobile equipment for ore haulage, rock drilling and explosives charging.

The underground operation consists of blasting/mucking using emulsion-based explosives, underground primary crushing in order to reduce the ore size to less than 150mm, transport of the ore to a storage bin and then the shaft skip loading pockets, hoisting of the ore to the surface, and backfilling of the voids left in the mine.

The aboveground operation consists of grinding, floatation, leaching (Zinc only), thickening and filtering in order to produce the final product – zinc and lead concentrates. These are transported by rail to Dublin Port for export.

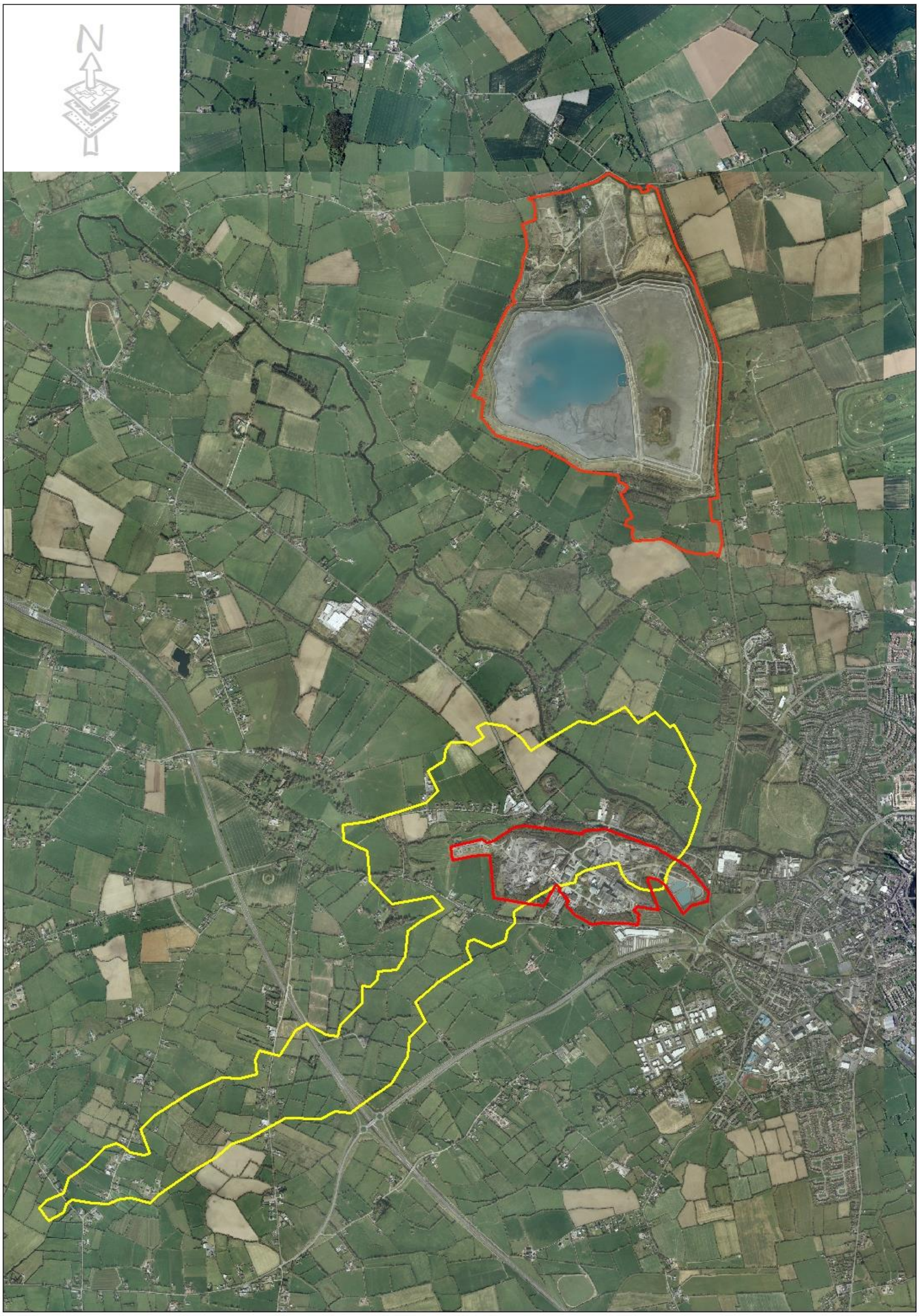


Figure 1.1 Location Map. [Licence Boundaries. Orebody Outline]

1.1 Environmental Liabilities Risk Assessment (ELRA)

BTM is obligated under condition 10 of its Industrial Emissions licence to undertake Environmental Liabilities Risk Assessment (ELRA) which addresses the liabilities from past and present activities. BTM is obliged to undertake periodic review of the ELRA to reflect any significant change on site, and in any case every three years following initial agreement

Mines in accordance with Condition 12.2.2 of the site's IE Licence (P0516-03), which states:
The licensee shall arrange for the completion, by an independent and appropriate qualified consultant, of a comprehensive and fully costed Environmental Liabilities Risk Assessment (ELRA).

The assessment shall include those liabilities and costs identified in Condition 10 for execution of the Plans for Mine Closure and Aftercare. A report on this assessment shall be submitted to the Agency for agreement.

ELRAs consider the risk of unplanned events occurring during the operation of a facility that could result in unknown liabilities.

The ELRA has been prepared in accordance with the EPA's 'Guidance on Assessing and Costing Environmental Liabilities, 2014'.

The known environmental liabilities for the site are calculated through the preparation and costing of the Closure and Restoration/Aftercare Plan.

2.1 Boliden Tara Mines

The approximate National Grid Reference of the Knockumber mine site is 284877E, 267985N and of the Randalstown Tailings Storage Facility (TSF) is 285160E, 271557N.

Orebody development at this mine commenced in 1973, with production beginning in 1977. Mining continues today at a rate of c.2.5 million tonnes of ore per year. Ore production encompasses the drilling, blasting and removal of the ore from underground deposits. Broken ore is primary crushed underground to less than 150 millimetres before being hoisted to the surface. Ore is then fed to an autogenous grinding mill which grinds the ore to a fine powder which is then pumped as aqueous slurry to metallurgic flotation cells. Within the flotation cells, galena (Lead sulphide) and sphalerite (Zinc sulphide) are differentially separated, while undesirable minerals such as pyrite are depressed. Differential flotation and selective depression of minerals are enhanced by chemical additives to the flotation circuit feed.

Once the target minerals have been extracted the tailings stream is cycloned to separate the coarse sand fraction from the finer slimes fraction. The coarse fraction of tailings is pumped, to the underground mined out areas. In so doing, approximately 50% of the tailings are used underground to backfill mined voids. The tailings used for backfilling is stabilised, chemically and physically, by mixing with cement. Since mining began in 1977 approximately half the waste tailings produced from processing the ore has been pumped as a mixed liquor (solids and water) to a Tailings Storage Facility (TSF) (also known in the industry as tailings dam, tailings pond). On an annual basis approximately 1.2 million tonnes of tailings are deposited for permanent storage in the TSF.

The TSF consisting of an impoundment contained by earth built embankment walls is located in the townland of Randalstown (Grid ref: E 285,100, N 271,545 Irish National Grid) approximately 2.5 km north of the town of Navan. The site is located in a topographically flat area at approximately 50m above mean sea level. The TSF is surrounded by a number of small tributaries of the river Blackwater which in turn is a tributary of the Boyne. The river Boyne catchment, which lies within Ireland's Eastern River Basin District (RBD), as designated under the European Water Framework Directive (WFD). The Eastern RBD incorporates the majority of County Meath and all or part of 11 other counties, covering approximately 6,300km2 and equal to a tenth of Ireland's land mass (Philips, 2005). The Boyne catchment area constitutes Hydrological Area 07 within the Eastern RBD and is made up of 95% agricultural land use, with the majority as pasture.

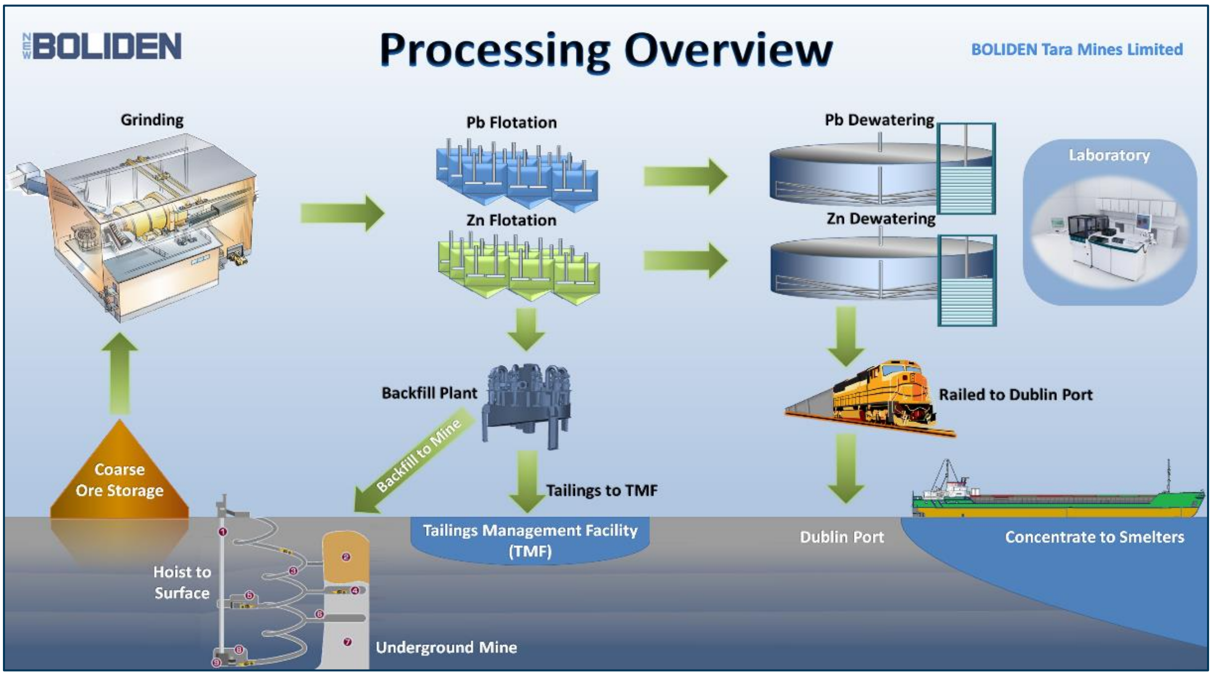


Figure 1.2 Process Overview

1.1.1 Description of the Environment of the Establishment

Population and Land Use

The BTM site comprises an area of 72 hectares and is entirely anthropogenic, owing to its industrial nature, and is continually undergoing disturbance and change. The topography of the BTM site is generally level and ground level is at an elevation of 50m OD (Malin Head). Refer to Figure 1.1 for the site layout and location.
The site is largely situated within a rural area although with the expansion of Navan town residential developments have extended out towards the mine.

The land uses surrounding the BTM mine site are as follows

- To the north are the Kells (R147) and Liscartan roads beyond which is largely agricultural land with some residential and light commercial properties. Further to the North (300m) is the River Blackwater.
- To the east is the redundant Navan-Kingscourt railway line and beyond the railway line is the town of Navan.
- To the south are the Knockumber Road L7418 (Townspark Road) and the Navan Retail Park. Running behind is the Athboy Road N51 which accesses the M3 motorway. The surrounding land is largely used for agriculture.
- West of the site is the Ladies Road, agricultural land and a small number of residential dwellings.

The land uses surrounding the BTM tailings facility site are primarrially used for agricultue

Sensitive Receptors

The following receptors are considered to be sensitive receptors in respect of a major accident occurring on the BTM site;

Table 1.1 Sensitive Receptors

Receptor	Comments
Human Presence	Residential dwellings and commercial properties within 1000m of the centre of the mine site are identified in figure 1.3 Residential dwellings within 1500 km of the Tailings Management Facility identified in figure 1.4
Protected Areas	There are two areas designated for nature conservation (SAC, SPA, NHA or pNHA) within 5 km of the Knockumber site. These are the River Boyne and River Blackwater Special Area of Conservation (SAC) and the River Boyne and River Blackwater Special Protection Area (SPA).

Receptor	Comments
Aquifer Category	The Geological Survey of Ireland (GSI) has classified the Calp Limestone formation beneath the site as a locally important (Lm) aquifer, as such it is classified as bedrock which is generally moderately productive.
Surface Water Bodies	The nearest surface water is the River Blackwater which flows into the River Boyne.

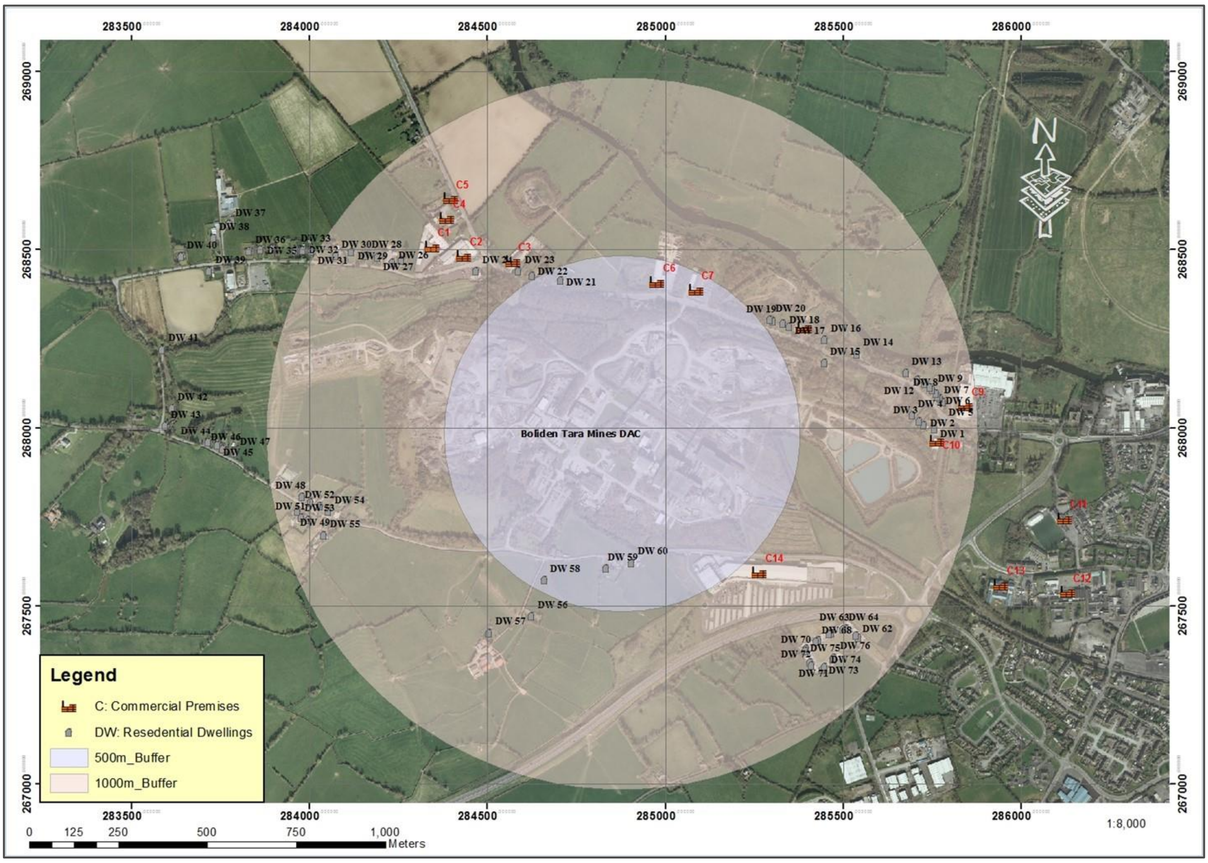


Figure 1.3 Mine site and surrounding sensitive receptors.

Figure 1.4 Tailings facility and surrounding sensitive receptors

Sensitive Environmental Areas Local to the Site

The River Boyne Estuary is located approximately 31km to the east of the site, which receives water from the River Boyne. No water bodies are located within the main site with the exception of the retention ponds, which are man-made structures.

The site lies in the catchment of the River Boyne, which is used for the abstraction of potable water for the greater Navan area. The closest water abstraction point downstream of the BTM site is approximately 20km at Staleen, County Louth. The River Blackwater (also used for the abstraction of potable water - abstraction point approx. 2 km upstream of the mine site), a tributary of the River Boyne, is situated approximately 300m to the north of the site and flows in an easterly direction towards the town of Navan where it joins the River Boyne.

River Boyne

The mine site and TSF are located within the Eastern River Basin District (ERBD) in Hydrometric Area No. 07, of the Irish River Network. Within the ERBD, the site is located within the River Boyne catchment area and the Blackwater North Water management unit. The 2nd cycle of the River Basin Management Plan (RBMP) is currently being prepared and in this all five River Basin Districts (RBDs) lying solely within the Republic will be merged to form one national RBD.

Within the RBMP and Programme of Measures, prepared in 2010, a minimum objective of achieving good status has been set for all water bodies, surface and groundwater, where the current status is less than good. In addition, an objective of no deterioration applies to all waters.

Following reassessment in 2009, the groundwater body designations in the vicinity of the BTM were revised[1]. The Navan Orebody groundwater body has been assimilated back into the Trim groundwater body, in which the BTM discharge emission points (SW1 and SW2) and associated surface water monitoring points are located.

BTM has two 'point source emissions' to surface water: Emission Point Reference **SW1** of a mixture of surface water, groundwater and treated process waste water to the River Boyne, and **SW2** of groundwater to the River Blackwater.

Discharge at SW1 includes treated waste water from the processing plant, drainage water from the mine and surface drainage water captured in the site water management system. The excess, treated waste water is discharged to the River Boyne at a flow dilution ratio of >100:1. Discharge is recorded and controlled from the Processing Department's automated control system.

Discharge at SW2 is clean groundwater, derived from the 'Nevinstown' mine area which has minimal or no contact with the orebody. This groundwater is collected in a dedicated reservoir and pumped directly to surface for discharge to the River Blackwater. Discharge is recorded and controlled from the Processing Department's automated control system.

In accordance with BTM's Industrial Emissions Licence (IEL) P0516-04, control and monitoring of process waste water emissions is carried as per Schedules C.2.1 and C.2.2 of the licence.

Surface water monitoring is carried out in accordance with Schedule C.8 of the IEL. River and stream samples are taken monthly at locations on the River Boyne, River Blackwater and its tributaries representing locations both upstream and downstream respectively of the BTM site and the discharge points SW1 (T0A and T0B) and SW2 (T11 and T4).

The EC Environmental Objectives (Surface Waters) (Amendment) Regulations 2012 Environmental Quality Standards (EQS) values are used as a guide for comparison with measured concentrations in surface waters.

Discharge emission points and surface water monitoring points are presented in Figure 1.5.

[1] Environmental Protection Agency, online mapping tool.

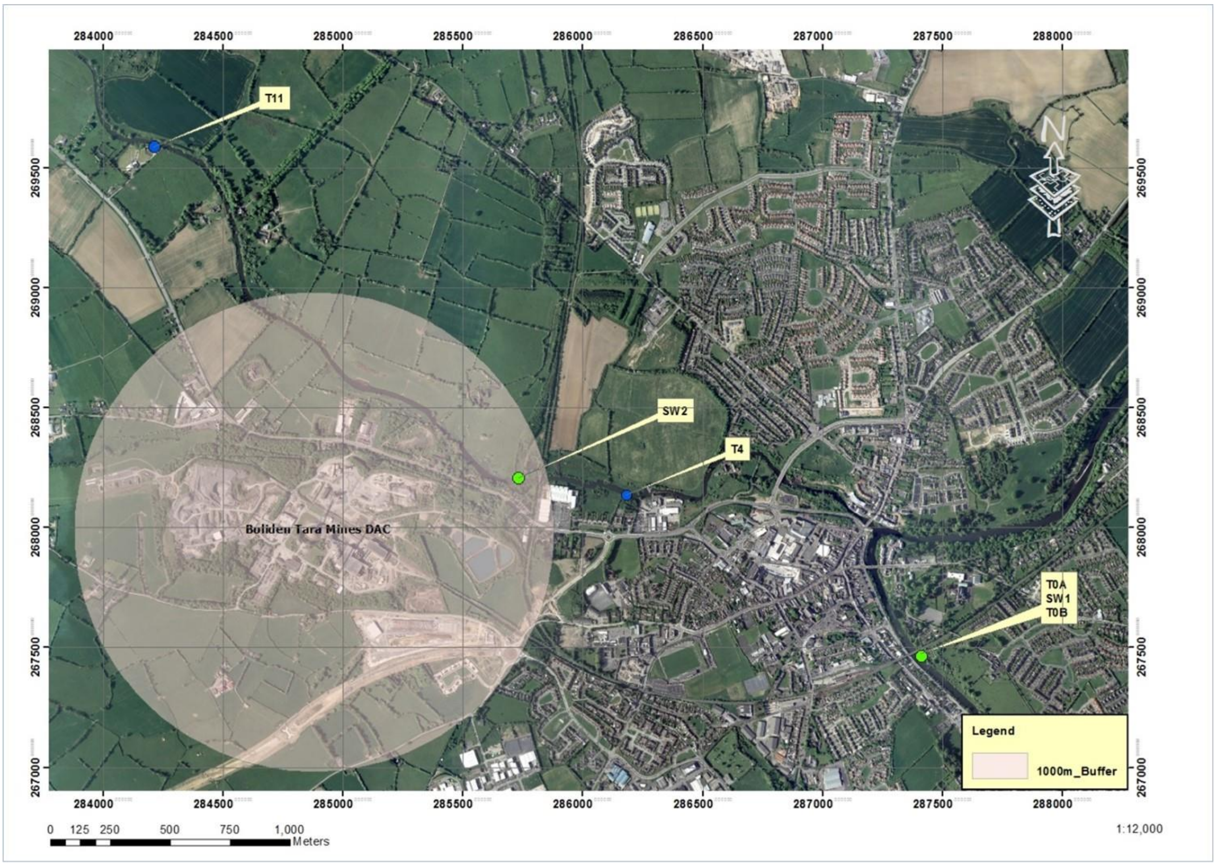


Figure 1.5 Surface water discharge emission points

The key objective for the River Blackwater is to restore this water body to good status. The key objective for the River Boyne and the Trim groundwater body is to protect these water bodies from deterioration.

Table 1.2 summarises the designations of surface water and groundwater bodies in the vicinity of the BTM site.

Table 1.2 Designated water bodies

Water body name	Designation	Overall status 2010 – 2015	Water Framework Directive (WFD) risk score
River Blackwater (from Nevinstown to confluence with the River Boyne)	Protected drinking water area	Moderate	At risk of not achieving good status by 2015
River Boyne (from upstream of T6 to the confluence with the River Blackwater)	River in Salmonid Regulations	Unassigned	
River Boyne (from the confluence with the River Blackwater to downstream of T5)	River in Salmonid regulations	Unassigned	
	River in nutrient sensitive area		

Surface Water Pathway from BTM site to the River Boyne

Surface runoff is collected by a system of drainage ditches which feed into the Main Site Drainage water pond, where suspended solids settle out prior to the water being pumped to the Reclaim water pond. Water from the reclaim pond is either pumped to the processing plant for reuse or is discharged to the River Boyne (refer to Section 1.2.3 for description of Water Management System).

River Boyne Water Quality

In accordance with the Water Framework Directive (WFD), each river catchment within the ERBD was assessed and a water management plan detailing the programme of measures put in place. Based on historical biotic data compiled by national statutory bodies, the recorded status of the River Boyne in the vicinity of the BTM site is “Moderate”.

The WFD recognised that, in some cases, it may not be possible to achieve all core objectives by 2015. For the River Boyne WMU Water Management Unit (“WMU”) the main pressure preventing achievement of Good Status is diffuse agricultural pollution. Full implementation of the measures is expected to correct this; however, it is estimated that the River Boyne in Navan will not achieve Good Status until 2021.

Table 1.3 shows the current status of the River Boyne and tributaries (Blackwater) in close proximity to the BTM site which are monitored as part of the WFD monitoring program.

Table 1.3 Status of the River Boyne and its tributaries

Water Body	Current WFD Status	Achieve Good Status by
Boyne	**Moderate**	**2021**
Blackwater	**Moderate**	**2021**

The EPA has been monitoring the water quality of the River Boyne and Blackwater for approximately 44 years. The results of the biological water quality monitoring at the EPA water quality monitoring locations local to the site is provided in Table 1.4 and the legends to explain the Biological Rating System are provided in Table 1.5.

Table 1.4 EPA Q Ratings (1988 – 2001)

Sampling Stations		River	Biological Quality Ratings (Q Values)												
EPA No.	Location		1973	1975	1977	1979	1981	1986	1990	1994	1997	2000	2003	2009	2012
RS07B011 790	Navan	Blackwater				-	-	-	-	-	-	3-4	3-4	3-4	3-4
RS07B041 800	Navan	Boyne				4	4-5	4	3-4	3-4	3-4	3-4	3-4	-	3-4
RS07B041 900	Navan	Boyne	4	4	3-4	3	3-4	4	2-3	3	2-3	3-4	3-4		3-4

Table 1.5 Biological Ratings System

Quality Ratings	Quality Class	Pollution Status	Condition
Q5, Q4-5, Q4	Class A	Unpolluted	Satisfactory
Q3-4	Class B	Slightly Polluted	Unsatisfactory
Q3, Q2-3	Class C	Moderately Polluted	Unsatisfactory
Q2, Q1-2, Q1	Class D	Seriously Polluted	Unsatisfactory

As can be seen from the monitoring data in Table 1.5 the River Boyne and River Blackwater have been classified between 'moderately polluted' and 'unpolluted' in the period 1973 to present.

The most recent Q classification data dating from 2012, classifies both water bodies as slightly polluted slightly, at the sampling stations in closest proximity to the site.

1.1.2 Geological and Hydrogeological setting

Mine site

Overburden in the landfill area is reported to comprise boulder clay (glacial till) and to vary in thickness from 6 meters in the north-eastern part of the landfill to greater than 10 meters in the North West. Onsite testing carried out by KT Cullen in 1998 indicate permeability of between 10-6 to 10-7 meters/second in the boulder clay. Borehole and trial pit investigations also completed by KT Cullen in 1998 within the landfill area reported a 3-4meter depth of waste.

The bedrock geology for the area as mapped by the Geological Survey of Ireland (GSI), is classified as being of a Lower Calp Limestone, which is described as basinal limestone. Historical site observations by KT Cullen (1998) indicate the presence of a dark grey limestone with some calcite and pyrite veining and inter bedded black shale. There are a number of north east trending faults mapped beneath the Tara site, one of which is reported to be located directly beneath the landfill.

Hydrogeology
Water levels previously recorded in the overburden indicate the presence of a shallow groundwater in the glacial till. Historical data suggests that the shallow groundwater discharges to the culverted stream underlying the landfill area. However, no further assessment of this has been carried out.
The principal bedrock aquifer beneath the site is mapped as a locally important aquifer within bedrock which is generally moderately productive. However, mine dewatering has lowered the water table in the underlying bedrock significantly. It is assumed that the bedrock groundwater flow regime is influenced by the mine water pumps. Mine water is discharged to the mine water pond, which discharges to the River Boyne.
Based on the subsoil thickness and permeability, the GSI has assigned a groundwater vulnerability rating of moderate for the groundwater beneath the site. The Water Framework Directive groundwater body risk score for the site is strongly expected to achieve good status. (EPA, Envision 2015)

Hydrology
The site lies in the catchment of the River Blackwater, a major tributary of the River Boyne, which is used for the abstraction of potable water. The River Blackwater is situated approximately 250m to the north of the site and flows in an easterly direction towards Navan Town where in joins the River Boyne. There are a number of smaller unnamed water course situated to the west of the site.
The River Blackwater is considered to have a Q rating of 2-4 which indicates moderate to poor water quality at the hydrometric station (station number 07037) in Navan town. There are no Q rating given for the adjacent to or up gradient of the site. The River Boyne is a designated salmonid River, but this classification is not extended to its tributaries. (gis.epa.ie/envision).

Tailings Storage Facility

The Tailings Storage Facility (TSF) is bounded by the Yellow River to the west, the Simonstown Stream to the east and the Blackwater River to the south. There are also two smaller streams, the Duog to the south east and Blake's stream to the north. These surface water courses are tributaries in the Boyne catchment, which lies within Ireland's Eastern River Basin District (ERBD), as designated under the European WFD. The ERBD incorporates the majority of County Meath and all or part of 12 other counties, covering approximately 6,300 km2 and equal to a tenth of Ireland's land mass.

The Boyne catchment area constitutes Hydrological Area 07 within the ERBD and is made up of 89% agricultural land use, with the majority as pasture. The rivers and streams surrounding the TMF at Randalstown have been classified overall as 'at risk' of pollution from various sources, along with most of the Boyne catchment.

The TMF extends over a total area of c. 2 km^2 making up around 10% of the Simonstown Stream catchment area and 2% of the Yellow River sub-catchment areas. The Yellow River flows southwards towards the Blackwater River draining an area of 38.1 km2 north and north-west of the dam. Blake's Stream, to the north of the dam, is a tributary of the Yellow River.
The Yellow River has an overall status as poor due to macroinvertebrate and ecological status. The general physic-chemical status of the river is good. The Yellow River is at risk due to diffuse sources and channelisation. The WFD objective for this river is to achieve a 'good status' by 2021.

The Simonstown stream, to the east, has a smaller catchment area of 9.7 km2 and used to flow beneath what is now the Stage 1 and 2 embankments. In 1977 the stream was diverted into a trapezoidal channel which runs parallel to the interceptor channel around the south eastern corner of the TMF. The Simonstown Stream returns to its original course near the TMF access road to the south before combining with the Duog and continuing westward toward the confluence with the Blackwater River.

The Blackwater River at Liscartan, downstream of inflow from the Yellow River and Randalstown stream, drains a total catchment area of 717 km2 and follows a meandering south easterly course towards the confluence with the River Boyne east of Navan. The Blackwater River in this area has a moderate status due to ecological and general physico-chemical status. The macroinvertebrate status is classed as good. This river is at risk due to channelisation. The WFD objective for this river is to restore the protected areas to a 'good status' by 2021.

Bedrock

The bedrock of the local area comprises Carboniferous strata incorporating the Pale Beds (Meath Formation) , Mixed Beds (Liscartan Formation) and Red Beds (Old Red Sandstone) underlain unconformably by the Lower Palaeozoic sequence (Rathkenny Formation). The TMF and the surrounding areas to the north and east are dominated by the Pale Beds and Lower Palaeozoic sequence. To the south and east the Shaley Pales (Moathill Formation) appear along with the Upper Dark Limestone (Ballysteen Formation).

The TMF is located in an area of major faults as shown on the bedrock geology map, mainly trending north-east to south-west. There is another fault that runs perpendicular to the major faults (north-west to south-east) and a smaller one in the north that trends east-west. Other bedrock in the area is made up of the Argillaceous Bioclastic Limestone to the east and some Mixed Beds in the south-east and south-west of the TMF.

Superficial Deposits

There are approximately 10 m of superficial deposits overlying the Bedrock however this thickness varies across the region. The superficial deposits are made up mainly of Boulder Clays and Boulder Silts (Glacial Till) to the north, east and south-east of the tailings pond. To the south and west of the TMF the superficial deposits constitute some Boulder Clays and Silts but also some poor to moderately well sorted sands and gravels. The thickness of these deposits can vary from 5 m to more than 10 m

Aquifer Properties

All groundwater bodies within Ireland have been mapped as part of WFD Implementation and classified as one of two overall types: bedrock or (unconfined) sands and gravels. Groundwater within County Meath is entirely hosted by bedrock, in keeping with most of the Eastern River Basin District (ERBD). The aquifer in the vicinity of Tara mines and the TMF is classified as 'poorly productive' (Phillips, 2005).

There are no superficial deposit aquifers defined at or within the immediate area of the TMF.
According to the Geological Survey of Ireland (GSI) online groundwater mapping tool, the Meath, Liscartan and Old Red Sandstone formations, which underlie part of the TMF and the area to the south and west, are classified as locally important aquifers, described as bedrock which is moderately

productive only in local zones. The Rathkenny Formation, which underlies part of the TMF and the area to the north, is classified as a poor aquifer, described as bedrock which is generally unproductive except for local zones.

The permeability of the Pale Beds can be highly variable, lying in the range 10-2 to 10-9 m/s, depending on the extent of fracturing. Areas of sands and gravels within the superficial deposits are also water-bearing and may constitute aquifers of local importance. The permeability of the superficial deposits is also variable ranging between 10-4 to 10-6 m/s in areas of sandy deposits and between 10-8 to 10-10 m/s in areas of clayey deposits (Knight Piésold, 1996).

Potential recharge is approximately 400 mm/year, but up to 50% of this may be rejected resulting in actual recharge being nearer to 200 mm/year or less where permeability is lower (Knight Piésold, 1996). GSI recharge zones published for this area describe moderate permeability subsoil overlain by poorly drained gley soil with an indicative recharge of 100 mm/year.

Groundwater flow

Groundwater flow is in a south-westerly direction towards the River Blackwater, with the smaller streams and ditches, such as the Yellow River and Simonstown Stream, exerting a local influence. Hydraulic gradients in the superficial deposits range from 0.001 to 0.01.

Groundwater dependent terrestrial ecosystems

A number of groundwater dependent terrestrial ecosystems have been identified within the Eastern River Basin District (ERBD), including the River Boyne and River Blackwater Special Area of Conservation (SAC). A small section of the River Blackwater at Boyne Island and Newtown Lough is classified as sensitive to changes in groundwater quantity and high sensitivity to changes in groundwater quality (Phillips, 2005). This SAC is located some distance upstream of the TMF and is not considered further in the hydrological assessment.

Groundwater Bodies

Groundwater bodies are the management unit for groundwater under the WFD. The TMF is located within the Navan Tailings groundwater body. This appears to be delineated on the basis of the likely area of influence of the TMF, bound to the west and southwest by the Yellow River and River Blackwater respectively, by the boundary of the TMF to the north and east and by geological boundaries to the southeast.

The adjoining groundwater bodies are the Athboy body to the west and the Wilkinstown body to the east. The proposed extension lies partially within the Navan Tailings, Wilkinstown and in a small area the Athboy (to the west) bodies. According to the groundwater body descriptions, groundwater flow in these bodies will be predominantly in the upper weathered zone, described as rapid throughflow, and some deeper flow along fractures and faults (ERBD,2010). Groundwater flow pathways in these bodies will tend to be relatively short, in general between 30 and 300 m, with groundwater discharging to streams and rivers across the aquifer.

Aquifer Classification & Vulnerability

The principal bedrock aquifer beneath the site is mapped as a locally important aquifer within the Lucan Formation which is generally moderately productive (refer to Figure 1.6). However, mine dewatering has lowered the water table in the underlying bedrock significantly. It has been determined that the bedrock groundwater flow regime is influenced by the mine water pumps.
Mine water is collected and pumped to surface into the mine water pond, from where it is either used in the processing plant or discharged to the River Boyne. Upon closure, once the working areas of the underground mine are flooded, the water in the upper weathered zone of the Upper Dark Limestone (UDL) is expected to recover to pre-mining conditions.

Based on the subsoil thickness and permeability, the GSI has assigned a groundwater vulnerability rating of 'moderate' for the groundwater beneath the site (Figure 1.7).

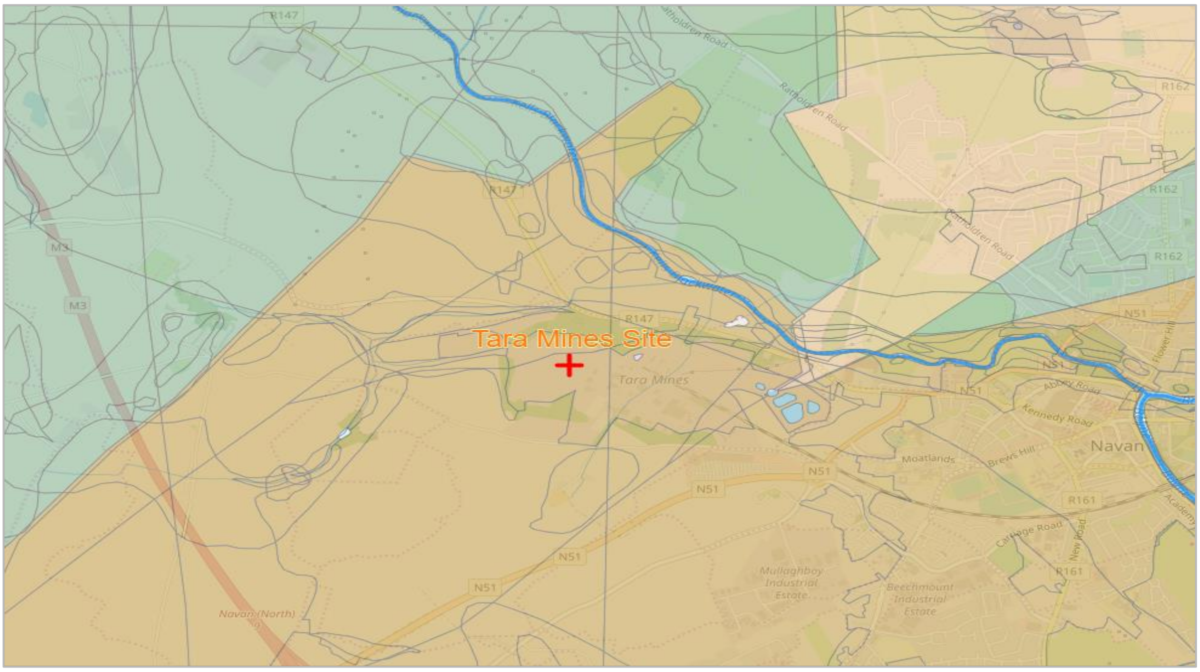


Figure 1.6 Aquifer map, showing locally important aquifer within the Lucan Formation (olive)

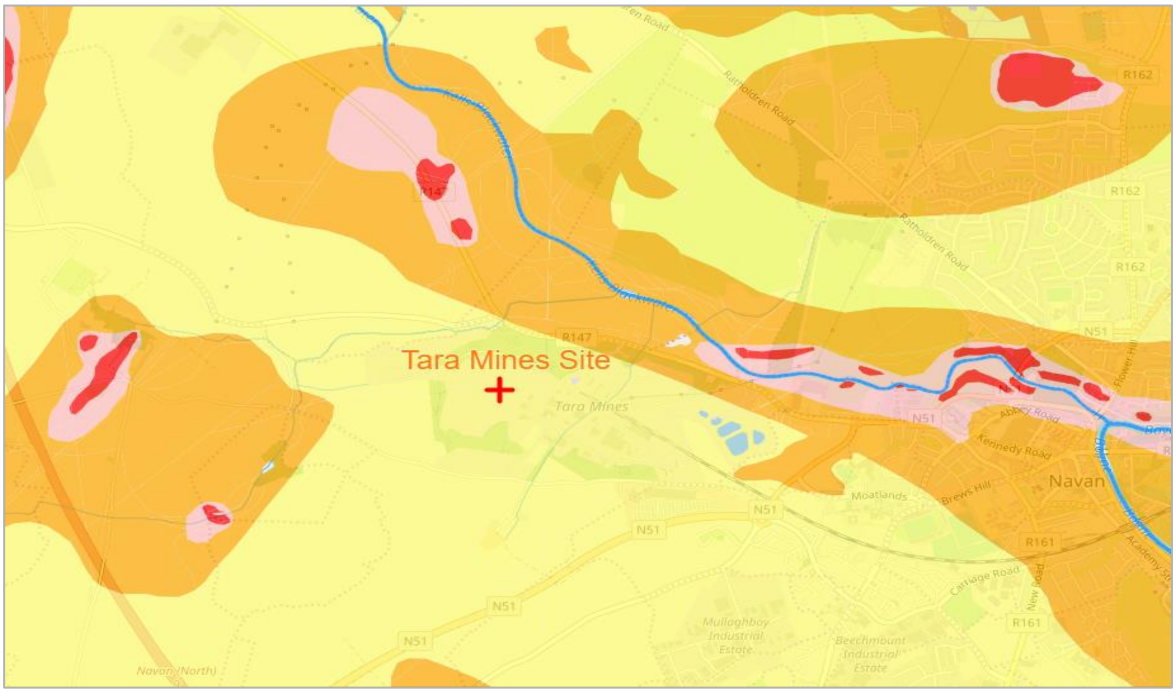


Figure 1.7 Vulnerability map, showing areas of moderate vulnerability (yellow)

Table 1.6 Designated sites of ecological importance within 5 km of the BTM site

National Parks & Wildlife Service (NPWS) Site Code	Designation	Site Name
IE0002299	SAC	River Boyne and River Blackwater
IE0004232	SPA	River Boyne and River Blackwater

The Geological Survey of Ireland (GSI) geological maps and records for the area were reviewed to determine the potential for the underlying site geology to initiate a major accident event.

Bedrock Geology

The bedrock geology for the area as mapped by the GSI is classified as being a locally important aquifer within the Lucan Formation which is generally moderately productive. There are a number of north east trending faults mapped beneath the BTM site and are illustrated on Figure 1.8.

Figure 1.8 GSI Bedrock Geology Mapping

Drift Geology/Landslides

Overburden is reported to comprise boulder clay (glacial till) and varies in thickness from 6 to 10 meters across the BTM site. The Teagasc soils map classifies the drift geology as the Elton Formation, defined as fine loamy drift with limestones.

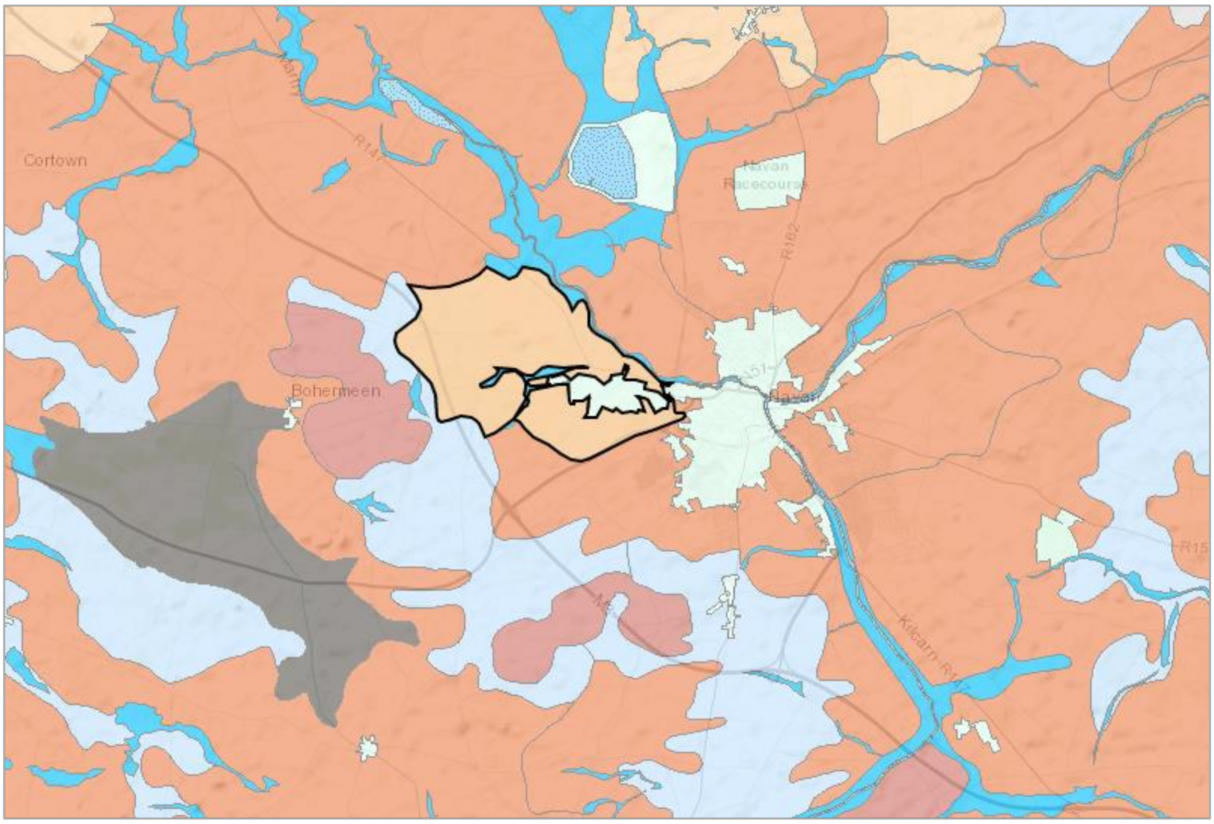


Figure 1.9 Teagasc Soils Map, showing BTM site location

It is generally accepted that brown earths are relatively mature, well-drained, mineral soils possessing a rather uniform profile that have not been extensively leached or degraded. Brown Earths possess medium soil texture and have good structure and drainage characteristics and are extensively cultivated. Hence, the risk of landslides or subsidence for the site is considered to be low.

The underground mine workings/conduits are progressively 'backfilled' as mine development works advance. Surface settlement is controlled and mitigated principally by two measures:

1. Retaining permanent (yielding) pillars of rock in strategic locations to provide direct support to the hanging wall (roof) rockmass; and
2. The use of backfill in each mined stope, which is placed as tight as possible against the stope roof to prevent potential for significant long term settlement.

Tara Mines have been monitoring surface settlement since mining commenced in the late 1970's.

Seismicity

Ireland is a seismically stable area and there is nothing to indicate this will change for the foreseeable future. However minor tremors are experienced from time to time.
The worst case major accident hazard scenarios for the site are assessed in the HAZID and Risk Assessment report in Chapter 3. It is not considered that the likelihood of such scenarios increases due to earthquake potential.

Flooding

The town of Navan is liable to flooding due to the presence of the River Boyne flowing through it as well as a number of large tributary inflows, including the River Blackwater which flow north of the BTM site. Flood prediction maps and reference to historical flooding events in Navan[2] indicate that some areas adjacent to the River Blackwater are prone to flooding however these areas are largely agricultural. Flood defence mechanisms in the centre of Navan have proven to be effective to prevent flooding in the town. The BTM site itself should not be directly affected by flooding; however roads could become impassable for trucks and thus reduce/prohibit access and egress from the site.

The Eastern CFRAM (Catchment Flood Risk Assessment and Management) study published in 2016 is currently the most up to date prediction tool for future flood events. The study has captured rivers such as the Boyne and calculated the worst case scenarios for a 0.1%, 1% and 10% annual exceedance probability (AEP) fluvial event. The data has been visually represented on a series of maps for each catchment phase, along with the predicted water levels at numerous points along each river course. Based on all available documentation the BTM site is safe from the effects of flooding and in its 41 year existence has never flooded and does not feature in any Flood Prediction Maps.

The Nevinstown River mostly culverted through the site and the River Glebe have the potential to flood however the scale of these is such that a flood event is not likely to have significant impact.
In conclusion, there has been no historical flooding of the site or any future predicted scenarios. There is potential for minor flooding within the vicinity of the site but there is no evidence of any potential for flooding to cause an onsite major accident scenario.

[2] Eastern CFRAM, 2016

1.1.3 Water Treatment / Effluent Discharge

There are three sources of water that are considered process water on site. These are as follows:

- Water ingress to the mine that is pumped out to maintain a suitable dry working environment
- Surface run-off
- Water from processing plant.

Water from these three sources is collected, pumped and treated prior to discharge to the River Boyne at Emission Point Reference SW1.
All water from the processing plant is pumped to the TSF. This water is recycled back to the reclaim pond on the BTM site after suspended solids have settled at the TSF. Minewater and surface run-off, representing a low risk waste water are treated in the onsite Water Treatment Plant.
The water treatment system comprises three stages of clarification in sediment-aeration ponds prior to discharge to the River Boyne.

At present, all minewater is pumped and collected at a central underground pumping station. The water enters a large settling sump where suspended solids settle out. The water is pumped to the surface via rising pipework infrastructure within the production shaft.

The pumped water is directed from underground outfalls to a minewater pond, acting as a primary settlement pond. Overflow from this minewater pond decants by controlled overflow to a secondary stage of settlement/clarification in the Reclaim Water Ponds. Water from the Reclaim Water Pond decants, via a controlled overflow, to a Clear Water Pond (Discharge pond).
The discharge from the Clear Water Pond to the River Boyne is via a weir structure, which measures and controls the discharge. The rate of discharge from the Clear Water Pond is dictated by the flow in the River Boyne, as a minimum dilution rate of >100:1 is required under licence conditions.
An automatic hydrometric gauging station has been installed on the River Boyne. This gauging station provides a real time record of water levels and flow in the River Boyne. Discharge from the site is controlled based on River Boyne flows.

Discharge at SW2 is clean groundwater, derived from the Nevinstown mine area which has minimal or no contact with the orebody. This groundwater is collected in a dedicated reservoir and pumped directly to surface for discharge to the River Blackwater. Discharge is recorded and controlled from the Processing Department's automated control system.

The site water system supplies the Processing and Mining operations and also manages the significant intake of water from the underground workings. The process water at BTM is re-circulated and re-used in the underground mining and surface milling processes. Potable water from the Navan town urban supply network is used for canteens and other utilities. Surface rainwater from the mine site and tailings dam facilities is also collected and becomes part of the overall BTM water system.
Because of the recirculation system, the BTM site accumulates an excess of water (> 600 m^3/h) which must be carefully managed. Retention of water is not possible over long periods as this may have an adverse effect on the operation of the TSF.

The excess water is discharged to the river Boyne under IEL conditions. The discharged water flow and quality is continuously monitored and controlled to satisfy the conditions specified in the licence.

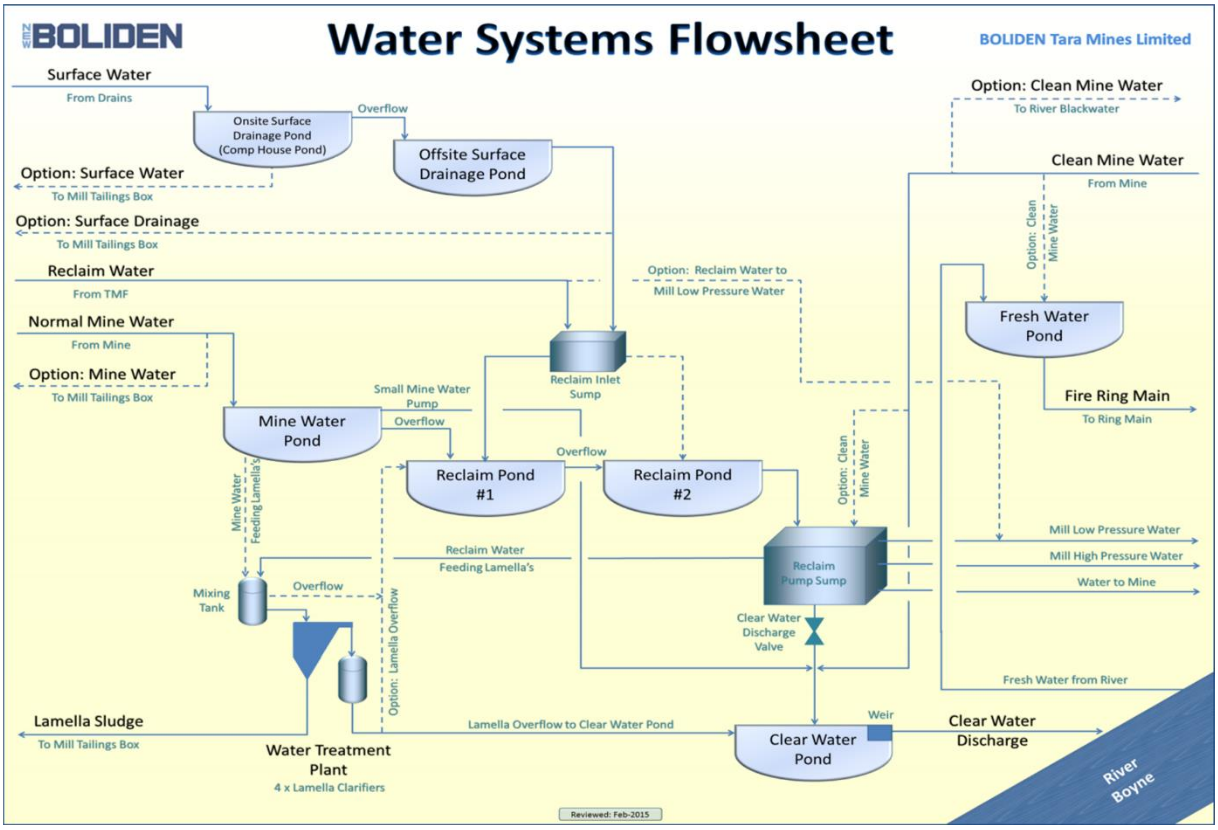


Figure 1.10 Water management system

1.1.4 Mining Operations

Development takes place in two phases: main development and exploration, in which sections of the orebody are outlined and made accessible for eventual mining and stope development. This involves the drilling, blasting, and recovery of the stope and pillar ore. Both forms of development are important sources of ore, contributing up to 400,000 tonnes annually to the total production target.

Mine development is planned to allow access to the orebody at varying levels and to prepare sections of the orebody for mining. Development drifts are driven at different dimensions depending on their intended purpose, for example a main haulage drift will have larger dimensions than a drift designed for ventilation purposes. It is necessary to have a significant amount of development in place before large-scale ore production commences. All development work is accessed from the existing mine and all ore resulting from development will be transported to the underground crushers / conveyor systems.

The predominant mining method is 'longhole open stoping' where ore thickness are sufficiently high (up to 12m), together with variations on room and pillar mining in areas of thinner ore (down to 4m). Cemented backfill is used for initial primary stoping and a mixture of cemented and un-cemented backfill for later (secondary) stoping. Longhole open stoping is sequential, that is, stopes are mined in sequence and each stope is filled before mining of adjacent stopes can commence. In room and pillar mining the roof stability is achieved through the design of stable rock pillars, provision of roof support where necessary and the use of regional (larger) pillars where the mining spans are large.

Hanging-wall drifts are driven some 40-50m above the orebody to facilitate exploratory diamond drilling, ventilation and backfill functions. Mine production is the generation of large tonnages of ore from stopes and pillars. All ore produced is transported by trucks and scoops to the primary crushers located underground.

Generally, stopes and pillars are laid out with their long axes parallel to strike. This has reduced the amount of footwall development in waste and facilitated stope access through haulage pillars that are essentially aligned down dip.

Stope and pillar dimensions have evolved over time from an initial 12.5m width for both, to the present less rigid dimensions. Widths for both are now determined on a case by case basis and are controlled by local features such as ore thickness, bedding planes, faults, joints, and adjacent openings. Heights are also variable and also depend on the thickness of the ore ranging from 10m to 80m. Average unit sizes are in the region of 25,000–30,000 tonnes per stope/pillar, giving rise to a total requirement of up to 80 stoping units per year in order to maintain the production figure of 2.6 million tonnes from stoping and pillar mining.

Blasting is carried out using emulsion based explosives where the broken ore is removed from the stope and taken to one of the crushing stations either by loader or truck depending on the distance of travel. The blasting/mucking sequence continues until the stope is completely mined out, after which it is subsequently filled with tailings sands, cement and/or development waste, the proportions of which are determined by location and adjacent mining plans.

Underground primary crushing results in the reduction of the ore size to less than 150mm, at rates of up to 800 tonnes per hour. Crushed ore is carried by conveyor to a storage bin of 3600t capacity located adjacent to the production shaft, where it is fed to the shaft skip loading pockets. The ore hoisting cycle is automatic, the control of the ore feeders, transfer conveyors and skip loading being regulated by the hoisting cycle and the weigh cells at each loading pocket. Ore is hoisted into two 15.5t capacity bottom dump skips running in balance, tipped into a small bin at the head-frame and then conveyed to a 35,000t surface storage building.

The purpose of backfilling is to fill mined out stopes underground, to maximise the amount of orebody mined and to maximise the storage capacity at the tailings storage facility.
Flotation tailings in the processing plant are pumped into primary and secondary cyclones. The overflow product from the cyclones consists of finer slimes which make up about 55% of the tailings produced. These slimes are pumped to the TSF. The underflow product from the cyclones consist coarser sands (45% of the tailings). It is these coarse sands that are used in the backfilling process.
The coarse sands collected from the underflow of the cyclones are mixed with cement in a sand to cement ratio of roughly 25:1 in a backfill mix tank. The backfill sands can be pumped underground via a continuous backfill pour where sands are pumped directly into the backfill mix tank where cement is added before being pumped underground via boreholes to the required mine area. If a continuous backfill pour is not feasible the sands can be stored in backfill sand tanks on surface and mixed with cement at a later date when backfilling is required. If the mine cannot take a backfill pour and the backfill storage tanks are full the mill can pump 100% of flotation tails to the TSF; approximately 1.2 million tonnes of tailings are pumped to the TSF per annum.

The voids left by the mining of stopes and pillars are filled with cycloned sand, which is produced in the concentrator from tailings and directed to the stopes through surface pipelines and boreholes that connect with the haulage levels. This operation is an essential part of the mining cycle, and close scheduling is required to meet production targets. The recovery of approximately 45% of the coarser mill tailings for backfill provides sufficient material to replace the ore mined from the stopes and pillars. Maximum fill recovery and utilisation also ensure efficient use of the available volume of the surface tailings management facility.

To facilitate the mining of pillars between the sand-filled stopes, the sand is given cohesion, by the addition of cement at dosage rates of between 3% and 9%, depending on planned exposures. Pillar voids are usually filled with un-cemented sand and/or waste rock. A blended cement consisting of 90%-95% ground granulated blast-furnace slag and 5%-10% normal Portland cement is used. Each stope filling operation is carefully planned to optimise future ore recovery from the pillars, and the economics of designed cement additions are continually analysed.

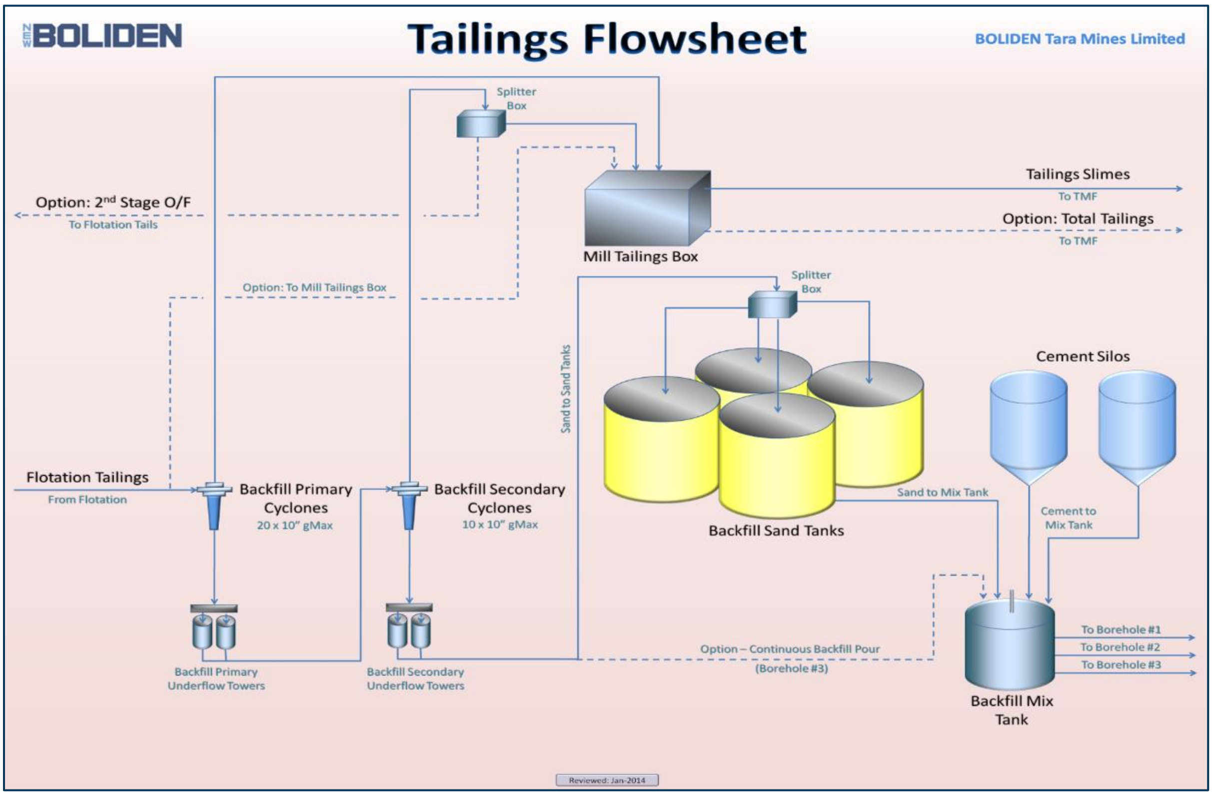


Figure 1.11 Backfilling Flow Diagram

The annual tonnage of waste rock mined in pursuit of ore is c.400,000 tonnes, most of which is recovered from remote parts of the mine in locations of future mining. Some waste rock is placed in stopes while some is brought to surface. The surplus waste stockpile has been classified as a reusable product by the EPA; subject to specific conditions (EPA Ref. P0516-01/ap12dh.doc). Much of the surplus rock is now used for backfilling and mine stabilisation purposes.

There are two separated concrete plants, also known as batching plants. Both plants combine various ingredients to form concrete products. Some of these inputs include sand, water, aggregate (rocks, gravel, etc.) and cement. There are no air emissions from the plants, all dust is collected in filters and returned to the mixer.

One plant is utilised for the production of large concrete blocks used for underground construction while the other plant produces shotcrete. The large concrete blocks are used to close off access to the stopes prior to filling with backfill.

Shotcrete is a concrete based mix which is sprayed through a hose at high velocity on to a rock surface for support. It can be impacted onto any type or shape of surface, including vertical or overhead areas. The quantity of shotcrete used has increased in recent years as the mine progress deeper into the south western sector of the orebody.

The positive impacts of the onsite production of concrete products include the reuse of surplus mine rock (when available) and the reduction in road traffic as previously all concrete had to be imported from offsite sources.

The efficient operation of the mine is critically dependent on a variety of mobile equipment designed specifically for the underground mining. Most of the scoops operate by remote control and are all equipped with noise insulated cabins for operator safety and comfort. The mobile fleet is powered by diesel engines.

The production and the development drilling fleet is all electro-hydraulically driven, incorporating the most up to date features, including the facility to programme the machines to drill while unattended. To assist the efficient running of the operation many service backup vehicles are used for shotcreting, loading explosives, pipe handling, bulkhead building, materials handling and other tasks. Mobile equipment includes 4x4 wheel drive vehicles, some of which are fitted with scissor lifts for general maintenance, while others are used for personnel transport.

The large lateral extent of the orebody, together with the variations in its thickness and depth, calls for a ventilation system that can be adapted to demand as the mining locations change. There are two primary reasons for mine ventilation:

- to provide oxygen rich air for underground operators and machines,
- to remove and dilute concentrations of noxious gases so as to render them harmless.

The extensive use of underground diesel equipment requires large volumes of fresh air to be passed through the mining access routes. Ventilation is by a 'pull' system whereby the fans are on the exhaust end of the system creating a negative flow.

The noxious gases to be removed are the emissions from the underground diesel equipment; these are carbon monoxide, carbon dioxide and nitrous oxides. In addition the gases generated as by-products of blasting are also removed and these are carbon monoxide, carbon dioxide, sulphur dioxide, ammonia and hydrogen sulphide. However blasting gases are all removed in the short period following blasting.

Exhaust gases are removed from the mine via Return Air Ventilation Raises (RARs). There are a total of seven return air raises currently in operation.

Water enters the mine in three ways:

- as natural ground water,
- as service water for the mining operations,
- as transport for the backfill.

The lowest pump station is fully automated, where variable speed slurry pumps operate to remove the dirty water. This water is pumped directly to the main pump station located in the shaft pillar where it is screened, clarified and pumped to the surface. The water entering the clarification system is screened to remove the >3mm material, and clarified with the use of a lamella thickener. An organic polymer is added to induce rapid settlement. A rake at the bottom directs the mud to the central discharge point where a mud pump lifts it to the mill tailings pump box on surface. Clean water overflow collects in two holding sumps, where clean water pumps then lift it 416m to the surface pond where it can be reused. The total pumping capacity of the mine is 21,600 m^3/d while the current total inflow to the mine is 13,000 m^3 / day.

1.1.5 Ore Processing

The ore is comprised of zinc and lead sulphide minerals, other minerals and limestone.

Typical composition of ore.

Ore Constituents	Percentage (%)
Lead	1.5 – 3.0
Zinc	7.0 – 9.0
Iron	2.0 – 5.0
Magnesium Oxide	6.4
Barium Oxide	4.4
Copper	0.004
Calcium Oxide	24.0
Silver	17 gm/dmt

The mineral particles must be physically liberated from the host rock in order to selectively recover the lead and zinc metal during the froth flotation stages. The minerals are tightly bound together within the ore and the separation is achieved in a number of processing stages. The process of reducing the ore particle size is known as Comminution.

The first stage is the crushing of the ore to minus 150mm in jaw crushers underground. After being hoisted to surface, this material passes to the coarse ore storage building from which it travels to the new *Autogenous grinding circuit*. The ore then passes to the autogenous grinding circuit and is mixed with water. The Autogenous grinding circuit reduces the ore particle size to less than 120 microns, a size range where the mineral particles and the host rock can be separated. Autogenous Mills use large particles of ore instead of steel balls for grinding media. The finely ground ore slurry is then pumped to the floatation stage of the process where the lead and zinc minerals are recovered respectively.

After grinding the finely ground ore slurry is then pumped to the flotation stage of the process where the lead and zinc minerals are separated from the host rock. The finely ground ore slurry is pumped from the grinding circuit to the flotation stage of the process.

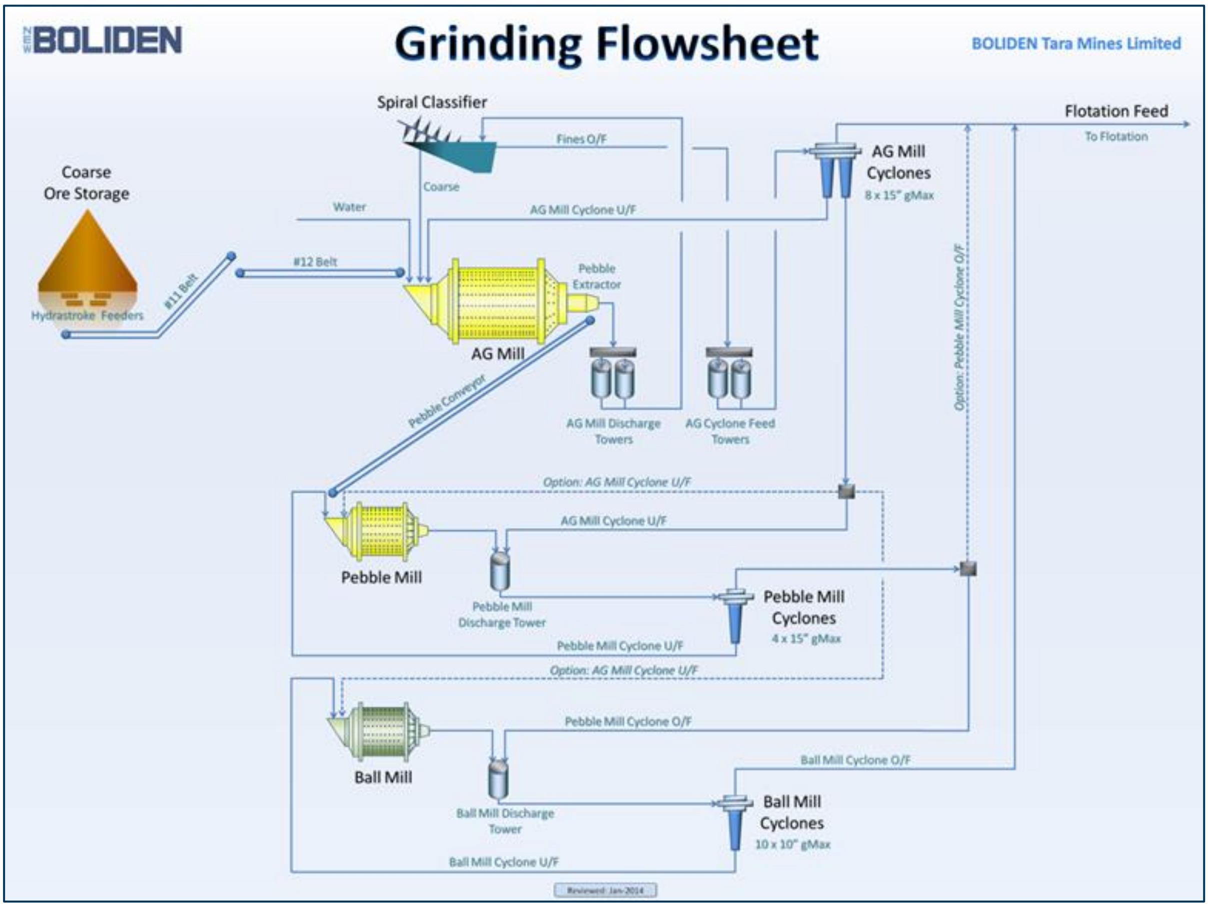


Figure 1.12 Grinding Flow Diagram

Target minerals are removed in the flotation process. The objective of the flotation circuit is to recover the maximum amount of lead and zinc minerals to produce a highly concentrated product of target quality, i.e. of target metal content.

The flotation process is divided into two distinct sequential stages. Lead minerals are recovered in the first stage followed by recovery of zinc minerals in the second stage.

Flotation is used to firstly extract the lead mineral particles to produce a lead concentrate. The tails from the lead flotation circuit is the feed to the zinc flotation circuit where the zinc minerals are floated to produce a zinc concentrate.

The flotation circuit consists of a series of tank-like cells in which there is a rotating agitator, which stirs the mixture of ground ore and water. Chemical reagents are added, one of which promotes frothing. Other agents alter the surface properties of the mineral particles and cause them to be attracted to bubbles generated by forcing air through the mixture by the agitators. These bubbles, coated with mineral particles, rise to the top of the mixture as a froth, and overflow the lips of the cells into collection troughs or launders.

Different combinations of reagents are used to selectively remove different minerals. Lead minerals are removed in the lead circuit and the remaining material is transferred to the zinc circuit for the removal of the zinc minerals.

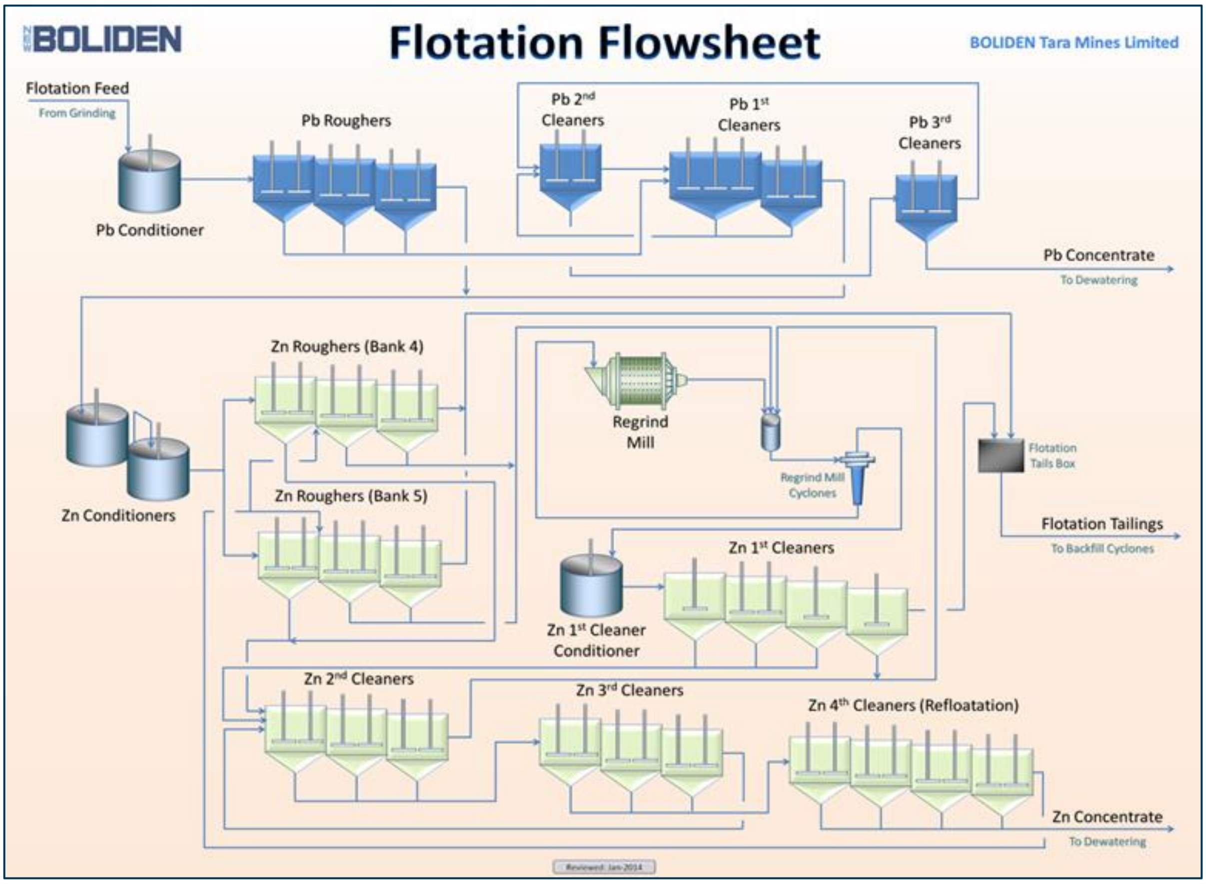


Figure 1.13 Floatation Flow Diagram

Following floatation, the resultant Pb and Zn concentrates have a very high water content and need to be dewatered. The concentrates are dewatered separately using thickening and filtration in *Metso* pressure filters.

Zinc concentrate is automatically distributed between a 15m high-rate thickener and / or the 29 m *Eimco* thickener. The High Rate thickener automatically regulates its feed valve to maintain a constant bed mass, and the balance of zinc concentrate production is automatically diverted to the conventional thickener. Flocculent addition to each thickener is automatically regulated and independently controlled. The overflow water is used in the grinding circuit.

Four independent monopump underflow systems, two per thickener, operate to supply a stock tank. From the Stock tank a centrifugal slurry pump fills each filter to the correct pressure. The two filters, each with an approximate capacity exceeding 40 tonnes per hour, dewater the total Zinc concentrate production to a final moisture content of < 8.5 %. Filtrate water is returned to a thickener, and the filter cakes are conveyed to the concentrate store.

The lead flotation concentrate is pumped to a thickener, the overflow of which returns to the grinding circuit. The thickener underflow system is fully automated and maintains a fixed level of controlled slurry density in a surge tank. The thickened lead concentrate is then pumped to two *Mesto* Pressure Filters which have a throughput total capacity of approximately 20 t/h with residual moisture of less than 6%. The pressure filter and conveyor system are fully automated.

Following dewatering the residual moisture content is less than 9% for zinc concentrate and for 6% lead concentrate. The final products produced at the mine are Zinc concentrate (56% Zn by weight) and Lead concentrate (65% Pb by weight). This material is conveyed to a 30,000 tonne capacity storage building, where it is loaded onto 55 tonne train wagons for rail transport to Dublin. From Dublin the concentrate is shipped to various smelters in Europe.

Concentrate is reclaimed from the storage pile by a front-end loader which feeds a conveyor system. Separate loading hoppers and conveyors are employed for the lead and zinc concentrates, but the shuttle conveyor is common to the two systems and incorporates a lid-lifter to handle the pressed-steel wagon covers. Each wagon stands on a rail-scale during loading, and the entire procedure is automated. Each train passes through an automated wagon washer before leaving the site prior to dispatch to Dublin Port. From time to time concentrate is transported by road to Drogheda using covered trucks, which are loaded inside the concentrate store and washed before leaving the site.

An on-site laboratory checks the quality of the ore and concentrates being produced. Annually the laboratory receives 25,000-30,000 samples on which quality control analyses are carried out.

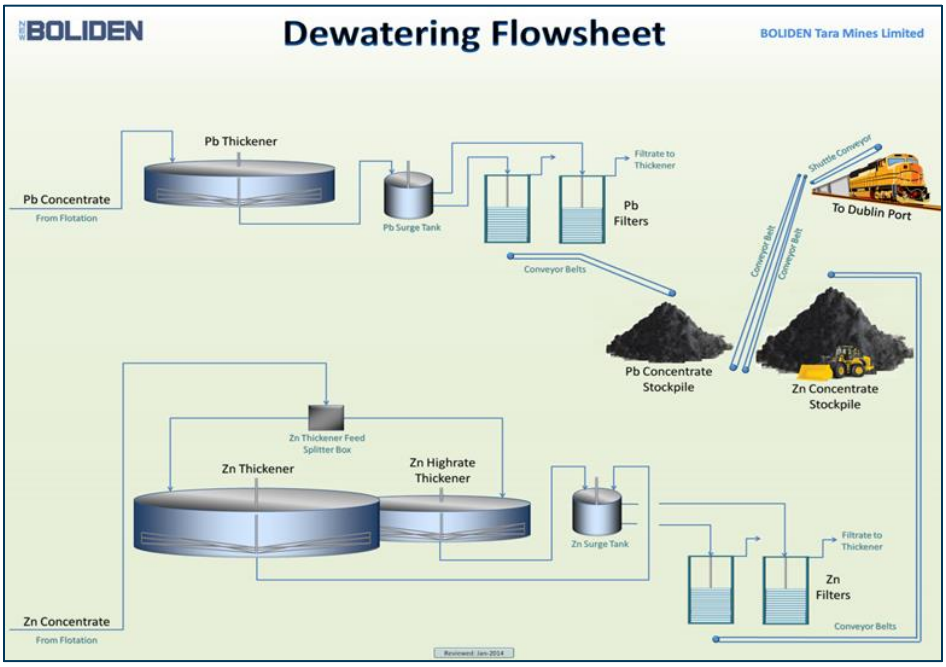


Figure 1.14 Dewatering Flow Diagram

3.1 Ongoing Assessment of Environmental Performance

The Company is certified to ISO 14001:2004 and is working towards certification for ISO 14001:2015. In order to assess the current on-going environmental performance of the organisation, ISO 14001 specifies the requirement to measure environmental performance periodically. This ensures that the company's environmental objectives and targets are being met and indicates areas where improvements can be made.

Furthermore, the organisation is subject to a number of audits, including external audits from the EPA, corporate audits and internal annual audits. This ensures standards are being complied with.

The Company is subject to the following principles and conditions:

Best Available Technologies (BAT):
BAT is a key principle in the Industrial Emissions Directive where emphasis is placed on pollution prevention techniques, including cleaner techniques and waste minimisation, rather than end-of-pipe treatment.

Waste Management:
The extraction and processing of minerals unavoidably generates significant amounts of waste. Tara operates and maintains well-developed waste management procedures. Compliance is undertaken in terms of waste management as outlined in the Companies IEL.

Environmental Management System (EMS):
The IEL and the associated EMS encourages improvement in the Company's environmental performance by setting a series of objectives and targets commonly associated with reducing the resource materials used (e.g. water, energy etc.) and waste products produced.

Environmental Management has always been at the core of operations at Tara since the development of the mine in 1973. Today Tara's Environmental Management System (EMS) ensures the company achieves best practice in all areas of environmental management and compliance and is accredited to ISO 14001:2004 EMS.

2.0 ELRA Methodology

2.1 Methodology

The methodology followed herein is that specified for ELRAs in the EPA's 'Guidance on Assessing and Costing Environmental Liabilities (2014)'.

It comprises the following elements:
- Scoping of ELRA
- Risk Assessment (Risk identification, risk analysis and risk evaluation)
- Risk Treatment
- Quantification (costing) of the environmental liabilities associated with the worst case scenario identified

The licence condition for the activity states that the ELRA should address the liabilities from past and present activities and that the assessment shall include those liabilities and costs identified in Condition 10 for execution of the Plans for Mine Closure and Aftercare.
In this regard, all aspects of the historic operation, the current site operation and the plans for the closure and aftercare of the mine that pose a plausible risk to the environment are covered in this ELRA.

The purpose of the ELRA is to identify and cost risks to the environment. It does not include health and safety type risks. In addition, the analysis and costing only covers the environmental aspects of an event, e.g. stopping it, clean-up of emissions/pollution caused, etc. It does not include other costs, which though associated, are non-environmental, e.g. legal fees/penalties and business interruption.

2.2 Risk Assessment

The EPA Guidance recommends that a risk management workshop is conducted with the relevant personnel and external experts as necessary to identify and quantify the risks inherent in the operation, closure, restoration and aftercare of the facility. The outputs of the workshop are:

- Identification of risks using risk identification tools and brainstorming exercises; and
- Risk classification tables.

Risk classification tables are required to evaluate and rank risks compared with each other. Risks are rated with respect to both likelihood of occurrence and severity in accordance with the classification tables provided below.

2.2.1 Risk Identification

For the purposes of the risk assessment, the facility was divided into 5 main areas or 'nodes' – the aboveground processing facility, other surface facilities, the underground mine, all water lines onsite, and the Tailings Management Facility (TMF). The ELRA that was previously prepared for the TMF has been incorporated into this revision of this ELRA. Consideration was given to environmental risks in these areas before and during decommissioning.

Risks were identified from the combination of the site processes and the general environmental type risks. These risks are detailed in the full Risk Register presented in Appendix I.

Those risks which scored ≥ 10 in the assessment are provided in Table 2.5 to give a summary of the higher scoring risks. Each risk was considered for relevance, potential hazards, environmental effects, potential severity and likelihood of occurrence. For each potential hazard to be considered appropriate for inclusion in the risk assessment table, it must have an effect on an environmental receptor, via one or a combination of the following:

1. Air Quality
2. Surface Water
3. Groundwater
4. Land Contamination

It should be noted that Human Beings were not considered as a stand-alone environmental receptor. This was due to the fact that any potential environmental risks to human beings would occur via air, water and/or land and therefore would be considered under the risks to each of the above environmental receptors. Direct risks to onsite personnel were also not considered as part of this environmental assessment as these are fully covered under the site's Health and Safety risk assessments and procedures.

2.2.2 Risk Analysis

The risk classification tables used for ranking the identified environmental risks at the Tara Mines site are provided in Tables 2.1 and 2.2 below, and are based on the EPA Guidance

Note.
The basis for the likelihood of occurrence and the costs of remediation as outlined in Tables 2.1 and 2.2 respectively, were agreed during the risk management workshop. The likelihood of occurrence description was discussed, and the consensus was reached within the workshop group as to the frequency with which each category is likely to occur.

Similarly, the risk severity description was discussed and the consensus was reached within the workshop group as to the monetary value that should be currently associated with remediation of the level of risk described. It is noted that these costs may change in line with future inflationary/deflationary changes and will therefore require review.

Table 2.1 Risk Classification Table – Likelihood of Occurrence

Rating	Likelihood	
	Category	Description
1	Very Low	Very Low Chance of occurrence
2	Low	Low Chance of occurrence
3	Medium	Medium Chance of occurrence
4	High	High Chance of occurrence
5	Very High	Very high Chance of occurrence

Table 2.2 Risk Classification Table – Consequence

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

2.2.3 Risk Evaluation

Each risk is allocated an initial risk score based by multiplying the occurrence score by the severity score. The risk scores are then displayed on a risk matrix which provides a visual tool for regular risk reviews since the success of mitigation can be easily identified.

This is displayed using colour coding to provide a broad indication of the critical nature of each risk as follows:

- **Red:** These are considered to be high-level risks requiring priority attention. These risks have the potential to be catastrophic and as such should be addressed quickly.
- **Amber:** These are medium-level risks that require action, but are not as critical as a red-coded risk.
- **Green:** These are lowest-level risks and indicate a need for continuing awareness and monitoring on a regular basis. Whilst they are currently low or minor risks, some have the potential to increase to medium or even high-level risks and must therefore be regularly monitored and if cost-effective practicable mitigation can be carried out to reduce the risk even further, this should be considered.

Table 2.3 Risk Matrix

Likelihood of Occurrence	Very High	5	5	10	15	20	25
	High	4	4	8	12	16	20
	Medium	3	3	6	9	12	15
	Low	2	2	4	6	8	10
	Very Low	1	1	2	3	4	5
			1	2	3	4	5
			Trivial	Minor	Moderate	Major	Massive
			Severity of Potential Hazard				

2.2.4 Assessment of Risks Prevention/Mitigation Measures

The current Risk Management Programme at the site (i.e. the current relevant operational controls, including monitoring, maintenance and procedures) is summarised in the 'Basis of Severity (including current controls)' and 'Basis of Likelihood (including current controls)' columns in the Risk Assessment worksheets in Appendix I.

All other risks identified, in particular any amber rated risks, will be continually monitored and managed as per the existing mitigation measures outlined in Appendix I, to minimise the potential of the risks occurring.

2.3 ELRA Results

2.3.1 Risk Assessment Summary

Table 2.4 below details any risks that scored ≥10 as per the aforementioned methodology that was used. Table 2.5 identifies control measures currently in place.

2.3.2 Site-Specific Risk Matrix

A Risk Matrix has been developed to allow the risks to be easily displayed and prioritised. The risk IDs have been numbered as per the Risk Assessment worksheets in Appendix I. The IDs have also been colour coded to provide a broad indication of the critical nature of each risk (as detailed in Section 2.2.3).

Table 2.4 Site Specific Risk Matrix

Likelihood	Very High	5	33, 44, 45, 46, 48, 50, 51, 53, 58, 59, 61	21, 34, 52, 56, 57, 69, 78, 79		28	
	High	4	2, 20, 49, 66,67	4, 11, 14, 29, 31, 32, 36, 40,		42	
	Medium	3	24, 37, 62	3, 5, 7, 8, 17, 18, 19, 22, 23 25, 26, 38, 54, 55, 68, 80, 84	39, 41, 60		
	Low	2	73	13, 16, 30	6, 12, 15, 27, 35, 43, 75, 76, 85	70, 71, 83	77
	Very Low	1			47	72	
			1	2	3	4	5
			Trivial	Minor	Moderate	Major	Massive
			Consequence				

2.3.3 Discussion of Risk Levels

It may be seen from Table 2.4 that there are two risks in the red area (high risk) and 28 risks in the amber area (medium risk). There are some current controls in place and some further mitigation measures have been proposed for some of these risks in order to reduce the potential likelihood of the risks occurring.

These are detailed in Appendix I of this report.

All other risks lie in the green zone. These risks require monitoring on an on-going basis. However, the current mitigation measures and regular monitoring should keep the risks in the low risk category.

Table 2.5 Risk Rating ≥10

Risk ID	Process	Potential Hazards	Environmental Effect	Basis of Severity (including current controls)	Basis of Likelihood (including current controls)	Risk Rating
28	Pumping of tailings to Randalstown TMF	Line leak	Contamination of surface water, groundwater and soil	• Approx. 3km in length (subsurface with 50m of pipeline running under River Blackwater) • 10% solids, 90% water - typically 1000m^3/hr flow in subsurface line • Line is walked daily for visual indications of leaks • Integrity testing is carried out - flow measurements taken at both ends of the pipe - automatic leak alarm (in the event of approx. 5% differential by volume between the 2 measurements) and tailings pump shuts down after 20mins, but can also be stopped manually before automatic shutdown • Pressure measurements independent of flow meters for verification of leak • Procedures updated since last leak specifying response when alarm sounds • Receptor is an SAC	• Previous leaks have occurred at joints due to temperature changes at exposed length of pipeline - this pipeline section has subsequently been covered - approx. 3m section) • Occurs once every 5 years on average	20
34	Storage and transfer of fuels	Leak/spillage of diesel, hydraulic oil etc.	Contamination of surface water, groundwater and soil	• All storage areas are bunded • Integrity testing of bunds • Leak detection system on fuel line • Closed-loop surface site water management system • New double-skinned bulk fuel storage tanks commissioned in 2017	Very high likelihood of hazard occurring especially during transportation around site.	10

Risk ID	Process	Potential Hazards	Environmental Effect	Basis of Severity (including current controls)	Basis of Likelihood (including current controls)	Risk Rating
42	Landfill	Leaching of historical deposits	Contamination of surface water, groundwater and soil	Historical sludge and industrial deposits	High likelihood of hazard occurring	16
52	Dewatering during operation	Dewatering aquifer	Medium term loss of water supply in domestic wells	• Medium term effect • No pollutant issue • Connection can be made to alternative water supply • Recovery of domestic wells is monitored on a regular basis	Has occurred	10
56	Hazardous Chemical Storage and Use	Leak/spillage form transfer pipeline of Diesel/hydraulic oil/engine oil from aboveground to fuel bays in mine	Mine water contamination	• Leak detection system on transfer lines. • Preventative and corrective clean up procedures in place • Visual inspection of pipelines in all fuel bays • Closed -loop surface site water management system • Integrity testing carried out on pipeline as per IEL conditions • Fuelling bays are bunded in accordance with EPA requirements	Small leaks occur regularly.	10
57	Hazardous Chemical Storage and Use	Potential leak from fuel bay/explosive emulsion bay	Mine water contamination	• Fuelling bays are bunded in accordance with EPA requirements • Bund integrity testing • All chemicals stored in bunded areas/bunded pallets • Visual inspection of pipelines in all fuel bays • Transport operations are manned and leaks would be immediately identified • Preventative and corrective clean up procedures in place • Closed-loop site surface water management system	• Leaks in storage areas occur periodically in the mine.	10

Risk ID	Process	Potential Hazards	Environmental Effect	Basis of Severity (including current controls)	Basis of Likelihood (including current controls)	Risk Rating
69	Decommissioning activities using heavy machinery - potential excavation	Leak from underground lines due to potential damage during decommissioning	Contamination of surface water, groundwater and soil	• Manned activity - pipeline damage and leaks will be identified and addressed immediately • All pipelines/storage tanks will be emptied and flushed as part of decommission process	Significant amount of underground pipeline at site with high likelihood of disturbance/damage during decommissioning	10
78	TMF operation	Dam wall failure with release of tailings and contained water	• Tailings solids impacts to local land / soils • Contained water seepage into soils • Contained water release to surface water bodies	• Large mass of tailings released • All of contained water volume (volume limited by operational control) • Requires physical clean-up	• Refer to Golder Dam Breakout Study • External Emergency Plan in Place with Local Competent Authority (Meath County Council, An Garda Siochana and the Health Service Executive)	10
79	TMF operation	Seepage (groundwater contamination)	Groundwater quality impact	• Groundwater monitoring programme in place. • Dam is designed with controlled permeability considerations. • Interceptor channel lower than groundwater level.	Seepage is known to occur • Refer to 'Risk Screening and technical Report't to demonstrate the TMF site's compliance with the Groundwater Regulations •	10

NEW BOLIDEN

Risk ID	Process	Potential Hazards	Environmental Effect	Basis of Severity (including current controls)	Basis of Likelihood (including current controls)	Risk Rating
80	TMF operation	Groundwater seepage into surface water – yellow river	Surface water quality impact (and macroinvertibrates)	• Seepage is captured in interceptor channel. • Directed to central collection area and pumped back into active dam.	•The seepage-to-surface water exists. • Refer to 'Risk Screening and technical Report't to demonstrate the TMF site's compliance with the Groundwater Regulations •	10

2.3.4 Risk Treatment

The identification of management and mitigation measures to reduce the risk either by reducing the likelihood of occurrence or the severity should it occur.

A statement of measures is presented in appendix IV detailing the measures necessary.
The statement identifies specific measures, a responsible individual and a timeframe for completion.
The ELRA is reviewed annually and the statement of measures is reviewed to monitor progress.
Pending the outcome of the actions identified the overall risk rating may be reviewed (ideally reduced).

See Table ii appendix IV.

3.0 Costing of Environmental Liabilities

The known environmental liabilities for the site are calculated through the preparation and costing of the Closure and Restoration/Aftercare Plan.
For unknown liabilities associated with the environmental risks identified, the methodology for costing the level of financial provision necessary is based on the worst-case scenario.

The worst case scenario refers to the event that poses the maximum environmental liability, i.e. the worst consequence, during the period to be covered by the financial provision. The likelihood is not taken into account in this analysis. Once a risk is considered plausible, it must be included in the risk assessment and the level of financial provision is based on the consequences alone.

The worst case scenario is the risk that has the highest consequence (severity) rating. This risk is to be taken as the basis for financial provision and shall be quantified and costed as detailed below as required by the EPA Guidance:

- The costs presented should be based on the control measures in place at the time of reporting.
- Planned mitigation measures cannot be included in the risk assessment or calculation until these measures have been fully implemented;
- Operators are required to present this information in sufficient detail to demonstrate a high level of confidence in the calculated costs;
- Operators may add additional line items as required to demonstrate as much key information as possible;
- For each cost item provided by the operator, a rationale for this cost must be provided.
- This rationale must be based on real, current cost estimates for the activity and the sources of the costs must be provided. The EPA will publish unit costs separately to accompany this guidance. The EPA published unit costs are not intended to substitute for the requirement for the operator to determine costs, but are provided to assist in validating the site-specific costings;
- A contingency fee shall be applied to the subtotal to allow for uncertainty in the cost estimate. This amount of the contingency fee should reflect the level of uncertainty in the detail provided. There may be links/domino-effects between individual risks, in which case a number of risks may need to be grouped to represent a worst case scenario.

3.1 Worst-Case Scenario

The plausible worst case scenario has been identified as a breach of the tailings storage facility embankment.

- Risk 78: A TMF dam wall failure leading to a release of tailings and contained water

Therefore, this is the risk to be costed as the 'worst case' scenario.

- The 'Worst Case' Scenario costings are presented in Appendix II.

3.1.1 TSF Breach Assessment

Golder Associates Ireland Limited (Golder) has been engaged update to the costing of the remediation of the plausible worst-case environmental liability scenario in response to queries from the Environmental Protection Agency (EPA) regarding the Environmental Liabilities Risk Assessment (ELRA).

To inform the exercise it was decided to review the Tailing Storage Facility (TSF) embankment failure assessment[3], further to referred to as 'Dam Break Assessment, 2020'.

The purpose of the assessment was to estimate the potential extent of flooding and potential pathways of an uncontrolled discharge of tailings to the down-gradient environment during the operational phase of the facility.

A non-Newtonian failure assessment was undertaken modelled to provide a worst-case scenario i.e. during the 'operational phase' of the development. Two potential breach locations were considered which represent the two tailings ponds which are currently operational.

The rural location of the Randalstown TMF and the relatively level downstream terrain, for the perimeter of the TMF, determines that the estimated costs for this plausible worst case scenario are primarily governed by the volume of tailings released by the hypothetical breach of the dam wall(s) although remediation costs for adjacent streams and rivers including Special Areas of Conservation (SACs) also have to be accounted for.

[3] Dam Break Assessment – Boliden Tara Mines, Randalstown Tailings Management Facility, September 2020

Methodology to determine potential release volume

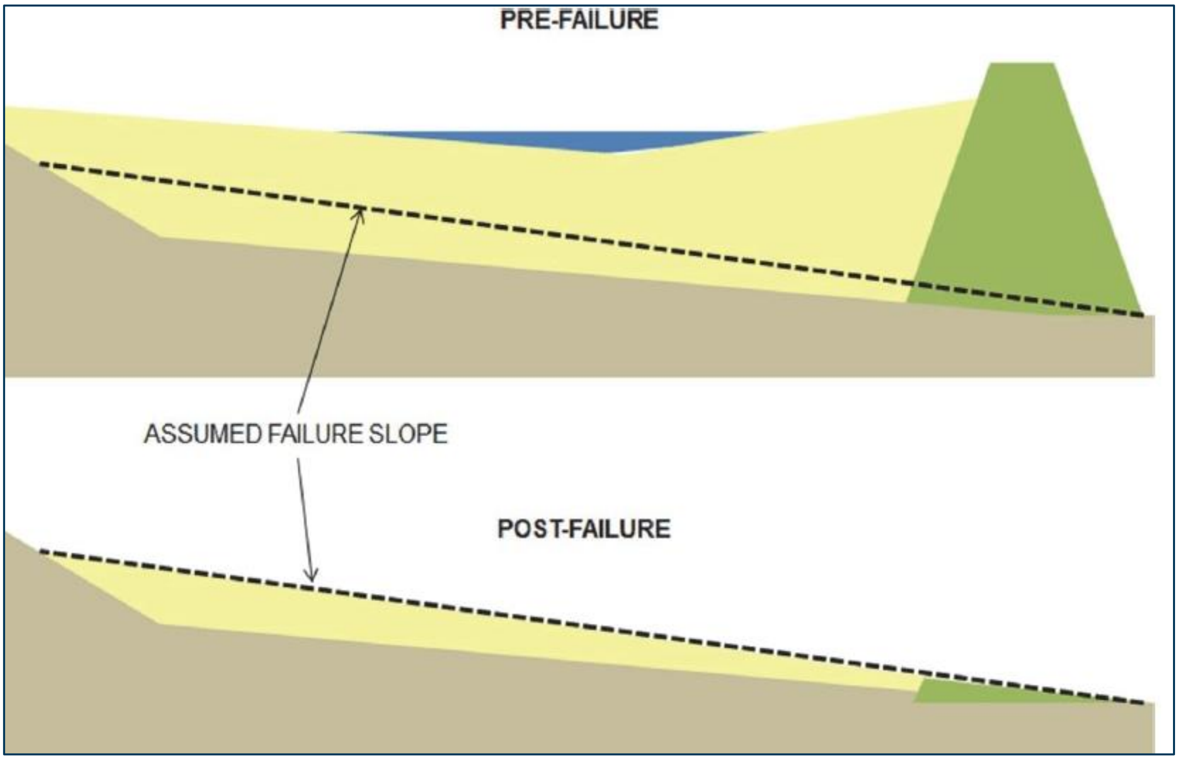


Figure 3.1 Discharge volume based on an assumed post-failure slope

Current best practice methodology to estimate release volume is the '***cone of depression method'***, as outlined in Schoeman (Schoeman 2018) and Martin (Martin et al. 2019). Unlike water dams, where a breach spanning the full height of the dam wall will result in the entire storage volume being released, it is widely accepted that tailings facilities are more likely to retain some solids due to the viscous nature of the tailings.

Applying this principle, some dam-break studies have assumed a post-failure tailings surface sloping at an angle of about 3 to 10° from the downstream toe.

From the assumed breach geometry, a tailings release cone (or a cone of depression) can be established by projecting the anticipated post liquefied residual shear strength angles upward from the base of the breach.

The outflow volume can then be estimated based on the volume of tailings contained in the cone. Factors including tailing characteristics, geometry of the facility, location, and topography all inform the model.

This method has gained industry acceptance and has been adopted in the new Canadian Dam Association (CDA) technical bulletin on tailings dam breach analysis (to be issued during 2020) and included as a tool for commercial tailings software i.e. Muk3D Tailings.

Cone of Depression Method

Figure 3.2 presents the series of steps to be undertaken during tailings dam breach analyses (TDBA), after Martin et al. (2019).

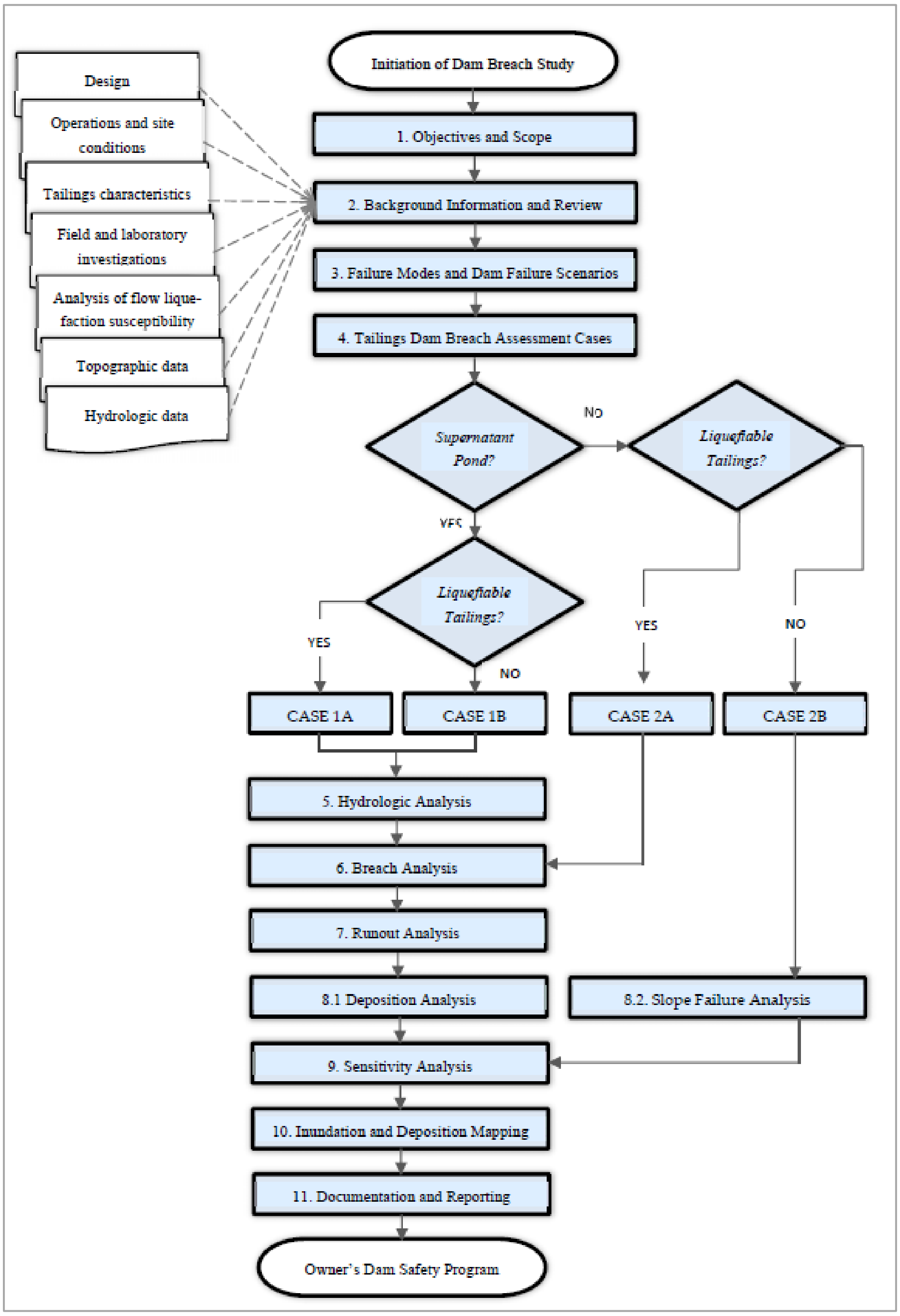


Figure 3.2 Process flow diagram for tailings dam breach analyses (Martin et al. 2019)

3.1.2 Chosen Scenario:

A physical breach of the dam followed by an uncontrolled release of stored materials (Liquid & Solids).

The dam break assessment considers two embankment locations:

- Stage 5B SE Corner
- Stage 6 NW corner

Both locations are assumed to be 'operational' with a pond of water on surface and for the purposes of a hypothetical breach, a liquefied tailings is assumed.

Breach of the TSF Stage 5 embankment

- Southeast corner of the Stage 5B dam wall
- Breach from Stage 5b crest, 1594 mAMD to elevation of perimeter road, 1576 mAMD.
- Dam Wall Breach Dimensions = 40.2 m average, 1(H):1(V) side slopes
- Dam Wall Volume = 32,200 m^3 of fill
- Discharge Volume = 1,834,000 m^3 comprising solids of 1,278,000 m^3, supernatant cap water of 250,000 m^3 and supernatant rainy-day water from a 24-hr 10,000-year event of 306,000 m3
- Downstream Flood Plain = 570 hectares (based on total impacted area)
- Contaminated Soils = 456,000 m^3 (based on "test and replace" approach with allowance for alternative treatment options ranging from replacing 300 mm depth of soil (15% allowance, remove sod only and replace with 100 mm topsoil (35% allowance) and plough ground and reseed (50% allowance).
- Note that this strategy takes into account, the largely inert nature of the Tara tailings stream.

Rehabilitation Basis:

- Repair the dam wall breach, pump contaminated water and haul tailings (816,000 m^3) and contaminated material (552,800 m^3) back to the TMF.
- Prepare area within existing TMF for deposition of recovered tailings and impacted soils.
- Construct a perimeter containment berm around the designated footprint to contain the contaminated soils to be hauled back to TMF.
- The contaminated soils shall be hauled, placed and graded to a shallow gradient (approx. 2 degrees) on the Main TMF and capped with a minimum 300 mm depth of clean, inert soil material sourced from the capping material stripped. It is assumed that 25% of the contaminated soils will need to be replaced by inert soil imported to site.

Step 2: Background Information

The Dam Break Assessment report (Golder 2020) clearly outlines all of the background information relevant to a dam breach in Sections 2.0 and 3.0. Only aspects of this information which is considered critical to the costing of the ELRA in particular will be considered further within this document.
Two dam breach scenarios were considered within the dam breach assessment.

Step 4: Tailings Dam Breach Assessment Cases

The Dam Break Assessment outlines the background information relevant to a dam breach (Sections 4.0 and 5.0).

The two main factors expected to have a major impact on the character and volume of the outflow from the TMF during a breach event are as follows:

- The presence of fluids (supernatant water and/or fluid tailings) on the surface of the TSF and
- The potential for liquefaction induced flowability of the tailings material.
- The physical process of a dam breach comprises two interrelated discharge mechanisms:
- **Process I** – initial discharge of supernatant pond that carries tailings and dam fill material creating and initial flood wave (Cases 1A and 1B); and
- **Process II** – discharge of flowable tailings due to tailings liquefaction (Cases 1A and 2A), or progressive slumping (failure) of unsupported tailings (Case 1B).
- Canadian Dam Association Guidelines (CDA 2014[4]) recommend that dam breach evaluations consider two hydrologic conditions:
- Sunny day failure – "a sudden dam failure that occurs during normal operations", which may be 'caused by internal erosion, piping, earthquakes, mismanagement leading to overtopping, or another event'.
- Flood induced or rainy-day failure – "a dam failure resulting from a natural flood of a magnitude that is greater than what the dam can safely pass".

Plausible worst case scenario

The plausible worst-case scenario (winter / spring season, breach of the east dam wall and rainy-day failure) is assessed and a 24-hour PMP (Probable Maximum Precipitation) flood event results in an additional 215 mm. Table 3.1 below presents the quantities of liquid and solids stored and the estimated release volumes.

[4] CDA 2014, Canadian Dam Association, Technical Bulletin 2014, Application of Dam Safety Guidelines to Mining Dams

Table 3.1 Estimated Total Release Volumes

Scenario	Free Water Impounded in TMF Supernatant Pond (Mm^3)	Tailings Slurry Outflow Volume (Mm^3)	Total Released Volume (Mm^3)	Approximate Tailings Impoundment Volume in TMF (Mm^3)	Percentage of Total Impoundment Volume Released (%)
1 (Stage 5B – Sunny Day)	0.250	1.278	1.528	31 (1)	4.9
2 (Stage 5B – Rainy Day)	0.556	1.278	1.834	31 (1)	5.8
3 (Stage 6 – Sunny Day)	0.250	0.816	1.066	9.940 (2)	10.5
4 (Stage 6 – Rainy Day)	0.377	0.816	1.193	9.940 (2)	11.6

Notes:

1. *As the Stage 5B failure location may result in tailings release from Stage 5A, the total volume presented is an estimate of the total tailings volume stored within Stages 1 to 5 (combined) of the facility to a fill elevation of 1,593m AMD. Estimate based on data records at the TMF.*
2. *Estimated total fill capacity of Stage 6 (Phase 2) facility to a fill elevation of 1,593 mAMD. Estimated from 3D modelling of the Stage 6 (Phase 2) design.*

Step 6: Breach Analyses

All parameters required for the modelling of the dam breach are presented in the Dam Break Assessment. Breach parameters define the initial and final shapes of the breach, the breach development time (or time to fail), and how the breach develops over time (e.g., linear, or nonlinear breach growth over time).

Table 3.2 below provides a summary of the assigned / calculated values used to determine the quantities for the updated ELRA costing provided in Appendix II.

Table 3.2 TSF dam breach parameters values to determine quantities for ELRA costing

Dam Breach Parameter	Stage 5b Parameters
Catchment Areas	1,417,800 m^2 (Stages 1 to 5 combined)
Estimated storage volumes in TMF Phase	31,000,000 m^3 (Stages 1 to 5 combined)
Breach average widths	40.2 m
Estimated volume of dam breach materials	32,200 m^3
Cone of depression angle	4 degrees
Rainy day supernatant water volume	556,251 m^3 consisting of: • 100,000 m^3 – Stage 5A • 150,000 m^3 – Stage 5B • 306,251 m^3 - PMP Event
Tailings breach discharge	1,278,000 m^3
Area impacted by rainy day breach scenario	570 hectares

Reference drawings are included in the report (Bam Breach Assessment (Golder 2020) which also shown the same information for the sunny day scenario as well as drawings which indicate the maximum velocity of the breached material.

3.2 Cost estimate for "worst case scenario"

This assessment indicates that the costs for remediating the modelled breach of Stage 5B would be approximately 6% higher than the costs for remediating the modelled breach of the Stage 6 TMF.

This is largely due to the higher quantity of tailings involved in the Stage 5B breach (57% higher) however this is mitigated to a large extent by a smaller impacted area for Stage 5B (17% smaller).

On this basis, it is considered that the dam breach for Stage 5B embankment resulting in a release of tailings and contaminated water' presents the plausible worst-case scenario.

3.2.1 Potential Impact on NATURA Sites

Directive 92/43/EEC on the Conservation of Natural Habitats and Wild Fauna and Flora – the 'Habitats Directive' - provides legal protection for habitats and species of European importance. Article 2 of the Directive requires the maintenance or restoration of habitats and species of European Community interest, at a favourable conservation status. Articles 3 - 9 provide the legislative means to protect habitats and species of Community interest through the establishment and conservation of an EU-wide network of sites known as Natura 2000.

Natura 2000 sites are Special Areas of Conservation (SACs) designated under the Habitats Directive and Special Protection Areas (SPAs) designated under the Conservation of Wild Birds Directive (79/409/EEC). The requirements of Articles 6(3) and 6(4) of the Habitats Directive have been transposed into Irish legislation by means of the Habitats Regulations, 1997 (S.I. No. 94 of 1997) and the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477/2011).

Specific requirements for remediation measures that may be required in the event of a plausible worst-case scenario event are detailed within the Environmental Liability Directive1 (ELD). In 2004, the European Union acted to bring a more uniform regime for the prevention and remediation of environmental damage by adopting Directive 2004/35/CE "on environmental liability with regard to the prevention and remedying of environmental damage".

This innovative legislation establishes for the first time in the EU, a comprehensive liability regime for damages to the environment, based on the 'polluter-pays' principle. By making those that have caused environmental damage liable for remediation of damage, the Environmental Liability Directive (ELD) provides a strong incentive to avoid damage occurring in the first place.

Effects to the River Boyne and River Blackwater SAC and River Boyne and River Blackwater SPA caused by a plausible worst-case scenario would be assessed and remediated in terms of adopting an ecologically relevant source-pathway model which would identify residual effects to species with a specific focus on qualifying species for the River Boyne and River Blackwater SAC and River Boyne and River Blackwater SPA. In essence, the mobilisation of silts and sediments to downstream receptors e.g. salmon spawning redds during a plausible worst-case scenario event may occur over a significant distance and the compensatory measures documented herewith are cognisant of this fact.

Two European Sites that lie within 15km of the Tailings facility:

- River Boyne and River Blackwater SAC (Site Code: 002299)
- River Boyne and Blackwater SPA (Site Code: 004232)

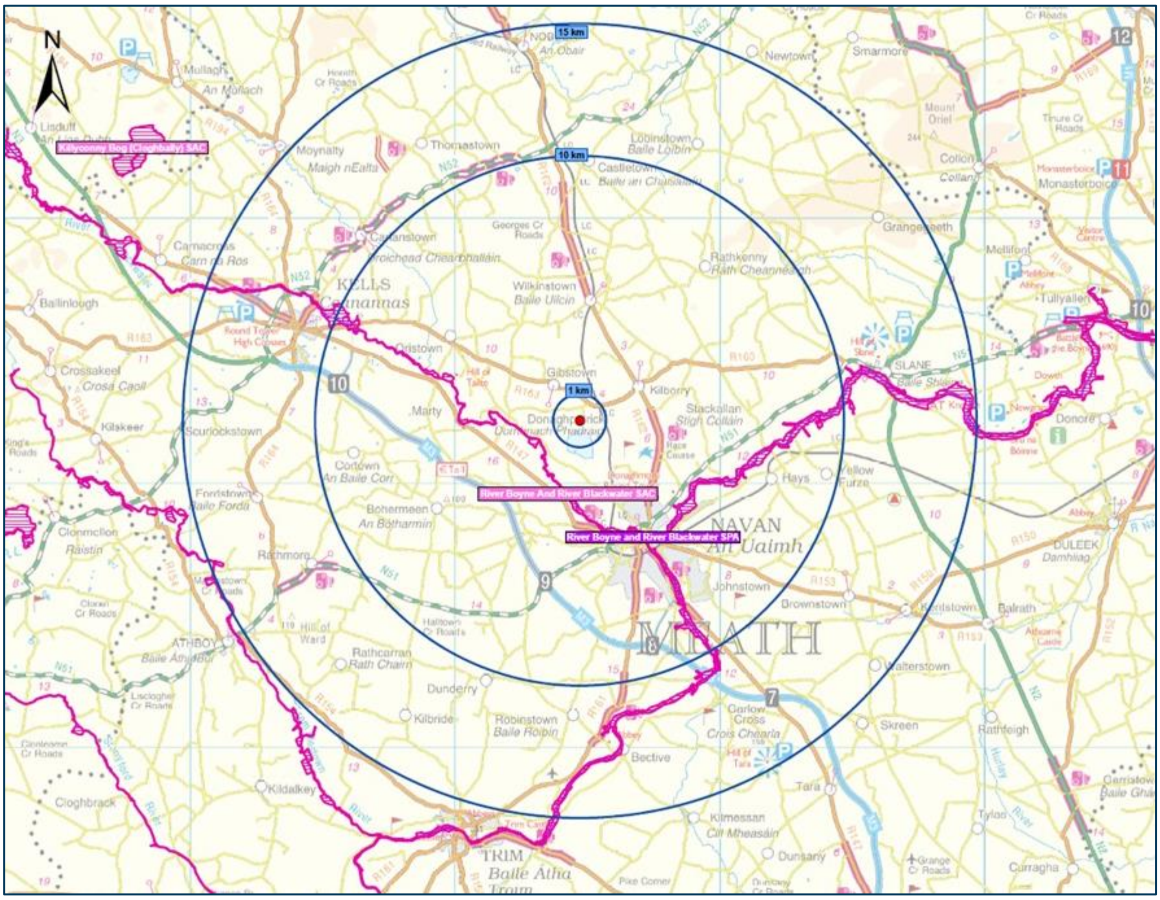


Figure 3.3 Natura 2000 Sites

Table 3.3 European Sites and their Qualifying Interests, Conservation Objectives and Threats and Pressures

European Site (including distance from proposed development)	Qualifying Interest(s) and Conservation Status[5]	Conservation Objective[6]	Threats and Pressures[7]
River Boyne and River Blackwater SAC Site Code: 002299 1.25km from Tara Mines	Alkaline Fens Alluvial Forests* River Lamprey (*Lampetra fluviatilis*) Atlantic Salmon (*Salmo salar*) Otter (*Lutra lutra*)	To maintain or restore the favourable conservation condition of the Annex I habitat(s) and/or the Annex II species for which the N2000 site has been selected: This is a generic conservation objective, available online at: http://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO002299.pdf.	Forestry (Afforestation) Grazing, Human induced change in hydraulic conditions, Cultivation Fertilisation, Leisure fishing Discharge, Urbanisation Roads & Motorways Walking, horse riding & non motorised vehicles. Mining Spread of invasive non native plant species.
River Boyne and River Blackwater SPA Site Code: 004232 1.25km from Tara Mines	Kingfisher (*Alcedo atthis*)	To maintain or restore the favourable conservation condition of the Annex I bird species (Kingfisher). This objective aim to maintain the favourable conservation condition of Kingfishers in River Boyne and River Blackwater based on a detailed list of attributes and targets. See online at: http://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO004232.pdf.	Urbanisation, Roads & Motorways Human induced change in hydraulic conditions Mining Spread of invasive alien plant species

5 The Status of EU Protected Habitats and Species in Ireland (Vol II & III), NPWS, 2013. http://www.npws.ie/publications/article17assessments/article172013assessmentdocuments/Article_17_Web_report_habitats_v1.pdf and http://www.npws.ie/publications/article17assessments/article172013assessmentdocuments/Article_17_Web_report_species_v1.pdf

6 Sourced from NPWS website – Conservation Objective Documents http://www.npws.ie/protectedsites/

7 Sourced from Natura 2000 Standard Data Forms (NPWS, November 2013) and/or professional judgement.

European Site (including distance from proposed development)	Qualifying Interest(s) and Conservation Status[5]	Conservation Objective[6]	Threats and Pressures[7]
Boyne Estuary SPA Site Code: 004080 c.30km from Tara Mines	Shelduck *Tadorna tadorna* Oystercatcher *Haematopus ostralegus* Golden Plover *Pluvialis apricaria* Grey Plover *Pluvialis squatarola* Lapwing *Vanellus vanellus* Knot *Calidris canutus* Sanderling *Calidris alba* Black-tailed Godwit *Limosa limosa* Redshank *Tringa totanus* Turnstone *Arenaria interpres* Little Tern *Sterna albifrons* Wetlands	To maintain or restore the favourable conservation condition of the Annex I bird species for which the N2000 site has been selected. This is a generic conservation objective, see online at: http://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO004080.pdf.	Urbanisation Siltation, dumping Reclamation Hydrographic changes Golf course Recreation Invasive alien species
Boyne Coast and Estuary SAC Site Code: 001957 c.30km from Tara Mines	Estuaries Mudflats and sandflats not covered by seawater at low tide Salicornia and other annuals colonizing mud and sand Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) Mediterranean salt meadows (*Juncetalia maritimi*) Embryonic shifting dunes Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes') *Fixed coastal dunes with herbaceous vegetation ('grey dunes')	To maintain or restore the favourable conservation condition of the Annex I habitat(s) and/or the Annex II species for which the N2000 site has been selected. This is a generic conservation objective, which aims to maintain the favourable conservation condition of coastal and marine habitats and species based on a detailed list of attributes and targets. See online at: http://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO001957.pdf.	Golf course Urbanisation Household waste disposal Reclamation Recreation Industrial waste disposal

3.2.2 Impact Severity

The dam break assessment has identified the extent of the inundation caused by a breach at the tailings facility. The worst case scenario could result in a combined 1,278,000 m3 of material affecting 570hectares.

It is predicted that in the event of a breach tailings could reach a section of the river Blackwater. The area affected would stretch from c. 1,000 m upstream of the confluence of the Yellow River and the Blackwater to a distance approximately 1,500 m downstream.

Much of the potential impacts on the Blackwater and the Boyne will be as a result of the PMP storm event as well as the surge both from the supernatant water ponds but also from the effect of tailings entering the river system.

Table 3.4 Release volumes

Scenario	Free Water Impounded in TMF Supernatant Pond (Mm^3)	Tailings Slurry Outflow Volume (Mm^3)	Total Released Volume (Mm^3)	Approximate Tailings Impoundment Volume in TMF (Mm^3)	Percentage of Total Impoundment Volume Released (%)
2 (Stage 5B – Rainy Day)	0.556	1.278	1.834	31 (1)	5.8

Primary Remediation

Primary remediation involves the physical clean-up of tailings, impacted soils and river sediments from the impacted area. This will be completed using a range of earthmoving equipment ranging from excavator and dumpers to dozers and compactors all overseen by a suitably qualified ecological clerk of works. In the event of removing tailings and impacted sediments from the riverbed, a long-reach excavator and road haulage trucks will be used. The primary remediation includes for replacements of river gravels, terrestrial soils as well as the restoration of riparian vegetation over the impacted area.

The potential affected area are identified in figure 3.4, with stretches of the river channel broken into discrete sections.

The physical clean-up is limited to the section of the river where it was anticipated that the greatest quantity of tailings solids are likely to enter the river in the plausible worst case scenario. This section extends to a total of 1,600 metres, where tailings may need to be removed. It is estimated that 18,000 m^3 of tailings material would be dredged from the river channel. This consideration takes cognisance of the fact that in the event of a PMP event, significant quantities of silt/soils will be washed into the river over its entire length and will sit on the riverbed. The river ecosystem has its own natural ways of dealing with such events; this is the basis for limiting the primary remediation works to the section of riverbed and riverbank where it is considered that the ecosystem will not be capable of naturally recovering within a reasonable period of time due to the presence of tailings.

It is noted that dredging of a riverbed is a highly disruptive process and removes all vegetation and riverbed gravels that constitutes one of the main habitats. Given the largely inert nature of the tailings, it is not considered to be of ecological benefit, to dredge more of the riverbed than is necessary for the habitat to recover.

It is noted that some of these tailings will become suspended and may settle out over the course of the next sections of the river. Much of these tailings would be undiscernible from the greater amounts of silts that will be washed into the river from the overall catchment during the PMP event.

Primary remediation involves the physical clean-up of tailings, impacted soils and river sediments from the impacted area. This will be completed using a range of earthmoving equipment ranging from excavator and dumpers to dozers and compactors all overseen by a suitably qualified ecological clerk of works. In the event of removing tailings and impacted sediments from the riverbed, a long-reach excavator and road haulage trucks will be used. The primary remediation includes for replacements of river gravels, terrestrial soils as well as the restoration of riparian vegetation over the impacted area.

Compensatory and Complimentary Remediation

The ELD recognises that full remediation takes time and therefore requires compensation for interim losses, in other words, for environmental resources or services forgone during the recovery period. This is presented as compensatory remediation and can also be provided at another site but within the same aquatic catchment by improving the status of the damaged species or other sufficiently similar species. Alternatively, compensatory remediation can be provided by conducting primary remediation that generates benefits over and above the baseline at the affected site (the excess part being counted as compensatory remediation credit).

All primary and compensatory remediation would be agreed via consultation with the competent authority, stakeholders (angling groups/rivers trusts and conservation bodies) and all relevant statutory agencies.

Ecosystem Enhancement – Catchment Based

Riparian land-use project working with farmers to protect and enhance natural resources in a way that benefits agricultural businesses, rivers and the wider community within the Boyne and Blackwater catchment. The consultancy project would involve areas such as nutrient management, soil health, water quantity and biodiversity. As well as delivering environmental value, effective land management can also improve water quality in rivers, reduce flood risk, improve soil quality, enhance biodiversity and improve carbon sequestration.

Budget cost: €50,000 over a two-year programme.

Aquatic Connectivity (migratory salmonids)

All river fish need to migrate at various points in their life cycle or at various times of year. They do this for a variety of reasons: to spawn; to make best use of feeding opportunities and to take refuge from extreme flows are just three examples. The rivers Boyne and Blackwater are host to a number of species that need open, unhindered access upstream and downstream to thrive. Obstacles to fish migration can be man-made (weirs, pipe bridges, dams, bridge footings) or natural (waterfalls and timber blockages, for example). All can have significant negative impacts on a river's fish populations.

Budget cost: €35,000.

Habitat Protection

Aquatic habitat can be protected for species such as lamprey, otter, salmon and kingfisher. Habitat degradation in rivers is often caused by overgrazing of bank side vegetation and the trampling of riverbanks by sheep and cattle. This results in the destabilisation of the banks, which cause streams to become wider and shallower.

It also leads to more silt in rivers.

The habitat protection project will work with stakeholders to identify upstream nursery and spawning habitat and deliver the following:

1. Fence out grazing animals to allow bankside vegetation to regenerate in a natural way. This gives the banks the protection against excessive erosion in high flows;
2. Manage the tree cover to produce dappled shade and, at the same time, cut back multi-stemmed trees back to single stems. This allows enough light into the river channel to enable plants and algae to grow, kick-starting the ecosystem. Of increasing importance, this also gives just enough shade to give a stream a degree of 'climate proofing';
3. Laying or pleaching-in hazel or willow and smaller stems horizontally with the flow creates cover and protection for juvenile salmonids. Severe erosion is also corrected by grading the banks and protecting their base with alder stems pinned to the bed.

Budget cost: €35,000

Fish Restocking

Any fish-kill associated with the plausible worse-case scenario is likely to be limited to the stretch of the river where the sediment is of such volume that it impacts on water oxygenation, or run-off volume is so great it impacts rapidly on water temperature. The sediment is non-hazardous, and will not impact in the same way as, for example an agricultural effluent pollution event.

A programme of salmonid (Salmo trutta and Salmo salar) restocking would be undertaken in cooperation with the inland fisheries.

Over a three year period of three years a combination of juvenile and adult fish would be reintroduced to the affected area.

Budget: €35,600

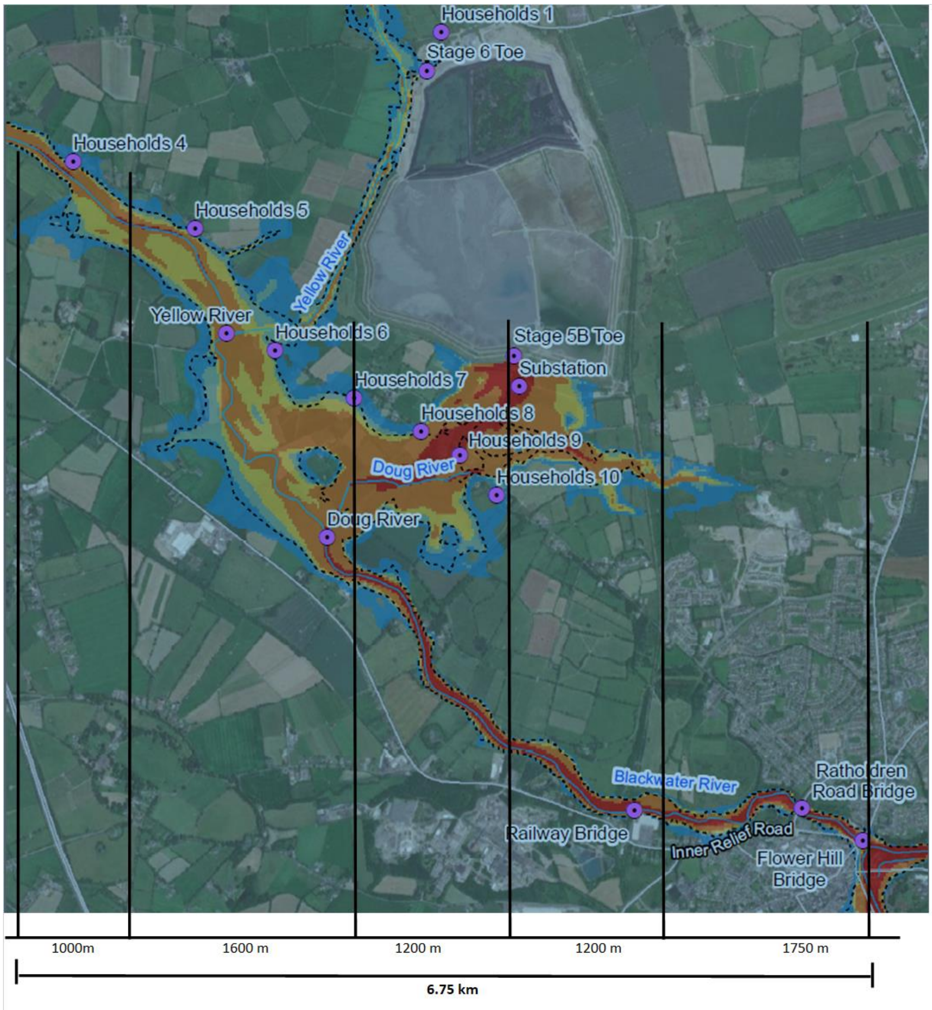


Figure 3.4 River Blackwater SAC/SPA affected areas

Table 3.5 Qualifying Interests with potential to be significantly impacted

European Site	Qualifying Interest	Description of potential impacts		
Boyne and Blackwater	River Lamprey (*Lampetra fluviatilis*)	The clean-up phase will requires instream works within the Yellow River, Doug and Blackwater river channels. Works will be supervised by a suitable qualified Ecologist. The Ecologist will specify the works and mitigation measures to minimise the potential impacts. Particular attention will have to be paid during any dredging works to protect River lamprey occurring in the River Blackwater main channel downstream of the affected site.	CHANGES IN HYDROLOGICAL REGIME CHANGES IN WATER QUALITY ALIEN INVASIVE PLANT SPECIES	CHANGE IN CHEMICAL AND/OR NUTRIENT STATUS OF WATER AND/OR SILT CHANGES IN DEPOSITION OF SILT IN HABITAT AGGRESSIVE COLONISATION BY ALIEN INVASIVE SPECIES IMPACTS ON FEEDING AMMOCOETES THROUGH SILTATION AND/OR BIOACCUMULATION
	Atlantic Salmon (*Salmo salar*)	The Ecologist will specify the works and mitigation measures to minimise the potential impacts. Particular attention will have to be paid during any dredging works to protect spawning beds in the River bed downstream of the affected site.		
	Otter (*Lutra lutra*)	Works will be supervised by a suitable qualified Ecologist. The Ecologist will specify the works and mitigation measures to minimise the potential impacts. Particular attention will have to be paid during any dredging works.	CHANGES IN HYDROLOGICAL REGIME CHANGES IN WATER QUALITY DISTURBANCE	CHANGE IN HYDROLOGICAL REGIME COULD IMPACT ON HOLTS CHANGE IN CHEMICAL/NUTRIENT STATUS COULD IMPACT ON PREY SPECIES BIOACCUMULATION OF CONTAMINANTS INCREASED DISTURBANCE COULD IMPACT USE OF HABITAT
Boyne and Blackwater SPA	Kingfisher (*Alcedo atthis*)	Water quality impacts arising from breach and subsequent clean up operation may affect fish and invertebrate populations in the River Blackwater. This in turn may effect Kingfisher populations, which forage on fish. Kingfisher nest on the Blackwater and availability of prey to feed young is critical to their survival. Kingfisher occurring in the River Blackwater main channel downstream of the proposed development site may potentially be affected due to water quality effects, with reference to foraging and prey abundance.	CHANGES IN HYDROLOGICAL REGIME CHANGES IN WATER QUALITY ALIEN INVASIVE PLANT SPECIES DISTURBANCE	CHANGE IN HYDROLOGICAL REGIME COULD IMPACT ON NESTING SITES CHANGE IN CHEMICAL/NUTRIENT STATUS COULD IMPACT ON PREY SPECIES BIOACCUMULATION OF CONTAMINANTSINCREASED DISTURBANCE COULD IMPACT USE OF HABITAT

The costs that have been allowed for the remediation of the SAC are included within the cost estimate attached in Appendix II relevant items are outlined below.

Table 3.6 Costs specific to Blackwater remediation

Item	Description	€
B230	Temporary Water Management in immediate breach area (Settlement Ponds, Filtration Berms, Sediment Catch Fences, Stream Diversions, Basic Treatment Systems, etc.).	150,000
B240	Temporary Water Management in Blackwater / Yellow River confluence area (Settlement Ponds, Filtration Berms, Sediment Catch Fences, Stream Diversions, Basic Treatment Systems, etc.). Provisional Sum	100,000
C640	1 x Long Reach Tracked Excavator - 25 tonne to 30 tonne (for cleaning base and edge of Blackwater River) (assume 8 weeks)	57,600
C650	2 x Eight Wheeler Road Trucks (hauling from Blackwater clean-up to TMF (assume 8 weeks)	52,800
G100	Management Plan	8,500
G110	Ecosystem Enhancement	85,000
G120	Habitat Protection	35,000
G130	Monitoring of the sediment levels and habitats	18,000
G140	Long term) 10 year) post event monitoring	120,000
G150	Fish restocking Programme	35,600
		662,500

An ecologist will be retained during the remediation works to ensure proper measures are carried out to protect the integrity of the site.

Long-term monitoring of several of the Qualifying Interests of these sites will be undertaken in order to determine the success of remediation measures.

3.3 Basis of Estimate for Plausible Worst-Case Scenario

The cost estimate for the remedial works associated with the plausible worst-case scenario are based on the following understanding and assumptions:

- Construction has been ongoing for the past three years on the Stage 6 TMF. This work is being undertaken by Priority Construction Ltd (PCL). The Day-works rates agreed for this long running construction project for plant and labour have been used in the ELRA cost estimate as they represent the most realistic construction contract rates for works at Tara
- Initial Emergency Response works are scheduled to occur over a seven day week due to the emergency nature of the works, subsequent to this, all remediation works are scheduled to occur over a six day week, working ten hours per day;
- Authority Charges are based on an anticipated level of attendance from the relevant regulators, namely Department of Environment, Climate & Communications (DECC) and the Environmental Protection Agency (EPA);
- Effort and durations for earthworks operations have been calculated based on a specific number of dump trucks carrying 13 m^3 per load and completing 30 loads per day i.e. 390 m^3 per dump truck per day. Based on this, an assessment is carried out to determine the most appropriate number of dump trucks and excavators required to achieve the most efficient outcome. This assessment also takes cognisance of the type and difficulty of the work to be completed;
- The volume of impacted soils to be removed and replaced is based on the premise that the Tara tailings is a largely inert tailings with low levels of metals and sulphates when compared to many other tailings. Hence, comparisons with previous dam failures does not necessarily present a good basis for remediation. In determining the quantity of soils that will need to be replaced, Golder has taken an approach where significant testing of the soils will be undertaken once the breached tailings have been removed and the original soils underneath can be accessed. It is recognised that in some cases, the topsoil material will be impacted through the excavation of the breached tailings and it will be necessary to remove the full depth of the topsoil in these areas. In other areas, it is expected that the topsoil will have been impacted through the leaching of sulphate and metals from the overlying tailings prior to its removal. These areas will be likely be the areas where significant deposits of tailings resulted; these areas will be identified through sampling and laboratory testing of the soils. Further, other areas will likely show little to no impacts as they will have been impacted more by a first flush of supernatant water. It is considered that areas where deeper deposits of tailings result or areas where it takes longer for remediation to resolve will result in greater potential for the topsoil to be impacted. Based on the above, it has been assumed that the following will apply:
- 15% of the impacted area will be heavily impacted through trafficking and greater depths of tailings / longer period of coverage. This layer will require complete removal and replacement with a 300 mm depth of fresh soil;
- 35% of the impacted area will be impacted to a relative extent requiring removal of the sod and replacement with 100 mm of replacement soils. It is expected that the sod will have retained much of the contaminants and then replacement with clean soil with mixing further improving the quality of the overall topsoil layer; and

- 50% of the impacted area will not be impacted in terms of contamination. This would eb confirmed through laboratory testing. These areas would be ploughed and reseeded to promote a fresh growth of grass.

- There are currently significant quantities of subsoil and topsoil stockpiled at the Randalstown TMF site. Further to this, there is still a significant quantity of soil available within the Simonstown Borrow Area as well as some other landholdings under the ownership of Tara. Currently, the construction of the Stage 6 TMF embankment walls is being undertaken using imported inert soil. It is expected that in the event that the current stockpiles of soil and topsoil were required to be used for the remediation of a dam breach scenario, that further materials could be imported to site to replenish the materials used for the remedial works.

- Provisional sums amounting to €250,000 have been allowed for temporary water management and water treatment. This figure is split into two components; the first being in the immediate area of the breach (€150,000) and the second being in the area of the Blackwater River confluence with the Yellow River (€100,000). The measures envisaged under this item include the construction of temporary water retention ponds, the construction of filtration berms, installation of silt traps and silt fences, construction of cut-off ditches and diversion channels to manage surface water and storm water

- An allowance has been made for the reconstruction of a single house. For the Stage 5B scenario, this is envisaged to be a house included within the “Households 9” cluster. In reality, it is considered that smaller scale repair works might be required to a number of houses, it has been considered appropriate to cost the full reconstruction of one house as a plausible worst case scenario. The total allowance of €300,000 includes cost for alternative accommodation for a period of one year.

Table 3.7 Remediation Costs

Item	Description	€
A	**Initial Emergency Response (1 week)**	
A100	Consultancy Fees	44,600
A200	Specialist Contractor Charges	44,800
A300	Authority Charges	69,000
	Sub-Total	**158,400**
B	**Breach Management (10 weeks)**	
B100	Consultancy Fees	87,000
B200	Specialist Contractor Charges	484,000
B300	Authority Charges	25,000
	Sub-Total	**596,000**
C	**Primary Clean-up**	
C100	Fill Materials	233,800
C200	Filling	176,680
C600	Tailings and Dam Wall Materials Clearance: Civil Works (37 weeks)	3,926,905
C700	Tailings and Dam Wall Materials Clearance: Pumping (6 weeks)	126,000
C800	Contaminated Soils Clearance: Prepare TMF Area & Construct Bunds	18,960
C900	Contaminated Soils Clearance: Civil Works (13 weeks)	1,381,380
C1000	Contaminated Soils Clearance: Pumping and Cleaning (3 weeks)	91,800
C1100	Contaminated Soils Clearance: Capping Contaminated Soils on TMF (2 weeks)	58,320
	Sub-Total	**6,013,845**
D	**Secondary Clean-up (13 weeks)**	
	Replace Contaminated Soils: Civil Works (4 weeks)	
D400	Filling (excavation from on-site stockpiles, haulage to breach area,	1,571,340
D500	Ancillary works	330,000
	Sub-Total	**1,901,340**
E	**Environmental Consultancy & Monitoring (30 weeks)**	
E100	Consultancy and Laboratory Fees	**296,000**
F	**Project Management & Consultancy Fees (30 weeks)**	
F100	Project Management/Site Supervision	1,124,800
F200	Consultancy Fees	178,000
F300	Authority Charges	40,000
	Sub-Total	**1,342,800**
G	**River Blackwater Compensatory & Complementary Remediation**	
G100	Management Plan	8,500
G110	Ecosystem enhancement	85,000
G120	Habitat Protection	35,000
G130	Monitoring of sediments and riparian habitat	18,000
G140	Long term monitoring	120,000
G150	Fish Restocking	35,600
	Sub-Total	**293,600**

Table 3.8 Costs Summary

A	Initial Emergency Response (1	158,400
B	Breach Management (10	596,000
C	Primary Clean-up	6,013,845
D	Secondary Clean-up (10 weeks)	1,901,340
E	Environmental Consultancy &	296,000
F	Project Management &	1,342,800
G	Blackwater Compensatory & Complementary Remediation	293,600
	Sub-Total	10,601,985
	20% Contingency	2,120,397
	GRAND TOTAL	**12,722,382**

The plausible worst-case scenario has been identified as a breach of the tailings storage facility embankment.

- Risk 78: A TMF dam wall failure leading to a release of tailings and contained water Therefore, this is the risk to be costed as the 'worst case' scenario.

- The 'Worst Case' Scenario Financial Model Table is included in this report as Appendix II.
- The remediation cost of the worst-case scenario, including 20% contingency, is €12,500,616.

4.0 Financial Provision

Once the known and unknown environmental liabilities for the site have been identified, the facility must put in place appropriate financial provisions to cover such liabilities. The EPA Guidance on Financial Provision for Environmental Liabilities (2015), and the Additional guidance on environmental impairment liability insurance (2017) have been referred to in this section.

4.1 Requirements of Financial Provision

The main requirements for a financial provision are as follows

- Secure: The financial provision must be secure for the duration of the licensee's obligations (including in the event of insolvency) under a licence so that funds are available to discharge the licensee's obligations
- Sufficient: The financial provision must be sufficient to meet all of the licensee's obligations and must be adequate to cover the cost of closure and environmental liability risks - Available when required: The funds must be available to the EPA when required to discharge the licensee's obligations at the relevant time

4.2 Financial Provision Instrument Options

There are a number of mechanisms for making a financial provision, as follows:

- Secured fund: A secured fund with a first ranking fixed charge in favour of the EPA is suitable financial provision for all liabilities.
- On demand performance bond: Perpetual and on-demand performance bonds are suitable financial provision for all liabilities. This is provided that the failure, on expiry, to renew or replace the bond with alternative financial provision is a drawdown event.
- Parent company guarantee: A parent company guarantee is a suitable financial provision for most liabilities. It is not suitable to cover inevitable closure costs.
- Charge on Property: A first ranking fixed charge on property in favour of the EPA suitable financial provision for all liabilities. However only certain percentage of the property's value may be used towards the satisfaction of the licensee's financial provision obligations
- Insurance: Environmental impairment liability insurance is suitable financial provision for potential liability from incidents arising on sites. This is provided the policy wording is acceptable to the EPA.

4.2.1Environmental Impairment Liability Insurance

Tara Mines achieves its financial provision obligations with respect to environmental liabilities through the environmental impairment liability insurance mechanism.

As such Tara Mines undertakes to ensure that the insurance meets the requirements as set out in Section 4.6 of the financial provision guidance, as follows:

a) Responds to environmental and pollution loss and damage in accordance with the Environmental Liability Directive;

b) responds to the release of pollutants, howsoever occurring;

c) Expressly provides for retroactive cover in respect of the operation of the licensed facility (effective from the original licence grant date of the licensed facility);

d)Extends coverage to the EPA as a named insured and loss payee under the policy, in the event that:

- the licensee policyholder becomes insolvent or bankrupt during the policy period; or
- the licensee policyholder is deceased; or c. the circumstances identified in part (v)(b) below arise;

e) In the event of a pollution event or in circumstances where the EPA has exercised its right to incur clean-up costs:

- does not prevent or restrict the EPA from notifying the insurer of a claim that the EPA has against the licensee policyholder at the same time as the EPA gives notice of that claim to the licensee policyholder; and
- requires the insurer, where pursuant to paragraph (a) the EPA has notified the insurer of a claim but the licensee policyholder has failed to notify the insurer of that claim, to accept receipt of and respond to the EPA's notice of claim as though it was a notice of claim given by and received from the licensee policyholder or the EPA itself was a named insured under the policy;

f) Requires, as a condition of making a policy application, that the licensee has disclosed to the insurer a copy of the approved ELRA report submitted in respect of the licensed facility. This is to be included as part of a schedule of disclosed information also to be required by the insurer;

g) requires, as a pre-condition to the policy taking effect, that the insurer has received payment of all premia for the policy, evidence of which must be provided by the insurer to the EPA as a pre-condition to the licence taking effect, and to the licensee's operation of the licensed facility commencing;

h) requires that the licensee policyholder and the insurer give the EPA not less than sixty (60) days' notice in writing of any policy cancellation; and

i) ring-fences the policy limits to the licensee's operation of the licensed facility having regard to the risk values identified in the licensee's ELRA report.

4.2.2 Known Environmental Liabilities

The known environmental liabilities associated with the site closure, aftercare and maintenance is covered in the site's Closure, Remediation and Aftercare Management Plan.

4.2.3 Unknown Environmental Liabilities

The estimated cost of unknown liabilities relating to the site in the ELRA (Worst Case Scenario – Major Dam Breach), including a contingency, is €12,514,062.

Appendices

Appendix I Risk Register / Risk Assessment Worksheets

Area: Aboveground Processing
Phase: Operational Phase

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
1	Ore Storage	Negligible	N/A	N/A	N/A	N/A	N/A
2	Ore grinding (transfer drain pipeline between AG mill building to old mill building)	Leak in underground drains - drain is partially buried	Contamination of surface water, groundwater and soil	1	4	Underground line only used during mill shut down (typically once a month)	4
3	Ore grinding (AG mill building - 2 sumps)	Leak in the sumps	Contamination of surface water, groundwater and soil	2	3	Medium likelihood of leaks from sumps	6
4	Process lines from AG mill building to old mill building - 3 lines (2 slurry, 1 water)	Leak from aboveground transfer pipelines	Contamination of surface water drainage pond	2	4	High likelihood of a small leak – occurs regularly	8

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
5	Old mill building (2 sumps)	Leak in the sumps or sump overflow	Contamination of surface water, groundwater and soil	2	3	Medium likelihood of leaks or overflow from sumps	6
6	Cyanide storage and make-up outside old mill building	System leaks	Toxic chemical to environment	3	2	System comprises fully welded lines	6
7	Reagents storage and make-up in old mill building	Leaks within the building and potentially getting into the sump	Contamination of surface water, groundwater and soil	2	3	Medium likelihood of leaks or overflow from sumps	6
8	Floatation (process is within old mill building)	Leak in the sumps or sump overflow	Contamination of surface water, groundwater and soil	2	3	Medium likelihood of leaks or overflow from sumps	6
9	Zinc Leaching	Shut down since 2010	N/A	N/A	N/A	N/A	N/A
10	Sulphuric acid Storage	Not used in process since 2011	N/A	N/A	N/A	N/A	N/A
11	Refloatation	Leak from overground process pipe or bund and/or sump	Contamination of surface water and groundwater	2	4	High likelihood of line leak occurring	8
12	Lead Thickener	Leak from thickener tank	Contamination of groundwater	3	2	Low likelihood of leak occurring	6

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
13	Lead Thickener	Leak from thickener tank	Contamination of surface water	2	2	Low likelihood of leak occurring - leaks would be easily identified	4
14	Zinc Thickener	Leak from overground process line from refloatation (approx. 30m)	Potential leak to surface water and groundwater	2	4	High likelihood of leak occurring	8
15	Zinc Thickener	Leak from thickener tank	Contamination of groundwater	3	2	Low likelihood of leak occurring	6
16	Zinc Thickener	Leak from thickener tank	Contamination of surface water	2	2	Low likelihood of leak occurring - leaks would be easily identified	4
17	Filtering - Lead	Leak from line to filter press	Contamination of ground from the sump	2	3	Medium likelihood of a leak from the line/sump	6
18	Filtering - Zinc	Leak from line to filter press	Contamination of ground from the sump	2	3	Medium likelihood of a leak from the line/sump	6
19	Water generated during filtering	Leak from line back to thickeners	Contamination of surface water	2	3	Medium likelihood of a leak from the line/sump	6

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
20	Concentrate load out	Generation of dusts	Air pollution	1	4	High likelihood of emission exceedence (however not occurred to date)	4
21	Backfill to mine - two pipelineslines to two separate boreholes	Leak from transfer line	Contamination of surface water and groundwater	2	5	Very high likelihood of leak occurring in the line	10
22	Backfill mixing	Leak from mixing tank	Contamination of surface water	2	3	Medium likelihood of a leak from the mixing tank/sump	6
23	Water Treatment Plant (lamella)	Underground leak from supply pipeline and product pipelines to reclaim pond or clear water pond	Contamination of groundwater	2	3	Medium likelihood of a leak - newly constructed plant	6
24	Water Treatment Plant	Leak from plant equipment	Contamination of surface water	1	3	Medium likelihood of a leak	3

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
25	Water Treatment Plant	Underground leak from treatment plant sludge line (approx. 1km) to mills tailing box	Contamination of groundwater	2	3	Medium likelihood of a leak - newly constructed plant	6
26	Flocculent supply and return lines from mill to lamella plant	Underground leak of flocculent	Contamination of groundwater	2	3	Medium likelihood of a leak - newly constructed plant	6
27	Clear water pond discharge to River Boyne	Water in Clear Water Pond not within permissible discharge limits.	Contamination of surface water	3	2	Low likelihood of water in Clean Water Pond not meeting discharge limits	6

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
28	Pumping of tailings to Randalstown TMF	Line leak	Contamination of surface water, groundwater and soil	4	5	• Previous leaks have occurred at joints due to temperature changes at exposed length of pipeline - this pipeline section has subsequently been covered - approx. 3m section) • Occurs once every 5 years on average	20
29	Pumping of reclaim water from TMF to reclaim pond sump	Line leak	Contamination of surface water, groundwater and soil	2	4	•Previous leaks have occurred at joints due to temperature changes at exposed length of pipeline - this section of pipeline has subsequently been covered - approx. 3m section) • Occurs once every 5 years on average • Gravity flow system has reduced likelihood	8

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
30	Ionising Radiation Units	Nuclear density gauges x 2 containing radioactive material	Potential leak of radioactive material to environment	2	2	Low likelihood of leak occurring	4

Area: Processing Departement
Phase: Decommissioning

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
31	Cleaning of buildings and plant during decommissioning	Loss of containment of ore concentrates, fuels, chemicals, wash water etc. during decommissioning clean-down	Contamination of surface water, groundwater, soil and air (demolition)	2	4	High likelihood of spills occurring during decommissioning	8
32	Decommissioning activities using heavy machinery	Leak from equipment and aboveground lines due to potential damage during decommissioning	Contamination of surface water, groundwater and soil	2	4	Significant potential for disturbance/damage of site facilities during decommissioning	8

Area: Other Surface Facilities
Phase: Operational Phase

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
33	Transport of chemicals and explosives	Leak/spillage	Contamination of surface water and groundwater	1	5	Small spillages occur on a regular basis	5
34	Storage and transfer of fuels	Leak/spillage of diesel, hydraulic oil etc.	Contamination of surface water, groundwater and soil	2	5	Very high likelihood of hazard occurring especially during transportation around site.	10
35	Disposal of wastes generated during operation via waste contractors	Mismanagement of waste by contractor	Contamination of surface water, groundwater and soil	3	2	Low likelihood of hazard occurring	6
36	Hazardous Waste storage area	Leak/spillage	Contamination of surface water, groundwater and soil	2	4	Occurs occasionally	8
37	Processes with the potential for small Fire	Ignition of Fuels/chemicals	• Fire water generation - can potentially lead to contamination of surface water, groundwater and soil • Air pollution	1	3	Medium likelihood of hazard occurring	3

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
38	Processes with the potential for large Fire	Ignition of Fuels/chemicals	• Fire water generation - can potentially lead to contamination of surface water, groundwater and soil • Air pollution	2	3	Medium likelihood of hazard occurring	6
39	Onsite water systems - ponds	Leak/seepage from ponds	Contamination of groundwater	3	3	Medium likelihood of a leak from ponds	9
40	Onsite water systems - ponds	Overflow of ponds during storm events	Contamination of surface water, groundwater and soil	2	4	High likelihood of hazard occurring - has occurred previously	8
41	Sewage Treatment plant	Leak or overflow from plant	Contamination of surface water	3	3	Medium likelihood of hazard occurring	9
42	Landfill	Leaching of historical deposits	Contamination of surface water, groundwater and soil	4	4	High likelihood of hazard occurring	16
70	Bulk Fuel Farm	Leak of fuel from bulk fuel farm tanks and associated pipework	Contamination of surface water, groundwater and soil	4	2	Low likelihood of risk occurring	8
71	Bulk Fuel Farm	Leak or spill during delivery of fuel to bulk fuel farm	Contamination of surface water, groundwater and soil	4	2	Low likelihood of risk occurring	8

Area: Other Surface Facilities

Phase: Decommissioning Phase

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
43	Disposal of wastes generated during decommissioning by waste contractors	Mismanagement of waste by contractor	Contamination of surface water, groundwater and soil	3	2	Low likelihood of hazard occurring	6
72	Electrical Substation	Leak or spill of oil from transformers	Contamination of surface water, groundwater and soil	4	1	Low likelihood of risk occurring	

Area: Underground Mine Areas
Phase: Operational Phase

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
44	Blasting	Leak/spillage of explosive emulsion	Mine water contamination	1	5	Occurs regularly in the mine	5

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
45	Blasting	Residual explosive emulsion in mine area after detonation (incomplete usage)	Mine water contamination	1	5	Normal operation	5
46	Blasting	Generation of fumes	• Air pollution - Ventilation of $H_2S/NO_2/NH_4/SO_2$ gas • Odour	1	5	Normal operation	5
47	Blasting	Blast Vibration	• Property Damage	3	1	• Good blast design • Within IEL Limits	3
48	Blasting	Blast Vibration	• Nuisance (noise)	1	5	• Good blast design • Within IEL Limits	5
49	Bolting	Leak/Spillage of Resin/cement used for securing bolts	Mine water contamination	1	4	Normal operation	4
50	Shotcrete	Leak/Spillage of shotcrete in mine	Mine water contamination	1	5	Normal operation	5
51	Backfill	• Leak as backfill enters the mine • Leak of excess backfill material out of the scope	Contamination of mine water	1	5	Normal operation	5

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
52	Dewatering during operation	Dewatering aquifer	Medium term loss of water supply in domestic wells	2	5	Has occurred	10
53	Primary Crushing	Dust generation	No significant potential environmental impact identified	1	5	Normal operation	5
54	Large Mine Fire	Leak/spillage at fuel bays. Ignition of flammable machinery parts - e.g. tyres/hydraulic oil	• Mine water contamination	2	3	Large fire in mine in 1997, 1999 and 2014	6
55	Large Mine Fire	Leak/spillage at fuel bays. Ignition of flammable machinery parts - e.g. tyres/hydraulic oil	• Air pollution - Generation of smoke/odour from return air exits including ethyl mercaptan • Odour	2	3	Large fire in mine in 1997, 1999 and 2014	6

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
56	Hazardous Chemical Storage and Use	Leak/spillage form transfer pipeline of Diesel/hydraulic oil/engine oil from aboveground to fuel bays in mine	Mine water contamination	2	5	Small leaks occur regularly.	10
57	Hazardous Chemical Storage and Use	Potential leak from fuel bay/explosive emulsion bay	Mine water contamination	2	5	• Leaks in storage areas occur periodically in the mine.	10
58	Use of hydrocarbons and chemicals underground	Leak of diesel/hydraulic oil from mobile and fixed equipment used during drilling, mucking etc. (potential of approx. 250 litre max. leak from any equipment item)	Mine water contamination	1	5	Small leaks from underground equipment occur regularly.	5
74	Exploration Drilling	Generation of Methane fumes	Air Pollution - Ventilation of Methane gas	1	2	Normal operations. Low likelihood of risk occurring	2

Area: Underground Mine Areas
Phase: Decommissioning Phase

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
59	Rewatering during decommissioning	Change to underground hydrogeology	Adverse Hydrogeological impact	1	5	Rewatering will occur during decommissioning	5
60	Rewatering during decommissioning	Dissolution of contaminants in recharged water	Groundwater contamination	3	3	It is considered that this is likely to occur during decommissioning	9

NEW BOLIDEN

Area: Water Lines
Phase: Operational Phase

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
61	Line for normal mine water from the underground mine to mine water pond	Leak from line	Contamination of surface water, groundwater and soil	1	5	Very high likelihood of leaks from long-term site pipelines	5
62	Line from the underground mine for "clean" water for direct discharge to the River Blackwater	Leak from line	N/A as water quality sufficiently good for direct discharge	1	3	Medium likelihood of new pipeline leak	3
63	Line from the TMF to sump at Reclaim pipeline	Leak from line	Contamination of surface water, groundwater and soil	2	4	• High likelihood of leaks from long-term site pipelines• Gravity flow system has reduced likelihood	8
64	Line from the surface drainage pond (Kells road) to sump at Reclaim pump house	Leak from line	Contamination of surface water, groundwater and soil	2	4	• High likelihood of leaks from long-term site pipelines • Has not occurred previously.	8

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
65	Line from the site to surface drainage pond (Kells road)	Leak from line	Contamination of surface water, groundwater and soil	2	4	• High likelihood of leaks from long-term site pipelines • Has not occurred previously. Gravity flow system	8
66	Line from the River Boyne to firewater pond	Leak from line	N/A as contents consist of clean river water	1	4	High likelihood of leaks from long-term site pipelines	4
67	Line from the clear water pond to the Boyne	Leak from line	N/A as Water discharged under strict IEL discharge limits	1	4	• High likelihood of leaks from long-term site pipelines • Gravity flow	4
68	Line from onsite surface drainage pond to the mill tailings box	Leak from line	Contamination of surface water, groundwater and soil	2	3	• Medium likelihood of new pipeline leak • Pipe installed in 2014 – made of PE	6

Area: Water Lines
Phase: Decommissioning Phase

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
69	Decommissioning activities using heavy machinery - potential excavation	Leak from underground lines due to potential damage during decommissioning	Contamination of surface water, groundwater and soil	2	5	Significant amount of underground pipeline at site with high likelihood of disturbance/damage during decommissioning	10

Area: Tailings Management Facility
Phase: Operational Phase

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
75	Tailings deposition	Negligible – tailings contained within active dam	N/A – localised to within the active cell	N/A	N/A	N/A	N/A
76	Tailings Dehydration	Dusting of tailings surface with fallout on adjacent land	• Contamination of agricultural products/grassland • Contamination of soils • Contamination of surface water • Ingestion of contaminated vegetation by livestock	3	2	Monitoring records results	6

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
77	TMF operation	Overtopping (no dam wall failure)	• Tailings pond water impacts to local land / soils • Pond water seepage into soils • Pond water release to surface water bodies	3	2	• TSF classified as a 'perimeter dam' – no external water flows in. Freeboard of 1m maintained during operation • Alarms on ABB (process control system) system monitoring the height of the freeboard	6
78	TMF operation	Dam wall failure with release of tailings and contained water	• Tailings solids impacts to local land / soils • Contained water seepage into soils • Contained water release to surface water bodies	5	2	• Refer to Golder Dam Breakout Study • External Emergency Plan in Place with Local Competent Authority (Meath County Council, An Garda Siochana and the Health Service Executive)	10
79	TMF operation	Seepage (groundwater contamination)	Groundwater quality impact	2	5	Seepage is known to occur • Refer to 'Risk Screening and technical Report't to demonstrate the TMF site's compliance with the Groundwater Regulations	10
80	TMF operation	Groundwater seepage into surface water – yellow river	Surface water quality impact (and macroinvertibrates	2	5	•The seepage-to-surface water exists. • Refer to 'Risk Screening and technical Report't to demonstrate the TMF site's compliance with the Groundwater Regulations	10

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
81	TMF Operation	Power failure leading to overtopping of interceptor channel	Tailings pond water impacts to local land / soils • Pond water seepage into soils • Pond water release to surface water bodies	2	3	• Alarms on ABB (process control system) system monitoring the water level in the interceptor channel • IEL Condition to provide and maintain a standby pump at the TMF to provide backup water pumping capacity in the occurrence of an emergency and to maintain a back-up power supply for the standby pump at the TMF.	6
82	TMF Operation	Spill or leak from tailing pipeline within TMF boundary	Contamination of surface water, groundwater and soil	2	4	• Occurs once every 10 years on average	8
83	TMF Operation	Spill or leak from reclaim pipeline within TMF boundary	Contamination of surface water, groundwater and soil	2	4	• Occurs once every 10 years on average	8

Area: Tailings Management Facility
Phase: Decommissioning Phase

Risk ID	Process	Potential Hazards	Environmental Effect	Severity Rating	Likelihood Rating	Basis of Likelihood (including current controls)	Risk Rating
84	TMF post-closure	Dam wall failure with release of tailings and pond water	• Tailings solids impacts to local land / soils • Limited pond water seepage into soils • Minimal amount of pond water release to surface water bodies	4	2	Refer to Golder Dam Breakout Study • External Emergency Plan in Place with Local Competent Authority (Meath County Council, An Garda Siochana and the Health Service Executive)	8
85	TMF post-closure	Seepage (groundwater contamination)	Groundwater quality impact	2	3	The plume exists CRAMP has provided for active post-closure monitoring	6
86	TMF post-closure	Seepage subsequently manifested as surface flow	Surface water quality impact	3	2	The seepage-to-surface water exists. CRAMP has provided for active post-closure monitoring	6

Appendix II Costing Worst case scenario: TSF Breach.

Scenario:
Breach of the TSF Stage 5 embankment

- Southeast corner of the Stage 5B Embankment Wall
- Breach from Stage 5b crest, 1594 mAMD to elevation of perimeter road, 1576 mAMD.
- Dam Wall Breach Dimensions = 40.2 m average, 1(H):1(V) side slopes
- Dam Wall Volume = 32,200 m^3 of fill
- Discharge Volume = 1,834,000 m^3 comprising solids of 1,278,000 m^3, supernatant cap water of 250,000 m^3 and supernatant rainy-day water from a 24-hr 10,000-year event of 306,000 m3
- Downstream Flood Plain = 570 hectares (based on total impacted area)
- Contaminated Soils = 456,000 m^3 (based on "test and replace" approach with allowance for alternative treatment options ranging from replacing 300 mm depth of soil (15% allowance, remove sod only and replace with 100 mm topsoil (35% allowance) and plough ground and reseed (50% allowance).
- Note that this strategy takes into account, the largely inert nature of the Tara tailings stream.

Rehabilitation:

- Repair the dam wall breach, pump contaminated water and haul tailings (816,000 m^3) and contaminated material (552,800 m^3) back to the TMF.
- Prepare area within existing TMF for deposition of recovered tailings and impacted soils.
- Construct a perimeter containment berm around the designated footprint to contain the contaminated soils to be hauled back to TMF.
- The contaminated soils shall be hauled, placed and graded to a shallow gradient (approx. 2 degrees) on the Main TMF and capped with a minimum 300 mm depth of clean, inert soil material sourced from the capping material stripped. It is assumed that 25% of the contaminated soils will need to be replaced by inert soil imported to site.

Table I Table of expenditure

Item	Description	Unit	Quantity	Rate	€
A	**Initial Emergency Response (1 week)**				
A100	**Consultancy Fees**				
A110	Site Inspection (2 x Senior Consultants for 2 days)	day	4.0	1,500.00	6,000
A120	Aerial Drone Surveys	sum	1.0	4,000.00	4,000
A130	Meetings with EPA, NPWS, MCC, IFI, DECC: (2 x Senior Consultants for 3 days)	day	6.0	1,500.00	9,000
A140	Provision of an ATTENDANT PERSON	day	7.0	800.00	5,600
A150	Design Report, Specification and CQA Plan	sum	1.0	20,000.00	20,000
	Sub-Total				**44,600**
A200	***Specialist Contractor Charges***				
A210	Contractor Crew and Plant (8 man crew)	day	7.0	4,000.00	28,000
A220	Temporary Works (Security Fencing, Ramps, Pumps, Pipes, Drainage, Signage, Traffic Signals, Lights and Generators)	day	7.0	2,000.00	14,000
A230	Security	day	7.0	400.00	2,800
	Sub-Total				**44,800**
A300	***Authority Charges***				
A310	Fire Brigade (2 x crews @ € 500 / hour x 48 hrs)	hr	96.0	500.00	48,000
A320	Garda (provisional sum)	sum	1.0		0
A330	EPA (3 persons for 5 days)	day	15.0	1,000.00	15,000
A340	Department of Environment, Climate & Communications) DECC (2 persons for 3 days)	day	6.0	1,000.00	6,000
	Sub-Total				**69,000**
				Page Total Carried to Summary	**158,400**
B	**Breach Management (10 weeks)**				
B100	**Consultancy Fees**				
B110	Site Visits and Meetings (1 x Senior Consultants for 20 days)	day	20.0	1,500.00	30,000
B120	Meetings with EPA, NPWS, MCC, IFI, DECC, etc. (1 x Senior Consultants for 6 days)	day	6.0	1,500.00	9,000
B130	Provision of 1 x ATTENDANT PERSONS	day	60.0	800.00	48,000
	Sub-Total				**87,000**

Item	Description	Unit	Quantity	Rate	€
B200	***Specialist Contractor Charges***				
B210	Contractor Crew and Plant (4 man crew)	day	60.0	2,000.00	120,000
B220	Temporary Works (Security Fencing, Ramps, Pumps, Pipes, Drainage, Signage, Traffic Signals, Lights and Generators)	day	60.0	1,500.00	90,000
B230	Temporary Water Management in immediate breach area (Settlement Ponds, Filtration Berms, Sediment Catch Fences, Stream Diversions, Basic Treatment Systems, etc.). Provisional Sum	sum	1.0	150,000	150,000
B240	Temporary Water Management in Blackwater / Yellow River confluence area (Settlement Ponds, Filtration Berms, Sediment Catch Fences, Stream Diversions, Basic Treatment Systems, etc.). Provisional Sum	sum	1.0	100,000	100,000
B250	Security	day	60.0	400.00	24,000
	Sub-Total				**484,000**
B300	***Authority Charges***				
B310	EPA (3 persons for 5 days)	day	15.0	1,000.00	15,000
B320	DECC (2 persons for 5 days)	day	10.0	1,000.00	10,000
	Sub-Total				**25,000**
				Page Total Carried to Summary	**596,000**
C	**Primary Clean-up**				
TMF Repair: Civil Works (1 to 2 weeks)					
C100	**Fill Materials**				
C110	Rock Fill (0mm to 300 mm)	m3	31000.0	7.00	217,000
C120	Rock Fill (0mm to 20 mm)	m3	1200.0	14.00	16,800
	Sub-Total				**233,800**
C200	**Filling**				
C210	Articulated Dump Truck - 25 tonne to 30 tonne	hr	280.0	85.00	23,800
C220	Articulated Dump Truck - 25 tonne to 30 tonne	hr	280.0	85.00	23,800
C230	Articulated Dump Truck - 25 tonne to 30 tonne	hr	280.0	85.00	23,800
C240	Tracked Excavator - 17 tonne to 21 tonne	hr	280.0	85.00	23,800
C250	Tracked Excavator - 25 tonne to 30 tonne	hr	280.0	85.00	23,800
C260	Vibratory Tandem Roller - 9 tonne to 12 tonne	hr	280.0	60.00	16,800
C270	General Operative	hr	280.0	45.00	12,600

Item	Description	Unit	Quantity	Rate	€
C280	General Operative	hr	280.0	45.00	12,600
C290	Civil Foreman	hr	280.0	56.00	15,680
	Sub-Total				**176,680**
C600	**Tailings and Dam Wall Materials Clearance: Civil Works (37 weeks)**				
C610	15 x Articulated Dump Truck - 25 tonne to 30 tonne	hr	32,325.0	85.00	2,747,625
C620	2 x Tracked Excavator - 25 tonne to 30 tonne	hr	4,310.0	85.00	366,350
C630	2 x Tracked Excavator - 30 tonne to 38 tonne	hr	4,310.0	90.00	387,900
C640	1 x Long Reach Tracked Excavator - 25 tonne to 30 tonne (for cleaning base and edge of Blackwater River) (assume 8 weeks)	hr	480.0	120.00	57,600
C650	2 x Eight Wheeler Road Trucks (hauling from Blackwater cleanup to TMF (assume 8 weeks)	hr	480.0	110.00	52,800
C660	2 x General Operatives	hr	4,310.0	45.00	193,950
C670	Civil Foreman	hr	2,155.0	56.00	120,680
	Sub-Total				**3,926,905**
				Total Carried to Summary	**4,337,385**
C700	**Tailings and Dam Wall Materials Clearance: Pumping (6 weeks)**				
C710	Contractor Crew and Plant (4 man crew)	day	36.0	2,000.00	72,000
C720	Pumps and pipe rental	day	36.0	1,500.00	54,000
	Sub-Total				**126,000**
C800	**Contaminated Soils Clearance: Prepare TMF Area & Construct Bunds (1 week)**				
C810	1 x Dozer	hr	60.0	90.00	5,400
C820	2 x Tracked Excavator- 25 tonne to 30 tonne	hr	120.0	85.00	10,200
C650	Civil Foreman	hr	60.0	56.00	3,360
	Sub-Total				**18,960**
C900	**Contaminated Soils Clearance: Civil Works (13 weeks)**				
C910	15 x Articulated Dump Truck - 25 tonne to 30 tonne	hr	11,700.0	85.00	994,500

NEW BOLIDEN

Item	Description	Unit	Quantity	Rate	€
C920	2 x Tracked Excavator - 25 tonne to 30 tonne	hr	1,560.0	85.00	132,600
C930	2 x Tracked Excavator - 30 tonne to 38 tonne	hr	1,560.0	90.00	140,400
C940	2 x General Operatives	hr	1,560.0	45.00	70,200
C950	Civil Foreman	hr	780.0	56.00	43,680
	Sub-Total				**1,381,380**
C1000	**Contaminated Soils Clearance: Pumping and Cleaning (3 weeks)**				
C1010	Contractor Crew and Plant (4 man crew)	day	18.0	2,000.00	36,000
C1020	Pumps and pipe rental	day	18.0	1,500.00	27,000
C1030	2 x Vacuum Tanker	day	18.0	800.00	14,400
C1040	2 x Jet Washer	day	18.0	800.00	14,400
	Sub-Total				**91,800**
C1100	**Contaminated Soils Clearance: Capping Contaminated Soils on TMF (2 week)**				
C1110	1 x Dozer	hr	120.0	90.00	10,800
C1120	2 x Tracked Excavator- 25 tonne to 30 tonne	hr	240.0	85.00	20,400
C1130	2 x Articulated Dump Truck - 25 tonne to 30 tonne	hr	240.0	85.00	20,400
C1140	Civil Foreman	hr	120.0	56.00	6,720
	Sub-Total				**58,320**
				Total Carried to Summary	**1,676,460**
D	**Secondary Clean-up (10 weeks)**				
	Replace Contaminated Soils: Civil Works (4 weeks)				
D400	**Filling (excavation from on site stockpiles, haulage to breach area, replacement of contaminated soils removed) (13 weeks for main earthworks contract with a further 4 weeks for levelling of topsoil, seeding etc.)**				
D410	15 x Articulated Dump Truck - 25 tonne to 30 tonne	hr	11,700.0	85.00	994,500
D420	2 x Tracked Excavator - 25 tonne to 30 tonne	hr	1,560.0	85.00	132,600
D430	2 x Tracked Excavator - 30 tonne to 38 tonne	hr	1,560.0	90.00	140,400
D440	1 x Dozer	hr	780.0	90.00	70,200
D450	2 x 4WD Tractors with harrows, seeding attachments	hr	480.0	50.00	24,000
D460	2 x General Operatives	hr	1,560.0	45.00	70,200

NEW BOLIDEN

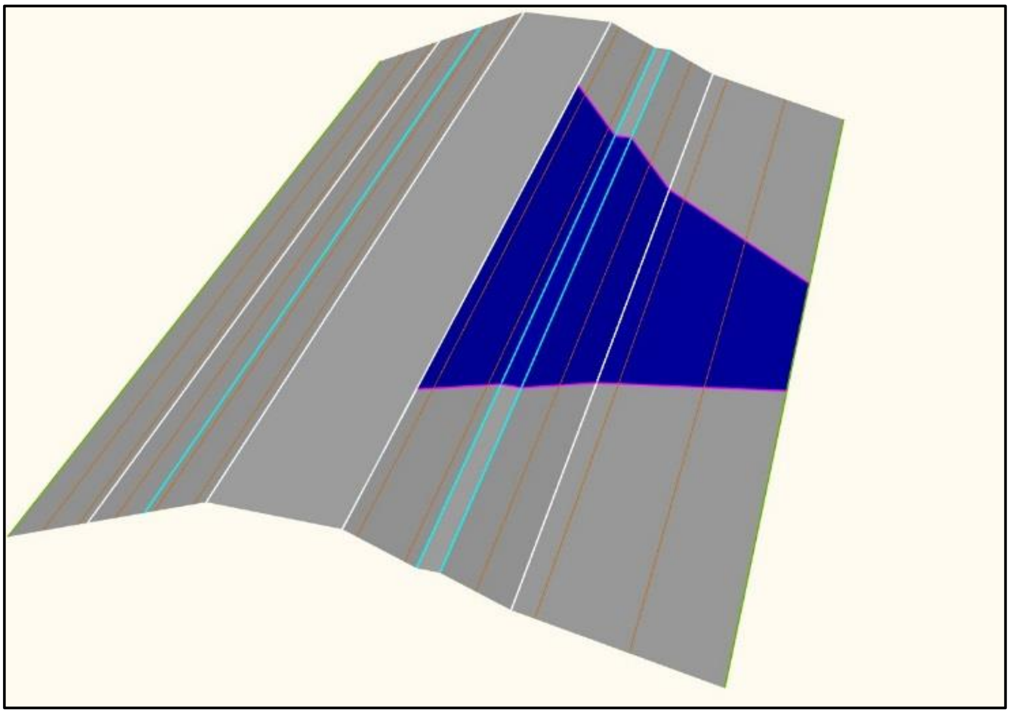
Item	Description	Unit	Quantity	Rate	€
D470	Civil Foreman	hr	780.0	56.00	43,680
D480	Provision of grass seed over 570 ha impacted area	ha	570.0	168.00	95,760
	Sub-Total				**1,571,340**
D500	**Ancillary works**				
D510	Repair/reconstruct house at Households 9 (including rental of alternative accommodation for construction)	sum	1.0	300,000.00	300,000
D520	Repairs to Perimter Channel, Pumps, Instrumentation	sum	1.0	20,000.00	20,000
D530	Repairs to Security Fencing, Access Roads etc.	sum	1.0	10,000.00	10,000
	Sub-Total				**330,000**
				Total Carried to Summary	**1,901,340**
E	**Environmental Consultancy & Monitoring (30 weeks)**				
E100	**Consultancy and Laboratory Fees**				
E110	EHS Consultant	hr	300.0	100.00	30,000
E120	Ecologist Consultant	hr	300.0	100.00	30,000
E130	Daily Inspections	hr	450.0	80.00	36,000
E140	Site Investigation and Sampling	sum	1.0	40,000	40,000
E150	Laboratory Testing	sum	1.0	100,000	100,000
E160	Reporting	sum	1.0	60,000	60,000
	Sub-Total				**296,000**
F	**Project Management & Consultancy Fees (30 weeks)**				
F100	**Project Management**				
F110	Project Manager	weeks	52.0	3,500.00	182,000
F120	Project Administration	weeks	30.0	3,000.00	90,000
F130	Project Prelims	weeks	52.0	14,000	728,000
F140	Security	day	312.0	400.00	124,800
	Sub-Total				**1,124,800**
F200	**Consultancy Fees**				
F210	Site Visits and Meetings (1 x Senior Consultants for 10 days)	day	10.0	1,500.00	15,000
F220	Meetings with EPA, NPWS, MCC, IFI, DECC: (1 x Senior Consultants for 6 days)	day	6.0	1,500.00	9,000

Item	Description	Unit	Quantity	Rate	€
F230	Provision of 1 x ATTENDANT PERSONS	day	180.0	800.00	144,000
F240	CQA Validation Report	sum	1.0	10,000.00	10,000
	Sub-Total				**178,000**
F300	***Authority Charges***				
F310	EPA (2 persons for 10 days)	day	20.0	1,000.00	20,000
F320	DECC (2 persons for 10 days)	day	20.0	1,000.00	20,000
	Sub-Total				**40,000**
				Total Carried to Summary	**1,342,800**

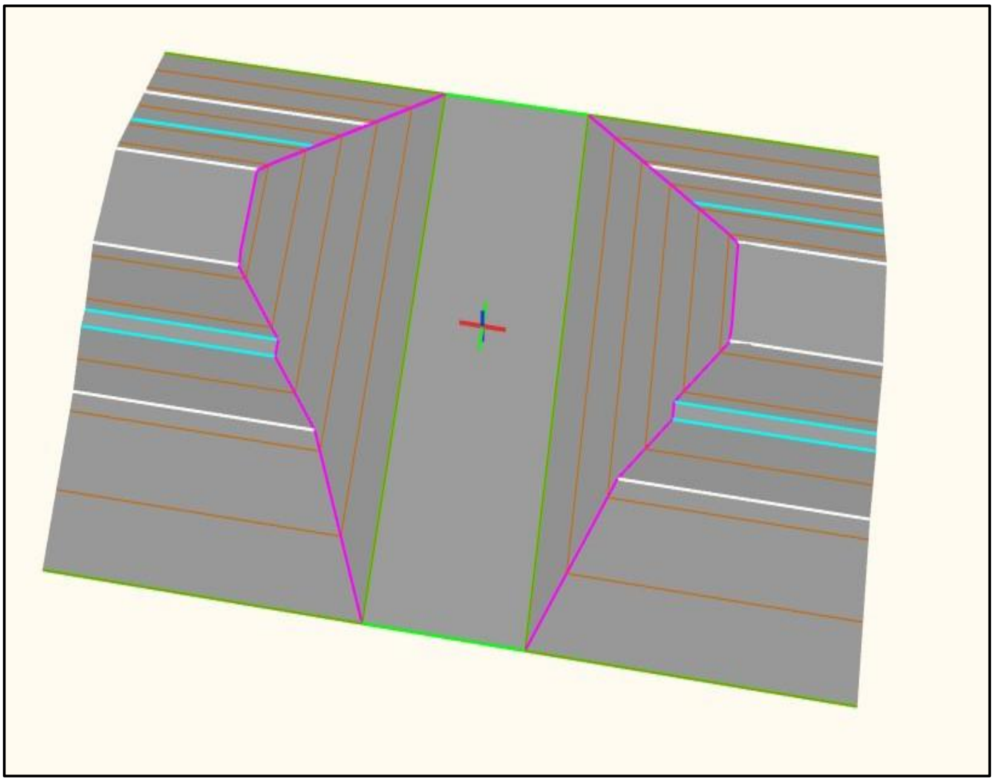
Item Nr	Description	Unit	Quantity	Rate	€
G	**River Blackwater Compensatory & Complementary Remediation**				
G100	Management Plan	#	1	8,500	8,500
G110	Ecosystem Enhancement	#	1	85,000.00	85,000
G120	Habitat Protection	#	1	35,000.00	35,000
G130	Monitoring of the sediment levels and habitats present basis of a period to verify these predictions	biannual	10[8]	1,800	18,000
G140	Long term) 10 year) post event monitoring	Annual	10	12,000	120,000
G150	Fish restocking	Annual	3	11,866	35,600
	Sub-Total				**293,600**

[8] 5-year post event

Summary		
A	Initial Emergency Response (1 week)	158,400
B	Breach Management (10 weeks)	596,000
C	Primary Clean-up	6,013,845
D	Secondary Clean-up (10 weeks)	1,901,340
E	Environmental Consultancy & Monitoring (30 weeks)	296,000
F	Project Management & Consultancy Fees (30 weeks)	1,342,800
G	Blackwater Compensatory & Complementary Remediation	293,600
	Total	**10,601,985**
	20% Contingency	**2,120,397**
	GRAND TOTAL	**12,722,382**



3D Model of TMF Breach Clean-out for Repair

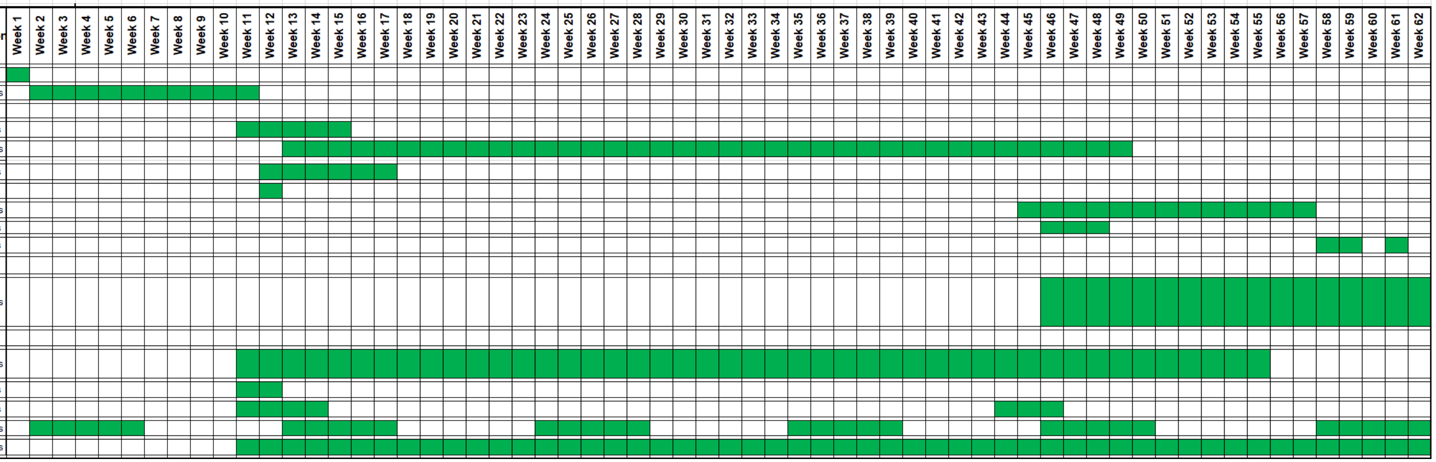


3D Model of Breach Slope Area

Appendix III Works Schedule

Remedial Works Schedule for Hypotethical Dam Breach Scenario on South Wall of Stage 5b

Item	Description	Duration
A	**Initial Emergency Response**	1 week
B	**Breach Management**	10 weeks
C	**Primary Clean-up**	
C100	TMF Repair: Civil Works	2 weeks
C600	Tailings and Dam Wall Materials Clearance: Civil Works	37 weeks
C700	Tailings and Dam Wall Materials Clearance: Pumping	6 weeks
C800	Contaminated Soils Clearance: Prepare TMF Area & Construct Bunds	1 week
C900	Contaminated Soils Clearance: Civil Works	13 weeks
C1000	Contaminated Soils Clearance: Pumping and Cleaning	3 weeks
C1100	Contaminated Soils Clearance: Capping Contaminated Soils on TMF	2 weeks
D	**Secondary Clean-up**	
D400	Filling (excavation from on site stockpiles, haulage to breach area, replacement of contaminated soils removed) (13 weeks for main earthworks contract with a further 4 weeks for levelling of topsoil, seeding etc.)	17 weeks
D500	Ancillary works	
D510	Repair/reconstruct house at Households 9 (including rental of alternative accomodation for construction)	45 weeks
D520	Repairs to Perimter Channel, Pumps, Instrumentation	5 weeks
D530	Repairs to Security Fencing, Access Roads etc.	4 weeks
E	**Environmental Consultancy & Monitoring**	30 weeks
F	**Project Management & Consultancy Fees**	52 weeks



Appendix IV Risk Treatment

Table ii Risk Treatment

Risk ID	Process	Potential Hazards	Risk Rating	'Statement of Measures'	Outcome	Actions	Schedule	Person Responsible
3	Ore grinding (AG mill building - 2 sumps)	Leak in the sumps	6	Sumps checked in accordance with IEL	Early identification of defects	Inspections	Weekly	Head of section: Processing
4	Process lines from AG mill building to old mill building - 3 lines (2 slurry, 1 water)	Leak from aboveground transfer pipelines	8	Sumps checked in accordance with IEL	Early identification of defects	Inspections	Weekly	Head of section: Processing
5	Old mill building (2 sumps)	Leak in the sumps or sump overflow	6	Sumps checked in accordance with IEL Intergity testing	Early identification of defects	Inspections Integrity test biannually	Weekly 2021	Head of section: Processing
6	Cyanide storage and make-up outside old mill building	System leaks	6	Sumps checked in accordance with IEL	Early identification of defects	Inspections	Weekly	Head of section: Processing

Risk ID	Process	Potential Hazards	Risk Rating	'Statement of Measures'	Outcome	Actions	Schedule	Person Responsible
7	Reagents storage and make-up in old mill building	Leaks within the building and potentially getting into the sump	6	Sumps checked in accordance with IEL Intergity testing	Early identification of defects	Inspections Integrity test biannually	Weekly Biannually due 2021	Head of section: Processing
8	Floatation (process is within old mill building)	Leak in the sumps or sump overflow	6	Sumps checked in accordance with IEL Intergity testing	Early identification of defects	Inspections Integrity test biannually	Weekly Biannually due 2021	Head of section: Processing
11	Re-floatation	Leak from overground process pipe or bund and/or sump	8	Leak identification	Early identification of defects	Inspections	Weekly	Head of section: Processing
12	Lead Thickener	Leak from thickener tank	6	Leak identification	Early identification of defects	Inspections	Weekly	Head of section: Processing
14	Zinc Thickener	Leak from overground process line from refloatation (approx. 30m)	8	Leak identification	Early identification of defects	Inspections	Weekly	Head of section: Processing

Risk ID	Process	Potential Hazards	Risk Rating	'Statement of Measures'	Outcome	Actions	Schedule	Person Responsible
15	Zinc Thickener	Leak from thickener tank	6	Leak identification Integrity testing	Early identification of defects	Inspections	Weekly Biannually due 2021	Head of section: Processing
17	Filtering - Lead	Leak from line to filter press	6	Leak identification	Early identification of defects	Inspections	Weekly	Head of section: Processing
18	Filtering - Zinc	Leak from line to filter press	6	Leak identification	Early identification of defects	Inspections	Weekly	Head of section: Processing

Risk ID	Process	Potential Hazards	Risk Rating	'Statement of Measures'	Outcome	Actions	Schedule	Person Responsible
21	Backfill to mine - two pipelineslines to two separate boreholes	Leak from transfer line	10	Leak identification	Early identification of defects	Inspections	Daily	Head of section: Processing
22	Backfill mixing	Leak from mixing tank	6	Leak identification	Early identification of defects	Inspections	Daily	Head of section: Processing
23	Water Treatment Plant (lamella)	Underground leak from supply pipeline and product pipelines to reclaim pond or clear water pond	6	Leak identification	Early identification of defects	Inspections	Daily	Head of section: Processing
25	Water Treatment Plant	Underground leak from treatment plant sludge line (approx. 1km) to mills tailing box	6	Leak identification	Early identification of defects	Inspections	Daily	Head of section: Processing

Risk ID	Process	Potential Hazards	Risk Rating	'Statement of Measures'	Outcome	Actions	Schedule	Person Responsible
26	Flocculent supply and return lines from mill to lamella plant	Underground leak of flocculent	6	Leak identification	Early identification of defects	Inspections	Daily	Head of section: Processing
27	Clear water pond discharge to River Boyne	Water in Clear Water Pond not within permissible discharge limits.	6	Leak identification	Early identification of defects	Inspections	Daily	Head of section: Processing
28	Pumping of tailings to Randalstown TMF	Line leak	20	Full upgrade of pipeline	Minimise likelihood of breach	Replace pipeline	2021/2022	Head of section: Processing
29	Pumping of reclaim water from TMF to reclaim pond sump	Line leak	8	Full upgrade of pipeline	Minimise likelihood of breach	Replace pipeline	2021/2022	Head of section: Processing

Risk ID	Process	Potential Hazards	Risk Rating	'Statement of Measures'	Outcome	Actions	Schedule	Person Responsible
34	Storage and transfer of fuels	Leak/spillage of diesel, hydraulic oil etc.	10	Leak identification	Early identification of defects	Inspections	Daily	Head of section: Fixed Plant
36	Hazardous Waste storage area	Leak/spillage	8	House keeping/daily inspection/keep storage to a minimum	Minimal quantities in storage	Daily inspection		Environmental Manager
39	Onsite water systems - ponds	Leak/seepage from ponds	9	Leak identification	Early identification of defects	Inspections	Daily	Head of section: Processing
40	Onsite water systems - ponds	Overflow of ponds during storm events	8	Storm water from off site stream divert	Reduce storm water requiring storage	Install divert	2021	Head of section: Processing
41	Sewage Treatment plant	Leak or overflow from plant	9	Connect to mains sewer	Illiminate all risk	Replace onsite treatment system	2021	Environmental Manager
42	Landfill	Leaching of historical deposits	16	Historical sludge and industrial deposits	Remove potential contaninants	Carryout Landfill remediation	2021	Environmental Manager
70	Bulk Fuel Farm	Leak of fuel	8	• Tanks are double-skinned • Pipework is protected Daily inspections	Early identification of defects	Inspections	Daily	Head of section: Fixed Plant

Risk ID	Process	Potential Hazards	Risk Rating	'Statement of Measures'	Outcome	Actions	Schedule	Person Responsible
54	Large Mine Fire	Leak/spillage at fuel bays. Ignition of flammable machinery parts - e.g. tyres/hydraulic oil	6	House keeping/daily inspection/keep storage to a minimum	Minimal quantities in storage	Daily inspection	Daily	Mine Manager
56	Hazardous Chemical Storage and Use	Leak/spillage form transfer pipeline of Diesel/hydraulic oil/engine oil from aboveground to fuel bays in mine	10	• Leak detection system on transfer lines. • Preventative and corrective clean up procedures in place • Visual inspection of pipelines in all fuel bays • Closed -loop surface site water management system • Integrity testing carried out on pipeline as per IEL conditions • Fuelling bays are bunded in accordance with EPA requirements	Early identification of defects	Inspections	Daily/Weekly/bi annually	Mine manager

Risk ID	Process	Potential Hazards	Risk Rating	'Statement of Measures'	Outcome	Actions	Schedule	Person Responsible
57	Hazardous Chemical Storage and Use	Potential leak from fuel bay/explosive emulsion bay	10	• Fuelling bays are bunded in accordance with EPA requirements • Bund integrity testing • All chemicals stored in bunded areas/bunded pallets • Visual inspection of pipelines in all fuel bays • Transport operations are manned and leaks would be immediately identified • Preventative and corrective clean up procedures in place • Closed-loop site surface water management system	Early identification of defects	Inspections	Daily/Weekly/bi annually	Mine manager
64	Line from the surface drainage pond (Kells road) to sump at Reclaim pump house	Leak from line	8	• Sub surface (offsite) • Any leaks in sub-surface section will be visible on the surface - • Approx. 1km in length				Head of section: Processing

Risk ID	Process	Potential Hazards	Risk Rating	'Statement of Measures'	Outcome	Actions	Schedule	Person Responsible
65	Line from the site to surface drainage pond (Kells road)	Leak from line	8	• Sub surface (offsite) • Any leaks in sub-surface section will be visible on the surface • Approx. 500m in length • Oil interceptor at exit of pond • Gravity flow system				Head of section: Processing
76	Tailings Dehydration	Dusting of tailings surface with fallout on adjacent land	6	Vegetation of beach areas	Minimise dudting	Rehabilitate omplete areas of stsge 5a	2021	Tailings Engineer
77	TMF operation	Overtopping (no dam wall failure)	6	Maintain freeboard	Minimise risk	Daily review of ABB system	Daily	Head of section: Processing
78	TMF operation	Dam wall failure with release of tailings and contained water	10	Continuous monitoring	Early identification of issues	Carryout all IEL monitoring and measuring	Daily/Weekly/Annually	Tailings Engineer
79	TMF operation	Seepage (groundwater contamination)	10	• Groundwater monitoring programme in place.	Early identification of issues	Carryout all IEL monitoring and measuring	Daily/Weekly/Annually	Env Manager. Tailings Engineer
81	TMF Operation	Power failure leading to overtopping of interceptor channel	6	• Standby generator on call • External emergency plan in place with statutory stakeholders.	Backup in place			Tailings Engineer

Risk ID	Process	Potential Hazards	Risk Rating	'Statement of Measures'	Outcome	Actions	Schedule	Person Responsible
82	TMF Operation	Spill or leak from tailing pipeline within TMF boundary	8	Leak identification	Early identification of defects	Inspections	Daily	Tailings Engineer
83	TMF Operation	Spill or leak from reclaim pipeline within TMF boundary	8	Leak identification	Early identification of defects	Inspections	Daily	Tailings Engineer

END.