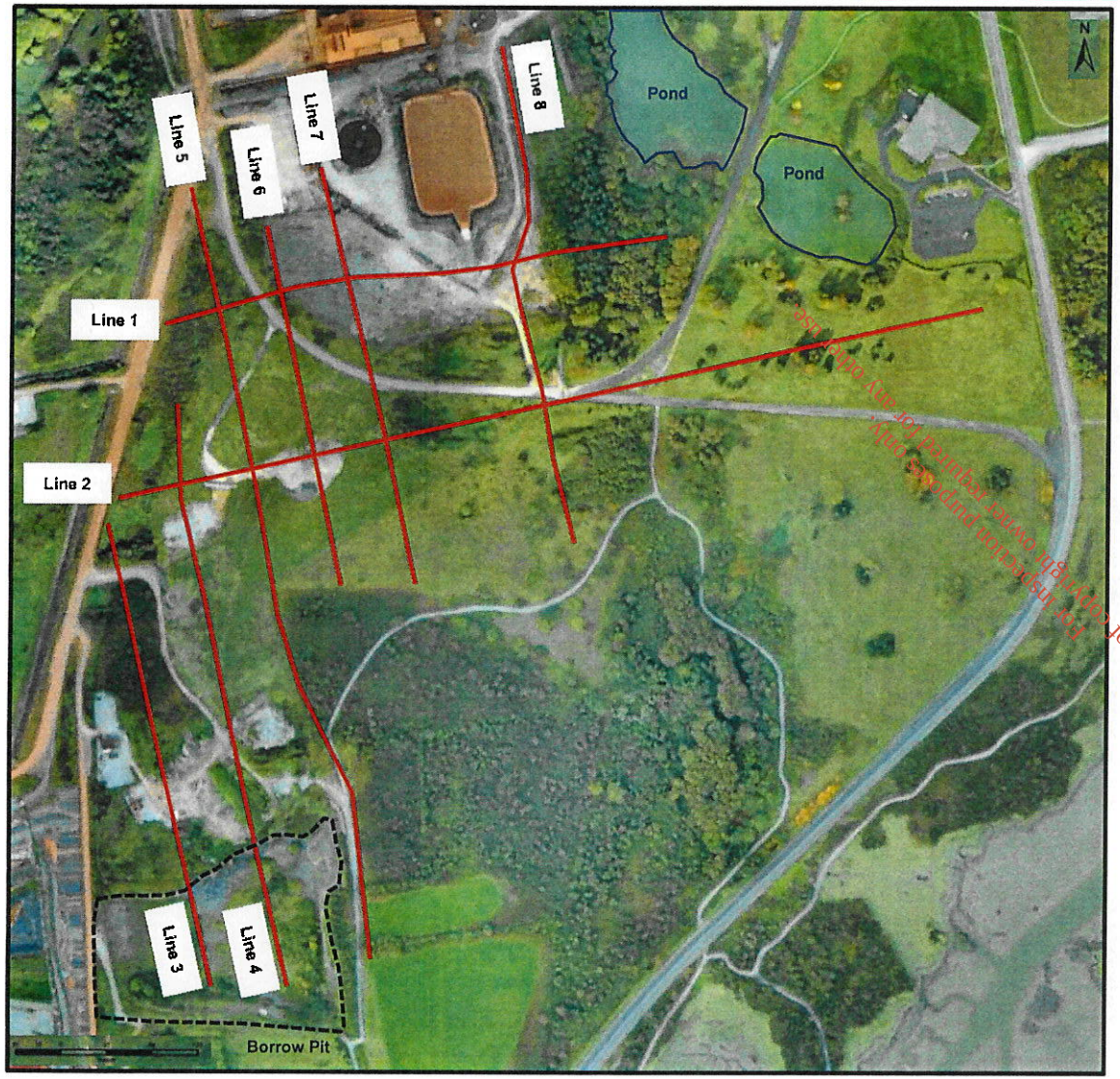
Borrow Pit Design

(February 2017)

RUSAL

Golder Associates

Aughinish: Location of Resistivity Lines



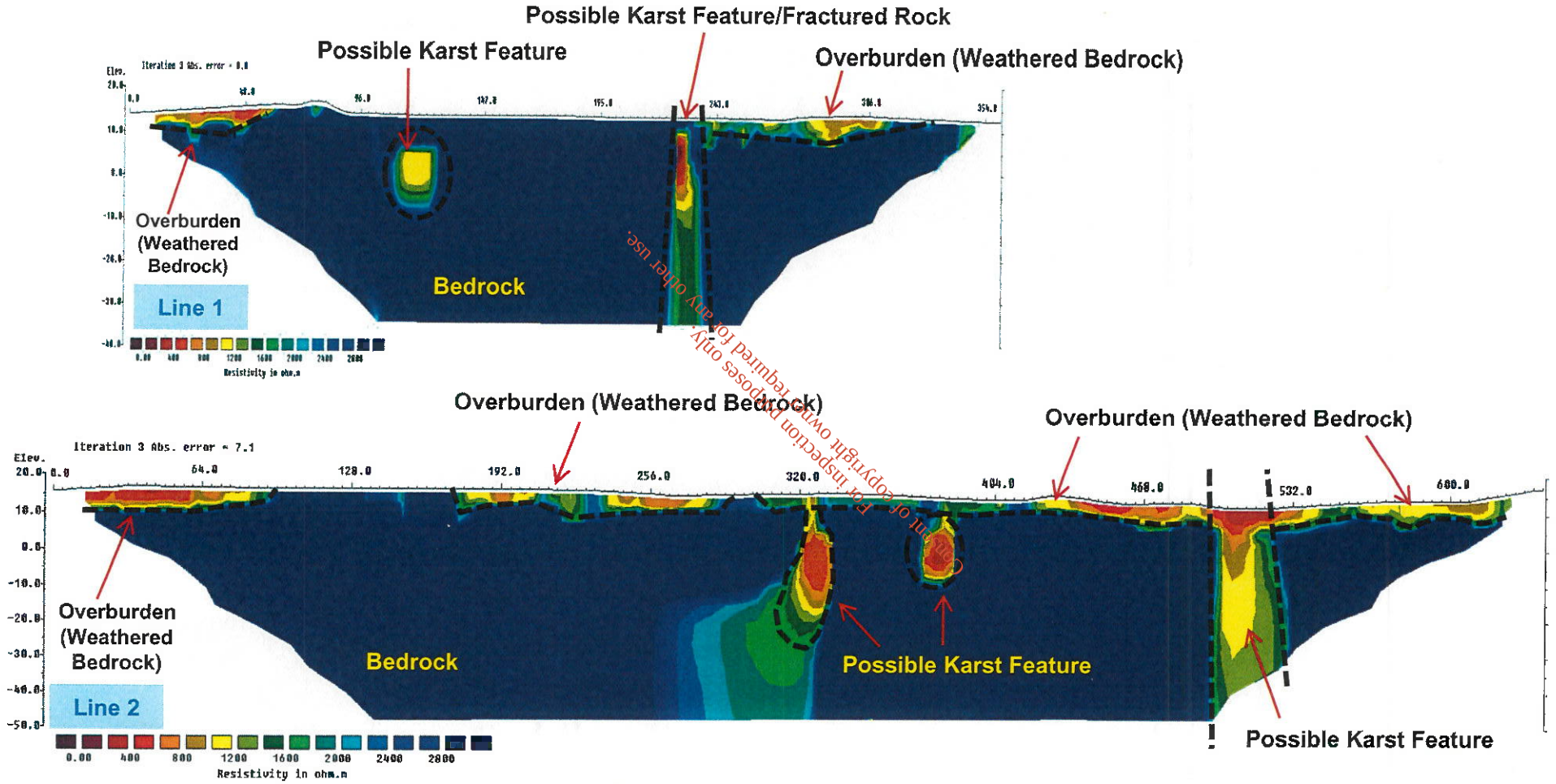
Lines 1 & 2 are from west to east - looking north
Lines 3 & 4 are from south to north - looking west
Lines 5, 6, 7 & 8 are from north to south - looking east

Resistivity Lines

- Line 1 - 360m
- Line 2 - 640m
- Line 3 - 327m
- Line 4 - 420m
- Line 5 - 540m
- Line 6 - 300m
- Line 7 - 300m
- Line 8 - 360m

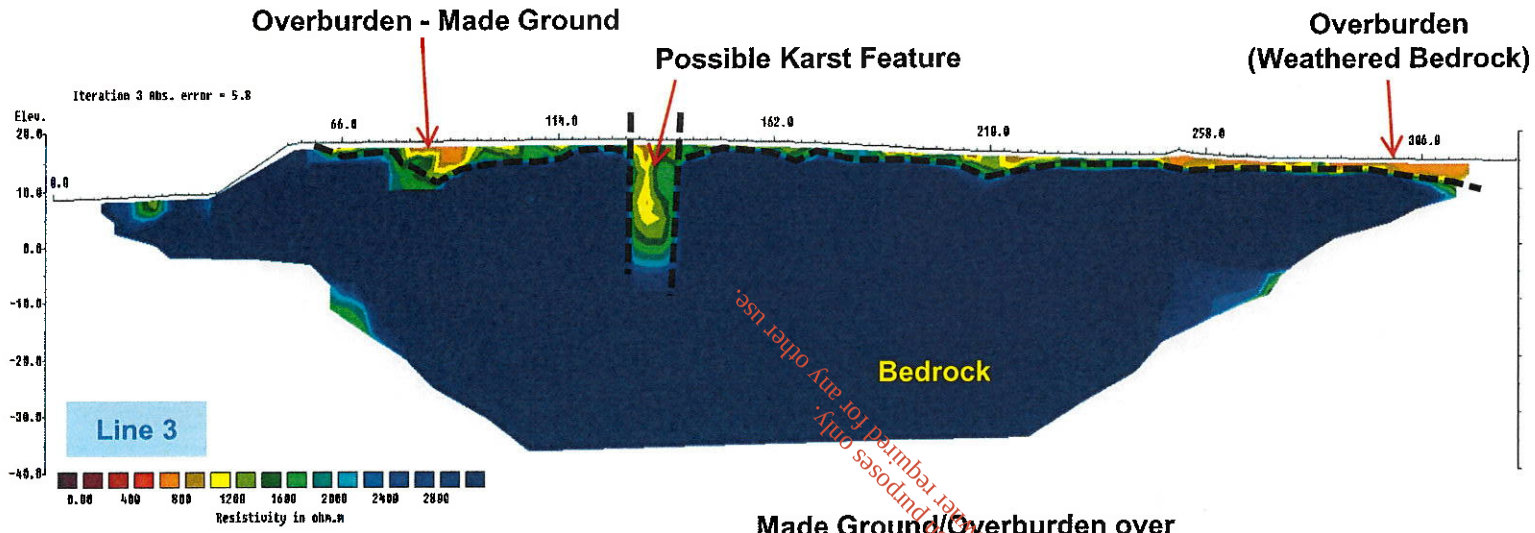
Golder Associates

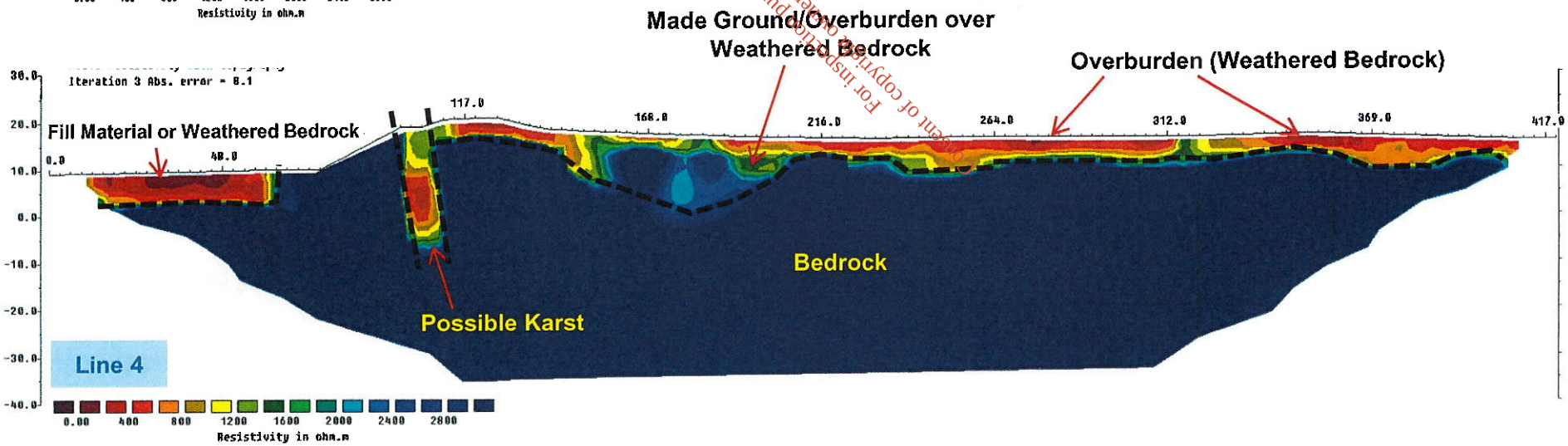
Aughinish: Lines 1 & 2 (W-E, Looking North)



200 ohm metre contour intervals

Aughinish: Lines 3 & 4 (S-N, Looking West)

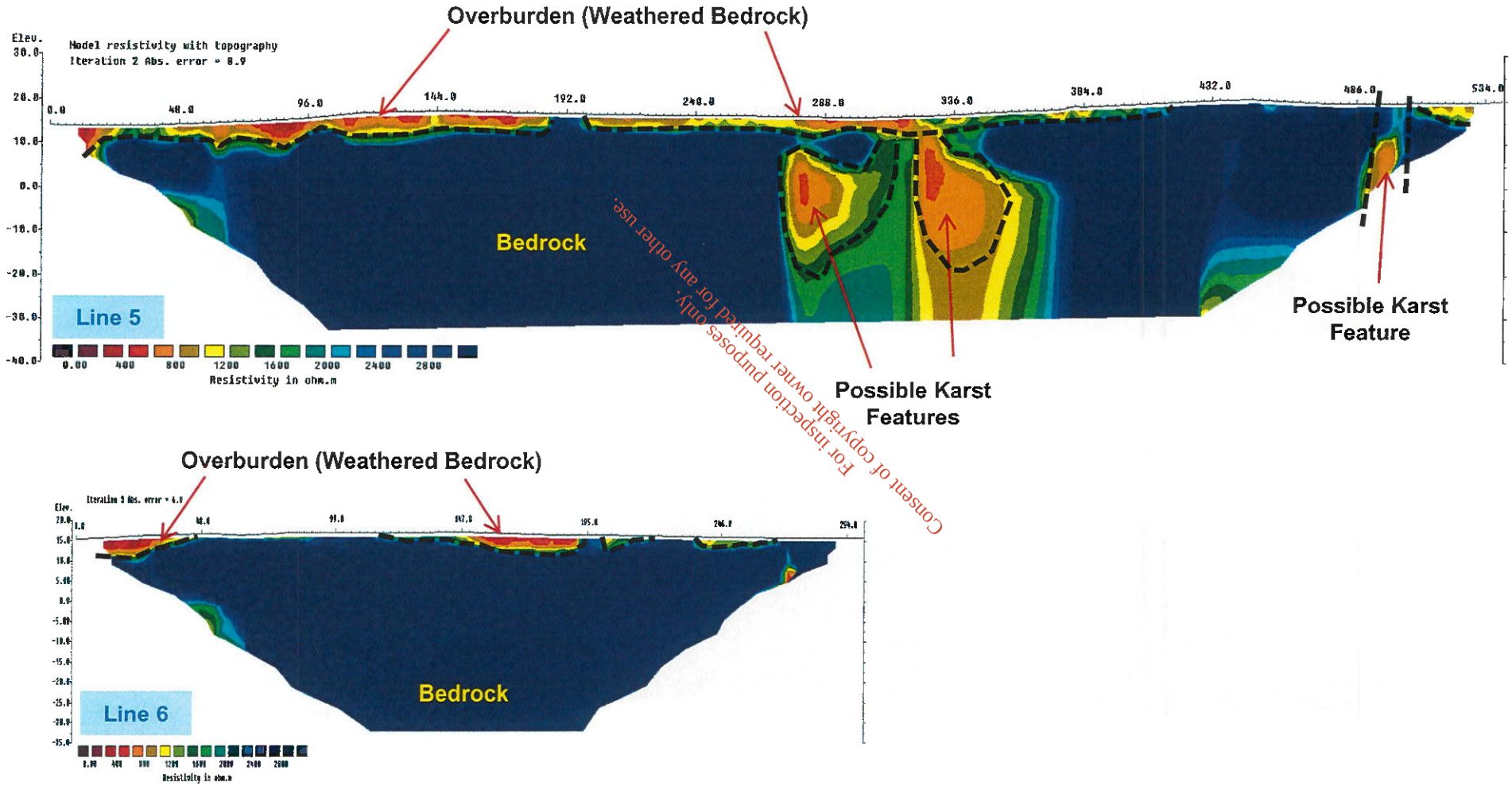




200 ohm metre contour intervals

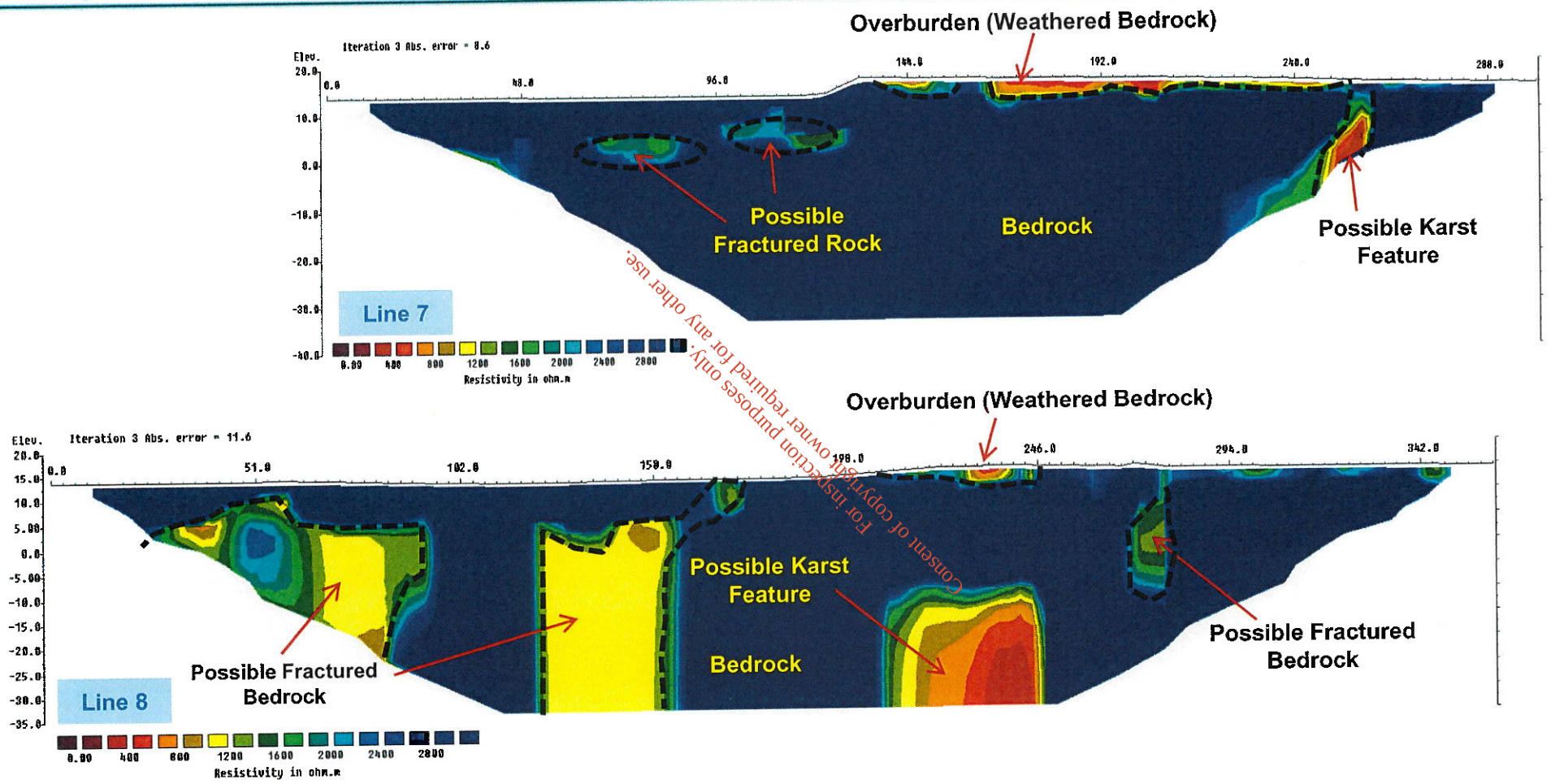
Golder Associates

Aughinish: Lines 5 & 6 (N-S, Looking East)



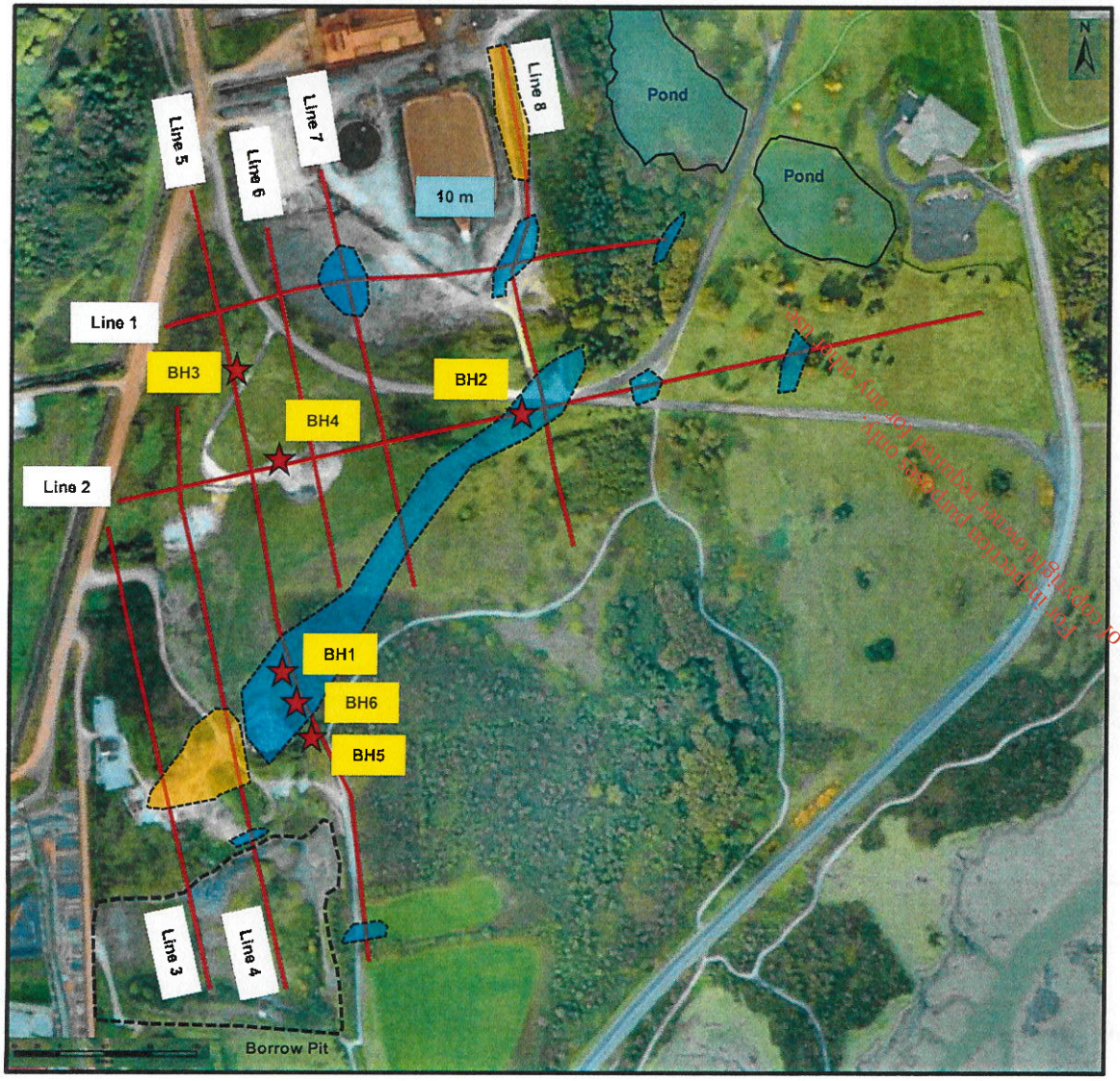
200 ohm metre contour intervals

Aughinish: Lines 7 & 8 (N-S, Looking East)



200 ohm metre contour intervals

Aughinish: Karst & Fractured Bedrock



SUMMARY

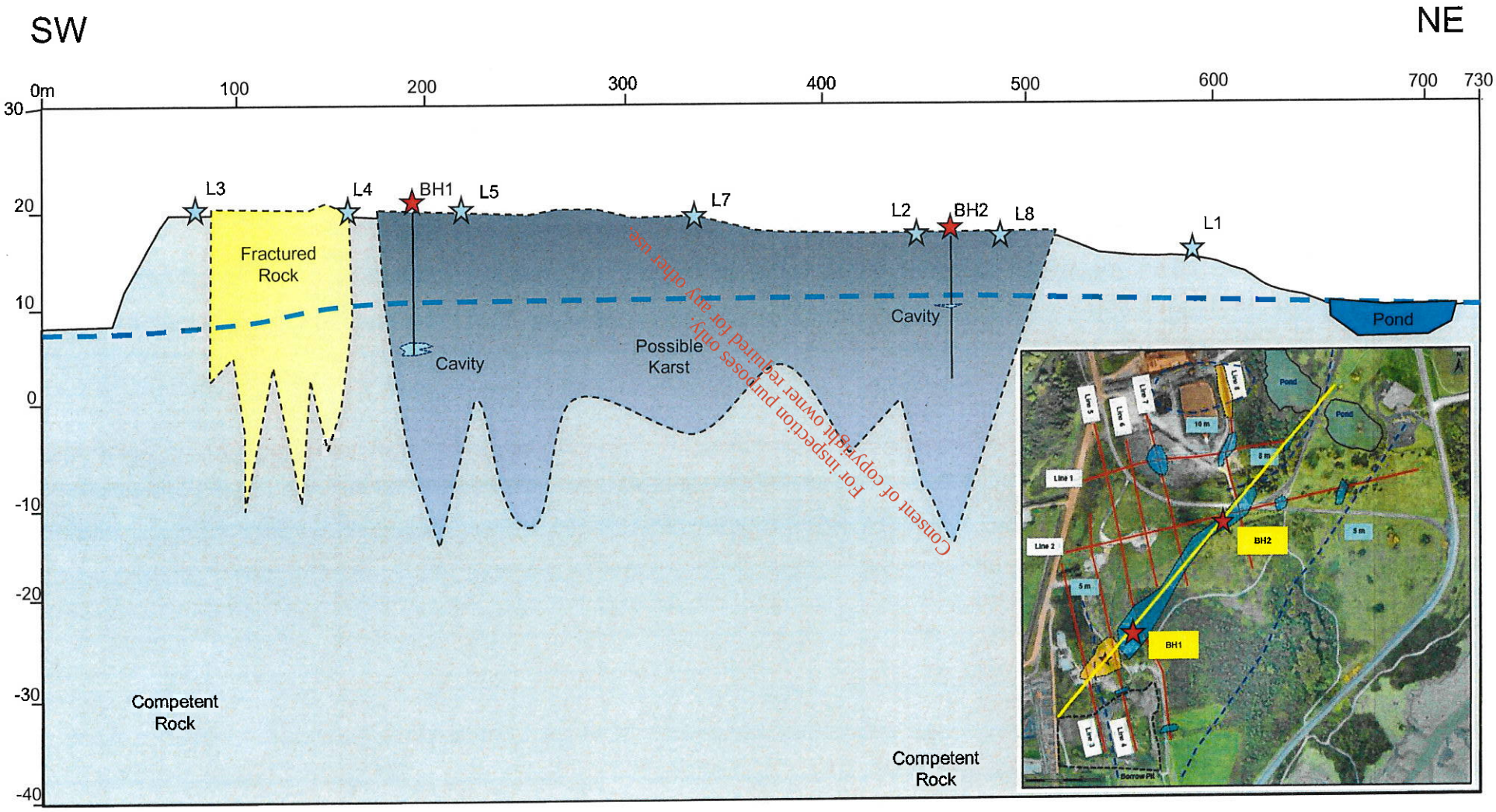
- NE/SW trending area of possible karst trending towards/from the pond(s) to an area just north of the existing borrow area.
- The Resistivity Survey indicates that there may be a possible connection – conduit for water to flow between the ponds and the borrow area.
- The Resistivity Survey shows that most of the bedrock has an apparent resistivity of >2,000 ohm metres and can be expected to be of good quality. Where resistivity values are less than ca. 400 ohm metres, lesser quality rock, fractured rock and/or karst features can be expected. The significance of these features is often much smaller than area shown in the resistivity survey sections.
- 6 BHs (**red star**) were drilled, with cavities encountered in BH1, BH2, BH3, BH5 & BH6

Possible karst feature

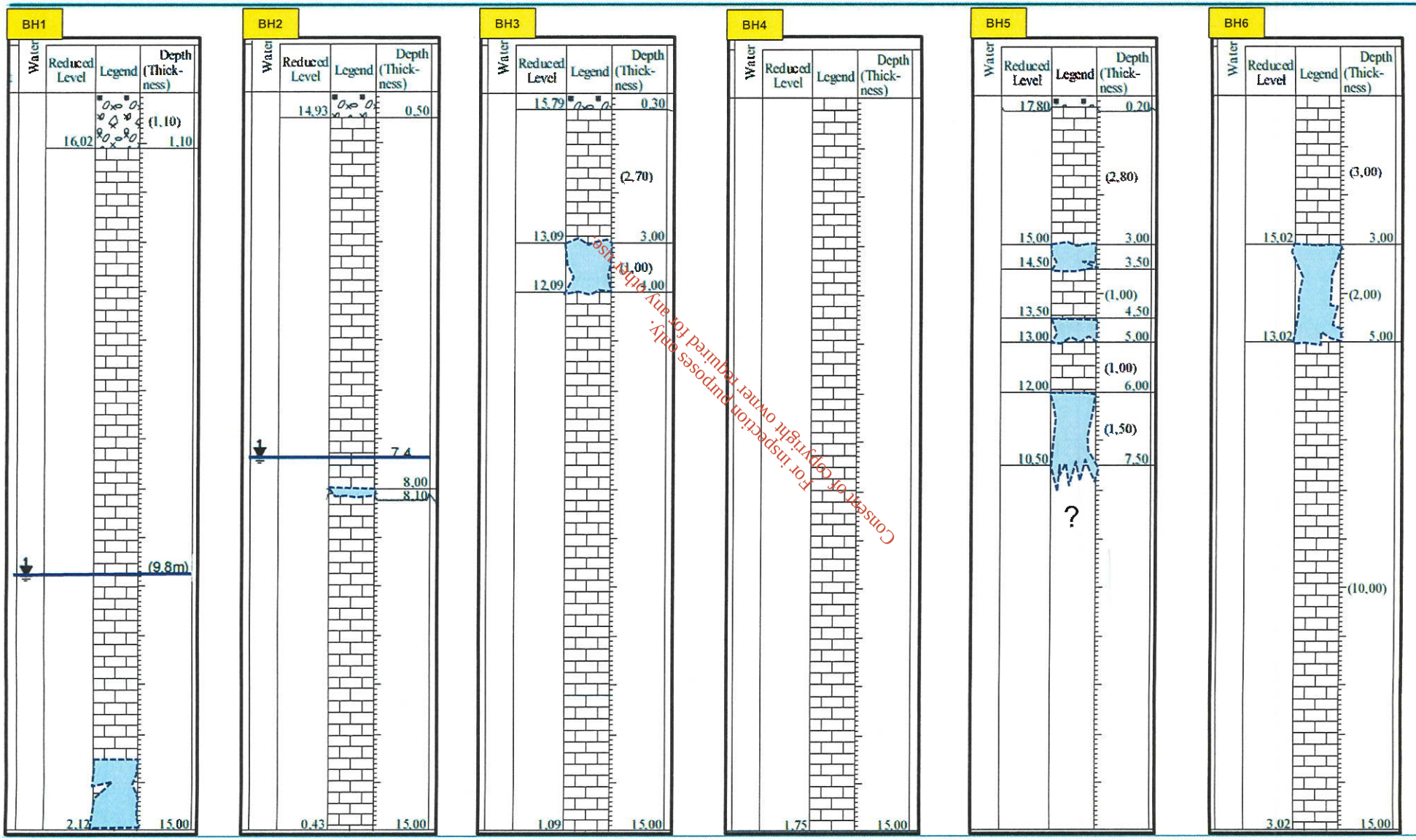
Possible fractured bedrock

Golder Associates

Cross Section Looking NW



BH Logs (Cavities in Blue)



BH5 was abandoned due to poor ground conditions

Golder Associates

APPENDIX 8.2: Borehole Logs

Golder Associates

BOREHOLE LOG

Project				BOREHOLE No
Aughinish Borrow Pit				BH-1
Job No	Date	Ground Level (m)	Co-Ordinates ()	
1667376	23-01-17	17.123 mAOD	E 128154.914, N 152562.776	
Contractor				Sheet
JS Drilling				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				16,02		(1,10) 1,10	Pale grey, silty gravelly OVERBURDEN with sub-angular to angular fragments < 6 m in diameter. Slight Fe-Ox stain on fragments.		
						(9.8m)	Pale to medium grey, fine grained Waulsortian LIMESTONE. Fragments are sub-angular to angular in shape, strong and < 5 cm in diameter. End of Hole @ 15 m.		
				2,12		15,00			

Boring Progress and Water Observations					
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt

Chiselling			Water Added	
From	To	Hours	From	To

GENERAL REMARKS

Water encountered at 13.3m during drilling and 24 hours later water settled at 9.8m. Slotted pipe installed from 13.5 to 7.5m and plain standpipe installed to the surface. Hole installed to 13.5 m due to collapse of hole from 13.5 to 15m.

All dimensions in metres Scale 1:93.75	Client Aughinish Alumina	Method/ Plant Used Beretta T44	Logged By C. Maguire

AGS3 UK BH AUGHINISH BORROW PIT.GPJ GINT STD AGS 3_1.GDT 13/2/17

Golder Associates

BOREHOLE LOG

Project				BOREHOLE No
Aughinish Borrow Pit				BH-2
Job No	Date	Ground Level (m)	Co-Ordinates ()	
1667376	24-01-17	15.427 mAOD	E 128313.979, N 152754.954	
Contractor				Sheet
JS Drilling				1 of 1

SAMPLES & TESTS			Water	STRATA					Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION			
				14,93		0,50	Pale grey silty gravelly OVERBURDEN. Fragments of limestone.			
							Pale to medium grey, fine grained Waulsortian LIMESTONE. Fragements are sub-angular to angular in shape and < 5 cm in diameter.			
			1			7.4				
						8,00				
						8,10	Cavity			
							Pale to medium grey, fine grained Waulsortian LIMESTONE. Fragements are sub-angular to angular in shape and < 5 cm in diameter. Slight Fe-Ox stain on some fragments from 10.5 to 15 m.			
				0,43		15,00				

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	Water encountered at 7.4m. Slotted pipe installed from 15 to 5 m and plain standpipe installed from 5 m to the surface.

All dimensions in metres Scale 1:93.75	Client Aughinish Alumina	Method/ Plant Used Beretta T44	Logged By C. Maguire

AGS3 UK BH AUGHINISH BORROW PIT.GPJ GINT STD AGS 3_1.GDT 13/2/17

Golder Associates

BOREHOLE LOG

Project				BOREHOLE No
Aughinish Borrow Pit				BH-3
Job No	Date	Ground Level (m)	Co-Ordinates ()	
1667376	25-01-17	16.085 mAOD	E 128110.385, N 152794.836	
Contractor				Sheet
JS Drilling				1 of 1

SAMPLES & TESTS			Water	STRATA					Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION			
				15,79		0,30	Pale to medium grey Silty Gravelly OVERBURDEN.			
						(2,70)	Pale to medium grey, fine grained Waulsortian LIMESTONE. Fragments are sub-angular to angular in shape, strong and < 6 cm in diameter.			
				13,09		3,00				
						(1,00)	Cavity			
				12,09		4,00				
							Pale to medium grey, fine grained Waulsortian LIMESTONE. Fragments are sub-angular to angular in shape, strong and < 5 cm in diameter. End of Hole @ 15 m.			
				1,09		15,00				

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No water encountered. Hole left open for possible future installation.

All dimensions in metres Scale 1:93.75	Client Aughinish Alumina	Method/ Plant Used Beretta T44	Logged By C. Maguire

AGS3 UK BH AUGHINISH BORROW PIT.GPJ GINT STD AGS 3_1.GDT 13/2/17

Golder Associates

BOREHOLE LOG

Project				BOREHOLE No
Aughinish Borrow Pit				BH-4
Job No	Date	Ground Level (m)	Co-Ordinates ()	
1667376	26-01-17	16.745 mAOD	E 128145.743, N 152721.134	
Contractor				Sheet
JS Drilling				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
							Pale to medium grey, fine grained Waulsortian LIMESTONE. Fragments are strong, sub-angular to angular in shape and < 6 cm in diameter. End of Hole @ 15 m.		
				1,75		15,00			

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No water encountered. Hole left open for possible future installation.

All dimensions in metres Scale 1:93.75	Client Aughinish Alumina	Method/ Plant Used Beretta T44	Logged By C. Maguire

AGS3 UK BH AUGHINISH BORROW PIT.GPJ GINT STD AGS 3_1.GDT 13/2/17

Golder Associates

BOREHOLE LOG

Project				BOREHOLE No
Aughinish Borrow Pit				BH-5
Job No	Date	Ground Level (m)	Co-Ordinates ()	
1667376	26-01-17	18.024 mAOD	E 128167.348, N 152541.720	
Contractor				Sheet
JS Drilling				1 of 1

SAMPLES & TESTS			Water	STRATA					Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION			
				17,80		0,20	Medium grey silty gravelly OVERBURDEN.			
						(2,80)	Pale to medium grey, fine grained Waulsortian LIMESTONE. Fragments are sub-angular to angular in shape and <6 cm in diameter.			
				15,00		3,00				
				14,50		3,50	Cavity.			
						(1,00)	LIMESTONE, same as previous.			
				13,50		4,50				
				13,00		5,00	Cavity.			
						(1,00)	LIMESTONE, same as previous.			
				12,00		6,00				
						(1,50)	Cavity. Hole terminated at 7.5 m.			
				10,50		7,50				

Boring Progress and Water Observations						Chiselling			Water Added	
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To

GENERAL REMARKS

No water encountered. Hole left open for possible future installation. Hole terminated at 7.5 m due to bad drilling conditions and many cavities.

All dimensions in metres Scale 1:93.75	Client Aughinish Alumina	Method/ Plant Used Beretta T44	Logged By C. Maguire

AGS3 UK BH AUGHINISH BORROW PIT.GPJ GINT STD AGS 3_1.GDT 13/2/17

Golder Associates

BOREHOLE LOG

Project				BOREHOLE No
Aughinish Borrow Pit				BH-6
Job No	Date	Ground Level (m)	Co-Ordinates ()	
1667376	27-01-17	17.657 mAOD	E 128164.196, N 152554.594	
Contractor				Sheet
JS Drilling				1 of 1

SAMPLES & TESTS				STRATA					
Depth	Type No	Test Result	Water	Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION	Geology	Instrument/ Backfill
				15,02		(3,00) 3,00	Pale to medium grey, fine grained Waulsortian LIMESTONE. Fragments are sub-angular to angular in shape, strong and < 5 cm in diameter.		
				13,02		(2,00) 5,00	Cavity.		
				3,02		(10,00) 15,00	LIMESTONE, same as previous. End of Hole at 15 m.		

Boring Progress and Water Observations						Chiselling			Water Added	
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To

GENERAL REMARKS

No water encountered. Hole left open for possible future installation.

All dimensions in metres Scale 1:93.75	Client Aughinish Alumina	Method/ Plant Used Beretta T44	Logged By C. Maguire

AGS3 UK BH AUGHINISH BORROW PIT.GPJ GINT STD AGS 3_1.GDT 13/2/17

9.0 WATER

9.1 Introduction

This chapter provides an assessment of the potential impacts of the proposed borrow area development on the surrounding hydrogeological and hydrological environment. The development proposes the extraction of limestone rock above the water-table in a northerly direction from an existing borrow pit face, over ca. 4.5 ha of land, to a depth of 8.5 m OD.

Hydrogeological aspects considered within this chapter include the underlying hydrogeology of the Site, groundwater vulnerability, aquifer status and groundwater quality. The potential hydrogeological impacts have been assessed for future impacts associated with extraction activities at the Application Site. Appropriate mitigation measures are proposed to offset any possible negative impacts associated with the proposed development.

The impacts of the proposed development on the hydrology of the Application Site are also discussed in this chapter.

9.2 Study Methodology

The hydrogeological and hydrological impacts associated with the proposed development at the Application Site were assessed by means of a desk study of the Site (review of available information), a number of freely available technical references (e.g. Geological Survey of Ireland (GSI) on-line publications), consultations with statutory bodies and fieldwork (a geophysical (resistivity) survey and subsequent drilling of six groundwater monitoring boreholes - refer to Appendices 8.1 (geophysical survey) and 8.2 (borehole logs)). A list of the information referenced as part of the desk study is presented in Section 9.8.

9.3 Existing Environment

The Application Site is adjacent to a large industrial site, with some of the soil cover having been removed due to previous activities, including the handling and temporary storage of overburden and aggregate materials used in the maintenance and construction of the BRDA.

Sub-soils

Sub-soils underlying the Application Site are either absent or consist of glacial till of Carboniferous origin (Figure 8.3). Large areas of made-ground occur to the west and north-east, with estuarine sediments also occurring to the west (Figure 8.3). The depth of overburden across the Application Site where it has not been stripped or re-worked is typically variable in thickness (ranging from ca. 0.5 to ca. 3 m).

Bedrock

The local geology 1:100,000 map (www.gsi.ie) of the Application Site (Figure 8.4) shows that the area is underlain by a pale grey limestone (Waulsortian Limestone). The Waulsortian limestones in the area are commonly karstified, often with cavities filled with sediments. Dissolution of the limestone creates a fissure flow regime (secondary permeability in the bedrock).

9.3.1 Regional Hydrology

The regional area drains to the Shannon Estuary (to the north) which is designated as a Special Area of Conservation (SAC). Along the stretch of coast in the area of the Site, mudflats and sandflats not covered by seawater at low tide are listed in the conservation objectives of the SAC with the objective of maintaining a stable or increasing area of habitat, subject to natural processes.

The River Shannon and River Fergus Estuaries Special Protection Area (SPA) also cover the area of the Shannon Estuary adjacent to the Site.

9.3.2 Local Hydrology

The area of the Site including the plant and the BRDA is bounded to the north and west by the Shannon Estuary, to the east and southeast by Poularone Creek and to the southwest by the Robertstown River to form Aughinish Island.

On the island, eighteen groundwater discharge points of measurable flow have historically been identified following the work of Ercon (1988), sixteen of the discharges, known as the Estuarine Streams (ES1 to ES16), are located around the perimeter of the Plant Area. The locations of the springs generally correspond to areas that were infilled during construction activities at Aughinish Island (where regrading works filled-in fracture zones in the bedrock surface). The springs are submerged during part of the tidal cycle and their flow varies significantly with seasonal fluctuations in rainfall.

In addition to the Estuarine Streams, two additional spring discharges exist in the Plant Area, a spring located to the north of Area 02 (TT4 Spring), and a waterbody lying at the southern end of the Plant Area, to the east of the South Pond.

In addition to the Estuarine Streams, two additional spring discharges exist in the Plant Area, a spring located to the north of Area 02 (TT4 Spring), and a waterbody lying at the southern end of the Plant Area, to the east of the South Pond.

The total calculated stream discharge was identified to be consistent with the groundwater recharge of 340-680 mm/year estimated by Dames & Moore in 1999. By water balance this would indicate that the Estuarine Streams are the dominant mechanism for the discharge of recharge to groundwater from the island, with negligible output via groundwater base flow to the estuary and Poulaweala Creek.

9.3.3 Groundwater - Hydrogeology

The groundwater present in the Waulsortian Limestone underlying the Site is a Regionally Important Aquifer for the water resources of County Limerick as a consequence of enhanced secondary permeability from faulting and fracturing and enhanced primary permeability from dolomitisation.

The interpretation of the hydrogeological conceptual model presented in Golder (2015) identified that the groundwater present beneath Aughinish Island comprises a freshwater lens isolated laterally from the mainland by being laterally hydraulically isolated by Poulaweala Creek, Poularone Creek and the Robertstown River and the underlying saline groundwater.

The Waulsortian Limestone bedrock beneath the Plant Area to the north of the Application Site has a very low primary permeability. As a consequence, flow of groundwater is dominated by the location of karstified fracture zones and valley infill. The depth at which groundwater is encountered across this area is typically within 1.5 m to 10 m of ground level which implies that the fracture zones start from a relatively shallow depth, and that, in the centre of the Plant Area, the groundwater flows preferentially through the limestone rock fill used to level the valleys during the construction of the plant.

It is also important to note that according to the GSI, an important factor in the development of karst in the region was the relative lowering of sea level by over 60 m, which is believed to have occurred during the Tertiary and Quaternary periods. When the sea level was lower, the rivers were able to cut deeply into their beds, and karst solution could penetrate well below the present-day water table creating a high porosity and permeability. This could mean that the depth of karst at the Site could penetrate the full depth of the freshwater lens and hence karstified preferential groundwater flow paths may be conceptualised in two dimensions rather than three (i.e. not depth).

Contours of groundwater data for February 2017 and May 2017 are presented in Figures 9.1 and 9.2 respectively. The overall trend between the two months indicates a stable groundwater contour pattern with seasonal fluctuations (primarily due to the karstic nature of the limestone).

The overall trend for groundwater flow in the Plant Area is that flow is radial from approximately the centre of the Plant Area and discharges via springs (the Estuarine Streams) to the Shannon Estuary and the Poulaphouca Creek.

In the area of the proposed Borrow Pit development, the contour maps indicate a variation in groundwater elevation of between ca. 7.9 m OD and ca. 5.1 m OD for OW13, from February to May 2017.

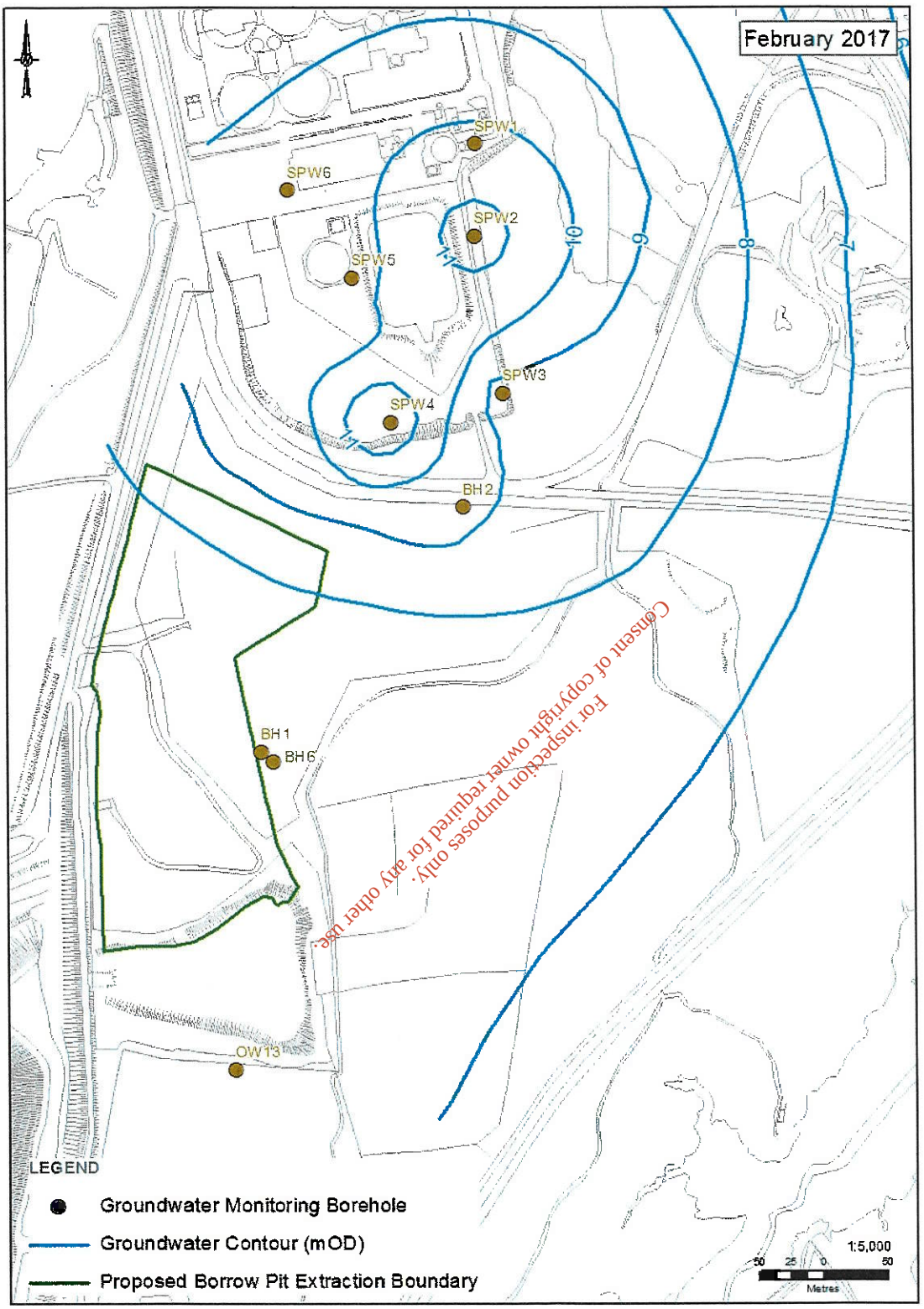


Figure 9.1: Groundwater elevation contours (February 2017)

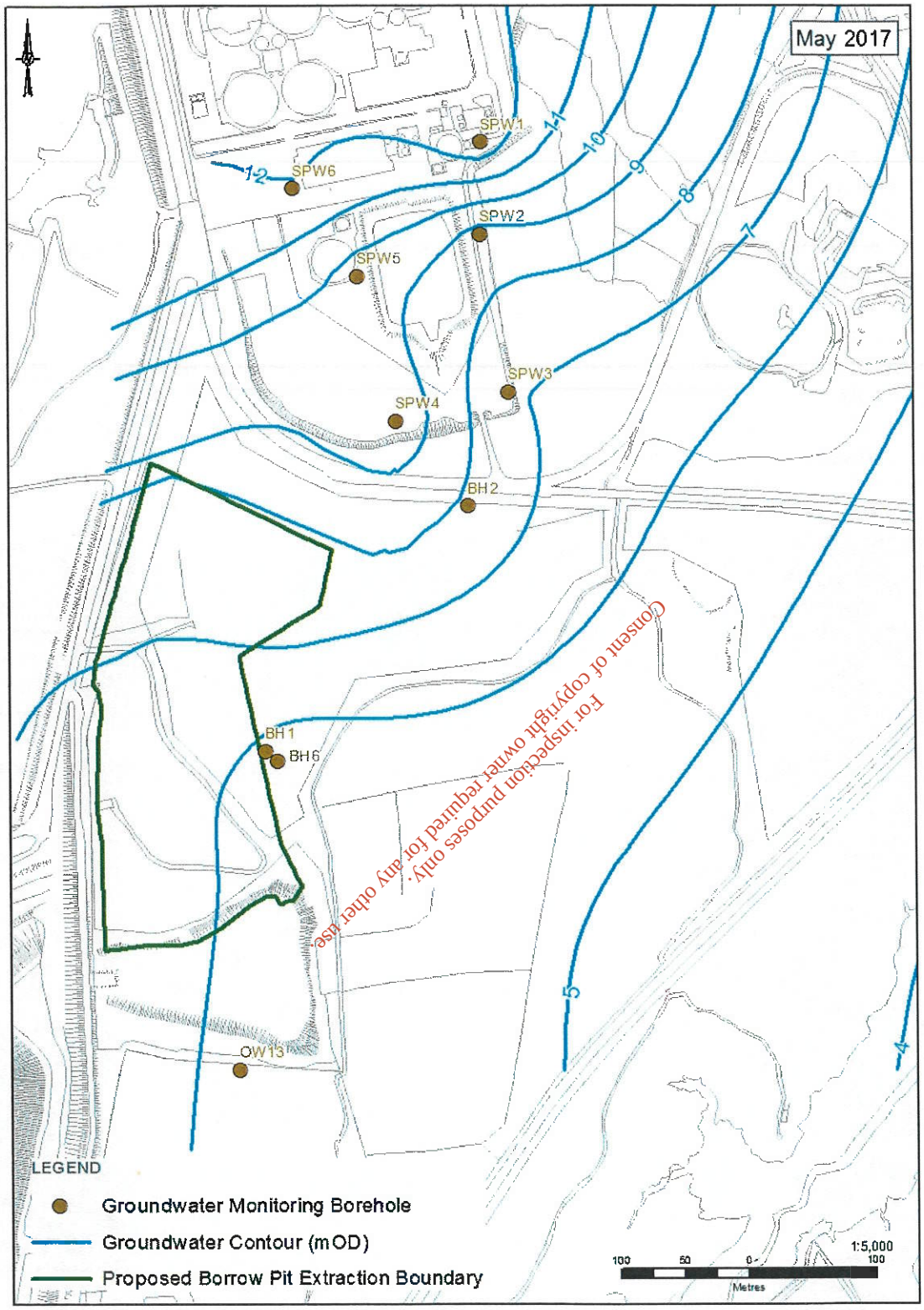


Figure 9.2: Groundwater elevation contours (May 2017)

9.3.3.1 Site Investigation

In order to understand the hydrogeological setting of the proposed Borrow Pit area a geophysical (Appendix 8.1 provides a summary of the geophysical survey) and intrusive

investigation were undertaken (Appendix 8.2 provides the lithological logs of the boreholes drilled).

Eight lines of resistivity were surveyed in order to understand the potential for the presence of dolomitisation or karstic features within the footprint of the proposed Borrow Pit area. The Waulsortian Limestone has very low primary permeability, hence it was important to ascertain the presence of enhanced primary permeability from dolomitisation or karst to examine the potential for the excavation to encounter permeable features that could connect either laterally to surface or groundwater bodies or vertically with the potential to flood the workings from groundwater.

Based on the interpretation of the geophysical survey presented in Appendix 8.1, possible areas of fractured bedrock and karst were identified in the proposed Borrow Pit area (Figure 9.3). As a consequence, these areas were targeted for investigation by the drilling of boreholes to identify whether the presence of karstic features could also include groundwater at a piezometric level that is above the base of the proposed excavation level (8.5 m OD) and in quantities that could be problematic to the excavation.

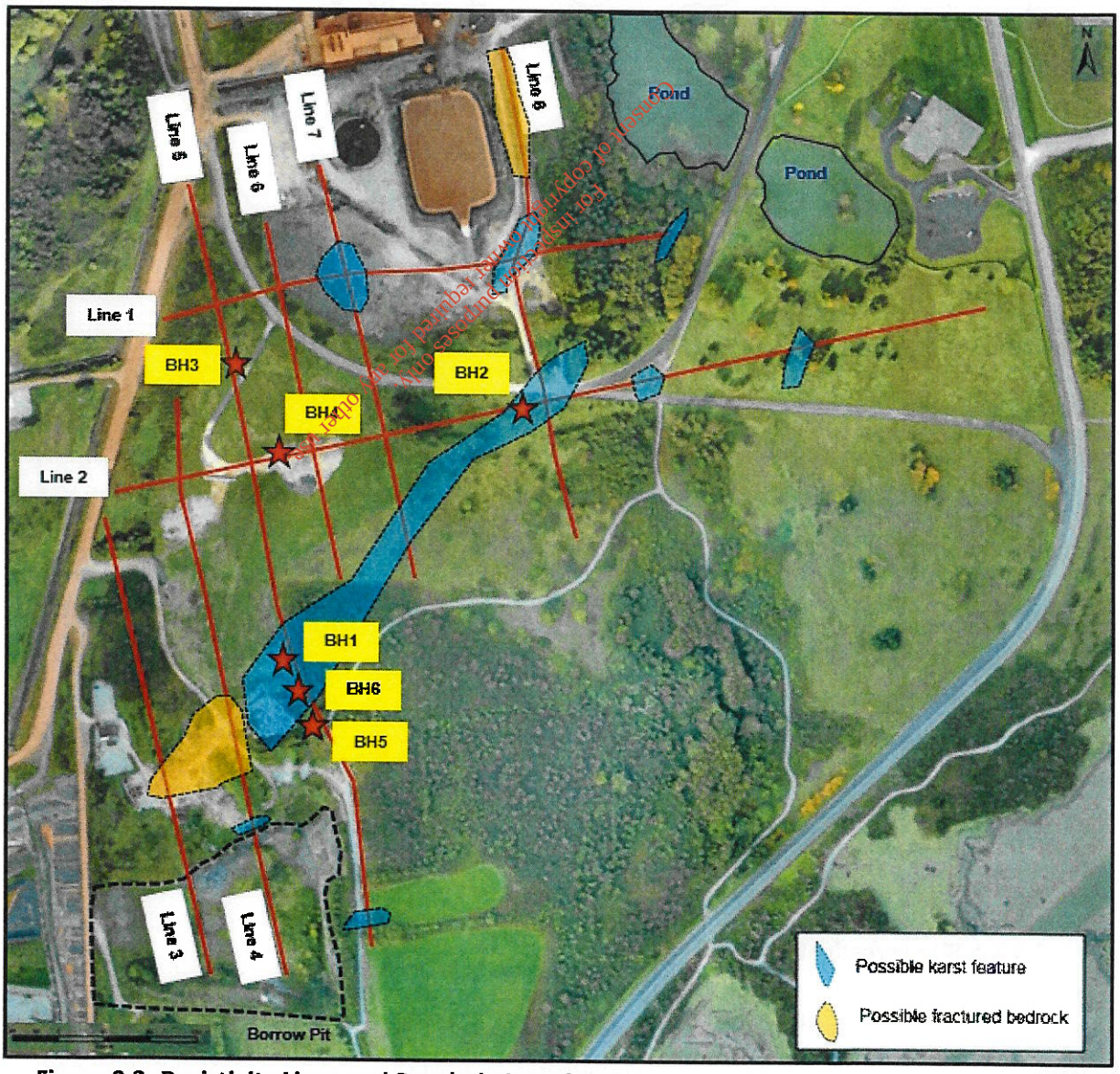


Figure 9.3: Resistivity Lines and Borehole Locations

Based on the findings of the geophysical survey six boreholes were drilled to 15 m depth below ground level which is deeper than the proposed depth of working. Borehole BH5 did not reach the target depth and was replaced by BH6 (Figure 9.3).

Of the boreholes drilled, BH1, BH2, BH3, BH5 and BH6 encountered cavities within the limestone, whilst no cavities were observed in BH4.

Water strikes during drilling were noted in BH1 and BH2 at elevations of 3.82 m OD rising to 7.32 m OD, and at 8.03 m OD respectively. No other water strikes were noted.

Following completion of drilling, the boreholes were developed and pumped in preparation for test pumping. The recovery of the water level was sufficiently slow that test pumping was not possible, thereby indicating that regardless of the presence of karst, the limestone was insufficiently transmissive to result in a rapid inflow of groundwater to the drilled boreholes in the areas considered.

Following the installation of the monitoring boreholes, the boreholes have been routinely monitored for groundwater level. BH3, BH4 and BH5 have been found to be dry. This indicates that either the elevation of groundwater is below the drilled depth or that a preferential flow feature and associated water-strike has not been encountered. In boreholes BH3, BH4 and BH5 the base of the boreholes are reportedly 1.09, 1.75 and 10.50 m OD respectively.

Monitoring data for groundwater elevation for boreholes BH1, BH2 and BH6 is presented in Table 9.1. Borehole BH2 is located closest to the Plant Area which has the highest groundwater levels due to the presence of karst and infilled valley features and sources of recharge.

BH1 and BH6 are located adjacent to the proposed Borrow Pit. The proposed Borrow Pit is expected to be developed to a depth of 8.5 m OD. The elevation of groundwater in these boreholes located approximately 10 m apart varies by approximately 1 m between the locations. This gradient between locations in the same formation indicates that either the water observed relates to perched waters in isolated karstic features, or that the aquifer transmissivity is low, hence enabling steep hydraulic gradients to develop.

Table 9.1: Groundwater Elevations from Monitoring Boreholes

Date	OW13	SPW2	SPW3	SPW4	SPW5	BH1	BH2	BH6
25 January 2017	-	-	-	-	-	7.32	8.03	-
7 February 2017	7.86	11.59	8.99	11.63	9.45	7.65	9.34	
14 February 2017	-	-	-	-	-	-	-	8.03
16 March 2017	8.02	11.40	8.70	11.25	9.79	-	-	
27 March 2017	7.98	11.19	8.74	11.32	9.78	-	-	-
5 April 2017	7.45	9.26	8.04	10.89	9.79	6.98	10.42	7.10
12 April 2017	7.19	-	7.69	10.52	9.73	6.46	9.74	6.55
19 April 2017	6.88	-	7.44	10.20	9.09	6.30	7.83	6.16
24 April 2017	6.66	10.52	7.29	10.02	9.60	6.13	9.79	5.90
3, 4 & 6 May 2017	5.06	8.52	7.10	9.77	9.49	5.79	7.85	5.44

Based on the findings of the investigation, it has been interpreted that the Waulsortian Limestone in the area of the proposed Borrow Area has limited secondary permeability. As a consequence, monitoring boreholes drilled to beneath the base of the proposed elevation of excavation have either not encountered groundwater or have encountered groundwater at elevations that do not compare laterally.

Where groundwater was encountered an attempt to conduct a pumping test was conducted in order to enable a first-order calculation for groundwater inflow to the excavation to be conducted. The groundwater recovery rates following pumping were sufficiently slow that a pumping test was not feasible.

The variability in groundwater elevation levels and steep gradients observed in the monitoring boreholes in the vicinity of the Borrow Area (refer to Table 9.1 above) indicate that the water present is either isolated in perched karstic features with limited interconnection or that the transmissivity of the formation is low hence limiting groundwater flow to the extent that steep gradients are being generated.

On the basis of the findings of these works, based on the locations investigated it is concluded that the proposed Borrow Pit excavation will encounter limited groundwater inflows and or isolated perched units of groundwater. The lateral extent of isolated seepages is interpreted to be limited and the transmissivity of the formation insufficiently large to measure by test pumping. Hence it is interpreted that the accumulation of surface water and precipitation in the excavation could be larger than any isolated seepages of groundwater.

9.3.3.2 Bedrock Aquifer

- The groundwater present in the Rathkeale Formation comprises a Locally Important Aquifer from bedrock that is moderately productive only in local zones. This reflects the presence of water bearing bands of marine argillaceous limestones within the mudstone. The GSI aquifer classification is presented on Figure 9.4.

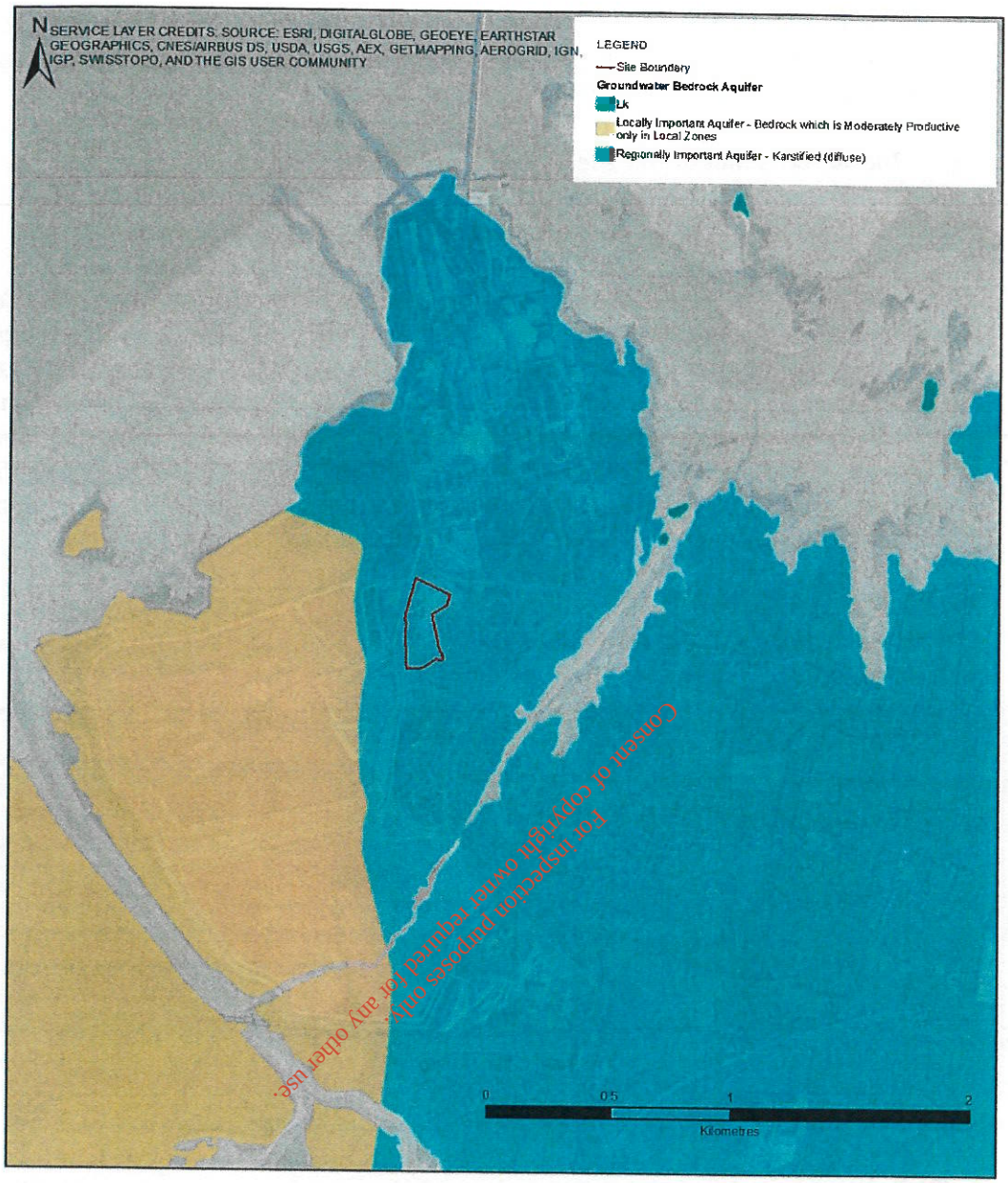


Figure 9.4: Bedrock aquifer map (application boundary in red)

The groundwater present in the Waulsortian Limestone is a Regionally Important Aquifer for the water resources of County Limerick as a consequence of enhanced secondary permeability from faulting and fracturing and enhanced primary permeability from dolomitisation.

9.3.3.3 Groundwater Vulnerability

'The vulnerability of groundwater depends on: (i) the time of travel of infiltrating water (and contaminants); (ii) the relative quantity of contaminants that can reach the groundwater; and (iii) the contaminant attenuation capacity of the geological materials through which the water and contaminants infiltrate. As all groundwater is hydrologically connected to the land surface, it is the effectiveness of this connection that determines the relative vulnerability to contamination. Groundwater that readily and quickly receives water (and contaminants) from the land surface is considered to be more vulnerable than groundwater

that receives water (and contaminants) more slowly and in lower quantities. The travel time, attenuation capacity and quantity of contaminants are a function of the following natural geological and hydrogeological attributes of any area:

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

*In summary, the entire land surface is divided into four vulnerability categories Table 9.2: extreme **(E)**, high **(H)**, moderate **(M)** and low **(L)** - based on the geological and hydrogeological factors described above. This subdivision is shown on a groundwater vulnerability map. The map shows the vulnerability of the first groundwater encountered (in either sand/gravel aquifers or in bedrock) to contaminants released at depths of 1-2 m below the ground surface. Where contaminants are released at significantly different depths, there will be a need to determine groundwater vulnerability using site-specific data. The characteristics of individual contaminants are not taken into account.' GSI 1999.*

Table 9.2: Extract from 'Groundwater Protection Schemes', Department of the Environment and Local Government, Environmental Protection Agency, Geological Survey of Ireland, 1999

Vulnerability Rating	Hydrogeological Conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Features
	High permeability (sand/gravel)	Moderate permeability (e.g. Sandy subsoil)	Low permeability (e.g. Clayey subsoil, clay, peat)	(Sand/gravel aquifers only)	(<30 m radius)
Extreme (E)	0 - 3.0m	0 - 3.0m	0 - 3.0m	0 - 3.0m	-
High (H)	> 3.0m	3.0 - 10.0m	3.0 - 5.0m	> 3.0m	N/A
Moderate (M)	N/A	> 10.0m	5.0 - 10.0m	N/A	N/A
Low (L)	N/A	N/A	> 10.0m	N/A	N/A

Notes: (1) N/A = not applicable.
(2) Precise permeability values cannot be given at present.
(3) Release point of contaminants is assumed to be 1-2 m below ground surface.

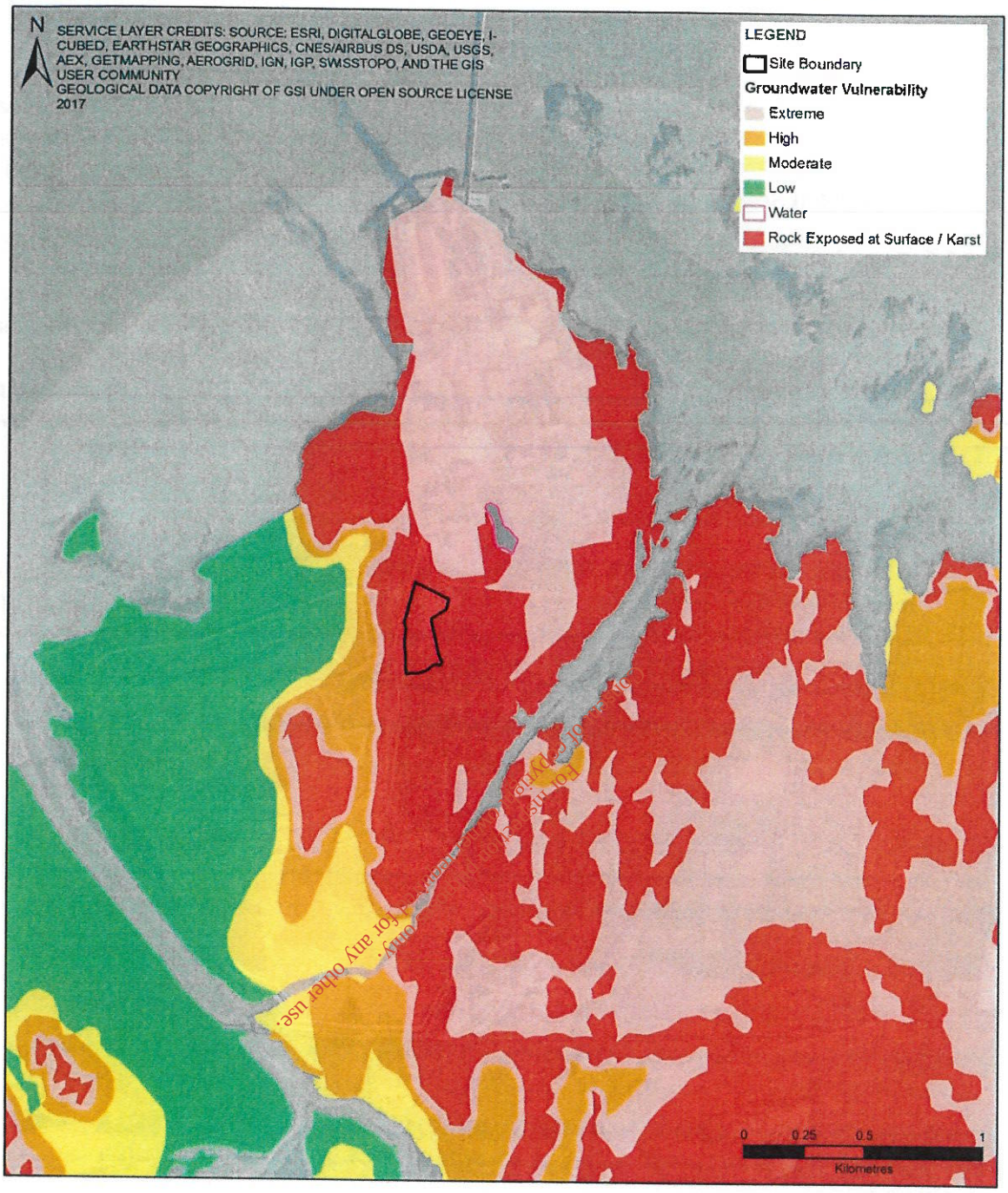


Figure 9.5: Groundwater vulnerability map (application area in black)

Groundwater vulnerability (Figure 9.5) under the proposed Borrow Area and most of the Plant Area is classified as Extreme, with 'rock at near surface or karst' being present. This is considered to reflect the presence of springs (estuarine streams) and bedrock outcrops in these areas.

Under the BRDA the groundwater vulnerability is classified to be between Low and Extreme, with 'rock at near surface or karst' this classification is dependent on the bedrock geology and presence of either glacial drift or alluvial deposits. It can be seen that the vulnerability of the Application Site has been correlated with the sub-soils occurring at the site (Figure 8.2).

9.3.3.4 Source Protection Zones

There are no source protection zones within the area of the proposed borrow area. The nearest source protection area to the proposed development is located ca. 11 km away, just north of Kilcolman. Two other source protection zones are located at Glin, ca. 22 km to the west and at Ardagh, ca. 19 km to the south of the Site.

9.3.3.5 Groundwater Basin

Groundwater basins have been defined by the GSI to determine the catchment areas and divides within areas, in a similar fashion to the river basins defined for surface water features. The Application Site occurs within an 'Industrial Facility' (IE_SH_G_252) as part of the Askeaton Groundwater Basin (GWB) (IE_S_G_010), which is characterized as having an overall status of 'poor'.

9.3.3.6 Karst Features

A number of karst features have been identified by the GSI within the vicinity of the proposed borrow area. In total, two karst features have been reported by the GSI (Figure 9.6). In addition a number of karst features have been identified across the Aughinish site from ground investigation programmes (see Appendices 8.1 and 8.2).

Figure 9.6: Karst features recorded by GSI (application boundary in red)

9.3.3.7 Groundwater Quality

Three groundwater monitoring boreholes provided analyses on existing groundwater quality across the Site (Figure 9.7).

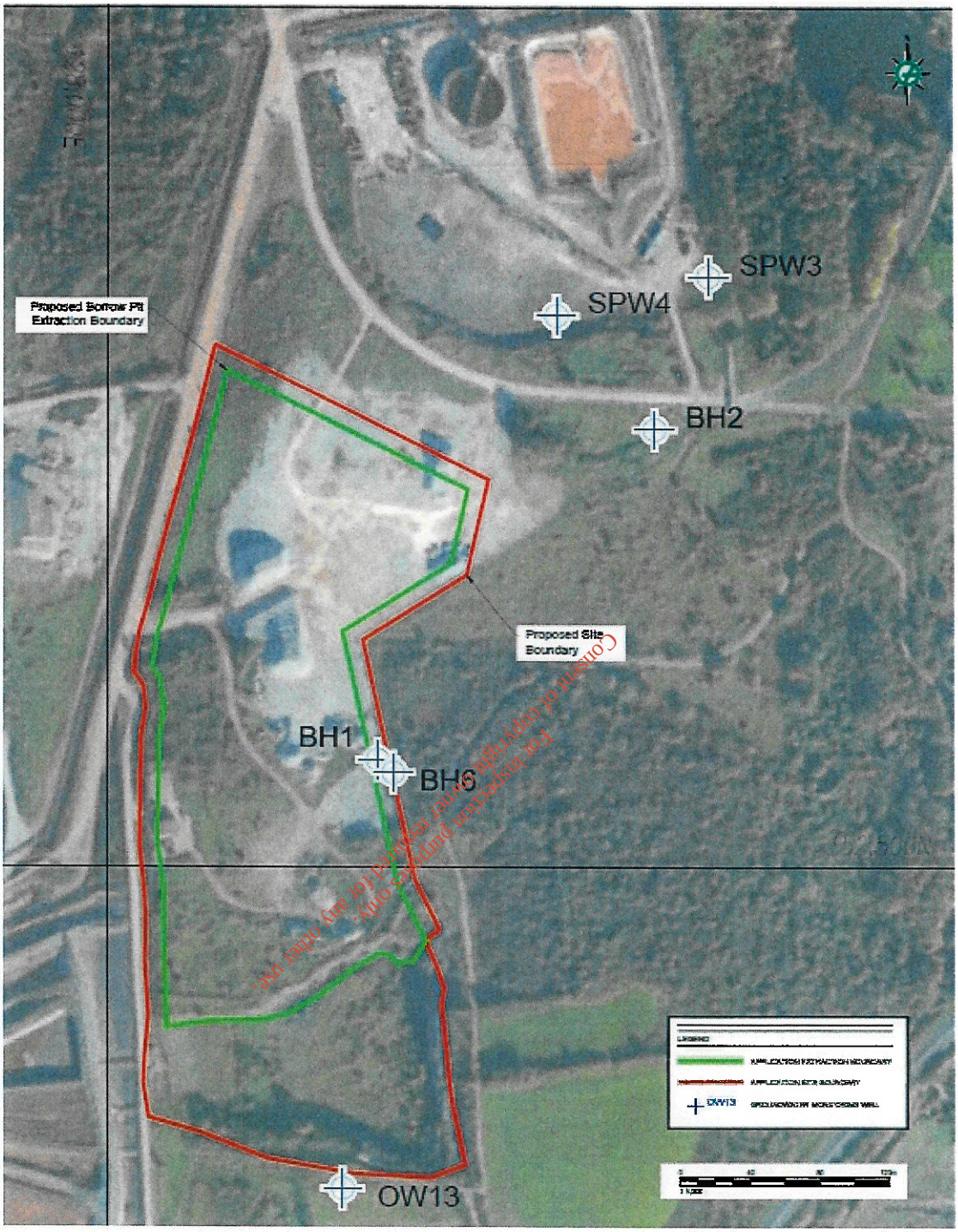


Figure 9.7: Plan showing location of groundwater monitoring boreholes

The results of the groundwater quality analyses at the Site are presented below and compared with EPA Interim Guideline Values for Groundwater Protection and S.I. No.9 (2010), the European Communities Environmental Objectives (Groundwater) Regulations regarding groundwater status (Table 9.3). The laboratory certificates for the results is included in Appendix 9.1.

Table 9.3: Groundwater Quality Results

Parameter	Units	EPA IGV	S.I. No.9	SPW3	SPW4	OW13
Date Sampled				**13/02/17**	**13/02/17**	**16/02/17**
Dissolved Al	µg/l	200	150	62.47	71.78	52.13
Dissolved As	µg/l	10	7.5	<0.352	<0.352	4.053
Dissolved Cd	µg/l	5	3.75	<0.09	<0.09	<0.09
Total Dissolved Cr	µg/l	30	37.5	1.76	<0.68	1.056
Dissolved Cu	µg/l	30	1500	7.17	5.81	2.357
Total Dissolved Fe	µg/l	200	-	7.87	34.42	51.94
Dissolved Pb	µg/l	10	18.75	0.43	<0.173	<0.173
Dissolved Mg	mg/l	50	-	4.07	2.49	4.53
Dissolved Hg	µg/l	1	-	<0.2	<0.2	<0.2
Dissolved Ni	µg/l	20	-	1.44	3.4	3.25
Dissolved Ti	µg/l	-	-	<5	<5	<5
Dissolved Zn	µg/l	100	-	43.36	41.13	74.15
Sulphate	mg/l	200	187.5	13.83	13.78	5.76
Fluoride	mg/l	1	-	0.1	0.21	0.05
Chloride	mg/l	30	24-187.5	18.68	18.32	20.89
Total Alkalinity as $CaCO_3$	mg/l	NAC	-	215.47	116.88	241.57
Electrical Conductivity	µS/cm	1000	800-1875	505	337	547
pH	pH units	6.5-9.5	-	7.79	8.35	7.69

9.3.3.8 Groundwater Flow Direction

Groundwater levels measured in groundwater monitoring boreholes across Aughinish Island indicate that groundwater flow is outwards from the central part of the 'Island' towards the coastline (Figures 9.1 and 9.2).

9.4 Predicted Impacts of the Proposed Development

The main predicted impacts which will be experienced when extraction of rock commences are as follows:

- Stripping of topsoil and overburden to access the limestone bedrock. The topsoil and overburden stripped will be used to construct screening berms along the perimeter of the Site (refer to Chapter 3.0); and
- Mechanical handling of materials. Processing of materials is proposed on the Site in the form of crushing (and screening) using a mobile crusher. Extraction by blasting, primary crushing by mobile crusher, haulage of aggregate and restoration of the areas extracted will be the activities at the proposed borrow area extension.

9.4.1 Potential Impacts on Groundwater

The main potential polluting impacts associated with the proposed development are the introduction of hydrocarbons to the underlying groundwater. Given the level of activity proposed at the Site, as long as mobile plant (and any other machinery brought on site) is properly maintained it is considered very unlikely that hydrocarbon pollution will become an issue at the Site. A number of other factors also indicate that the likelihood of negatively impacting the groundwater will be very low. These include:

- Extraction will take place above the water-table to a depth of 8.5 m OD (as was the case in the existing borrow area);
- Monitoring boreholes located in the vicinity of the proposed extension area show groundwater levels below the level of the proposed borrow area extension (Table 9.1);
- The proposed borrow area extension will be a continuation of an existing borrow area that has previously been used for the purpose of supplying aggregate for construction and maintenance on Aughinish Island;
- The development area of the Application Site is not located within a Source Protection Area of a public water supply scheme; and

9.5 Mitigation Measures

It is proposed that the following mitigation measures will be put in placed at the Site to ensure that no adverse environmental impacts will occur to the underlying hydrogeology as a result of the proposed activities:

- Adoption of the existing Environmental Management System (EMS) and other procedures (including Health and Safety) for the Aughinish Site;
- No excavation shall take place below 8.5 m OD on the Application Site;
- All soil / overburden stockpiles shall be covered (i.e. vegetated) to minimise the risk of rain / wind erosion;
- Restoration of topsoil and overburden will be carried out on a *'phased-basis'* to reduce the vulnerability of the bedrock aquifer to possible contamination;
- Mobile plant will use the existing concrete apron at the current Site garage for refuelling. Semi-static plant (i.e. mobile crusher) or tracked excavators will refuel over a drip tray with an absorbent mat;
- Any processing plant and / or mobile plant on the Application Site shall be regularly maintained, and where plant is damaged or leaking it will be fixed or replaced immediately, as part of the ongoing operational management of the borrow area to reduce the risk of leaks;
- No storage of hydrocarbons will take place on the Application Site;
- An emergency spill kit (including absorbers) will be available for use in the event of an accidental spill on the floor of the borrow area; and
- Water monitoring will continue to be undertaken using the monitoring boreholes presented in Figure 9.7, to ensure that no pollution of groundwater is occurring.

The planning of the extraction and continuing good housekeeping during operations, by adhering to best extraction practices within the borrow area, will mitigate against potential impacts on the surrounding environment.

9.6 Residual/Likely Significant Effects

The materials to be extracted from the Application Site will be used as raw materials in the construction and maintenance of the BRDA, which is considered an acceptable use of the resource. The extraction of the limestone unit on the Application Site is an important aggregate resource but not an unusual geological unit and no geological importance or heritage value is attributed to this unit at the Application Site.

In the long-term, there will be no deleterious effects on the groundwater below the floor of the borrow area as the proposed borrow area extension will be restored on a *'phased-basis'* throughout the life of the development.

9.7 Cumulative Impacts

The proposed development will take place above the water-table and there will be no discharge to surface water. The in-depth intrusive hydrogeological investigations undertaken as part of this EIAR indicate that there will be minimal impact to the groundwater regime associated with this proposed development, as the bedrock underlying the proposed borrow pit void extension is essentially 'tight'.

As no active borrow pits occur in the immediate vicinity of the proposed development, there will be no cumulative impacts on the surface water or groundwater environments as a result of this proposed activities at the Site.

9.8 References

Golder (2015) Groundwater Conceptual Model, Risk Screening and Technical Assessment Report, 13514150608.504/A.4

A Geological Description of The Shannon Estuary to accompany The Bedrock Geology 1:100,000 scale map series, Sheet 17, Clare and Limerick, Geological Survey of Ireland (GSI), 1995;

Environmental Protection Agency (EPA) Water Quality in Ireland 2004-2006, 2008;

S.I. No. 9 - European Communities Environmental Objectives (Groundwater) Regulations 2010;
S.I. No. 389 - European Communities Environmental Objectives (Groundwater) (Amendment) Regulations 2011;

Geological Survey of Ireland interactive web maps; and

Environmental Protection Agency (EPA) interactive web maps.

APPENDIX 9.1: Laboratory Certificates for Groundwater Quality Results

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email info@fitzsci.ie

A copy of this certificate is available on www.fitzsci.ie

Customer	Sean O' Sullivan Aughinish Alumina Ltd Auginish Island Askeaton Co Limerick Ireland	*Lab Report Ref. No.*	3120/568/32
		Date of Receipt	24/02/2017
		Sampled On	20/02/2017
		Date Testing Commenced	24/02/2017
		Received or Collected	Delivered by Customer
Customer PO		*Condition on Receipt*	Acceptable
Customer Ref	SPW 3	*Date of Report*	15/03/2017
Ref 2		*Sample Type*	Groundwater
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Aluminium (Dissolved)	177	ICPMS	62.47	ug/L	
Arsenic (Dissolved)	177	ICPMS	<0.352	ug/L	
Cadmium (Dissolved)	177	ICPMS	<0.09	ug/L	
Chromium (Dissolved)	177	ICPMS	1.76	ug/L	
Copper (Dissolved)	177	ICPMS	7.17	ug/L	
Iron (Dissolved)	177	ICPMS	7.87	ug/L	
Lead (Dissolved)	177	ICPMS	0.43	ug/L	
Magnesium (Dissolved)	184	ICPMS	4.065	mg/L	
Mercury (Dissolved)	178	ICPMS	<0.2	ug/L	
Nickel (Dissolved)	177	ICPMS	1.44	ug/L	
Titanium (Dissolved)	227	ICPMS	<5	ug/L	
Zinc (Dissolved)	177	ICPMS	43.36	ug/L	

Signed : A Haverman
Aoife Harmon - Technical Supervisor

Date : 15/03/2017

Acc. : Accredited Parameters by ISO 17025:2005
PVL - Parametric Value Limit as per EU (Drinking water) Regulations (SI 122 2014)
For bacterial analysis a result of 0 means none detected in volume examined
All organic results are analysed as received and all results are corrected for dry weight at 104 C
Results shall not be reproduced, except in full, without the approval of Fitz Scientific
Results contained in this report relate only to the samples tested (P) : Presumptive Results
** : The test result for this parameter may be invalid as it has exceeded the recommended holding time (BS EN ISO 5667-3:2012)

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		Date of Receipt	24/02/2017
		Sampled On	20/02/2017
		Date Testing Commenced	24/02/2017
		Received or Collected	Delivered by Customer
		Condition on Receipt	Acceptable
Customer PO		**Date of Report**	15/03/2017
Customer Ref	SPW 4	**Sample Type**	Groundwater
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Aluminium (Dissolved)	177	ICPMS	71.78	ug/L	
Arsenic (Dissolved)	177	ICPMS	<0.352	ug/L	
Cadmium (Dissolved)	177	ICPMS	<0.09	ug/L	
Chromium (Dissolved)	177	ICPMS	<0.68	ug/L	
Copper (Dissolved)	177	ICPMS	5.81	ug/L	
Iron (Dissolved)	177	ICPMS	34.42	ug/L	
Lead (Dissolved)	177	ICPMS	<0.173	ug/L	
Magnesium (Dissolved)	184	ICPMS	2.492	mg/L	
Mercury (Dissolved)	178	ICPMS	<0.2	ug/L	
Nickel (Dissolved)	177	ICPMS	3.4	ug/L	
Titanium (Dissolved)	227	ICPMS	<5	ug/L	
Zinc (Dissolved)	177	ICPMS	41.13	ug/L	

Signed : A Harmon

Aoife Harmon - Technical Supervisor

Date : 15/03/2017

Acc. : Accredited Parameters by ISO 17025:2005
PVL - Parametric Value Limit as per EU (Drinking water) Regulations (SI 122 2014)
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		Date of Receipt	24/02/2017
		Sampled On	20/02/2017
		Date Testing Commenced	24/02/2017
		Received or Collected	Delivered by Customer
		Condition on Receipt	Acceptable
Customer PO		*Date of Report*	16/03/2017
Customer Ref	OW 13	*Sample Type*	Groundwater
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Aluminium (Dissolved)	177	ICPMS	52.13	ug/L	
Arsenic (Dissolved)	177	ICPMS	4.053	ug/L	
Cadmium (Dissolved)	177	ICPMS	<0.09	ug/L	
Chromium (Dissolved)	177	ICPMS	1.056	ug/L	
Copper (Dissolved)	177	ICPMS	2.357	ug/L	
Iron (Dissolved)	177	ICPMS	51.94	ug/L	
Lead (Dissolved)	177	ICPMS	<0.173	ug/L	
Magnesium (Dissolved)	184	ICPMS	4.534	mg/L	
Mercury (Dissolved)	178	ICPMS	<0.2	ug/L	
Nickel (Dissolved)	177	ICPMS	3.246	ug/L	
Titanium (Dissolved)	227	ICPMS	<5	ug/L	
Zinc (Dissolved)	177	ICPMS	74.15	ug/L	

Signed : A Harmon
Aoife Harmon - Technical Supervisor

Date : 16/03/2017

Acc. : Accredited Parameters by ISO 17025:2005
PVL - Parametric Value Limit as per EU (Drinking water) Regulations (SI 122 2014)
For bacterial analysis a result of 0 means none detected in volume examined
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		Date of Receipt	24/02/2017
		Sampled On	20/02/2017
		Date Testing Commenced	24/02/2017
		Received or Collected	Delivered by Customer
		Condition on Receipt	Acceptable
Customer PO		*Date of Report*	08/03/2017
Customer Ref	OW-13	*Sample Type*	Groundwater
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Alkalinity (Dissolved)	102	Colorimetry	241.57	mg/L CaC03	
Chloride (Dissolved)	100	Colorimetry	20.89	mg/L	
Sulphate (Dissolved)	119	Colorimetry	5.76	mg/L as SO4	

Signed : A Harmon

Aoife Harmon - Technical Supervisor

Date : 08/03/2017

Acc. : Accredited Parameters by ISO 17025:2005
PVL - Parametric Value Limit as per EU (Drinking water) Regulations (SI 122 2014)
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	Auginish Island	*Sampled On*	20/02/2017
	Askeaton	*Date Testing Commenced*	24/02/2017
	Co Limerick	*Received or Collected*	Delivered by Customer
	Ireland	*Condition on Receipt*	Acceptable
Customer PO		*Date of Report*	08/03/2017
Customer Ref	SPW 3	*Sample Type*	Groundwater
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Alkalinity (Dissolved)	102	Colorimetry	215.47	mg/L CaC03	
Chloride (Dissolved)	100	Colorimetry	18.68	mg/L	
Sulphate (Dissolved)	119	Colorimetry	13.83	mg/L as SO4	

Signed : A Harmon
Aoife Harmon - Technical Supervisor

Date : 08/03/2017

Acc. : Accredited Parameters by ISO 17025:2005
PVL - Parametric Value Limit as per EU (Drinking water) Regulations (SI 122 2014)
For bacterial analysis a result of 0 means none detected in volume examined
All organic results are analysed as received and all results are corrected for dry weight at 104 C
Results shall not be reproduced, except in full, without the approval of Fitz Scientific
Results contained in this report relate only to the samples tested (P) : Presumptive Results
** : The test result for this parameter may be invalid as it has exceeded the recommended holding time (BS EN ISO 5667-3:2012)

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		Date of Receipt	**24/02/2017**
		Sampled On	**20/02/2017**
		Date Testing Commenced	**24/02/2017**
		Received or Collected	**Delivered by Customer**
		Condition on Receipt	**Acceptable**
Customer PO		***Date of Report***	**08/03/2017**
Customer Ref	**SPW 4**	***Sample Type***	**Groundwater**
Ref 2			
Ref 3			

CERTIFICATE OF ANALYSIS

Test Parameter	SOP	Analytical Technique	Result	Units	Acc.
Alkalinity (Dissolved)	102	Colorimetry	116.88	mg/L CaC03	
Chloride (Dissolved)	100	Colorimetry	18.32	mg/L	
Sulphate (Dissolved)	119	Colorimetry	13.78	mg/L as SO4	

Signed : A Harmon

Aoife Harmon - Technical Supervisor

Date : 08/03/2017

Acc. : Accredited Parameters by ISO 17025:2005
PVL - Parametric Value Limit as per EU (Drinking water) Regulations (SI 122 2014)
For bacterial analysis a result of 0 means none detected in volume examined
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** : The test result for this parameter may be invalid as it has exceeded the recommended holding time (BS EN ISO 5667-3:2012)

10.0 AIR QUALITY & CLIMATIC FACTORS

10.1 Introduction

This chapter assesses the likely impact on air quality and climate associated with a proposed borrow pit at Aughinish Alumina Ltd. (AAL). AAL is located on Aughinish Island, Askeaton, Co. Limerick. AAL estimate that there is a requirement for c. 374,000 m^3 (equates to c. 673,200 tonnes) over ten years of rock post-2017 to provide for ongoing works associated with the Bauxite Residue Disposal Area (BRDA) over the lifetime of the permitted development at the site. Permission was previously granted (by An Bord Pleanála on 16 February 2007 (Reg. Ref. 05/1836 ABP Ref. PL13.217976.)) for up to 70,000 tonnes per annum to be imported from local quarries to meet this demand, however the proposed borrow pit would see AAL meet the demand for the ongoing BRDA construction and maintenance within its own landholding.

10.1.1 Ambient Air Quality Standards

Air quality significance criteria are assessed on the basis of compliance with the appropriate standards or limit values. The applicable standards in Ireland include the Air Quality Standards Regulations 2011, which incorporate EU Directive 2008/50/EC, which combines the previous air quality framework and subsequent daughter directives (see Table 10.1). Although the EU Air Quality Limit Values are the basis of legislation, other thresholds outlined by the EU Directives are used which are triggers for particular actions (see Appendix 10.1).

The concern from a health perspective is focussed on particles of dust which are less than 10 microns in diameter. EU ambient air quality standards (Council Directive 2008/50/EC transposed into Irish law as S.I. 180 of 2011) centres on PM_{10} (particles less than 10 microns) as it is these particles which have the potential to be inhaled into the lungs and cause some adverse health impact. Council Directive 2008/50/EC also sets an ambient standard for $PM_{2.5}$ (particles less than 2.5 microns in diameter) which came into force in 2015 (see Table 10.1).

Ireland ratified the United Nations Framework Convention on Climate Change (UNFCCC) in April 1994 and the Kyoto Protocol in principle in 1997 and formally in May 2002[1,2]. For the purposes of the EU burden sharing agreement under Article 4 of the Kyoto Protocol, in June 1998, Ireland agreed to limit the net growth of the six GHGs under the Kyoto Protocol to 13% above the 1990 level over the period 2008 to 2012[3,4]. The UNFCCC is continuing detailed negotiations in relation to GHGs reductions and in relation to technical issues such as Emissions Trading and burden sharing. The most recent Conference of the Parties (COP22) to the agreement was convened in Morocco in December 2016.

With regard to dust deposition, the German TA-Luft standard for dust deposition (non-hazardous dust)[5] sets a maximum permissible emission level for dust deposition of 350 mg/(m^2*day) averaged over a one year period at any receptors outside the site boundary. Recommendations outlined by the Department of the Environment, Health & Local Government (6) in 2004 apply the TA Luft limit of 350 mg/(m^2*day) to the site boundary of quarries.

Pollutant	Standard	Limit Type	Value
Dust deposition (non-hazardous dust)	TA-Luft as interpreted by DOEHLG (2004)	Average daily dust deposition at the boundary of the site	350 mg/(m^2*day) Total Dust
PM_{10}	EU Directive 2008/50/EC (S.I. 180 of 2011)	24-hour limit value for protection of human health - not to be exceeded more than 35 times/year	50 µg/m^3
		Annual limit for protection of human health	40 µg/m^3
$PM_{2.5}$	EU Directive 2008/50/EC (S.I. 180 of 2011)	Annual limit value for protection of human health	25 µg/m^3

Table 10.1 Air Quality Standards for Dust Deposition, PM_{10} & $PM_{2.5}$.

10.2 Methodology

The air quality assessment has been carried out following procedures described in the publications by the EPA[7-9] and using the methodology outlined in the guidance documents published by the USEPA[10-12].

10.2.1 Dispersion Modelling Methodology

In order to assess the dust deposition flux at the AAL facility boundary, and the PM_{10} and $PM_{2.5}$ concentrations at sensitive locations beyond the site boundary associated with the proposed activities, air dispersion modelling was undertaken. Modelling using the United States Environmental Protection Agency (USEPA) new generation dispersion model AERMOD[10] (version 16216r) was used as recommended by the USEPA[11]. The model is a steady-state Gaussian plume model used to assess pollutant concentrations associated with industrial sources. The model has been designated the regulatory model by the USEPA for modelling emissions from industrial sources in both flat and rolling terrain[11]. The AERMET meteorological pre-processor[12] was used to generate hourly boundary layer parameters for use by AERMOD. Dust generation rates were calculated from factors derived from empirical assessment and detailed in the USEPA database entitled "Compilation of Air Pollution Emission Factors", Volume 2, AP-42 (1986, updated periodically)[13]. The emission factors have been presented in Appendix 10.2. The air dispersion modelling input data consists of detailed information on the physical environment (including land use and terrain features), emission rate information and a full year of meteorological data. Using this input data, the air dispersion model predicts ambient ground level concentrations and deposition fluxes for each hour of the modelled meteorological year. The model post-processes the data to identify the location and maximum value of the worst-case ground level concentration and deposition flux in the applicable format for comparison with the relevant limit values. The worst-case concentration / deposition level is then added to the existing baseline concentration / deposition level, where relevant, to give the worst-case predicted ambient concentration / deposition level of the relevant pollutants.

The modelling incorporated the following features:

- A receptor grid was created at which concentrations would be modelled focusing on the area surrounding the borrow pits. In addition boundary receptors around the proposed borrow pit were input into the model giving a total of 4,813 calculation points for the model.

- Detailed terrain has been mapped into the model using SRTM data with 30m resolution. The site is located in an area of gently rolling terrain. All terrain features have been mapped in detail into the model using the terrain pre-processor AERMAP[12].

- Hourly-sequenced meteorological information has been used in the model. Meteorological data over a five year period (Shannon Airport, 2012 – 2016) was used in the model (see Figure 10.1).

- The source and emission data have been incorporated into the model.

10.2.2 Terrain

The AERMOD air dispersion model has a terrain pre-processor AERMAP[13] which was used to map the physical environment in detail over the receptor grid. The digital terrain input data used in the AERMAP pre-processor was obtained from SRTM. This data was run to obtain for each receptor point the terrain height and the terrain height scale. The terrain height scale is used in AERMOD to calculate the critical dividing streamline height, H_{crit}, for each receptor. The terrain height scale is derived from the Digital Elevation Model (DEM) files in AERMAP by computing the relief height of the DEM point relative to the height of the receptor and determining the slope. If the slope is less than 10%, the program goes to the next DEM point. If the slope is 10% or greater, the controlling hill height is updated if it is higher than the stored hill height.

In areas of complex terrain, AERMOD models the impact of terrain using the concept of the dividing streamline (H_c). As outlined in the AERMOD model formulation[12] a plume embedded in the flow below H_c tends to remain horizontal; it might go around the hill or impact on it. A plume above H_c will ride over the hill. Associated with this is a tendency for the plume to be depressed toward the terrain surface, for the flow to speed up, and for vertical turbulent intensities to increase.

AERMOD model formulation states that the model "captures the effect of flow above and below the dividing streamline by weighting the plume concentration associated with two possible extreme states of the boundary layer (horizontal plume and terrain-following). The relative weighting of the two states depends on: 1) the degree of atmospheric stability; 2) the wind speed; and 3) the plume height relative to terrain. In stable conditions, the horizontal plume "dominates" and is given greater weight while in neutral and unstable conditions, the plume traveling over the terrain is more heavily weighted"[12].

The terrain in the region of the facility is complex in the sense that the maximum terrain in the modelling domain peaks at 141m which is above the release height of the borrow pit. However, in general, the region of the site has gently sloping terrain particularly in the immediate vicinity of the facility.

10.2.3 Geophysical Considerations

AERMOD simulates the dispersion process using planetary boundary layer (PBL) scaling theory[12]. PBL depth and the dispersion of pollutants within this layer are influenced by specific surface characteristics such as surface roughness, albedo and the availability of surface moisture. Surface roughness is a measure of the aerodynamic roughness of the surface and is related to the height of the roughness element. Albedo is a measure of the reflectivity of the surface whilst the Bowen ratio is a measure of the availability of surface moisture.

AERMOD incorporates a meteorological pre-processor AERMET[12] to enable the calculation of the appropriate parameters. The AERMET meteorological pre-processor requires the input of surface characteristics, including surface roughness (z_0), Bowen Ratio and albedo by sector and season, as well as hourly observations of wind speed, wind direction, cloud cover, and temperature. The values of albedo, Bowen Ratio and surface roughness depend on land-use type (e.g., urban, cultivated land etc.) and vary with seasons and wind direction. The assessment of appropriate land-use type was carried out to a distance of 10km from the meteorological station for Bowen Ratio and albedo and to a distance of 1km for surface roughness in line with USEPA recommendations[13,14].

In relation to AERMOD, detailed guidance for calculating the relevant surface parameters has been published[15]. The most pertinent features are:

- The surface characteristics should be those of the meteorological site (Shannon Airport) rather than the installation;
- Surface roughness should use a default 1km radius upwind of the meteorological tower and should be based on an inverse-distance weighted geometric mean. If land use varies around the site, the land use should be sub-divided by sectors with a minimum sector size of 30°;
- Bowen ratio and albedo should be based on a 10km grid. The Bowen ratio should be based on an un-weighted geometric mean. The albedo should be based on a simple un-weighted arithmetic mean.

AERMOD has an associated pre-processor, AERSURFACE[14], which has representative values for these parameters depending on land use type. The AERSURFACE pre-processor currently only accepts NLCD92 land use data which covers the USA. Thus, manual input of surface parameters is necessary when modelling in Ireland. Ordnance survey discovery maps (1:50,000) and digital maps such as those provided by the EPA, National Parks and Wildlife Service (NPWS) and Google Earth® are useful in determining the relevant land use in the region of the meteorological station. The Alaska Department of Environmental Conservation has issued a guidance note for the manual calculation of geometric mean for surface roughness and Bowen ratio for use in AERMET[12]. This approach has been applied to the current site.

10.2.4 Process Emissions

Borrow pit/quarrying activities typically emit dust. Dust is characterised as encompassing particulate matter with a particle size of between 1 and 75 microns (1-75µm). Deposition typically occurs in close proximity to each site and potential impacts generally occur within 500 metres of the dust generating activity as dust particles fall out of suspension in the air. Larger particles deposit closer to the generating source and deposition rates will decrease with distance from the source. Sensitivity to dust depends on the duration of the dust deposition, the dust generating activity, and the nature of the deposit. Therefore, a higher tolerance of dust deposition is likely to be shown if only short periods of dust deposition are expected and the dust generating activity is either expected to stop or move on.

The potential for dust to be emitted will depend on the type of activity being carried out in conjunction with environmental factors including levels of rainfall, wind speed and wind direction. This report identifies and quantifies the dust sources from the proposed borrow pit.

The likely significant impacts from the "do-something" scenario are focused on dust generation from the proposed Borrow Pit. However, the likely significant impacts for the do-nothing scenario are due to increased road traffic emissions. The UK Design Manual for Roads and Bridges guidance[15], on which Transport Infrastructure Ireland guidance was based sets out how impacts due to increased road traffic emissions are calculated.

10.2.5 Dust Generation Rates

Dust generation rates depend on the site activity, particle size, the moisture content of the material and weather conditions. Dust emissions are dramatically reduced where rainfall has occurred due to the cohesion created between dust particles and water and the removal of suspended dust from the air. It is typical to assume no dust is generated under "wet day" conditions where rainfall greater than 0.2mm has fallen.

Large particle sizes (greater than 75 microns) fall rapidly out of atmospheric suspension and are subsequently deposited in close proximity to the source. Particle sizes of less than 75 microns are of interest as they can remain airborne for greater distances and give rise to the potential dust nuisance at nearby sensitive receptors. This size range would broadly be described as silt. Emission rates are normally predicted on a site-specific particle size distribution for each dust emission source. In the absence of such information, the particle size distribution outlined in AP-42 Appendix B.2.2 for Category 3 (mechanically generated aggregate)[13] has been used and is outlined in Table 10.2. The moisture content of limestone has been estimated at 2.1%, which is based on a literature review.

Cumulative % ≤ Stated Size	Particle Size, µm	Minimum Value	Maximum Value	Standard Deviation
4	1.0	-	-	-
11	2.0	-	-	-
15	2.5	3	35	7
18	3.0	-	-	-
25	4.0	-	-	-
30	5.0	-	-	-
34	6.0	15	65	13
51	10.0	23	81	14

Table 10.2 Category 3 Mechanically Generated Aggregate Taken From AP-42[13]

Dust deposition typically occurs in close proximity to the dust-generating source. The proposed borrow pit is located within the main AAL site and therefore the nearest sensitive locations beyond the AAL boundary are mostly greater than 1 km from the extraction of material. Generally, the potential for severe dust impacts is greatest within 100 m of dust generating activities, though residual impacts can occur for distances beyond 100 m. Hence, it is unlikely that the nearest sensitive receptors outside the landholding of AAL would be impacted due to dust deposition associated with the proposed borrow pit.

10.3 Receiving Environment

10.3.1 Meteorological Data

Meteorological conditions significantly affect the level of dust emissions and subsequent deposition downwind of the source. The most significant meteorological elements affecting dust deposition are rainfall and wind-speed. High levels of moisture either retained in soil or as a result of rainfall help suppress the generation of dust due to the cohesive nature of water between dust particles. Rain also assists in removing dust from the atmosphere through washout. Wind can lift particles up into the air and transport the dust downwind as well as drying out the surface. The worst dust deposition conditions typically occur therefore during dry conditions with strong winds.

Shannon Airport meteorological station, which is located approximately 15 km north-east of the site, collects data in the correct format and has a data collection of greater than 90%. Long-term hourly observations at Shannon Airport meteorological station provide an indication of the prevailing wind conditions for the region (see Figure 10.1). Results indicate that the prevailing wind direction is from south to north-westerly in direction over the period 2012 - 2016. The mean wind speed is approximately 4.7 m/s over the period 1981-2010. Calm conditions account for only a small fraction of the time in any one year peaking at 130 hours in 2010 (1.5% of the time). There were also no missing hours over the period 2012 – 2016.

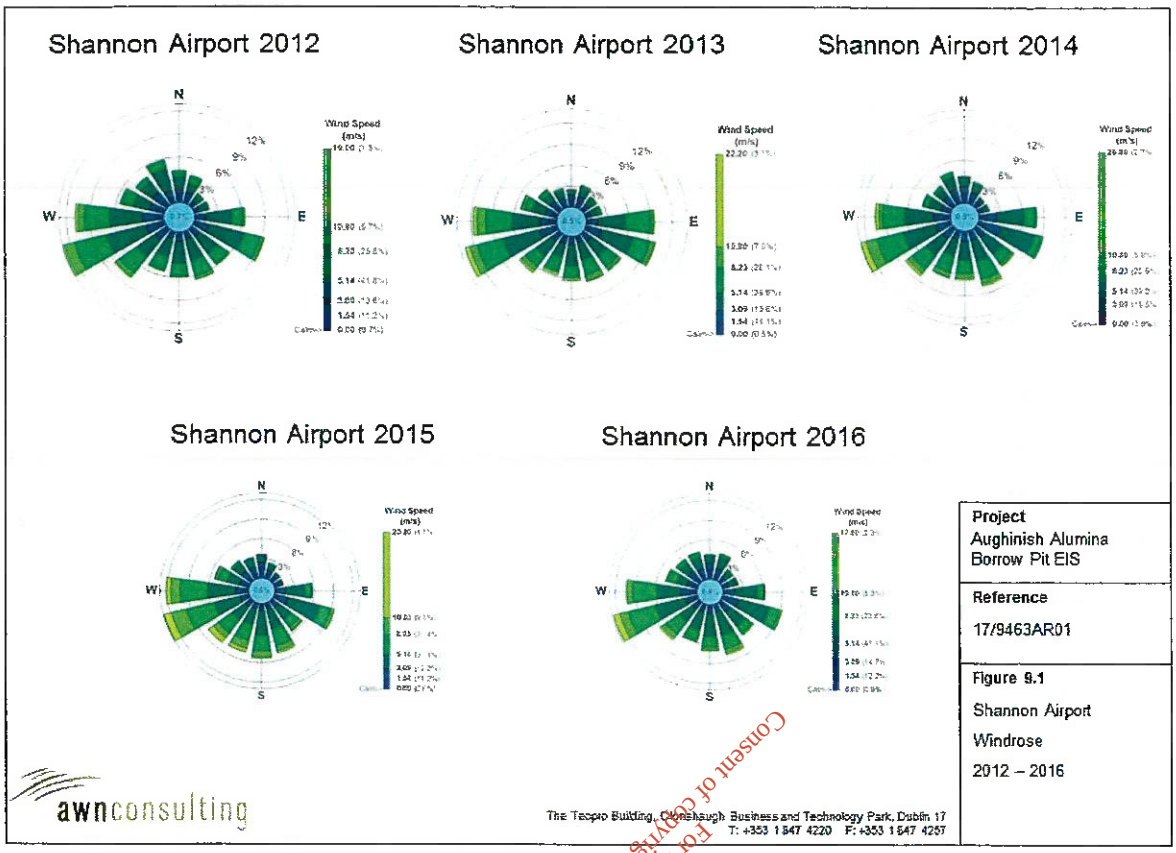

Figure 10.1: Shannon Airport Windrose 2012-2016

10.3.2 Background Sources of Dust

The sources of dust arising from the facility contribute to background levels of dust. Dust is present naturally in the air from a number of sources including weathering of minerals, and pick-up across open land and dust generated from fires. A study by the UK ODPM[17] gives estimates of likely dust deposition levels in specific types of environments. In open country a level of 39 mg/(m^2*day) is typical, rising to 59 mg/(m^2*day) on the outskirts of town and peaking at 127 mg/(m^2*day) for a purely industrial area. A level of 39 mg/(m^2*day) has been applied as the background dust deposition level for the region of the facility in Aughinish, County Limerick.

10.3.3 Dust Deposition Monitoring

Results of dust deposition monitoring at 24 locations within the AAL boundary from January 2011 to August 2016 are summarised in Table 9.3. The average dustfall levels measured at the locations were within the TA Luft limit value of 350 mg/(m^2*day) over the years 2011 to 2016 with a maximum annual average of 117 mg/(m^2*day) at DG11. The monthly average across all sites ranges from 8 - 117 mg/(m^2*day). Overall, dustfall levels are low, with the monthly average across all twenty four sites reaching at most 33% of the TA Luft limit value in August 2011. The closest dust guage to the proposed borrow pit is DG13, this has an average concentration from 2011 to 2016 of 37 mg/m^2*day. As dustfall levels in the Borrow Pit are relatively low, the estimate of 37 mg/m^2*day is an appropriate background level for the area.

Dust Gauge	Annual Average Deposition Concentration - mg/(m^2*day)					
	2011	2012	2013	2014	2015	2016
DG4	54	48	90	62	65	47
DG5	18	24	19	37	37	17
DG6	23	21	23	58	50	31
DG7	26	42	23	73	57	54
DG8	24	38	30	48	28	22
DG9	23	26	22	46	30	14
DG10	25	21	16	23	51	10
DG11	117	23	17	110	49	23
DG12	36	37	28	34	28	17
DG13	28	31	18	17	27	104
DG20	22	18	21	30	27	18
DG21	37	39	16	47	28	30
DG22	34	24	31	31	39	20
DG23	11	20	26	18	22	10
DG24	71	26	37	54	35	14
DG25	36	28	47	44	38	15
DG26	64	25	50	41	53	17
DG27	23	16	10	19	26	22
DG28	27	22	18	35	28	8
DG29	22	23	31	79	100	9
DG30	42	40	45	43	50	12
DG31	0	0	0	27	45	16
DG32	0	0	0	20	39	14
DG33	0	0	0	15	18	19
MAX	117	48	90	110	100	104
AVERAGE	32	25	26	42	40	23

Note 1: Limit value is TA Luft limit of 350 mg/m2*day

Table 10.3 Dust Deposition Monitoring on AAL Landholding

10.3.4 Background Sources of PM_{10} and $PM_{2.5}$

Long-term PM_{10} monitoring was carried out at the Zone D locations of Castlebar, Claremorris, Enniscorthy and Kilkitt in 2015. The PM_{10} annual averages for these four locations in 2015 ranged from 9.2 to 18 $\mu g/m^3$[3(18)]. The PM_{10} annual average in 2015 for the rural Zone D location of Kilkitt was 9.2 $\mu g/m^3$[3(18)]. In addition, data from the Phoenix Park provides a good indication of urban background levels, with an annual average in 2015 of 12 $\mu g/m^3$[3(18)]. Based on the above information, a conservative estimate of the background PM_{10} concentration for Aughinish of 15 $\mu g/m^3$ has been used. In relation to the maximum 24-hour averaging period (expressed as the 90th%ile), a value of 18.0 $\mu g/m^3$ calculated from real monitoring data for Kilkitt for 2015 of 18.0) was employed using the methodology outlined in Appendix E of AG4[9].

Year	Claremorris	Kilkitt	Shannon Town	Castlebar
2010	-	18.6	-	27.4
2011	20.3	17.9	20.5	26.7
2012	17.7	15.9	23.1	19.8
2013	21.0	18.6	-	26.9
2014	15.2	15.4	-	15.2
2015	16.5	17.7	-	22.2
Average	**18.1**	**17.4**	**21.8**	**23.03**

Table 10.4 90th%ile of 24-Hour PM_{10} Concentrations In Zone D Locations 2010 - 2015 ($\mu g/m^3$)

Year	Claremorris	Kilkitt	Shannon Town	Castlebar
2010	-	10	-	15
2011	12	9	11	14
2012	10	9	11	12
2013	13	11	-	15
2014	10	9	-	12
2015	10	9	-	13
Average	**11**	**10**	**11**	**14**

Table 10.5 Annual Mean PM_{10} Concentrations In Zone D Locations 2010 - 2015 ($\mu g/m^3$)

The results of $PM_{2.5}$ monitoring at the Zone D location of Claremorris in 2015[19] indicated an average $PM_{2.5}/PM_{10}$ ratio of 0.6. Based on this information, a conservative ratio of 0.7 was used to generate a background $PM_{2.5}$ concentration of 10.5 $\mu g/m^3$.

In relation to the annual averages, the ambient background concentration is added directly to the process concentration. However, in relation to the short-term peak concentration, concentrations due to emissions from elevated sources cannot be combined in the same way. Guidance from the UK DEFRA[20] and the EPA[9] advises that for PM_{10} an estimate of the maximum combined pollutant concentration can be obtained as shown below:

PM_{10} - The 90.4th%ile of total 24-hour mean PM_{10} is equal to the maximum of either A or B below:

a) 90.4th%ile of 24-hour mean background PM_{10} + annual mean process contribution PM_{10}

b) 90.4th%ile 24-hour mean process contribution PM_{10} + annual mean background PM_{10}.

10.4 Likely Significant Impacts

AAL operates a long-established alumina extraction plant, located on Aughinish Island on the southern side of the Shannon Estuary near the village of Foynes, Co. Limerick. The landholding extends to c. 338 ha. A landscape contractor's compound is currently located within the proposed borrow pit area.

AAL estimate there is a requirement for c. 374,000 m³ (equates to c. 673,200 tonnes) over ten years of rock post-2017 to provide for ongoing works associated with the BRDA over the lifetime of the permitted development at the site. The extracted rock will be used within the confines of the site and will not be transported off site. The maximum annual production rate is expected to be 81,000 tonnes per annum. AAL has a limited store of rock on site which is used in the ongoing construction and maintenance works associated with the BRDAs on site. This existing stockpile of rock is due to be used during the 2017/2018 period and thus alternative rock sources within the AAL landholding are being investigated.

10.4.1 Construction Phase Impact

Dust

Construction dust has the potential to cause local impacts through dust nuisance at the nearest sensitive receptors. Construction activities such as excavation, earth moving and backfilling may generate quantities of dust, particularly in dry and windy weather conditions. While dust from construction activities tends to be deposited within 200m of a construction site, the majority of the deposition occurs within the first 50m. The extent of any dust generation depends on the nature of the dust (soils, peat, sands, gravels, silts etc.) and the nature of the construction activity. In addition, the potential for dust dispersion and deposition depends on local meteorological factors such as rainfall, wind speed and wind direction. Vehicles transporting material to and from the site also have the potential to cause dust generation along the selected haul routes from the construction areas.

The TII publication "*Guidelines for the treatment of Air Quality During the Planning & Construction of National Road Schemes*"[21] outlines the approach for defining significance in terms of construction impacts. Under Section 4.2.6 Construction Impacts, the guidance document states that:

"*The significance of impacts due to vehicle emissions during the construction phase will be dependent on the number of additional vehicle movements, the proportion of HGVs and the proximity of sensitive receptors to site access routes. If construction traffic would lead to a significant change (>10%) in* Annual Average Daily Traffic *(AADT) flows near to sensitive receptors, then concentrations of nitrogen dioxide, PM_{10} and $PM_{2.5}$ should be predicted using the approach described previously*"[21].

The construction phase of the "do-something" proposal will not lead to any increase in AADT and therefore the impact on sensitive receptors due to construction phase traffic is predicted to be temporary, reversible and imperceptible.

Appendix 8 of the "*Guidelines for the treatment of Air Quality During the Planning & Construction of National Road Schemes*" discusses construction phase impacts. Table 9.6 below shows the risk from dust soiling ranges from 25m – 100m and in relation to PM_{10}, the risk ranges from 10m – 25m depending on the scale of the construction activity. Given that

the façade of the nearest residences is approximately 1 km from the proposed site, the guidance above would indicate that there is negligible potential for impacts from soiling, PM_{10} and to vegetation and therefore, no significant impacts expected when the mitigation measures outlined in Section 10.5.1 are taken into account. Due to the type of work required, the construction phase and site set up for a development such as a borrow pit is predicted to be insignificant. The impact due to construction dust at sensitive receptors is predicted to be temporary, reversible and imperceptible.

Source		Potential Distance for Significant Effects (Distance from source)		
Scale	**Description**	**Soiling**	**PM_{10}**	**Vegetation Effects**
Major	Large construction sites with high use of haul routes	100m	25m	25m
Moderate	Moderate sized construction sites with moderate use of haul routes	50m	15m	15m
Minor	Minor construction sites with limited use of haul routes	25m	10m	10m

Source: Appendix 8: Assessment of Construction Impacts taken from *"Guidelines for the treatment of Air Quality During the Planning & Construction of National Road Schemes"* (TII, 2011)

Table 10.6 Assessment Criteria for the Impact of Dust Emissions from Construction Activities with Standard Mitigation in Place

Climate

There is the potential for a number of greenhouse gas emissions to the atmosphere during the demolition and construction phases of the development. Greenhouse gas emitting sources such as construction vehicles, generators etc., have been considered and these may give rise to CO_2 and NO_2 emissions.

However, due to the nature of activities CO_2 and NO_2 emissions will have an imperceptible, temporary impact on climate.

10.4.2 Operational Phase Impact

The proposed Borrow Pit extraction area extends to c. 4.5ha with a crushing/stockpiling area to the south. The blasting/crushing operations at the Borrow Pit will be restricted to a period between April and September.

Rock will be extracted by blasting means. The mobile crusher and screener will initially be based in the former borrow pit footprint to the south of the proposed borrow pit site. As the borrow pit develops to the north, it is envisaged that the plant will follow suit.

The blasting programme would be scheduled to meet the rate of crushing and screening with a single blast expected to produce 7,500 m^3 to 8,500 m^3 of rock fill (13,500 tonnes to 15,300 tonnes per blast). A blast would be required every 15 working days (3 weeks) to meet the expected production with up to 7 blasts required per year.

The proposed development will not result in the removal of any materials outside of the landholding of AAL. The operational hours of the Borrow Pit will be 08:00 to 18:00 Monday to Friday.

The borrow pits are located in an area of limestone. For the purposes of this assessment it has been assumed that a maximum of 81,000 tonnes of stone will be extracted over a one year period. This extraction rate has been used in order to estimate the worst-case impact of the borrow pit in the surrounding environment.

For the purpose of the assessment an estimate of 5 truck movements, within the borrow pit boundary and out of the borrow pit to the main AAL facility of the site per hour has been assumed for the "do something" scenario.

The following operations are the main dust generating sources or activities at the Borrow Pit:

1) Movement of empty trucks along paved roads
2) Movement of empty trucks along unpaved haul roads within the borrow pit
3) Drilling and blasting of material
4) Extraction of material
5) Crushing of material
6) Screening of material
7) Stockpiling of material
8) Loading of material
9) Movement of full trucks along unpaved haul roads within the borrow pit
10) Movement of full trucks along paved roads
11) Wind erosion at dump areas, stockpiles and exposed Borrow Pit surface.

Air Quality

Dust

For the "do something" scenario, emissions from the combined operational processes lead to a dust deposition level averaged over the full year of 4.96 mg/(m^2*day) at the AAL boundary (see Table 9.7 and Figure 9.2). Based on a background deposition rate of 37 mg/(m^2*day) in the region of the site, the combined dust deposition level including the borrow pit peaks at 41.96 mg/(m^2*day) which is 12% of the TA Luft Limit Value of 350 mg/(m^2*day). 2016 had higher concentrations than the average for the past six years, even using this worst case background scenario the combined dust deposition level including the borrow pit peaks at 106.7 mg/(m^2*day) which is 31% of the TA Luft Limit Value of 350 mg/(m^2*day)

Thus, the impact of the proposed extension is to increase ambient dust deposition level by a maximum of 4.96 mg/(m^2*day) which is 1.4% of the TA Luft Limit Value of 350 mg/(m^2*day) and a long-term, reversible and negligible impact.

Pollutant / Scenario	Background Level (mg/(m²*day))	Process Contribution (mg/(m²*day))	Predicted Deposition (mg/(m²*day))	Limit Value (mg/(m²*day)) Note 1
Dust "Do Something" / 2012	37	3.81	40.81	350
Dust "Do Something" / 2013	37	4.96	41.96	350
Dust "Do Something" / 2014	37	2.77	39.77	350
Dust "Do Something" / 2015	37	4.77	41.77	350
Dust "Do Something" / 2016	37	4.08	41.08	350

Note 1 TA-Luft as interpreted by DOEHLG (2004)

Table 10.7 Dispersion Modelling Results for Dust Deposition

PM_{10}

Predicted PM_{10} concentrations at the AAL boundary are significantly lower than the ambient air quality standards at the worst-case off site location for the "do something" scenarios (see Table 10.8 and Figures 10.9). For the "do something" scenario, the predicted 24-hour (90^{th}%ile) and annual concentrations (excluding background) at the worst-case off site location peak at 13.6 and 8.6 µg/m³, respectively. Based on a background PM_{10} concentration of 12 µg/m³ in the region of the proposed borrow pit, the combined annual PM_{10} concentration including the proposed borrow pit peaks at 20.6 µg/m³. This predicted level equates to at most 52% of the annual limit value of 40 µg/m³. The predicted 24-hour PM_{10} concentration (including background) peaks at 26.7 µg/m³ which is 53% of the 24-hour limit value of 50 µg/m³ (measured as a 90.4^{th}%ile). However, concentrations at the worst case sensitive receptor are significantly lower than the worst case off site location.

The impact of the proposed borrow pit is to increase ambient annual mean PM_{10} concentrations at the worst-case sensitive receptor location by 0.07 µg/m³. This equates to significantly less than 1% of the annual PM_{10} limit value of 40 µg/m³ and a long-term, reversible and negligible impact.

Pollutant / Scenario	Annual Mean Background ($\mu g/m^3$)	Averaging Period	Process Contribution PM_{10} ($\mu g/m^3$)	Predicted Emission Concentration PM_{10} ($\mu g/m^3$) Note 2	Standard ($\mu g/m^3$) Note 1
PM_{10} "Do Something" / 2012	N/A	90.4th%ile of 24-hr means	6.27	20.0	50
	12	Annual Mean	1.95	14.0	40
PM_{10} "Do Something" / 2013	N/A	90.4th%ile of 24-hr means	13.62	26.7	50
	12	Annual Mean	8.63	20.6	40
PM_{10} "Do Something" / 2014	N/A	90.4th%ile of 24-hr means	13.62	22.1	50
	12	Annual Mean	4.09	16.1	40
PM_{10} "Do Something" / 2015	N/A	90.4th%ile of 24-hr means	8.42	20.3	50
	12	Annual Mean	2.23	14.2	40
PM_{10} "Do Something" / 2016	N/A	90.4th%ile of 24-hr means	5.77	19.4	50
	12	Annual Mean	1.40	13.4	40

Note 1 S.I. 180 of 2011 and EU Directive 2008/50/EC

Note 2 90.4th%ile of 24-Hr PM_{10} Concentration Calculated Using Background data based on Kilkitt PM_{10} (Annual Mean = 12 $\mu g/m^3$, 90th%ile = 18 $\mu g/m^3$)

Table 10.8 Dispersion Modelling Results for PM_{10}

$PM_{2.5}$

Predicted $PM_{2.5}$ concentrations at the worst-case off site location are significantly lower than the limit value of 25 $\mu g/m^3$ (see Table 10.9 and Figure 10.4) for the "do something" scenario.

For the "do something" scenario, the predicted annual concentration (excluding background) at the worst-case off site location peaks at 0.98 $\mu g/m^3$. Based on a background $PM_{2.5}$ concentration of 10.5 $\mu g/m^3$ in the region of the Proposed borrow pit, the annual $PM_{2.5}$ concentration including the Borrow Pit operations peaks at 11.48 $\mu g/m^3$. This peak level equates to 46% of the annual limit value for $PM_{2.5}$. However, concentrations at the worst case sensitive receptor are significantly lower than the worst case off site location.

The impact of the proposed borrow pit is to increase ambient annual $PM_{2.5}$ concentrations at the worst-case sensitive receptor by 0.02 $\mu g/m^3$. This equates to less than 1% of the annual limit value of 25 $\mu g/m^3$ and a long-term, reversible and negligible impact.

Pollutant / Scenario	Annual Mean Background ($\mu g/m^3$)	Averaging Period	Process Contribution $PM_{2.5}$ ($\mu g/m^3$)	Predicted Immission Concentration $PM_{2.5}$ ($\mu g/m^3$)	Standard ($\mu g/m^3$) Note 1
$PM_{2.5}$ "Do Something" / 2012	10.5	Annual Mean	0.82	11.32	25
$PM_{2.5}$ "Do Something" / 2013	10.5	Annual Mean	0.97	11.47	25
$PM_{2.5}$ "Do Something" / 2014	10.5	Annual Mean	0.98	11.48	25
$PM_{2.5}$ "Do Something" / 2015	10.5	Annual Mean	0.93	11.43	25
$PM_{2.5}$ "Do Something" / 2016	10.5	Annual Mean	0.79	11.29	25

Note 1 S.I. 180 of 2011 and EU Directive 2008/50/EC

Table 10.9 Dispersion Modelling Results for $PM_{2.5}$

Climate

There is the potential for a number of greenhouse gas emissions to atmosphere from the proposed borrow pit plant and trucks. Borrow Pit vehicles, generators etc., may give rise to CO_2 and N_2O emissions. However, due to the size and nature of the activities at the proposed borrow pit, CO_2 and N_2O emissions have a negligible impact on climate. Greenhouse gas emissions, as a result of the Borrow Pit, are imperceptible in terms of Ireland's obligations under the Kyoto Protocol[1,2].

10.4.3 Do 'Nothing' Impact

The "do-nothing" scenario assumes the site will be brownfield site or remain as a landscape contractor compound. AAL has a limited store of rock on site which is used in the ongoing construction and maintenance works associated with the BRDAs on site. This existing stockpile of rock is due to be used during the 2017/2018 period and thus alternative rock sources such as the proposed borrow pit within the AAL landholding are being investigated.

An application for planning permission for expansion of the existing alumina production facility at Aughinish Island from 1.6 million tonnes per annum (mtpa) to 1.95 mtpa was granted by An Bord Pleanála on 16 February 2007 (Reg. Ref. 05/1836 ABP Ref. PL13.217976.) As part of the grant of that permission, it was proposed that rock material required to facilitate ongoing production of alumina would be sourced from external quarries. The do-nothing scenario will assume that this material is required to be imported to AAL from nearby quarries as per the granted planning permission.

The UK Design Manual for Roads and Bridges guidance[15], on which Transport Infrastructure Ireland guidance was based, states that road links meeting one or more of the following criteria can be defined as being 'affected' by a proposed development and should be included in the local air quality assessment:

- Road alignment change of 5 metres or more;
- Daily traffic flow changes by 1,000 AADT or more;
- HGVs flows change by 200 vehicles per day or more;
- Daily average speed changes by 10 km/h or more; or
- Peak hour speed changes by 20 km/h or more.

The do-nothing scenario will create a maximum of 50 truck movements in and 41 truck movements out of the site per day, however this is averaged to 9 HGV movements per day over the 10 year period. The nature of the "do nothing" scenario is such that there is no significant predicted impact on traffic when compared to the guidance above. Therefore, using the DMRB screening criteria, no road links can be classed as 'affected' by the "do nothing" scenario and thus, traffic emission impacts do not require inclusion in the air quality assessment.

For the "do nothing" scenario, emissions from the combined operational processes at the AAL facility lead to a dust deposition level averaged over the full year of 37 mg/(m^2*day) at the closest dust gauge to the borrow pit. This is based on an average deposition rate monitored between 2011 and 2016 at DG13, which is the closest to the boundary of the Proposed borrow pit. Thus, the dust deposition level for the "do nothing" scenario is 10.5 % of the TA Luft Limit Value of 350 mg/(m^2*day).

The do-nothing scenario is unlikely to alter the current dust deposition concentrations at the boundary of the proposed borrow pit as minimal additional dust deposition is predicted to occur due to the delivery of the required stone from other quarries rather than the extraction of it from the proposed borrow pit.

10.5 Mitigation Measures

In order to sufficiently ameliorate the likely air quality impact, a schedule of air control measures has been formulated for the construction phase associated with the proposed development.

10.5.1 Construction Phase - Air Quality

The greatest potential impact on air quality during the construction phase is from construction dust emissions, $PM_{10}/PM_{2.5}$ emissions and the potential for nuisance dust.

In order to minimise dust emissions during construction, a series of mitigation measures have been prepared in the form of a dust minimisation plan. This includes mitigation measures recommended in the Institute of Air Quality Management Guidance on the Assessment of Dust from Demolition and Construction Version 1.1 for sensitive receptors. Provided the dust minimisation measures outlined in the Plan (see Appendix 10.3) and site management plan are adhered to, the air quality impacts during the extraction phase will not be significant.

In summary the measures which will be implemented will include:

- Hard surface roads will be swept to remove mud and aggregate materials from their surface while any un-surfaced roads will be restricted to essential site traffic.
- Furthermore, any road that has the potential to give rise to fugitive dust must be regularly watered, as appropriate, during dry and/or windy conditions.
- Vehicles exiting the main AAL site boundary shall make use of a wheel wash facility where appropriate, prior to entering onto public roads.
- Vehicles using site roads will have their speed restricted, and this speed restriction must be enforced rigidly. On any un-surfaced site road, this will be 25 kph, and on hard surfaced roads as site management dictates.
- Vehicles delivering material with dust potential (soil, aggregates) will be enclosed or covered with tarpaulin at all times to restrict the escape of dust.
- Public roads outside the AAL site will be regularly inspected for cleanliness, and cleaned as necessary.
- Material handling systems and site stockpiling of materials will be designed and laid out to minimise exposure to wind. Water misting or sprays will be used as required if particularly dusty activities are necessary during dry or windy periods.
- During movement of materials both on and off-site, trucks will be stringently covered with tarpaulin at all times. Before entrance onto public roads, trucks will be adequately inspected to ensure no potential for dust emissions.

At all times, these procedures will be strictly monitored and assessed. In the event of dust nuisance occurring outside the site boundary, movements of materials likely to raise dust would be curtailed and satisfactory procedures implemented to rectify the problem before the resumption of operations.

10.5.2 Construction Phase - Climate

Construction traffic and embodied energy of construction materials are expected to be the dominant source of greenhouse gas emissions as a result of the construction phase of the development. Construction vehicles, generators etc., may give rise to some CO_2 and N_2O emissions. However, due to nature of these works, the impact on climate will not be significant.

However, some site-specific mitigation measures can be implemented during the construction phase of the proposed development to ensure emissions are reduced further. In particular the prevention of on-site or delivery vehicles from leaving engines idling, even over short periods. Minimising waste of materials due to poor timing or over ordering on site will aid to minimise the embodied carbon footprint of the site.

10.5.3 Operational Phase – Air Quality/Dust

For the purposes of the air dispersion modelling assessment, the following mitigation measures are assumed to be in operation:

- Speeds on all unpaved onsite roads are restricted to 25 km/hr;
- Speeds on all paved onsite roads are restricted to 30 km/hr;
- Use of watering during crushing/screening to increase moisture content;
- Internal haul roads are watered twice daily on dry days;

These measures should be enforced to ensure that dust nuisance due to the borrow pit activities is minimised beyond the site boundary.

As the current proposal will not lead to any significant increase in AADT traffic levels, the scheme may be viewed as being below significance criteria and thus the prediction of the concentrations of nitrogen dioxide, PM_{10} and $PM_{2.5}$ at sensitive receptors is not required under the guidelines. However, mitigation measures in relation to vehicle-derived pollutants from the HGV's and other vehicles have focused generally on improvements in both engine technology and fuel quality. EU legislation, based on the EU sponsored Auto-Oil programmes, has imposed stringent emission standards for key pollutants (REGULATION (EC) No 715/2007) for passenger cars which was complied with in 2009 (Euro V) and 2014 (Euro VI).

As outlined in the Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes[15] the guidance states that "for the purpose of the EIAR, it should be assumed that pollutant concentrations will decline in future years, as a result of various initiatives to reduce vehicle emissions both in Europe and in Ireland" (Page 52). A range of legislation in Europe over the period 1992 – 2013 has significantly reduced the allowable steady cycle emissions of both NO_X and PM from road vehicles with NO_X emission reductions for HDV (Heavy Diesel Vehicles) a factor of 20 and PM a factor of 36 over this period (Euro I to Euro VI). In relation to LDV (Light Diesel Vehicles) the reduction of NO_X and PM from road vehicles has also been significant with NO_X emission reductions from HDV a factor of 12 and PM a factor of 40 over this period (Euro I to Euro VI). Although actual on-road emission reductions will be less dramatic, significant reductions in vehicle-related NO_X and PM emissions are to be expected over the next 5-10 years as the fleet turns over.

10.5.4 Operational Phase – Climate

Alongside the improvements in air quality emissions, improvements in emissions impacting climate are also likely. These improvements are as a result of the on-going comprehensive vehicle inspection and maintenance program, fiscal measures to encourage the use of alternatively fuelled vehicles and the introduction of cleaner fuels.

CO_2 emissions for the average new vehicle fleet were reduced to 120 g/km by 2012 through EU legislation on improvements in vehicle motor technology and by an increased use of biofuels. This measure has reduced CO_2 emissions from new cars by an average of 25% in the period from 1995 to 2008/2009 whilst 15% of the necessary effort towards the overall climate change target of the EU has been met by this measure alone[22].

Additional measures included in the National Climate Change Strategy[23,24] include: (1) VRT and Motor Tax rebalancing to favour the purchase of more fuel-efficient vehicles with lower CO_2 emissions; (2) continuing the Mineral Oils Tax Relief II Scheme and introduction of a biofuels obligation scheme; (3) implementation of a national efficient driving awareness campaign, to promote smooth and safe driving at lower engine revolutions; and (4) enhancing the existing mandatory vehicle labelling system to provide more information on CO_2 emission levels and on fuel economy.

10.6 Cumulative Impact

AAL operates a long-established alumina extraction plant. The landholding extends to c. 338 ha. The proposed borrow pit is near the centre of the landholding and therefore any significant cumulative impacts are likely to be due to activity by AAL. Long standing monitoring at the site for dust deposition were shown in Section 10.3.3, these include any dust generated onsite. Therefore, there is no predicted additional cumulative impacts which are not included in the background environmental contribution.

Overall, monitored dustfall levels are low between 2011 to 2016, with the monthly average across all four sites reaching at most 33% of the TA Luft limit value in August 2011. As dustfall levels near the borrow pit area are relatively low the estimate of 37 mg/m^2*day is an appropriate background level for the area.

10.7 Residual Impacts

Modelled emissions from the AAL borrow pit will lead to ambient concentrations which are within the relevant ambient air quality standards for dust, PM_{10} and $PM_{2.5}$. Compared to the "do nothing" scenario, the impact of the proposed extension at the worst case location outside the AAL boundary will be to increase levels of dust, PM_{10} and $PM_{2.5}$ by between 1% - 27% of the ambient air quality standards. However, all ambient concentrations for the "do something" scenario will remain below the ambient air quality standards and there will be no requirement to source the material from quarries outside of the site. The worst case impact at a sensitive receptor for dust, PM_{10} and $PM_{2.5}$ significantly less than 1% of the ambient air quality standards. Thus, the impact on air quality and climate of the proposed borrow pit is not significant at sensitive receptors and thus no residual impact is anticipated.

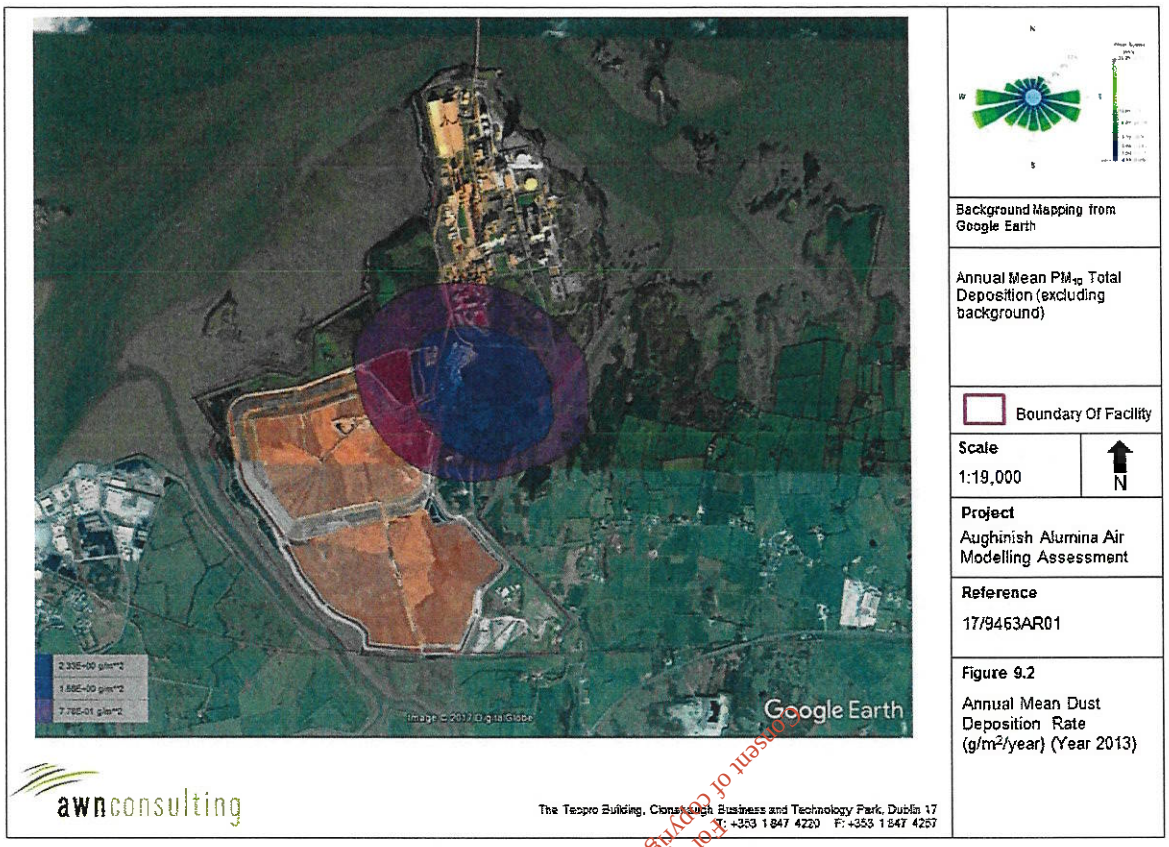

Figure 10.2: Annual Mean Dust Deposition Rate (g/m²/year)

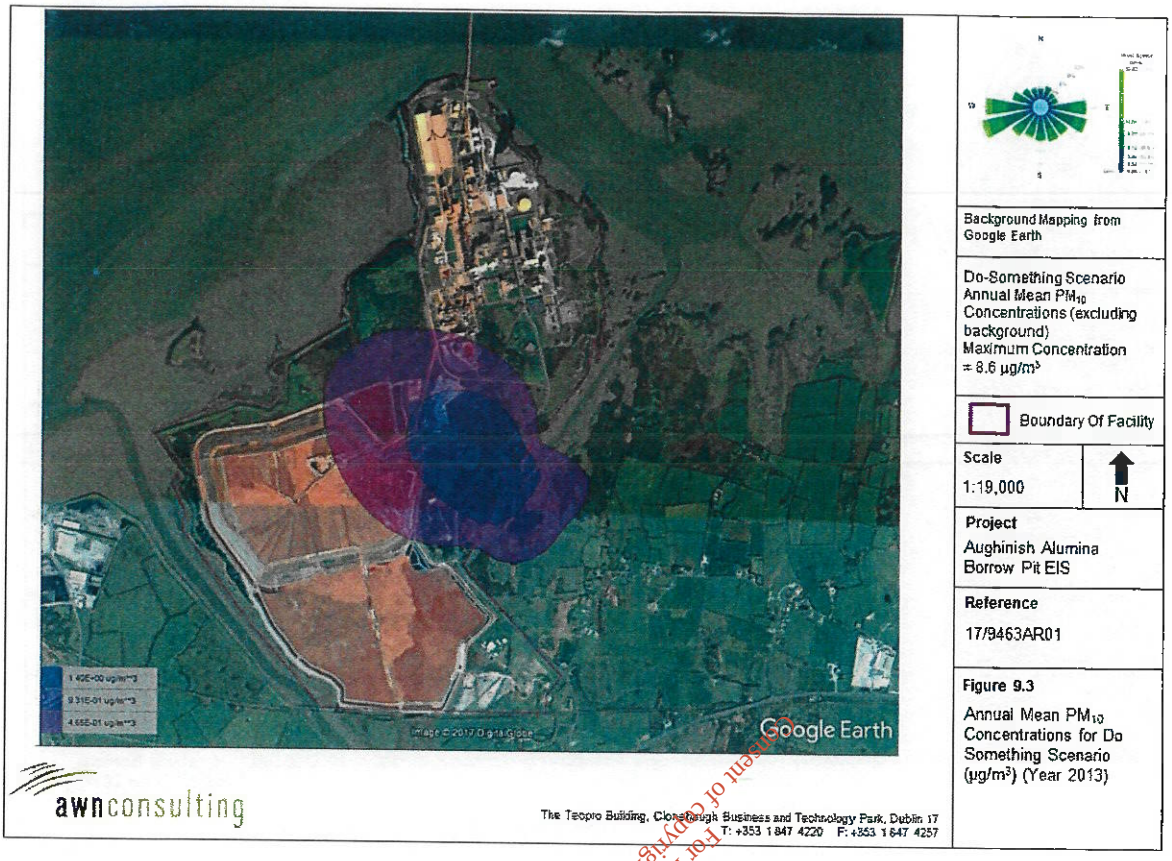

Figure 10.3: Annual Mean PM_{10} concentrations for Do Something Scenario (µg/m^3)

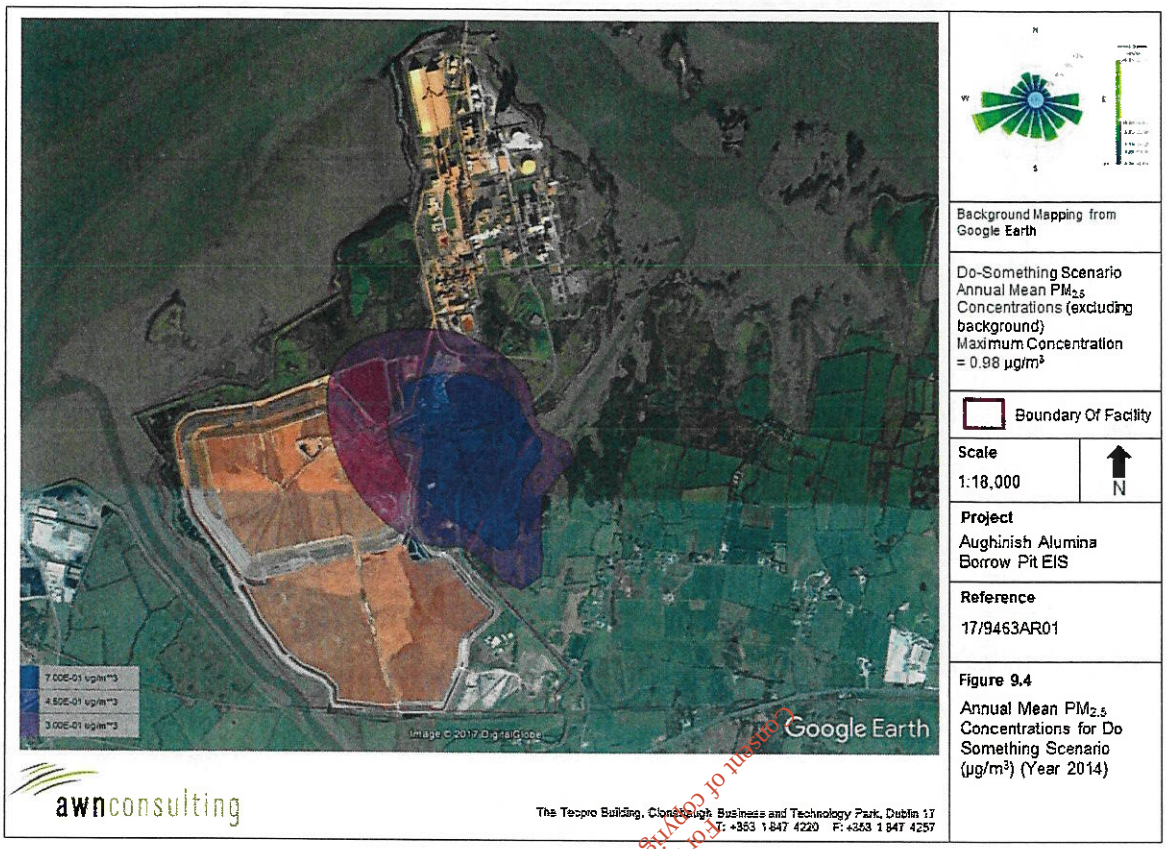

Figure 10.4: Annual Mean $PM_{2.5}$ concentrations for Do Something Scenario (µg/m^3)

10.8 References

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(23) DEHLG (2006) Ireland's Pathway to Kyoto Compliance - Review of the National Climate Change Strategy
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APPENDIX 10.1 – AMBIENT AIR QUALITY STANDARDS

National standards for ambient air pollutants in Ireland have generally ensued from Council Directives enacted in the EU (& previously the EC & EEC) (see Table 10.1). The initial interest in ambient air pollution legislation in the EU dates from the early 1980s and was in response to the most serious pollutant problems at that time. In response to the problem of acid rain, sulphur dioxide, and later nitrogen dioxide, were both the focus of EU legislation. Linked to the acid rain problem was urban smog associated with fuel burning for space heating purposes. Also apparent at this time were the problems caused by leaded petrol and EU legislation was introduced to deal with this problem in the early 1980s.

In recent years the EU has focused on defining a basis strategy across the EU in relation to ambient air quality. In 1996, a Framework Directive, Council Directive 96/62/EC, on ambient air quality assessment and management was enacted. The aims of the Directive are fourfold. Firstly, the Directive's aim is to establish objectives for ambient air quality designed to avoid harmful effects to health. Secondly, the Directive aims to assess ambient air quality on the basis of common methods and criteria throughout the EU. Additionally, it is aimed to make information on air quality available to the public via alert thresholds and fourthly, it aims to maintain air quality where it is good and improve it in other cases.

As part of these measures to improve air quality, the European Commission has adopted proposals for daughter legislation under Directive 96/62/EC. The first of these directives to be enacted, Council Directive 1999/30/EC, has been passed into Irish Law as S.I. No 271 of 2002 (Air Quality Standards Regulations 2002), and has set limit values which came into operation on 17th June 2002. Council Directive 1999/30/EC, as relating to limit values for sulphur dioxide, nitrogen dioxide, lead and particulate matter. The Air Quality Standards Regulations 2002 detail margins of tolerance, which are trigger levels for certain types of action in the period leading to the attainment date. The margin of tolerance varies from 60% for lead, to 30% for 24-hour limit value for PM_{10}, 40% for the hourly and annual limit value for NO_2 and 26% for hourly SO_2 limit values. The margin of tolerance commenced from June 2002. It started to reduce from 1 January 2003, continuing every 12 months thereafter by equal annual percentages to reach 0% by the respective attainment date for each pollutant. A second daughter directive, EU Council Directive 2000/69/EC, limit values for both carbon monoxide and benzene in ambient air is also included in the Air Quality Standards Regulations 2002. This has also been passed into Irish Law under the Air Quality Standards Regulations 2002.

The most recent EU Council Directive on ambient air quality was published on the 11/06/08. Council Directive 2008/50/EC combines the previous Air Quality Framework Directive and its subsequent daughter directives. This has also been passed into Irish Law under the Air Quality Standards Regulations 2011 (S.I. 180 of 2011) (see Table 10.1). Provisions were also made for the inclusion of new ambient limit values relating to $PM_{2.5}$. The margin of tolerance specific to each pollutant were also slightly adjusted from previous directives. In regards to existing ambient air quality standards, it is not proposed to modify the standards but to strengthen existing provisions to ensure that non-compliances are removed. In addition, new ambient standards for $PM_{2.5}$ are included in Directive 2008/50/EC. The approach for $PM_{2.5}$ is to establish a target value of 25 $\mu g/m^3$, as an annual average (to be attained everywhere by 2010) and a limit value of 25 $\mu g/m^3$, as an annual average (to be attained everywhere by 2012), coupled with a target to reduce human exposure generally to $PM_{2.5}$ between 2010 and 2020. This exposure reduction target will range from 0% (for $PM_{2.5}$ concentrations of less than 8.5 $\mu g/m^3$ to 20% of the average exposure indicator (AEI) for

concentrations of between 18 - 22 µg/m^3. Where the AEI is currently greater than 22 µg/m^3 all appropriate measures should be employed to reduce this level to 18 µg/m^3 by 2020. The AEI is based on measurements taken in urban background locations averaged over a three year period from 2008-2010 and again from 2018-2020. Additionally, an exposure concentration obligation of 20 µg/m^3 has been set which was to be complied with by 2012 again based on the AEI.

Although the EU Air Quality Limit Values are the basis of legislation, other thresholds outlined by the EU Directives are used which are triggers for particular actions. The Alert Threshold is defined in Council Directive 96/62/EC as "a level beyond which there is a risk to human health from brief exposure and at which immediate steps shall be taken as laid down in Directive 96/62/EC". These steps include undertaking to ensure that the necessary steps are taken to inform the public (e.g. by means of radio, television and the press).

The Margin of Tolerance is defined in Council Directive 96/62/EC as a concentration which is higher than the limit value when legislation comes into force. It decreases to meet the limit value by the attainment date. The Upper Assessment Threshold is defined in Council Directive 96/62/EC as a concentration above which high quality measurement is mandatory. Data from measurement may be supplemented by information from other sources, including air quality modelling.

Under the terms of EU Framework Directive on Ambient Air Quality (96/62/EC), geographical areas within member states have been classified in terms of zones. The zones have been defined in order to meet the criteria for air quality monitoring, assessment and management as described in the Framework Directive and Daughter Directives. Zone A is defined as Dublin and its environs, Zone B is defined as Cork City, Zone C is defined as 21 urban areas with a population greater than 15,000 and Zone D is defined as the remainder of the country. The Zones were defined based on among other factors, population and existing ambient air quality.

EU Council Directive 96/62/EC on ambient air quality and assessment has been adopted into Irish Legislation (S.I. No. 33 of 1999). The act has designated the Environmental Protection Agency (EPA) as the competent authority responsible for the implementation of the Directive and for assessing ambient air quality in the State. Other commonly referenced ambient air quality standards include the World Health Organisation[A1]. The WHO guidelines differ from air quality standards in that they are primarily set to protect public health from the effects of air pollution. Air quality standards, however, are air quality guidelines recommended by governments, for which additional factors, such as socio-economic factors, may be considered.

(A1) World Health Organisation (2006) Air Quality Guidelines - Global Update 2005 (and previous Air Quality Guideline Reports 1999 & 2000)

APPENDIX 10.2 - EMISSION FACTORS

Emission Factors Used In Dust Emission Calculations (USEPA, 1986 & subsequent updates):

Road Haulage (Unpaved)

$E = [281.9 * k * (s/12)^{a} (W/3)^{b} ((365-P)/365)$ g/veh km

Where:
s = surface silt content (3.9%)
k = 4.9 (Total Dust), 1.8 (PM_{10}), 0.15 ($PM_{2.5}$)
W = mean vehicle weight (30 tonnes)
a = 0.9 ($PM_{10}/PM_{2.5}$), 0.7 (Total Dust)
b = 0.45
P = 211 wet days

Road Haulage (Paved)

$E = [k * (sL)^{0.91} * (W)^{1.02}](1-(P)/4N)$ g/veh km

Where:
sL = surface silt loading (0.06 g/m^2)
k = 24 (Total Dust), 4.6 (PM_{10}), 0.66 ($PM_{2.5}$)
W = mean vehicle weight (30 tonnes)
P = 211 wet days
N = 365 days

Material Loading

$E = k(0.0016) * (U/2.2)^{1.3} / (M/2)^{1.4} ((365-P)/365)$ kg/Mg

Where:
k = 0.74 (Total Dust), 0.35 (PM_{10}), 0.053 ($PM_{2.5}$)
M = moisture content (2.1%)
U = mean wind speed (4.7 m/s)
P = 211 wet days

Operation	Total Dust Emission Rate	PM_{10} Emission Rate	$PM_{2.5}$ Emission Rate
Crushing	1.33E-07 g/s/m^2	5.91E-08 g/s/m2	1.08E-08 g/s/m2
Conveyor Transfer	1.54E-08 g/s/m2	5.66E-09 g/s/m2	1.44E-09 g/s/m2
Screening	2.41E-07 g/s/m2	8.29E-08 g/s/m2	5.40E-09 g/s/m2
Blasting & Drilling	1.75E-07 g/s/m2	8.91E-08 g/s/m2	6.63E-09 g/s/m2
Stockpiling	1.73E-05 g/s/m2	8.64E-06 g/s/m2	3.46E-06 g/s/m2

APPENDIX 10.3 - Dust Minimisation Plan

A dust minimisation plan will be formulated for the construction phase of the project, as construction activities have the potential to generate some dust emissions, however some of the items contained in this plan may be useful for the operational phase also. The potential for dust to be emitted depends on the type of construction activity being carried out in conjunction with environmental factors including levels of rainfall, wind speeds and wind direction. The potential for impact from dust depends on the distance to potentially sensitive locations and whether the wind can carry the dust to these locations. The majority of any dust produced will be deposited close to the potential source and any impacts from dust deposition will typically be within two hundred metres of the construction area. This two hundred metre range is still within the AAL facility boundary and therefore significant impacts outside the AAL boundary are not predicted.

In order to ensure mitigation of the effects of dust nuisance, a series of measures will be implemented. Site roads shall be regularly cleaned and maintained as appropriate, dry sweeping of large areas should be avoided. Hard surface roads shall be swept to remove mud and aggregate materials from their surface while any un-surfaced roads shall be restricted to essential site traffic only. Furthermore, any road that has the potential to give rise to fugitive dust must be regularly watered, as appropriate, during dry and/or windy conditions.

Vehicles using site roads shall have their speeds restricted where there is a potential for dust generation. Vehicles delivering material with dust potential to an off-site location shall be enclosed or covered with tarpaulin at all times to restrict the escape of dust.

Vehicles exiting the main AAL site shall make use of a wheel wash facility where appropriate, prior to entering onto public roads, to ensure mud and other wastes are not tracked onto public roads. Public roads outside the site shall be regularly inspected for cleanliness, and cleaned as necessary. Before entrance onto public roads, trucks will be adequately inspected to ensure no potential for dust emissions. Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable. Record should be kept of all inspections of the haul routes and any subsequent action in a site log book.

Material handling systems and site stockpiling of materials shall be designed and laid out to minimise exposure to wind. Sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place. Water misting or sprays shall be used as required if particularly dusty activities are necessary during dry or windy periods, activities such as scabbling should be avoided. Bulk cement and other fine powder materials are delivered in enclosed tankers.

At all times, the procedures put in place will be strictly monitored and assessed by the contractor. In the event of dust nuisance occurring outside the site boundary, satisfactory procedures will be implemented to rectify the problem. Dust monitoring should continue to be maintained on the AAL site to ensure dust mitigation measures are controlling emissions. Dust monitoring should be conducted using the Bergerhoff method in accordance with the requirements of the German Standard VDI 2119. The Bergerhoff Gauge consists of a collecting vessel and a stand with a protecting gauge. The collecting vessel is secured to the stand with the opening of the collecting vessel located approximately 2m above ground

level. The TA Luft limit value is 350 mg/(m^2*day) during the monitoring period between 28-32 days.

The Dust Minimisation Plan shall be reviewed at regular intervals to ensure the effectiveness of the procedures in place and to maintain the goal of minimisation of dust through the use of best practice and procedures. The name and contact details of a person to contact regarding air quality and dust issues should be displayed on the site boundary, this notice board should also include head/regional office contact details. Community engagement before works commence on site should be put in place, including a communications plan. All dust and air quality complaints should be recorded and causes identified, along with the measures taken to reduce emissions. This complaints log should be available for viewing by the local authority, if requested. Daily on and off site inspections should occur for nuisance dust and compliance with the dust management plan. This should include regular dust soiling checks of surfaces such as street furniture, windows, and cars within 100m of the site boundary. Cleaning should be provided if necessary.

11.0 NOISE AND VIBRATION

11.1 Introduction

This chapter assesses the potential noise and vibration impact of the proposed Borrow Pit development at Aughinish Alumina. The assessment of impacts has been undertaken in the context of current relevant standards and guidance, and identifies any requirements or possibilities for mitigation.

11.2 Methodology

The study has been undertaken using the following methodology:

- Baseline noise monitoring undertaken in the vicinity of the development site has been reviewed in order to characterise the receiving noise environment;
- A review of the most applicable standards and guidelines has been conducted in order to set a range of acceptable noise, vibration and air overpressure criteria for the proposed development;
- Predictive calculations have been performed during the construction phase of the project at the nearest sensitive locations to the development site;
- Predictive calculations have been performed to assess the potential impacts associated with the operation of the development at the most sensitive locations surrounding the development site;
- Assessment of potential cumulative impacts that may arise as a result of the proposed development, and;
- A schedule of mitigation measures have been proposed to reduce, where necessary, the identified potential impacts relating to noise, vibration and air overpressure from the proposed development.

11.3 Receiving Environment

As part of Aughinish Alumina's operating license (ref. Industrial Emissions Licence Reg No. P0035-06) the site is required to carry out annual noise monitoring. The results of the 2016 annual noise monitoring have been used to define the baseline noise environment for the purposes of this planning application. The 2016 annual noise monitoring and associated report was prepared by OES Consulting and this report is included in Appendix 11.1. A summary of the baseline noise environment in the area of the proposed development is provided below.

- Noise monitoring was conducted by OES Consulting between 23-25 August and 12-13 October 2016.
- Measurements were conducted at nine (9) site boundary and five (5) nearby noise sensitive locations in the vicinity of the existing site (See Figure 10.1).
- Noise surveys were conducted in accordance with ISO 1996-2:2007 *Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels* and following the procedures outlined in the EPA *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities* (NG4), January 2016.
- Noise measurements were conducted at each boundary and noise sensitive location for daytime, evening and nighttime periods.

- At Location **NSL1**, measured daytime ambient noise levels were in the range 44 to 46dB L_{Aeq} with background noise levels in the range 40 to 42dB L_{A90}. The measured evening-time ambient noise level was 48dB L_{Aeq} with a background noise level of 46dB L_{A90}.
- At Location **NSL2**, measured daytime ambient noise levels were in the range 45 to 48dB L_{Aeq} with background noise levels in the range 34 to 37dB L_{A90}. The measured evening-time ambient noise level was 47dB L_{Aeq} with a background noise level of 42dB L_{A90}. The measured nighttime ambient noise levels were in the range 35 to 38dB L_{Aeq} with background noise levels in the range 31 to 32dB L_{A90}.
- At Location **NSL3**, measured daytime ambient noise levels were in the range 48 to 50dB L_{Aeq} with background noise levels in the range 41 to 42dB L_{A90}. The measured evening-time ambient noise level was 49dB L_{Aeq} with a background noise level of 39dB L_{A90}. The measured nighttime ambient noise levels were in the range 41 to 43dB L_{Aeq} with background noise levels in the range 28 to 31dB L_{A90}.
- At Location **NSL4**, measured daytime ambient noise levels were in the range 57 to 59dB L_{Aeq} with background noise levels in the range 33 to 36dB L_{A90}. The measured evening-time ambient noise level was 36dB L_{Aeq} with a background noise level of 30dB L_{A90}. The measured nighttime ambient noise levels were in the range 33 to 34dB L_{Aeq} with background noise levels in the range 28 to 30dB L_{A90}.
- At Location **NSL5**, measured daytime ambient noise levels were in the range 56 to 57dB L_{Aeq} with background noise levels in the range 34 to 38dB L_{A90}. The measured evening-time ambient noise level was 57dB L_{Aeq} with a background noise level of 35dB L_{A90}. The measured nighttime ambient noise levels were in the range 49 to 58dB L_{Aeq} with background noise levels in the range 29 to 30dB L_{A90}.
- Noise sources that contribute to the measured noise levels include distant activity from the existing Aughinish Alumina facility as well as other noise sources such as traffic on the existing Local and National road network, noise from the nearby port, birdsong, pedestrian voices, dog barking, occasional aircraft movements and some slight wind generated noise on nearby foliage.
- Specific noise emissions from the existing Aughinish Alumina facility are in compliance with the sites noise emission limit values, as outlined in relevant License Conditions (i.e. daytime limit of 55 dB $L_{Ar\ (30\ minute)}$, Evening-time limit of 50 dB $L_{Ar(30\ minute)}$ and Night-time limit of 45dB $L_{Aeq\ (15\text{-}30\ minutes)}$), at specified noise sensitive locations.
- No tonal noise characteristics are present in noise emissions from site operations when measured at noise sensitive locations.

Figure 11.1 Site Context and Noise Monitoring Locations

11.4 Likely Significant Impacts

During the construction phase, the range of activities with potential to generate noise and vibration emissions to off-site sensitive receptors will include site preparation works, construction of the proposed earth bund at the development boundary, internal road construction and erection of any temporary buildings/compounds that may be required.

During the operational phase, the potential significant sources of noise and vibration are those associated with rock removal (i.e. blasting activities, crushing of rock and any other rock breaking that may be required), as well as vehicular movement to, from and within the site.

The relevant impacts associated with the construction and operational phases are addressed in the following sections.

11.4.1 Construction Phase

11.4.1.1 Criteria for Assessing Construction Noise Impacts

Currently there is no statutory Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. Local authorities typically control construction activities by imposing limits on the hours of operation. In order to minimise the impact on nearby sensitive locations, it is common practice to limit the times of day during which it is permissible to carry out construction work that could create high levels of noise. It is acknowledged that higher noise levels are generally accepted during a construction phase of a project compared to its long term operational phase, as these works are temporary in nature and are varied over the course of a project depending on the works involved. In the absence of specific guidelines, reference is made to British Standard, BS

5228: 2009+A1 2014 *Code of Practice for Noise and Vibration Control on Construction and Open Sites* Part 1 (BS5228-1) which sets out an approach for setting appropriate construction noise limits for residential dwellings.

The BS 5228 'ABC method' calls for the designation of a noise sensitive location into a specific category (A, B or C) based on exiting ambient noise levels in the absence of construction noise. This then sets a threshold noise value that, if exceeded, indicates a significant noise impact is associated with the construction activities, as summarised in Table.11.1.

Assessment Category and Threshold Value Period (L_{Aeq})	Threshold Value (dB)		
	Category A [A]	Category B [B]	Category C [C]
Daytime (08:00 – 18:00hrs)	65	70	75

Table 11.1 Example Threshold of Significant Effect at Dwellings (Daytime Operation)

Note A: Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values.

Note B: Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as category A values.

Note C: Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than category A values.

Taking into account the standard above and making reference to the baseline noise environment monitored around the development site, a construction noise limit of **65dB L_{Aeq}** is proposed during daytime periods. It is not expected that construction works will take place outside of the above daytime hours.

11.4.1.2 Criteria for Assessing Construction Vibration Impacts

Guidance relevant to acceptable vibration within buildings during construction works is contained in the following documents:

- British Standard BS 7385: 1993: *Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration*, and;
- British Standard BS 5228: 2009 +A1 2014: *Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration* (BS5228-2).

Both standards contain the same guidance relating to building damage criteria for intermittent vibration such as those generated during construction. The standards note that the risk of cosmetic damage to residential buildings starts at a Peak Particle Velocity (PPV) of 15mm/s at 4Hz rising to 20mm/s at 15Hz and 50mm/s at 40Hz and above for unreinforced or light framed structures. The standard also notes that below 12.5mm/s PPV the risk of damage tends to zero. Taking the above into consideration the vibration criteria in Table 11.2 are recommended.

Allowable vibration (in terms of peak particle velocity) at the closest part of sensitive property to the source of vibration, at a frequency of		
Less than 10Hz	10 to 50Hz	50 to 100Hz (and above)
12 mm/s	20 mm/s	50 mm/s

Table 11.2 Recommended Allowable Vibration During Construction Phase

11.4.1.3 Assessment of Construction Impacts

A variety of items of plant will be in use for the purpose of site preparation works, construction of the proposed earth bund at the development boundary, internal road construction and erection of any temporary buildings/compounds that may be required. There will also be vehicular movements to and from the site that will make use of existing roads. Due to the nature of these activities, there is potential for the generation of elevated levels of noise in the vicinity of existing noise sensitive properties.

It is possible to predict indicative noise levels using guidance set out in BS 5228-1 for the main phases of the proposed construction works however, assuming a typical level of noise generated from the site and using noise source data as outlined in BS 5228-1 for typical plant and equipment that would be expected to be utilised for construction works.

The nearest noise sensitive locations to the proposed construction works are the properties to the southeast of the site boundary (i.e. NSL2 and NSL5). The closest noise sensitive location to the site boundary is NSL2, located approximately 1km from the closest boundary of the proposed Borrow Pit.

Table 11.3 outlines typical plant items and associated noise levels that are anticipated at the nearest noise sensitive location (i.e. NSL2) to significant construction works.

Phase	Plant Item (BS 5228 Ref.)	Plant Noise Level at 10m Distance[3] (dB L_{Aeq})	Predicted Construction Noise Level at 1,000m Distance (dB $L_{Aeq,1hr}$)
Site Clearance / Berm Formation	Tracked excavator (C2.14	79	37
	Tracked excavator (C2.14)	79	37
	Dump Truck (C2.30)	79	37
	Dump Truck (C2.30)	79	37
	Compressor (D7.08)	70	28
	Diesel Generator (C4.76)	61	19
	Total noise from site clearance/berm formation at 1,000m		**43**

Table 11.3 Predicted Noise Emission Levels at Nearest NSL during Construction Phase

Construction noise levels at the closest noise sensitive property to site are comfortably below the adopted construction noise criterion of 65dB $L_{Aeq,T}$.

[3] All plant noise levels are derived from BS 5228: Part 1

Irrespective of the above predicted values, Section 11.5.1 outlines typical good-practice construction noise and vibration mitigation measures that should be adopted during the development's construction phase.

11.4.2 Operational Phase

11.4.2.1Criteria for Assessing Operational Noise Impacts

Industrial Emissions Licence Noise Criteria

The appropriate noise criteria for the operational phase of the proposed development is set out in Conditions and Schedules outlines in the sites Industrial Emissions Licence (IEL), registration number P0035-06, the relevant extracts are reproduced below.

> *4.5 Noise*
> Noise from the installation shall not give rise to sound pressure levels ($L_{Aeq,T}$) measured at the specified noise sensitive locations (including those specified in *Schedule C.5 Noise Monitoring Locations*, of this licence) which exceed the limit value(s).

The noise sensitive locations outlined in Schedule C.5 are NSL's 1 to 5 (as indicated in Figure 10.1). Table 11.4 outlines the relevant noise criteria as outlined in Schedule B.4 *Noise Emissions* of the sites IEL.

Daytime dB $L_{Ar,T}$ (30 minutes)	Evening time dB $L_{Aeq,T}$ (30 minutes)	Night-time dB $L_{Aeq,T}$ (15-30 minutes)
55	50	45[Note 1]

Table 11.4 IEL Schedule B.4 Nosie Emission Criteria (Operational Phase)

Note 1: There shall be no clearly audible tonal component or impulsive component in the noise emission from the activity at any noise sensitive location

Traffic on Public Roads

In order to assist with the interpretation of the noise associated with vehicular traffic on existing public roads, Table 11.5 offers guidance as to the likely impact associated with any particular change in traffic noise level (Source DMRB, 2011).

Change in Sound Level (dB L_{A10})	Subjective Reaction	Magnitude of Impact
0	Inaudible	No Impact
0.1 – 2.9	Barely Perceptible	Negligible
3 – 4.9	Perceptible	Minor
5 – 9.9	Up to a doubling of loudness	Moderate
10+	Doubling of loudness and above	Major

Table 11.5 Likely Impact Associated with Change in Traffic Noise Level

Air Overpressure during Blasting

The EPA document *Environmental Management Guidelines Environmental Management in the Extractive Industry (Non-Scheduled Minerals)*, 2006, provides guidance in relation to air overpressure during blasting operations, as reproduced below.

> *"In relation to blasting activities within quarry development, it is recommended that the following (vibration and) air overpressure ELVs are adopted and applied at the nearest vibration and air overpressure sensitive location (e.g. a residential property):*
>
> > *Air overpressure: 125 dB (linear maximum peak value), with a 95% confidence limit".*

11.4.2.2Criteria for Assessing Operational Vibration Impacts

Vibration during General Site Activity

For general day-to-day activity within the Borrow Pit (i.e. excluding blasting), it is recommended that a vibration limit is set in relation to human response to vibration in buildings i.e. potential for vibration disturbance as opposed to potential building damage (which would attract higher limit values). Table B.1 of BS5228-2 provides guidance on effects of vibration levels when measured in terms of PPV (mm/s). Table B.1 of BS5228-2 confirms that at 1.0mm/s *"it is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents*".

As such, it is estimated that general operational phase vibration (excluding blasting) will be less than 1.0mm/s (PPV) at nearby sensitive receptors.

Vibration during Blasting

The EPA document *Environmental Management Guidelines Environmental Management in the Extractive Industry (Non-Scheduled Minerals)*, 2006, provides guidance in relation to vibration during blasting operations, as reproduced below.

> *"In relation to blasting activities within quarry development, it is recommended that the following vibration (and air overpressure) ELVs are adopted and applied at the nearest vibration and air overpressure sensitive location (e.g. a residential property):*
>
> > *Ground-borne vibration: Peak particle velocity = 12 mm/s, measured in any of the three mutually orthogonal directions at the receiving location (for vibration with a frequency of less than 40 Hz)".*

It is understood that there have been discussions between the Applicant and Gas Networks Ireland in relation to potential vibration emissions affecting a nearby Gas pipeline. It is our understanding that the proposal that a vibration limit of 50mm/s (PPV) should not be exceeded at the pipeline during blasting is acceptable to Gas Networks Ireland. In this regard trial blasting and vibration monitoring at the pipeline is likely to be required in order to ensure compliance with the agreed vibration limit.

11.4.2.3Assessment of Operational Impacts

During the operational phase of the proposed development, the potential noise and vibration impacts relate to the following:

- General Operational Phase Site Activity,
- Blasting, and;
- Additional Vehicular Traffic from Development.

Each is assessed in the following sections.

General Operational Phase Site Activity

During the operational phase of the proposed development a variety of items of plant will be in use for the purposes of the rock extraction process. There will also be vehicular movements to and from the site that will make use of existing roads.

Indicative noise levels have been predicted using guidance set out in BS 5228-1, assuming a typical level of noise generated from the site and using noise source data as outlined in BS 5228-1 for typical plant and equipment that would be expected to be utilized for operational phase works.

The nearest noise sensitive locations to the proposed site are the properties to the southeast of the site boundary (i.e. NSL2 and NSL5). The closest noise sensitive location to the site boundary is NSL2, located approximately 1km from the closest boundary of the proposed Borrow Pit.

Table 11.6 outlines typical plant items and associated noise levels that are anticipated at the nearest noise sensitive location (i.e. NSL2) to site works.

Phase	Plant Item (BS 5228 Ref.)	Plant Noise Level at 10m Distance[4] (dB L_{Aeq})	Predicted Operational Noise Level at 1,000m Distance (dB $L_{Aeq,1hr}$)
Operational	Tracked excavator (C2.14)	79	30
	Dump Truck (C2.30)	79	30
	Wheeled loader (C9.8)	86	37
	Excavator mounted rock breaker (C9.11)	93	44
	Tracked semi-mobile crusher (C9.15)	96	47
	Total Operational Noise at 1,000m		49

Table 11.6 Predicted Noise Emission Levels at Nearest NSL During Operational Phase

Operational noise levels at the closest noise sensitive property to site are comfortably below the daytime operational noise criterion of 55dB $L_{Ar,T}$.

[4] All plant noise levels are derived from BS 5228: Part 1

Irrespective of the above predicted values, Section 11.5.2 outlines typical good-practice' noise and vibration mitigation measures that should be adopted during the operational phase.

Blasting

It is understood that blasting will be required approximately every 15 working days, in order to achieve the expected production, with a total of 6 to 7 blasts required per year.

Due to the uncertainties with meteorological conditions and specific charge variations, it is not possible to predict with certainty the maximum air overpressure values that will be experienced at nearby sensitive locations. In order to control air overpressure during blasting, the best practical approach is to implement a scheme to reduce pressure levels at the source, and monitor air overpressure at receivers. An approach is specified in Section 11.5.2 to ensure that the specified air overpressure limit values are not exceeded.

Similarly, in relation to vibration from blasting, the specific charge variations and uncertainties in relation to ground conditions mean that vibration levels from blasting cannot be predicted with certainty. In order to control vibration, the best practical approach is to implement a scheme to reduce vibration levels at the source, and monitor vibration at receivers. An approach is specified in Section 11.5.2 to ensure that the blasting vibration limit values are not exceeded.

We also refer to Appendix 11.2, *Borrow Pit: Phase 1 BRDA Blast Vibration Assessment* prepared by Golder Associates. This report provides an assessment of the effect of blasting within the footprint of the proposed Borrow Pit and was found to pose minimal risk to the stability of the adjacent BRDA. The report also provides for recommendations which will be incorporated into the proposed development.

Additional Vehicular Traffic from Development

A traffic impact assessment relating to the proposed development has been prepared as part of this EIAR. Information from this report has been used to determine the predicted change in noise levels in the vicinity of the adjacent road network along which traffic will travel to and from the site.

Upon review of the traffic assessment report, it is noted that, in the 'Do Something' scenario, rock will be sourced from the borrow pit within the AAL site, as opposed to external HGV trips associated with sourcing rock from external quarries. As a result, heavy vehicle traffic volumes will be slightly reduced in comparison to the 'Do Nothing' scenario.

Table 11.7 summarises the calculated change in noise level for the assessment years 2017 (Base Year), 2018 (Year of Opening), 2023 (Year of Opening + 5) and 2033 (Year of Opening + 15).

Year	Link	AADT (%HGV)		Predicted Change in Traffic Noise Level, dB (L_{A10})
		No Development i.e. Do Nothing	With Development i.e. Do Something	
2017 Base Year	L1234	1,358	1,344	0.0
	N69	5,982	5,968	0.0
2018 YoO	L1234	1,375	1,361	0.0
	N69	6,058	6,044	0.0
2023 YoO +5	L1234	1,464	1,450	0.0
	N69	6,450	6,436	0.0
2033 YoO +15	L1234	1,631	1,617	0.0
	N69	7,173	7,158	0.0

Table 11.7 Predicted Change in Road Traffic Noise Level During Operational Phase

Referring to Table 11.5, the calculated change in noise level on the existing road network will be inaudible and there will be no associated impact.

11.5 Mitigation Measures

11.5.1 Construction Phase

With regard to construction activities, best practice control measures for noise and vibration from construction sites are found within BS 5228 (2009 +A1 2014) *Code of Practice for Noise and Vibration Control on Construction and Open Sites* Parts 1 and 2. Whilst construction noise and vibration impacts are expected to be minimal and well within the criteria set out in this document, the contractor will ensure that all best practice noise and vibration control methods will be used, as necessary in order to ensure emissions to external noise sensitive locations are not significant. In this regard, various mitigation measures can be considered and applied during the construction of the proposed development, such as:

- Limiting the hours during which site activities likely to create high levels of noise or vibration are permitted;
- Establishing channels of communication between the contractor/developer, Local Authority and residents;
- Appointing a site representative responsible for matters relating to noise and vibration;
- Monitoring levels of noise during critical periods and at sensitive locations;
- Maintaining site access roads even so as to mitigate the potential for vibration from lorries.
- Selection of plant with low inherent potential for generation of noise and/ or vibration;

Furthermore, it is envisaged that a variety of practicable noise control measures will be employed. These may include:

- Erection of barriers as necessary around items such as generators or high duty compressors;
- Situate any noisy plant as far away from sensitive properties as permitted by site constraints and the use of vibration isolated support structures where necessary.

We recommend that noise and vibration from construction activities to off-site residences be limited to the values set out in Tables 11.1 and 11.2 respectively.

11.5.2 Operational Phase

11.5.2.1 General Operational Phase Site Activity

The same general noise and vibration mitigation measures outlined in relation to the construction phase are proposed in order to control operational phase noise and vibration emissions. If rock breaking is employed, the following are examples of measures that should be considered in order to mitigate noise emissions from these activities:

- Fit suitably designed muffler or sound reduction equipment to the rock breaking tool to reduce noise without impairing machine efficiency.
- Ensure all leaks in air line are sealed.
- Use a dampened bit to eliminate ringing.
- Erect acoustic screen between compressor or generator and noise sensitive area. When possible, line of sight between top of machine and reception point needs to be obscured.
- Enclose breaker or rock drill in portable or fixed acoustic enclosure with suitable ventilation.

11.5.2.2 Air Overpressure from Blasting

Air overpressure can be controlled at source by careful attention to blast design. A method statement will be produced by the developer to ensure that the noise, vibration and air overpressure impacts of blasting operations are minimised. Monitoring of air overpressure levels will be carried out at a position representative of the nearest residential dwellings during blasts to ensure that acceptable levels are not exceeded. The monitoring data will enable control of the blast air overpressure levels as the data will enable blast technicians to modify blasting techniques (i.e. charge sizes) if required. As air blast intensity is a function of total charge weight, then a reduction in the total amount of explosives used can also reduce the air overpressure value.

Other practical methods to reduce air overpressure are set out below.

- Restriction of hours within which blasting can be conducted (e.g. 08.00 to 18.00 hours Monday to Friday).
- A public information campaign undertaken before any work and blasting starts (e.g. 24-hour written notification).
- The firing of blasts at similar times to reduce the 'startle' effect.
- On-going circulars informing people of the progress of the works.
- The implementation of an onsite documented complaints procedure.
- The use of independent monitoring by external bodies for verification of results.
- Ensuring appropriate burden to avoid over or under confinement of the charge.
- Trial blasts to assist in blast designs and identify potential zones of influence.

11.5.2.3 Vibration from Blasting

Specific to blasting, the following mitigation measures will be employed in order to control vibration impact during blasts:

- Restriction of hours within which blasting can be conducted (e.g. 08.00 to 18.00 hours Monday to Friday).
- A public information campaign undertaken before any work and blasting starts (e.g. 24-hour written notification).
- Trial blasts will be undertaken to obtain scaled distance analysis;
- Ensuring appropriate burden to avoid over or under confinement of the charge;
- Accurate setting out and drilling;
- Appropriate charging;
- Appropriate stemming with appropriate material such as sized gravel or stone chipping;
- Delay detonation to ensure small maximum instantaneous charges;
- Decked charges and in-hole delays;
- Blast monitoring to enable adjustment of subsequent charges;
- Good blast design to maximise efficiency and reduce vibration;
- Avoid using exposed detonating cord on the surface.

11.5.2.4 Additional Vehicular Traffic from Development

Noise mitigation measures with respect to the traffic from the development are not deemed necessary.

11.6 Cumulative Impacts

Noise emissions from the existing Aughinish Alumina facility are monitored annually and are found to be comfortably within the IEL noise criteria for daytime, evening and night-time periods. With consideration of the current site noise emissions and predicted noise emission values associated with the proposed borrow pit, the cumulative noise emissions are also expected to remain comfortably within the IEL noise criteria at all nearby noise sensitive locations.

11.7 Residual Impacts

11.7.1 Construction Phase

During the construction phase of the project there is the potential for impacts on nearby noise sensitive properties due to noise emissions from site activities. The application of binding noise limits, hours of operation, along with implementation of appropriate noise and vibration control measures, will ensure that noise and vibration impact will not have a significant impact on the surrounding environment. The resultant residual noise impact from this source will be of minor, perceptible short term impact.

11.7.2 Operational Phase

11.7.2.1 General Operational Phase Site Activity

Noise and vibration levels associated with operational plant and equipment are expected to be well within the adopted criteria values at the nearest sensitive properties taking into account the site layout, location of proposed plant areas and distances to nearest

residences. Assuming the operational noise levels do not exceed the adopted design goals, the resultant residual noise impact from this source will be of minor, perceptible long term impact.

11.7.2.2 Air Overpressure from Blasting

Once consideration is given to the range of mitigation measures outlined in Section 11.5.2.2, air overpressure will be controlled so as not to exceed the adopted criteria, the resultant residual impact from this source will not be significant.

11.7.2.3 Vibration from Blasting

Once consideration is given to the range of mitigation measures outlined in Section 11.5.2.3, vibration from blasting will be controlled so as not to exceed the adopted criteria, the resultant residual impact from this source will not be significant.

11.7.2.4 Vehicular Traffic from Development

The predicted noise level associated with traffic is predicted to be of insignificant impact along the existing road network. In the context of the existing noise environment, the overall contribution of induced traffic is not considered to pose any significant impact to nearby residential locations.

APPENDIX 11.1: Annual Environmental Noise Survey 2016