Appendix 6.1

HAZID report

Hazard Identification and Risk Assessment for

Resource Recovery Centre, Ringaskiddy

***Prepared for*:**

Indaver Ireland Ltd

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Contents

1 INTRODUCTION

1.1 Background

At the request of Indaver Ireland Ltd, Byrne Ó Cléirigh (BÓC) has conducted a Hazard Identification and Risk Assessment (HAZID&RA) exercise for a proposed resource recovery centre at Ringaskiddy.

This report has been prepared as a follow up document to the previous studies that were carried out for the proposed facility, in 2001 and in 2008. On those occasions, the design and scope of the facility incorporated a wider range of waste materials and included a wider range of activities. One of the implications of this was that the Seveso Regulations[1] applied to the previous site designs. However, for the current proposal, the scope of the site is different and it does not incorporate some of the elements from the previous design (e.g. a bulk storage tank farm for waste solvents or a waste drum storage area). As such the number of hazards at the site and the associated risks presented by the activity have been greatly reduced when compared with the previous assessments and so the Seveso Regulations no longer apply to the facility.

Nonetheless the decision was taken to reassess the risks presented by the facility to human health and to the environment using the same criteria as were applied for the 2001 and 2008 assessments. This formal risk assessment exercise plays a key role for Indaver in demonstrating that the risks presented by the facility can be considered to be As Low As Reasonably Practicable (ALARP).

These Regulations do not apply because as the quantities of hazardous materials at the site will be below the thresholds set out under this legislation. Appendix 5 of this report contains an assessment of the expected composition of the flue gas residues. This exercise was conducted to determine whether the concentrations of contaminants in the ash would be sufficient for the entire ash residue stream to require classification as Hazardous to the Aquatic Environment.

Nevertheless there are several materials that will be stored and handled at the site which could give rise to an accident scenario presenting a risk to human health or the environment and so this report sets out the findings of the risk assessment exercise that was conducted by Indaver.

1.2 Description of Site

Indaver proposes to develop a Resource Recovery Centre in Ringaskiddy in County Cork for the treatment of household, commercial and industrial, hazardous and non-hazardous waste. The proposed development, the Ringaskiddy Resource Recovery Centre, will include a waste-to-energy facility. The facility will use robust and proven technology to process up to 240,000 tonnes per annum of residual waste. Energy and other useful materials will be recovered from this residual waste, which is currently landfilled or exported. The waste-to-energy facility will produce approximately 21 megawatts of electricity.

Included in the proposed development is an upgrade of the local road (L2545) adjacent to the Indaver site in order to alleviate local flooding issues along the road. In addition, the proposed development will include beach nourishment along the eastern boundary of the Indaver site that will address local coastal erosion issues. Finally, the ground levels of the western portion of the Indaver site will be raised.

A copy of the site layout drawing is shown as Figure 1.1. This shows the full extent of the site area. Figure 1.2 focuses on the east side of the site, which is where the potentially hazardous installations

[1] Previously SI 74 of 2006 (Seveso II), since replaced by SI 209 of 2015 (Seveso III)

that were examined in the course of the HAZID&RA exercise are located. The layout drawings can be examined in more detail in Appendix 1.

The site for the Ringaskiddy Resource Recovery Centre is situated at the north-eastern corner of the Ringaskiddy peninsula and occupies an area of approximately 12 hectares. Figure 1.3 shows the location of the facility and the surrounding area.

Figure 1.1: Site Layout (Full Site Footprint)

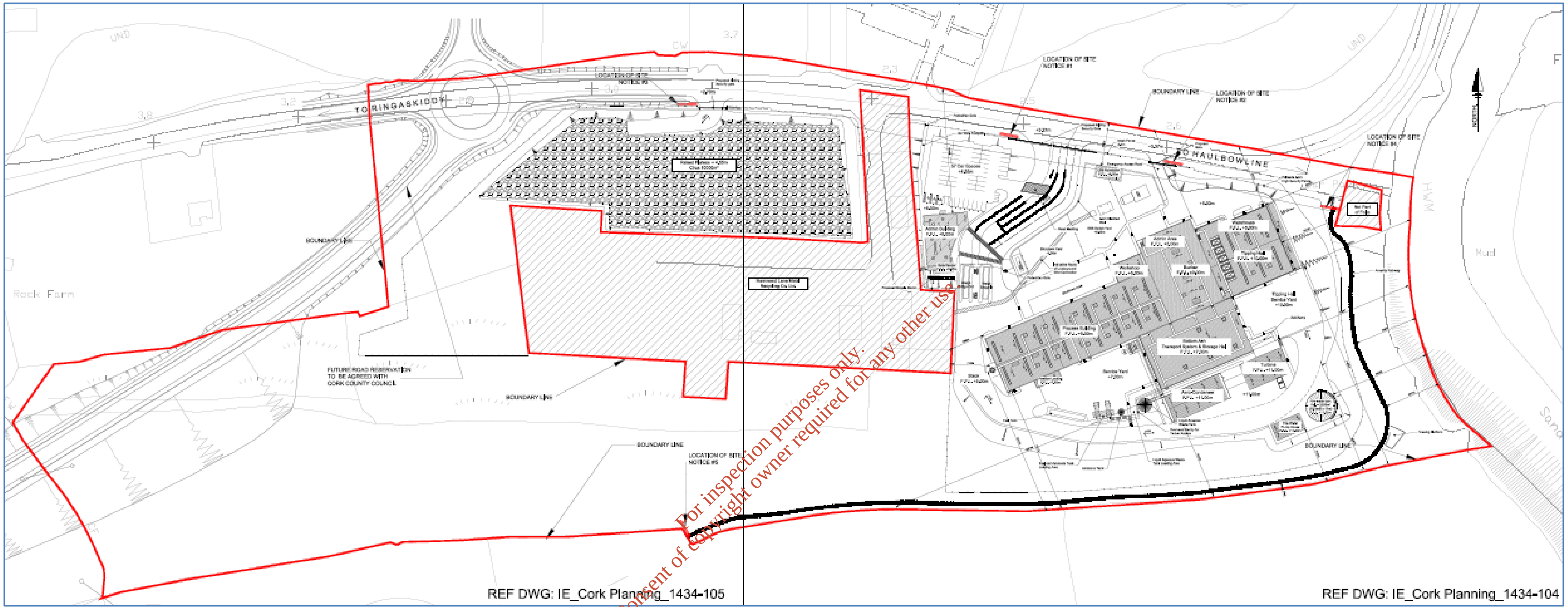


Figure 1.2: Site Layout (Installations)

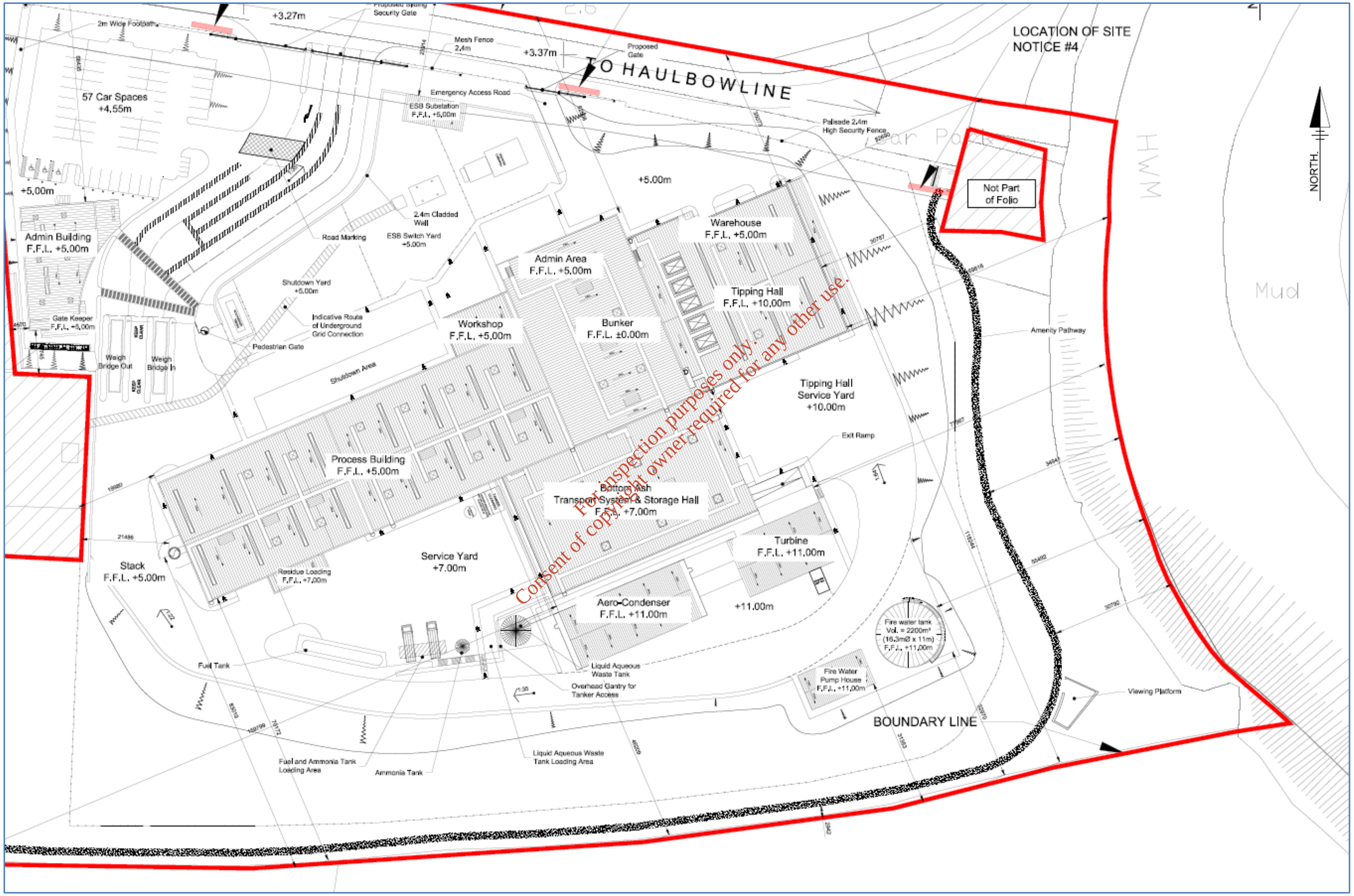
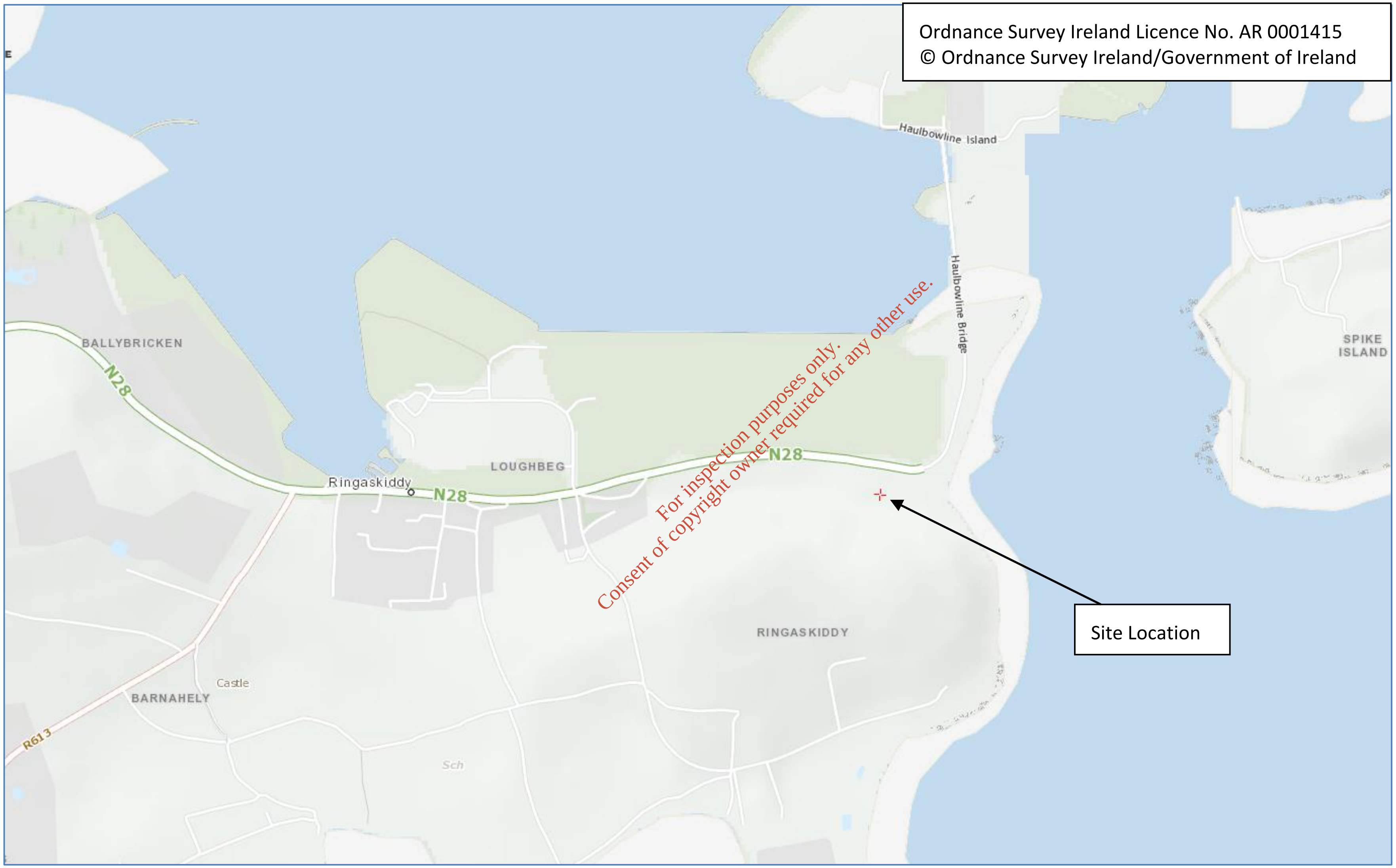


Figure 1.3: Location of Indaver Site



1.3 Description of Surroundings

1.3.1 Neighbouring Land Use

The proposed site is located to the east of Ringaskiddy village. The other developments in the vicinity of the Indaver site are described here.

There is a metal reclamation works at Hammond Lane, which is located directly to the west of the proposed Indaver facility. Due to the proximity of this site to the proposed development, the HAZID&RA Team gave consideration to the potential risk that an incident at the metal reclamation works could act as an initiator to an accident scenario at the Indaver establishment.

Apart from the Hammond Lane site, the next nearest building to the Indaver site at which there is industrial/commercial activity is a warehousing operation located immediately opposite the Indaver site, to the north. There is also the National Maritime College of Ireland site, which is adjacent to this warehousing facility.

There are a number of Seveso establishments in the vicinity of the planned development at Ringaskiddy, as follows:

- Pfizer – Pharma (API) – upper tier
- Novartis – Pharma (API) – upper tier
- Carbon Chemical Group – Chemical suppliers – upper tier
- GlaxoSmithKline – Pharma – upper tier
- Hovione – Pharma – lower tier

The closest of these sites to Indaver is the Hovione establishment, which is located c.800 m from the planned Indaver facility. There is no risk that an accident at Indaver could present any risk to any of these Seveso establishments.

We do not have details of the Specified Areas that have been established around these existing establishments; in the event that the Indaver site falls within this range of any of these Seveso sites, the operators will be required to provide Indaver with an information package on the hazards presented by their establishment. However the separation distances are too large for an accident at any of these facilities to present any risk of domino effects or escalation effects to Indaver.

1.3.2 Geology and Hydrogeology

Referring to the Geological Survey of Ireland (GSI) website[2], we have obtained details of the geology and hydrogeology of the site and surrounding area. The details are shown in Figure 1.4, Figure 1.5 and Figure 1.6 on the following pages.

The bedrock immediately under the site is identified on the GSI website as a mixture of "Marine (Cork Group) (extends into the Visean), mudstone, sandstone and thin limestone" and "Waulsortian mudbank, pale-grey massive limestone". The aquifer immediately under the site is identified as locally important, with bedrock that is moderately productive only in local zones. There are also some karstified areas in the wider vicinity of the site. The aquifer under the site is shown as extremely vulnerable, with the area to the south of the site identified as comprising rock near surface or karst.

[2] http://www.gsi.ie/

Figure 1.4: Details of the Bedrock in the Vicinity of the Indaver Site (© Geological Survey of Ireland)

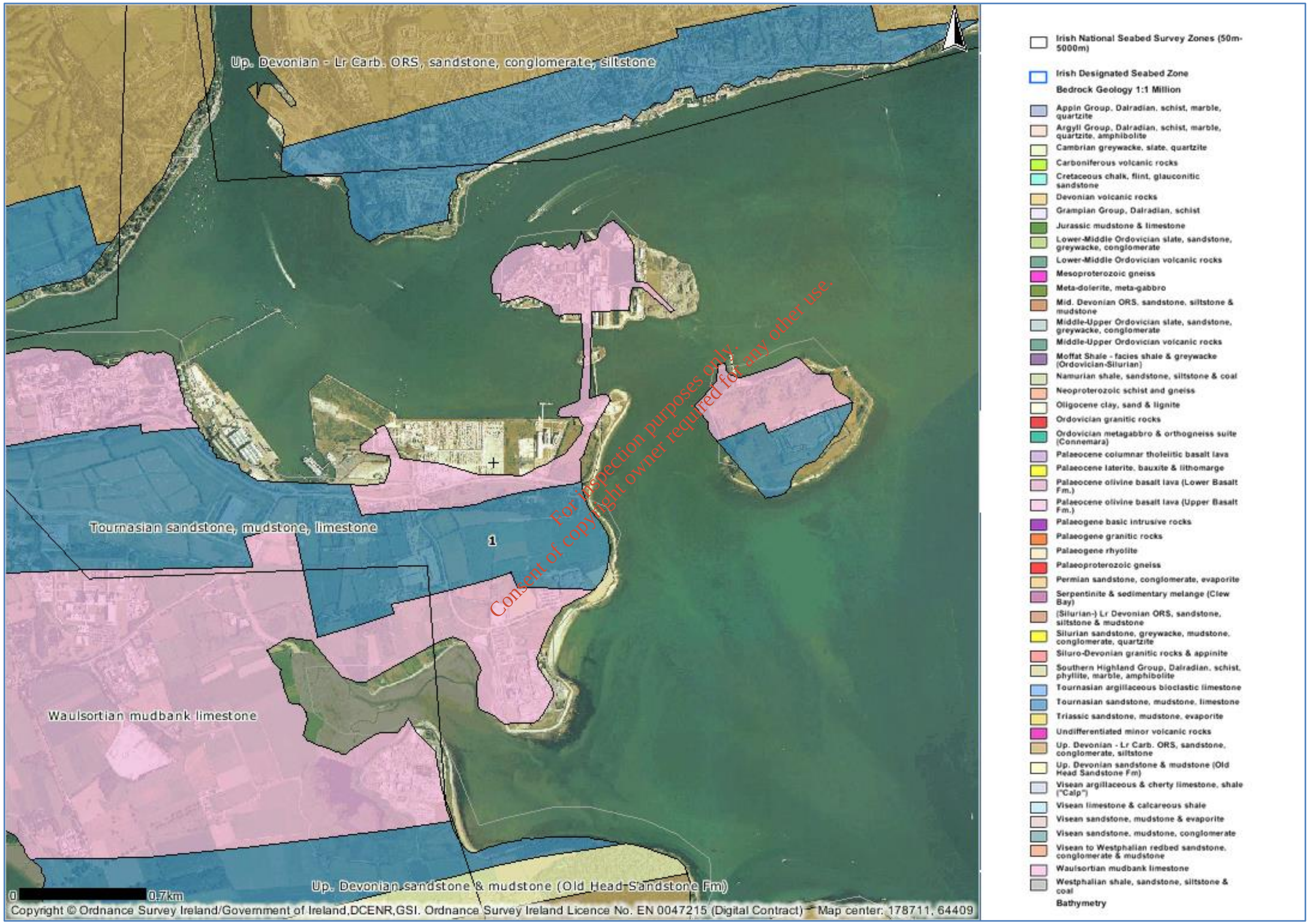


Figure 1.5: Details of Aquifer Classification in Vicinity of the Indaver Site (© Geological Survey of Ireland)

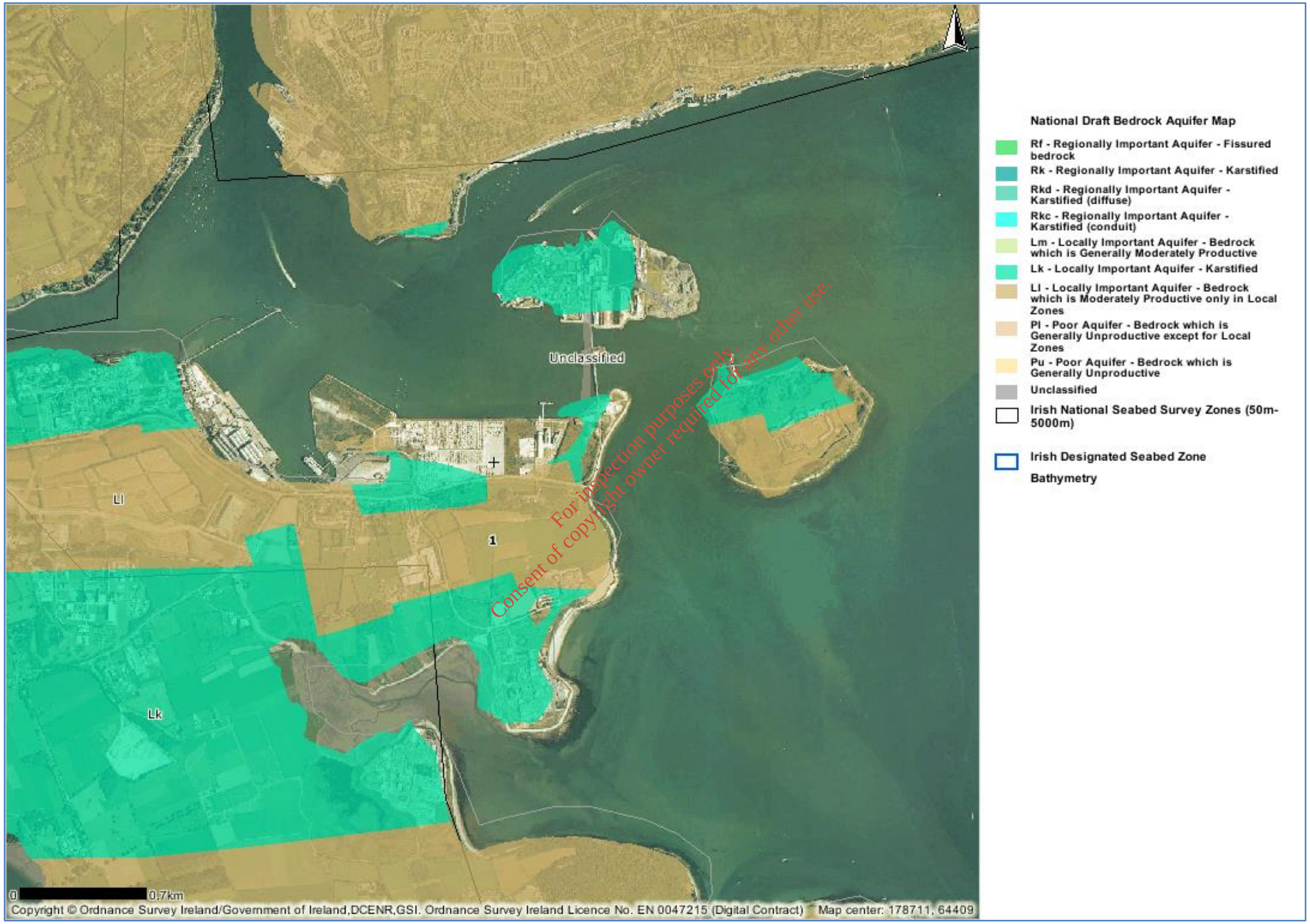


Figure 1.6: Details of Aquifer Vulnerability in Vicinity of the Indaver Site (© Geological Survey of Ireland)

1.3.3 Flora and Fauna

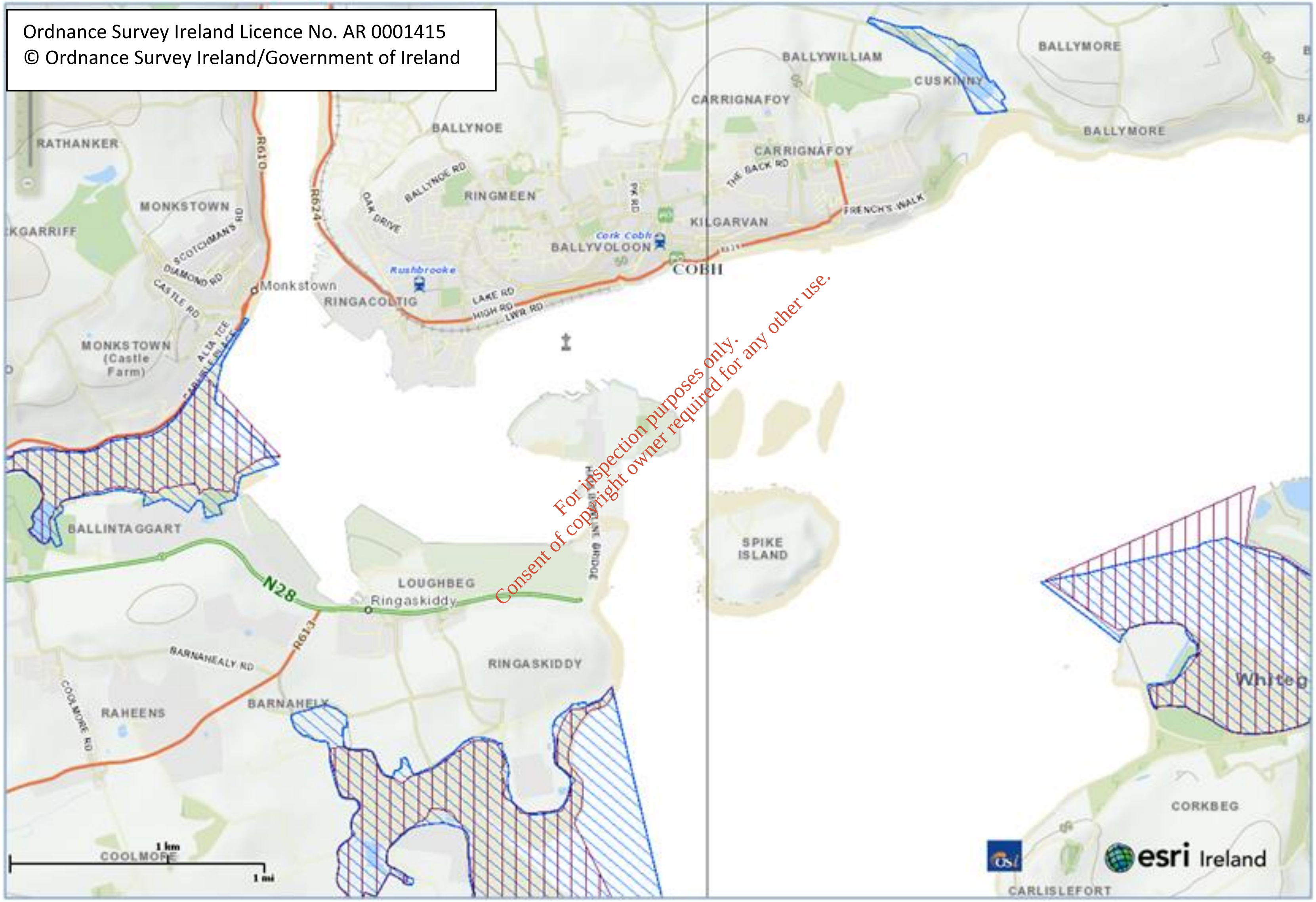
There are several protected sites in the vicinity of the proposed development. These are as shown in Figure 1.7 and Table 1.1.

Table 1.1: Protected Sites (NPWS)

Site Code	Site Name		
001979	Monkstown Creek	pNHA	Located NW of the site
001066	Lough Beg (Cork)	pNHA	Located S of the site
001987	Cuskinny Marsh	pNHA	Located NE of the site
001084	Whitegate Bay	pNHA	Located E of the site
004030	Cork Harbour	SPA	There are several areas of Cork Harbour which are designated as SPA, including at Monkstown, Lough Beg and Whitegate Bay

None of these protected sites lie in the immediate vicinity of the proposed Indaver site.

Figure 1.7: Protected Sites in the Vicinity of the Indaver Development



1.3.4 Watercourses (Tides and Currents)

Cork Harbour is an important and attractive water body with many beneficial uses. The harbour, a drowned river valley, is the tidal estuary of the River Lee and extends about 20 km from Cork City to the open sea. In simple terms, the upper harbour estuary widens uniformly in the direction of the open sea and the tidal currents move simply up and down the estuary as the tide ebbs and flows.

According to the Admiralty Chart, the tidal data for Passage West and for Cobh are as shown in Table 1.2.

Table 1.2: Tidal Data for Cobh

Location	Lat N	Long W	Heights in metres above datum				Datum and Remarks
			MHWS	MHWN	MLWN	MLWS	
Cobh	51°50'	8°18'	4.1	3.3	1.3	0.5	0.13 m above OD (Dublin)
Passage West	51°52'	8°20'	4.4	3.6	1.5	0.7	0.13 m above OD (Dublin)

1.3.5 Weather Conditions

For the purposes of the risk assessment exercise detailed in this report, the meteorological parameters of most interest are ambient temperature, wind speed, atmospheric stability and rainfall. High ambient temperatures lead to increased evaporation rates from spilled materials. Low wind speeds and high atmospheric stability lead to reduced dispersion of a release, allowing higher concentrations to accumulate in the atmosphere. High wind speeds on the other hand can give rise to high angles of flame tilt in the event of a pool fire.

Cork Airport is the closest weather monitoring station to the site and weather data for this station was obtained from Met Éireann for the period 1981 to 2010, which is the latest 30-year period reported on by Met Éireann. This is shown in Table 1.3 overleaf.

The temperature data shows that the average daily maximum temperature varies from 8.2°C in January to 18.7°C in July. The highest temperature recorded at the station over the 30-year reporting period was 28.7°C.

Wind speed and atmospheric stability are strongly interrelated. Greater atmospheric stability is found at low wind speeds and only certain combinations of wind speed and stability can occur. The data shows an average wind speed of 10.5 knots or 5.4 m/s.

Table 1.3: Cork Airport Weather Data, 1981 – 2010 (Met Éireann)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
TEMPERATURE (degrees Celsius)													
mean daily max	8.2	8.3	9.9	11.8	14.4	17.0	18.7	18.5	16.5	13.2	10.3	8.5	12.9
mean daily min	3.0	3.1	4.0	4.9	7.4	10.0	11.8	11.8	10.2	7.7	5.2	3.7	6.9
mean temperature	5.6	5.7	6.9	8.4	10.9	13.5	15.3	15.2	13.3	10.5	7.8	6.1	9.9
absolute max.	16.1	14.0	15.7	21.2	23.6	27.5	28.7	28.0	24.7	21.4	16.2	13.8	28.7
min. maximum	-4.3	-1.6	1.4	5.0	7.6	10.7	12.8	11.9	10.4	6.0	0.6	-3.2	-4.3
max. minimum	10.6	10.6	10.9	11.4	15.1	16.2	19.0	18.4	17.3	15.4	12.8	11.6	19.0
absolute min.	-8.0	-4.7	-4.3	-2.3	-0.9	3.7	6.7	5.3	2.3	-0.9	-3.3	-7.2	-8.0
mean num. of days with air frost	4.6	4.1	1.8	1.2	0.0	0.0	0.0	0.0	0.0	0.2	1.2	3.6	16.7
mean num. of days with ground frost	12.8	11.8	9.7	7.8	2.1	0.1	0.0	0.0	0.5	2.4	7.3	11.0	65.3
mean 5cm soil	4.5	4.5	5.9	8.3	12.0	15.0	16.4	15.7	13.1	9.8	6.8	5.2	9.8
mean 10cm soil	4.8	4.8	5.9	7.9	11.3	14.1	15.7	15.2	13.0	10.0	7.2	5.6	9.6
mean 20cm soil	5.5	5.5	6.6	8.5	11.5	14.2	15.8	15.7	13.9	11.0	8.1	6.3	10.2
RELATIVE HUMIDITY (%)													
mean at 0900UTC	89.8	89.4	87.8	83.1	80.6	81.3	83.2	85.4	88.4	90.1	90.7	90.5	86.7
mean at 1500UTC	83.7	78.9	75.5	71.3	70.9	71.5	72.9	72.8	75.4	80.4	83.4	85.4	76.8
SUNSHINE (hours)													
mean daily duration	1.8	2.4	3.3	5.3	6.2	5.8	5.4	5.2	4.3	3.0	2.3	1.7	3.9
greatest daily duration	8.5	10.0	11.5	13.6	15.5	16.0	15.3	14.4	11.9	10.3	8.7	7.6	16.0
mean no. of days with no sun	10.1	7.9	6.3	3.1	2.1	2.5	2.0	2.6	3.6	6.4	8.6	11.9	67.1
RAINFALL (mm)													
mean monthly total	131.4	97.8	97.6	76.5	82.3	80.9	78.8	96.8	94.6	138.2	120.0	133.1	1227.9
greatest daily total	45.7	49.9	55.2	34.2	34.9	59.7	73.2	60.9	58.9	52.1	47.9	41.9	73.2
mean num. of days with >= 0.2mm	20	17	19	16	15	14	15	15	16	19	19	19	204
mean num. of days with >= 1.0mm	16	13	14	11	12	10	10	11	11	15	14	15	152
mean num. of days with >= 5.0mm	9	6	5	5	5	5	5	5	5	8	7	8	73
WIND (knots)													
mean monthly speed	12.1	12.0	11.6	10.3	10.1	9.4	9.0	9.0	9.4	10.7	10.9	11.6	10.5
max. gust	78	83	70	62	59	49	57	54	58	75	66	80	65.9
max. mean 10-minute speed	52	54	43	40	40	33	40	38	39	48	46	56	44.1
mean num. of days with gales	2.3	1.8	1.3	0.3	0.3	0.0	0.1	0.2	0.3	1.0	1.2	1.9	10.8
WEATHER (mean no. of days with..)													
snow or sleet	3.1	3.1	2.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.2	11.3
snow lying at 0900UTC	0.7	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.0
hail	1.0	1.1	1.4	1.9	0.7	0.2	0.1	0.0	0.1	0.3	0.2	0.4	7.4
thunder	0.2	0.1	0.1	0.1	0.6	0.5	0.8	0.3	0.0	0.4	0.1	0.1	3.3
fog	7.8	6.8	8.5	7.5	7.6	7.6	8.4	8.8	9.1	8.7	7.6	8.4	96.8

1.3.6 Listed Buildings and Monuments

Figure 1.8 is a map of the site and surroundings, taken from the Archaeological Survey of Ireland's website[3]. There are three monuments shown on this map, one in close proximity to the site and two located in the wider surrounding area, as follows. The descriptive text is taken from the Archaeological Survey of Ireland's website:

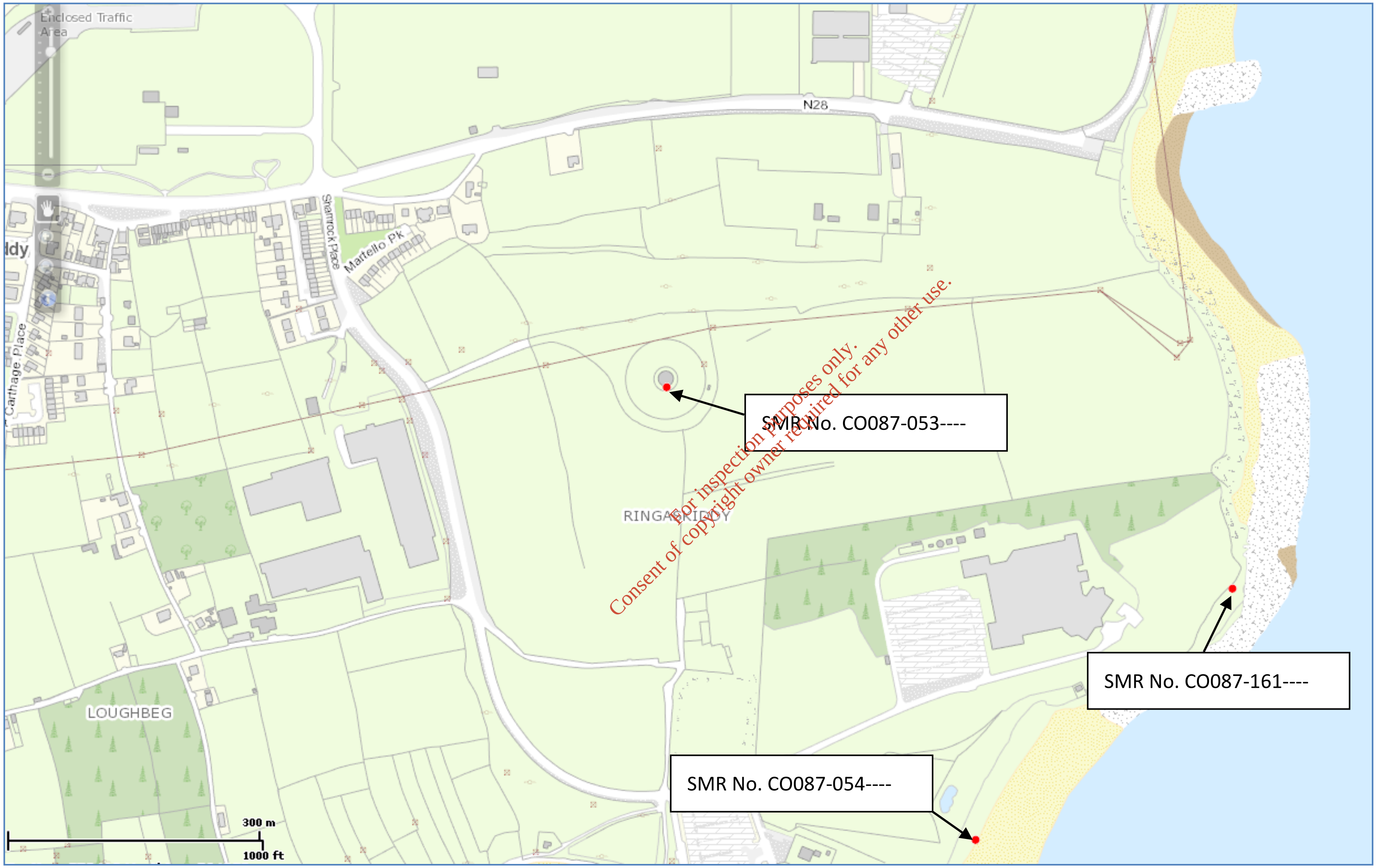
- SMR No. CO087-053---- Martello Tower. (On highest point of Ringaskiddy promontory, overlooking Cork Harbour. Circular tower (diam. 15.5m E-W; 10.9m N-S; H 12.1m) with flattened profile to N and S; enclosed by dry fosse (Wth 4.6m; D 3.1m); within circular enclosure (diam. 100m) marked by ordnance stones. Built of coursed limestone ashlar. Door at 1st floor level on E side closed by iron door; access to interior not gained. Enlarged window opes, at 1st floor level, to N, S and W show an attempt at conversion. Largest of Cork Harbour Martellos; it was under construction 1813-15 (Kerrigan 1978, 148; Enoch 1975, 30).)
- SMR No. CO087-161---- Midden. There are no further details on the Archaeological Survey of Ireland's website.
- SMR No. CO087-054---- Midden. Narrow lens of midden material extends for 30m N-S along shoreline just above high tide mark and measures 0.1m in thickness. Deposit contains cockles, limpets and winkles with some oyster and razor shells. Large scatter of shells (c. 100m E-W) on beach at low tide level.)

The Martello Tower is located southwest of the site footprint.

There is no risk to any of these buildings in the event of an accident arising at the Indaver facility.

[3] http://webgis.archaeology.ie/NationalMonuments/FlexViewer/

Figure 1.8: Location of National Monuments in Vicinity of Site (© Archaeological Survey of Ireland)



2 HAZARD IDENTIFICATION AND RISK ASSESSMENT

2.1 Risk Assessment Methodology

A formal Hazard Identification & Risk Assessment exercise (HAZID&RA) was carried out to identify all potential accident scenarios that could arise at each area of the site where dangerous substances are stored or handled. Each scenario was assessed using the HAZID&RA methodology in order to determine its likelihood of occurrence and the severity of impact to people and the environment if it did occur. This approach gives a semi-quantitative assessment of the overall level of risk associated with each accident scenario identified by the HAZID&RA Team. The Team took account of any relevant prevention or mitigation measures in place when assessing the risks associated with each scenario.

Each scenario was assigned a semi-quantitative Risk Rating, based on the findings of this analysis. The Risk Ratings were then compared with the various criteria established in the risk assessment methodology in order to determine the significance of the risks associated with each scenario. This approach allowed Indaver to prioritise attention on the scenarios presenting the highest risk and to ensure that all necessary measures would be in place to prevent accidents occurring and to limit the consequences of any such accidents for human health and the environment.

The methodology used is based on a technique outlined in Annex D of BS 8800: 1996, Guide to Occupational Health and Safety Management Systems. Similar risk assessment techniques have also been outlined by the IChemE[4] and the US Naval Weapons Centre's Practical Risk Analysis for Safety Management. It is described in more detail in the following sub-sections. A flowchart to illustrate this methodology is included in Appendix 2.

2.1.1 HAZID&RA Team

The HAZID&RA Team comprised the following personnel:

- Elaine Cafferty — Project Development Advisor, Indaver
- Oliver Kelly — Project Engineer, Indaver
- Thomas Leonard — Partner, Byrne Ó Cléirigh
- Robert Harte — Project Engineer, Byrne Ó Cléirigh

The Team members between them have appropriate training in hazard identification, risk assessment and consequence analysis and had knowledge of the complete range of operations that will be conducted on the site. They also drew upon specialist input from other members at Indaver and at BÓC where required.

[4] Institute of Chemical Engineers Course, Practical Quantitative Hazard Assessment, 1985

2.1.2 Areas Assessed

The resource recovery centre was sub-divided into the following areas, each of which was assessed in turn by the HAZID&RA Team:

- Bunker
- Furnace
- Boiler
- Dry Reactor
- Activated Carbon Silo
- Bag House
- Flue Gas Residue Storage
- Flue Gas Cooling Section (water quench / heat exchanger)
- ID Fan
- Stack
- Aqueous HCl IBC
- Piperacks
- General storage area (fuel oil, ammonia and aqueous waste tanks)

These areas represent the various locations at the site where dangerous substances are stored or handled and which were considered as potentially presenting a risk of a significant accident scenario. Following the assessment of the HAZID&RA Team, not all of these areas were found to present a credible risk of an accident scenario. Further details of the assessment can be obtained from the HAZID&RA Worksheets in Appendix 3.

2.1.3 Accident Scenarios

Each area was assessed in detail by the HAZID&RA Team. For each area the Team identified the various accident scenarios, or end events, that could arise and noted them in the HAZID&RA Worksheets. This process involved cataloguing all the potential scenarios that could occur for each area; each scenario was described and an assessment made of the potential consequences that could result. A copy of the Worksheet is included in Appendix 3.

2.1.4 Assessment of Severity Ratings

Each scenario was assigned two Severity Ratings with values between 1 and 5, in accordance with the criteria set out in Table 2.1. The first Severity Rating was used to characterise the potential impacts to people, while the second Severity Rating was used to characterise the potential impacts to the environment.

Table 2.1: Severity Ratings for Accident Scenarios

Severity Rating	Category Description	Health & Safety		Environmental Impact
		On-Site	Off-Site	
0	Negligible	None	None	None
1	Minor	Minor injury	None	None
2	Appreciable	Multiple injuries with return to work	Discomfort	Discoloration of water or air
3	Severe	Major permanent disability	Some hospitalisation for screening	Minor short term damage to adjacent land or water courses
4	Very Severe	Single fatality	Minor injuries	Significant short term damage or minor long term damage requiring clean up action
5	Catastrophic	Multiple fatalities	Major injuries or fatalities	Major incident with significant loss of species or habitat

When assessing impacts to health & safety, consideration is given to both on-site and off-site impacts, based on the descriptors shown above, in order to determine the appropriate Severity Rating.

2.1.5 Identification of Initiating Events

Once the various accident scenarios for a particular area have been identified and Severity Ratings assigned to each, the HAZID&RA Team then examined the various initiating events which could potentially give rise to each scenario and the details were set out in the Risk Assessment Register (RAR) sheet. The potential initiating events which were considered included, inter alia, mechanical failure, human error, control equipment failure, as well as external events such as lightning strike or domino effects from an external event. A copy of the RAR worksheets is included in Appendix 3.

2.1.6 Assessment of Frequency Ratings

Each scenario (based on the combination of End Event and Initiating Event) was assigned a Frequency Rating using the HAZID&RA methodology. Table 2.2 shows the criteria used when assigning Frequency Ratings for each scenario.

Table 2.2: Frequency Ratings for Accident Scenarios

Frequency Rating	Descriptor	Frequency Range per Annum
1	Virtually Impossible	$< 1 \times 10^{-8}$
2	Improbable	1×10^{-8} to 1×10^{-5}
3	Unlikely	1×10^{-5} to 1×10^{-3}
4	Infrequent	1×10^{-3} to 0.1
5	Occasional	0.1 to 10
6	Frequent	> 10

The following sources of information were referred to when assigning Frequency Ratings to the various scenarios:

- Literature review: Published figures of generic data, including those developed by the Dutch Committee for the Prevention of Disasters' Guidelines for Quantitative Risk Assessment (the Purple Book) and industry specific studies. Historical data of this type encompasses all relevant contributory aspects including the reliability of equipment, human factors, operational methods, quality of construction, inspection, maintenance, operation, surrounding environment etc.
- Operational conditions: The HAZID&RA Team explicitly accounted for the planned level of activity at the site and on the site layout (e.g. deliveries per annum of material, lengths of unbunded pipeline sections, etc.). The potential risk of knock-on effects from adjacent establishments or other external factors was also considered.
- Professional judgement: The Team members, between them, had appropriate training in hazard identification, risk assessment and consequence analysis and had knowledge of the complete range of operations on site.

2.1.7 Calculation of Risk Rating

The HAZID&RA Team calculated numerical Risk Ratings for each scenario identified in the course of the exercise using the following equations:

$$R_H = S_H \times L$$
$$R_E = S_E \times L$$

Where: R_H is the overall Risk Rating with respect to health and safety for a scenario
R_E is the overall Risk Rating with respect to the environment for a scenario
S_H is the Severity Rating with respect to health and safety for an end event
S_E is the Severity Rating with respect to the environment for an end event
L is the Likelihood Rating for a specific initiating event – end event combination

The Risk Ratings for each scenario were assessed using a matrix, as set out in Table 2.3.

Table 2.3: Matrix of Risk Ratings

Risk Rating		Severity				
		1	**2**	**3**	**4**	**5**
Frequency	**1**	1 - Trivial	2 - Trivial	3 - Trivial	4 - Trivial	5 - Minor
	2	2 - Trivial	4 - Trivial	6 - Minor	8 - Minor	10 - Moderate
	3	3 - Trivial	6 - Minor	9 - Moderate	12 - Substantial	15 - Priority
	4	4 - Trivial	8 - Minor	12 - Substantial	16 - Priority	20 - Priority
	5	5 - Minor	10 - Moderate	15 - Priority	20 - Priority	25 - Priority
	6	6 - Minor	12 - Substantial	18 - Priority	24 - Priority	30 - Priority

A Risk Reduction Register (RRR) was then completed for each scenario on the back of this assessment. This was used to set out any specific scenarios or locations at the site where the HAZID&RA Team identified or recommended additional risk reduction or mitigation measures. When making these recommendations, consideration was given to the risk level associated with each scenario using the criteria set out above.

The findings of the Hazard Identification & Risk Assessment (HAZID&RA) exercise are discussed in more detail in the following sub-sections and copies of the HAZID&RA Worksheets are included in Appendix 3.

Table 2.4: Significance of Risk Ratings

Risk Rating	Risk Level	Action and Timescale
≤ 4	Trivial	Generally no action is required for scenarios with such low risk levels and if so there would be no need for detailed working to demonstrate ALARP (i.e. are As Low As Reasonably Practicable).
5 to 8	Tolerable	No additional controls are required in most cases. Consideration may be given to a more cost-effective solution or improvement that imposes no additional cost burden. Monitoring is required to ensure that controls are maintained.
9 to 11	Moderate	Efforts should be made to reduce the risk, but the cost of prevention should be carefully measured and limited. Risk reduction measures should be implemented within a defined time period. Where a moderate risk is associated with a scenario whose consequences are in the category of Very Severe or Catastrophic (Severity Rating 4 or 5) further assessments may be necessary to establish more precisely the likelihood of harm as a basis for determining the need for improved control measures.
12 to 14	Substantial	The activity should not be started until the risk has been reduced. Considerable resources may have to be allocated to reduce the risk. Where the risk involves a current activity, urgent action should be taken.
≥ 15	Priority	The activity should not be started or continued until the risk has been reduced. If it is not possible to reduce risk, even with unlimited resources, this activity must be prohibited.

2.2 Human Factors

The possibility of human error was considered throughout the various areas covered by the risk assessment exercise.

For all transfers of materials at the site, there will be procedural controls in place to supplement the technical controls that are designed to prevent accidents, including loss of containment of hazardous materials, from occurring.

All deliveries or movements of waste will be controlled by ensuring that they are carried out in accordance with documented Standard Operating Procedures and are carried out by trained personnel.

The layout of the site is also designed with the following considerations with respect to the locations of occupied buildings and the arrangements where operators must use or handle dangerous substances.

The provision of good separation distances between occupied buildings and hazardous areas / dangerous substances. There will also be a site plan in place which shows the emergency escape routes and assembly points.

The layout will be designed to minimise the risk of uncontrolled sources of ignition from reaching hazardous areas. This will include ATEX zoning of the site, where required, and the use of suitable (Ex-rated) equipment in zoned areas.

Where an operator's activities involve the use or handling of dangerous substances, they will be provided with training on the tasks to be carried out as well as with information on the hazards associated with the materials involved. Personnel will also be provided with appropriate PPE for the tasks being carried out.

For any instances in which an operator is required to provide direct intervention in the event of abnormal operating conditions and/or a developing accident scenario, they will be provided with the necessary training to do so (Emergency Response Team members).

In each case the roles to be taken by personnel will be documented. Operators who are required to carry out these response plans receive training to ensure that they are fully aware of the steps to be carried out in response to an accident or incident and also that they are fully aware of the hazards and risks associated with the relevant plant or equipment. They will also be provided with appropriate PPE to assist them in carrying out their required tasks.

Indaver will also ensure that there are appropriate staffing levels at the site at all times to ensure safe operating and to implement emergency response measures, where necessary.

2.3 Criteria for Eliminating Scenarios from the Risk Assessment

The HAZID&RA methodology used for this report involves the systematic assessment of all scenarios identified by the HAZID&RA Team, which includes events which are considered to have very low probability of occurrence. Table 2.2 shows that any scenario identified which was found to have a frequency of occurrence of less than 10^{-5} per annum would be assigned a Likelihood Rating of 2. In other words, the methodology allows for extremely remote events to be included in the risk assessment exercise.

It can be seen in Table 2.4 that highly remote events with potentially catastrophic consequences are considered to present a Medium Risk rather than a Low one. This means that these scenarios are examined further, particularly with respect to determining the potential impacts arising from such an event. This means that Indaver would need to consider implementing further risk reduction measures for these scenarios if the HAZIRD&RA Team found it necessary or desirable to do so.

2.4 External Impacts / Off Site Risks

2.4.1 Earthquake

The School of Cosmic Physics (part of the Dublin Institute for Advanced Studies) was consulted regarding the risks posed by seismic activity in Ireland. The School has had a seismic network in operation in Ireland since 1978. They have indicated that Ireland is seismically very stable and that there is nothing to suggest that this will change in the coming millennia.

Figure 2.1 is a map produced by the US Geological Survey showing the record of seismic incidents in Europe from 1900 to 2006. This shows that there were no earthquakes exceeding the threshold of M3.5 recorded in Ireland during the time period.

Figure 2.1: Earthquake Incidents in Europe (US Geological Survey)

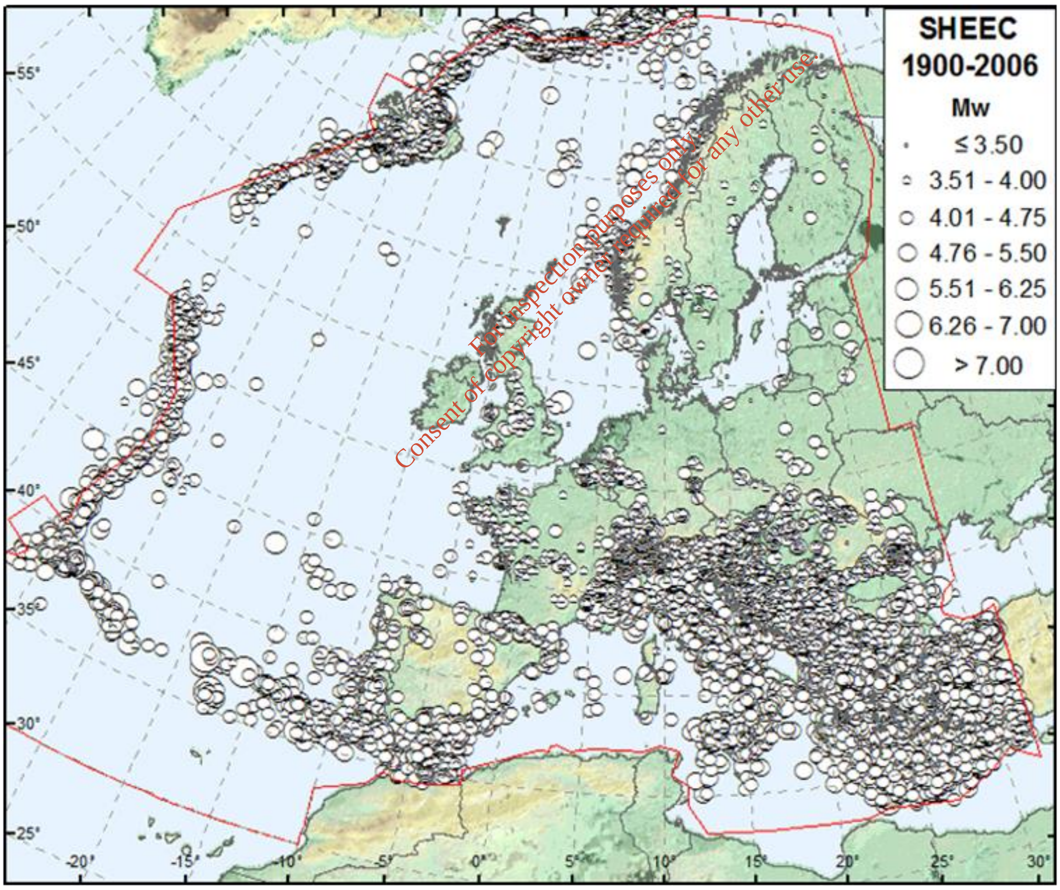
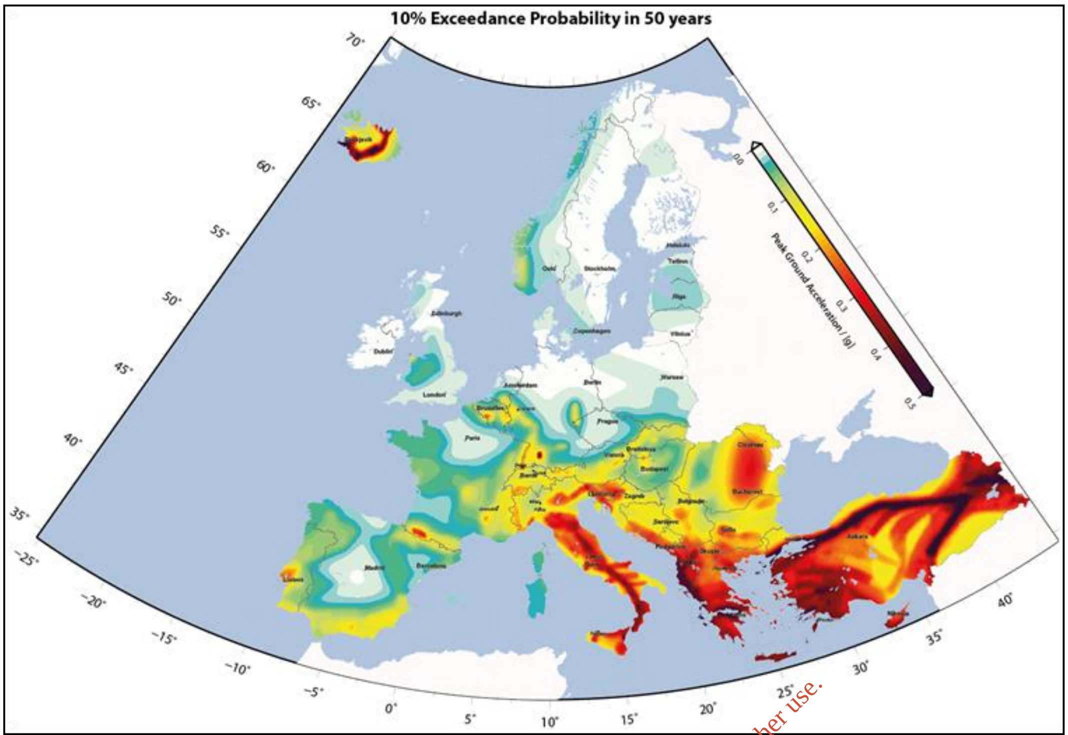


Figure 2.2 is another map produced by the US Geological Survey. This shows the seismic hazard map for Europe.

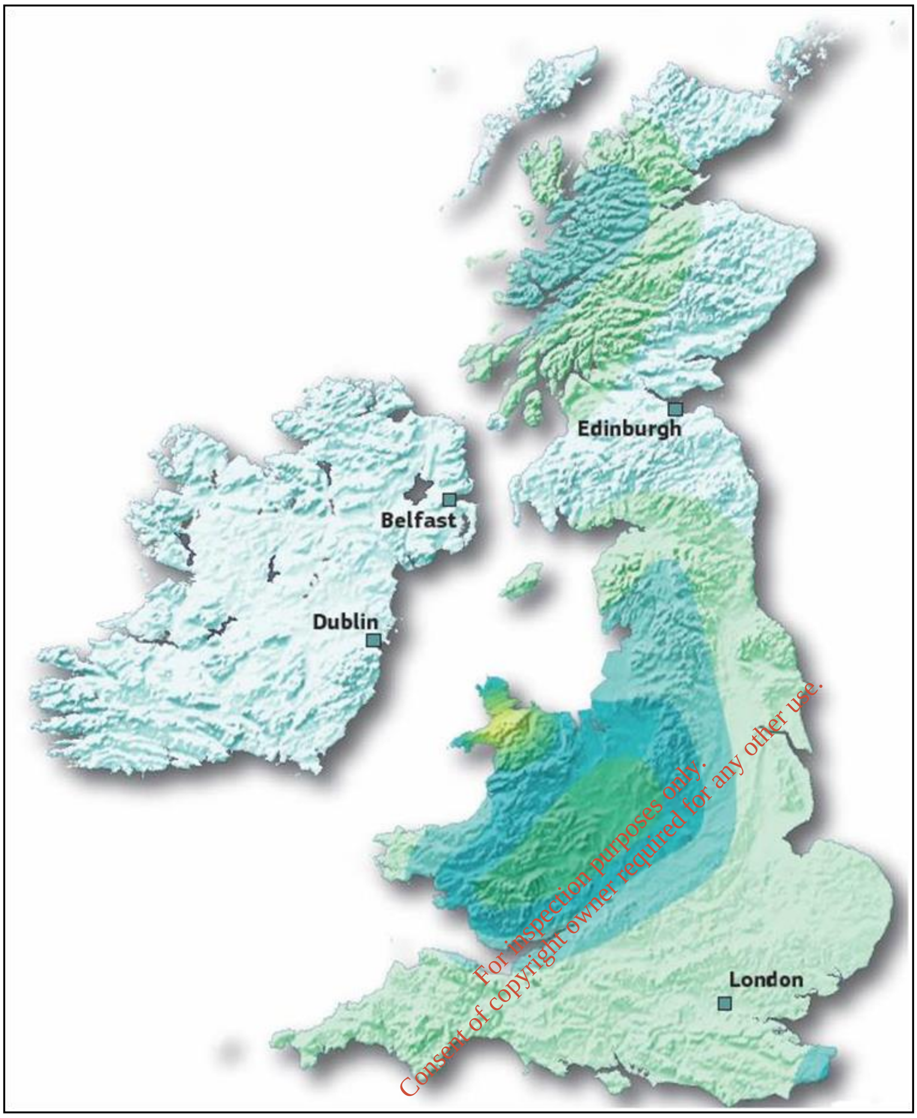
Figure 2.2: Earthquake Hazard of Europe (US Geological Survey)



This map illustrates that the risk of earthquakes in Ireland is amongst the lowest in Europe. The map shows the peak horizontal ground acceleration (PGA, measured in 'g' – gravitational acceleration) predicted to be reached or exceeded with a 10% probability in 50 years. This corresponds to the average recurrence of such ground motions every 475 years, as prescribed by the national building codes in Europe for standard buildings.

Figure 2.3 shows this same map, zoomed in more closely. Low hazard areas (PGA ≤ 0.1 g) are coloured in blue-green, moderate hazard areas in yellow-orange and high hazard areas (PGA > 0.25 g) in red. As can be seen from the plot, Ireland is a low hazard area.

Figure 2.3: Earthquake Hazard Map for Ireland



2.4.2 Flooding

There is no credible risk of an accident occurring at the Ringaskiddy site as a result of a flooding event. Even in the worst case rainfall event, the highest quantity of rainfall that could fall onto a bund area would be 73.2 mm in 24-hours, based on the rainfall data shown in Table 1.3. Any build up of water in the bunds could therefore be easily managed by Indaver operators by allowing the rainwater to drain via oil-water separators, in accordance with normal operating procedures at the site.

Indaver will also upgrade the road drainage network in the vicinity of the site in order to further protect against flood risk. A flood study was conducted as part of the planning application process. It was found that flooding has previously occurred in the vicinity of the site, as there was inadequate drainage on the road network. However, upgrade works will be conducted on the L2545 road are part of the proposed development, including improvement of the drainage systems in order to mitigate against future flood risks. The ground at the site will have a finished floor level of at least 5 m above ordnance datum, which is greater than the observed tidal range.

2.4.3 Power Failure

There are no accident scenarios identified at the site which would be associated with a power failure. If a power failure occurred to a key item of plant or equipment at the same time as potentially hazardous materials were being delivered to the site (e.g. a delivery of aqueous ammonia to the storage tank), the transfer would be halted for the duration of the loss of power event.

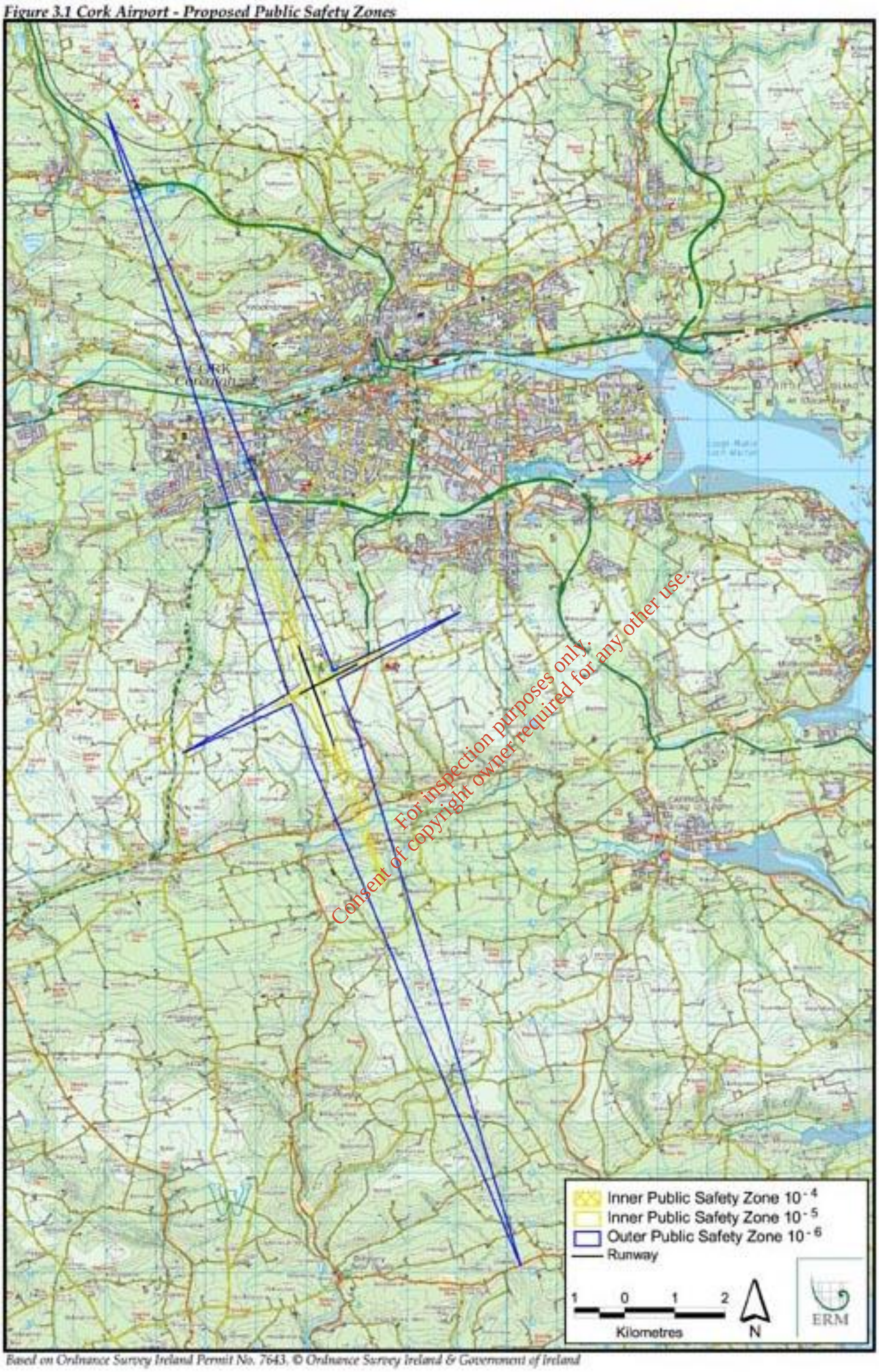
2.4.4 Aircraft Impact

The closest airport to the Ringaskiddy site is Cork Airport, which is located at a distance of c.13 km from the proposed development. Figure 2.4 shows the plot of the Public Safety Zone (PSZ) for this airport. This is taken from report[5] by ERM (Environmental Resources Management) Ireland Ltd, which was commissioned by the Department of Transport and the Department of the Environment and Local Government.

The aim of these PSZs was to protect people on the ground from the risk of an aircraft crash by using land use planning controls on developments in the vicinity of airports. Essentially a PSZ is used to prevent inappropriate use of land where the risk to people is the greatest.

[5] Public Safety Zones: Cork, Dublin and Shannon Airports, ERM, June 2003 (Draft) on behalf of Department of Transport and Department of Environment & Local Government.

Figure 2.4: Public Safety Zone (PSZ) for Cork Airport (ERM)



The plot shows that the PSZ runs in a north-south direction. The proposed development at Ringaskiddy is located to the east of the airport, just outside the range of the map shown. As such the development is comfortably outside of the PSZ contour. The risk of an aircraft impacting the proposed Ringaskiddy development is therefore considered to be extremely remote.

2.4.5 High Wind Speeds

Met Éireann has produced a map[6] showing the estimated maximum gust speeds for a 50-year return period in Ireland. Typical maximum gust speeds for Ireland range up to 50 m/s depending on the location of the site. For a development at Ringaskiddy, the estimated speed for this return period is c.48 m/s.

According to the Department of Geography in University College Cork (UCC), there were approximately 12 or 13 tornadoes in Ireland in 2000. The Department of Geography in UCC indicated that when considering the risk of tornadoes, the probability that one will touch down at a particular location in Ireland is very low. Furthermore, most tornadoes in Ireland are classified as weak in accordance with the Torro Tornado Intensity scale and have wind speeds less than 100 mph (i.e. they are comparable to the maximum gust speeds reported at Ringaskiddy in any case).

As a result no credible accident scenario resulting from high wind loading was included as an initiating event by the HAZID Team.

2.4.6 Extremes in Ambient Temperature

From the temperature data in Table 1.3, the highest ambient temperature at the site (based on a 30-year return period) would be of the order of 28.7°C. There are no scenarios envisioned in which high ambient temperatures could give rise to an accident scenario at the site.

The site will be provided with a fire fighting water main to supply a network of hydrants and water cannons. This will be designed to meet the necessary standards and the requirements of the Fire Certificate and those of the insurance company. The ring main will be under ground and any chambers for hydrants will be insulated and heat traced, the underground ring main will surface inside the building and in areas such as the tipping hall and bunker the internal ring main will be insulated.

2.4.7 Off Site Initiating Events

Hammond Lane

The only credible off-risk identified by the HAZID&RA Team which could potentially give rise to an impact at the Ringaskiddy site is in the event of a fire at the adjacent Hammond Lane facility. This site is located immediately to the west of the Waste to Energy plant.

The HAZID&RA Team considered the potential for a fire to occur at the Hammond Lane site. The main stock piles of material at the site comprise light scrap metal / car shred and so present little fire hazard. Car tyres are removed prior to arrival on site. There are also some smaller stockpiles, comprising foam from car seats and other plastic materials from cars, which would present a more credible potential for fire. In the event of a fire arising in one of these stockpiles, this would require an emergency response to be implemented at the Hammond Lane site. The Emergency Response Team at Indaver would mobilise in such a scenario, to review whether any actions should be taken at the site, but it is not envisaged that any fire scenario arising at Hammond Lane would present any risk of escalation / domino effects to the Indaver facility.

[6] http://www.met.ie/climate-ireland/wind.asp#

DePuy Wind Energy

The HAZID&RA Team also considered the potential risk to the site posed by the DePuy Wind Energy Project to the south of the Indaver site footprint. This comprises wind turbine, with a hub height of 99 m and a turbine radius of 50.5 m, giving a tip height of 149.5 m. This turbine is located c.300 m distance from Indaver and so there is no risk of impact to the Indaver facility in the event of a tower collapsing.

Further examination was conducted to determine if there could be the potential for impact to Indaver in the event of catastrophic failure of a turbine blade when rotating at high speed. The UK HSE's Research Report 968 (RR968)[7] provides more detail on this topic.

The HSE's report refers to various California County ordinances which suggest setback distances for wind turbines of between 1.25 and 3 times the overall turbine height, depending on the location. The document also reviews various studies and methodologies that have been developed to assess the risks presented by wind turbines. One such study included a risk assessment methodology for ice throw from turbine blades, from which a safety threshold of 200-250 m from any wind turbine was proposed. Another study proposed a methodology to estimate the risks to people and properties from a fragment of a wind turbine, considering both drag and lift effects. This concluded that the probabilities of striking a fixed target is less than 10^{-7} per year per turbine and the risk to a person is less than 10^{-9} per year per turbine. However, the HSE noted that many of these studies were limited by omitting the wind turbine's size from the calculations.

The HSE's assessment, based on a comparable turbine size, produced a series of graphs showing the probability of impact for various failure scenarios. These are reproduced here are Figure 2.5. The plots show that the risk of impact tends to generally increase as the size of the blade fragment decreases.

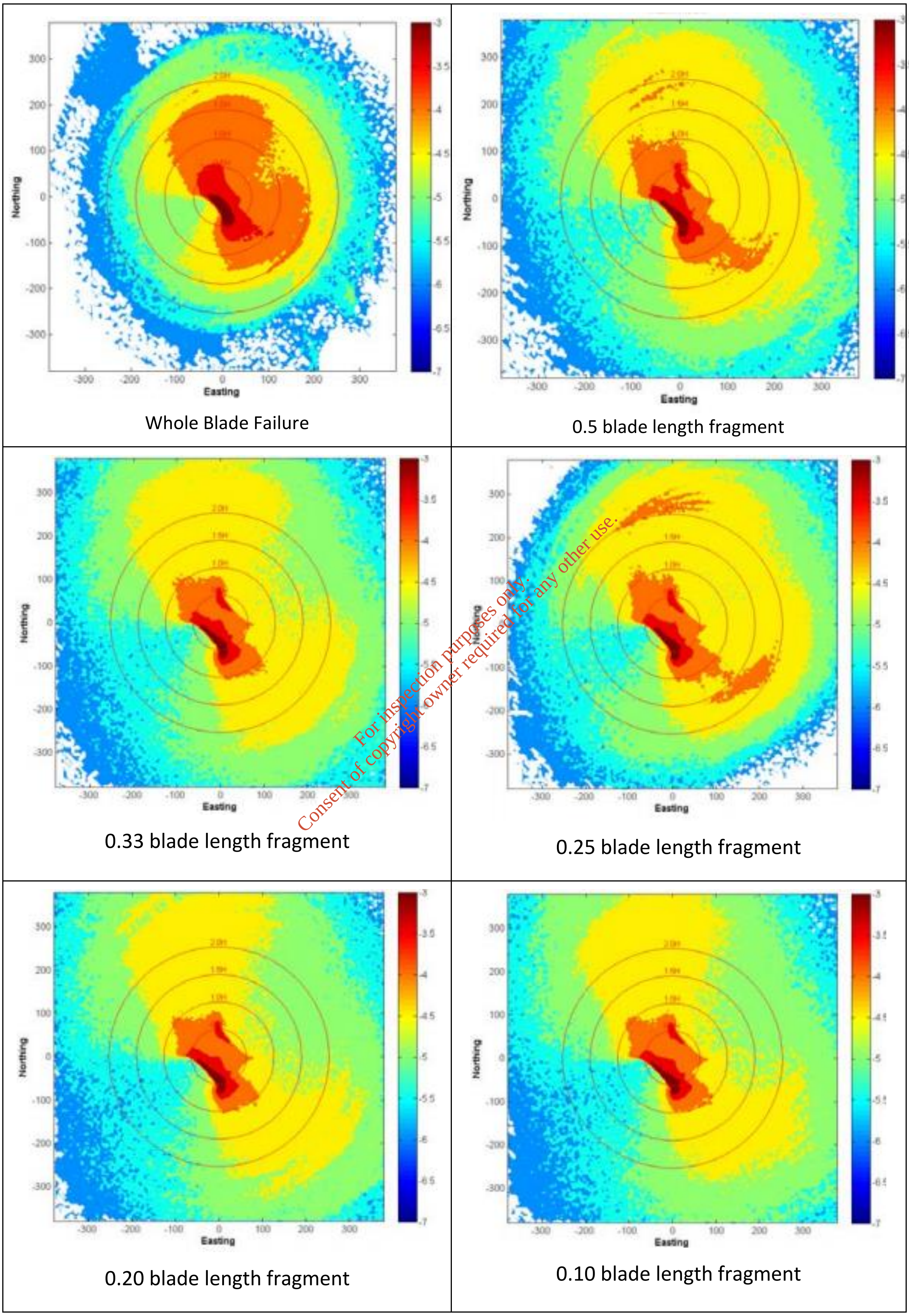
The focus of the HSE's assessment was on locations within 2.0 x H (i.e. twice the hub height) of the turbine. By comparison, the closest point at the Indaver site is at 3 x H from the turbine and the majority of the site is much further then this (in excess of 5 x H at the far end of the site). Nevertheless we have referred to this data in order to extrapolate the risks at greater distances in order to estimate the risk presented to the Indaver site.

These plots show what are referred to as conditional Location Specific Individual risks (LSIR), where the condition is that the failure has already occurred. These show the estimated probability that a 5 x 5 m receptor would be impacted if failure of the turbine did occur. Based on our review of the six figures above, we have conservatively estimated the probability of impact at a typical location at the Indaver site to be of the order of 2.4×10^{-6} per incident.

This figure must be scaled up in order to account for the much larger footprint of the Indaver site where dangerous substances are stored and handled. The modified value works out as 3.8×10^{-3} per incident.

[7] "Study and development of a methodology for the estimation of the risk and harm to persons from wind turbines", UK HSE

Figure 2.5: Location Specific Risks in the Event of Blade Turbine Failure (UK HSE RR 9680)



The level of risk is then calculated by multiplying the probability of impact by the probability of blade turbine failure. The HSE's report states that the probability of major failure of a turbine in this manner is in the range from 10^{-3} per annum to 10^{-4} per annum.

Based on this conservative assessment of the HSE's data, the probability of a fragment of a wind turbine blade is estimated to be in the range 3.8 x 10^{-7} per annum to 3.8 x 10^{-6} per annum, i.e. it is conservatively estimated to be of the order of one in one million per annum.

Based on the above, there is good separation distance between the wind turbine and Indaver's facility. Although the potential risk of impact to the facility to the site cannot be completely ruled out, the probability of the site being impacted by a turbine blade is extremely remote.

2.5 Suitability of Information Used

Due to the range of materials stored at the site, the HAZID&RA Team examined scenarios involving flammable risks (fires and explosions), risks of acute toxic exposure to people and risks of spills to the environment.

When assessing the impacts of accident scenarios to people in the vicinity, a consequence modelling exercise was carried out, using a range of pre-determined endpoints. Some of the endpoints used are also of relevance for emergency response planning.

2.5.1 Consequence Modelling – Thermal Radiation Endpoints

The following thermal radiation and thermal dose endpoints were used for this assessment.

- 4 kW/m^2: Sufficient to cause pain to persons exposed if unable to reach cover within 20 seconds. However, with appropriate protective clothing, emergency response actions lasting several minutes may be undertaken. The distance to this heat flux level is often used by fire responders when determining the limiting distance at which personnel can be deployed.
- 6.3 kW/m^2: This is the heat flux reported by the Chemical Industries Association (CIA)[8] as a maximum level to which an emergency exit should be exposed.
- 8 kW/m^2: This is the threshold value reported in IP19[9] at which protective cooling water may be required to prevent escalation of a fire event to exposed items of plant and equipment.
- 25 kW/m^2: This heat flux is reported in the Green Book[10] as being sufficient to cause Damage Level 2 in steel structures (serious discolouration of surface, peeling off of paints and/or appreciable deformations of structural elements).

[8] "Guidance for the location and design of occupied buildings on chemical manufacturing sites" 2010 (Chemical Industries Association)

[9] "Model Code of Safe Practice Part 19: Fire precautions at petroleum refineries and bulk storage installations" (Energy Institute)

[10] "Methods for the determination of possible damage to people and objects resulting from releases of hazardous materials (CPR 16E)" (TNO)

2.5.2 Consequence Modelling – Explosion Overpressures

The following overpressure endpoints were used for this assessment:

- 30 mbar: Glass breakage
- 70 mbar: Glass fragments may be generated as a result of window breakage
- 140 mbar: Doors and windows removed. Some distortion to steel frame buildings and cladding removed. This is also equivalent to exposure to a Dangerous Dose.
- 210 mbar: This endpoint is used by some agencies for the purpose of emergency response planning

There is no factoring for exposure time in the case of explosion scenarios as they are effectively instantaneous events.

2.5.3 Consequence Modelling – Acute Toxic Exposure

For scenarios involving a release of materials classed as acutely toxic to people, the impacts of exposure were calculated by reference to the Probit function, which takes the following form, as set out in the HSA's Land Use Planning guidance document:

$$Probit = a + b \times ln(C^n \times t)$$

Where a, b and n are material-specific values, taken from published data, C is the exposure concentration (the units will depend on the literature source used for determining a, b and n, but will be either mg/m^3 or ppm) and t is the exposure time in minutes.

The Probit function can then be used to directly calculate the risk to people exposed and express them as a probability of lethal impacts in the surrounding area, using the following equation:

$$Probability = \frac{1}{\sqrt{2\pi}} \int_{u=-\infty}^{u=Y-5} exp\left(-\frac{u^2}{2}\right) du$$

Where u is an integration variable.

In the cases of any materials for which Probit data was not available, reference was made to the UK HSE guidance "Assessment of the Dangerous Toxic Load (DTL) for Specified Level of Toxicity (SLOT) and Significant Likelihood of Death (SLOD)". The UK HSE has published data for a wide range of materials on the dose exposure (i.e. the concentration and the exposure time) that would correspond to both the SLOT (1% lethality) and the SLOD (50% lethality).

In addition to consideration of toxic doses, each scenario was also modelled to the AEGL-2 endpoint Acute Exposure Guideline Level), which is used for emergency response purposes. This threshold was determined by the US EPA as the "airborne concentration of a substance above which is it predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape. For any materials for which AEGL endpoint data was not available, then reference was made instead to alternate endpoints, such as the AEGL-2[11] endpoint established by the US EPA and which is widely used for emergency response purposes.

[11] Acute Exposure Guideline Level 2 – this is defined by the US EPA as the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible

2.5.4 Assessment of Impacts – Releases to the Aquatic Environment

There are a number of materials that will be stored and handled at the Ringaskiddy development which are classed as Toxic to the Environment.

The bunker will be used to store large quantities of incoming waste. As the bunker waste is solid, a spill of material (e.g. during a delivery to the site) is not mobile and so would be easily recoverable. Furthermore, in the event of a fire in this area, the bunker would retain the fire fighting water applied to the waste. Indaver will also conduct a fire water retention study for the site.

The primary environment hazard arises not from the bunker material but rather from the residue that is formed at the back end of the process, which can contain elevated concentrations of various heavy metals. We have examined the properties of the waste residue in order to determine the appropriate hazard classification. The assessment in Appendix 5 shows that the Seveso Regulations do not apply to this waste but nonetheless it is environmentally hazardous.

The other potentially environmentally hazardous materials of note are fuel oil and ammonia:

- Fuel oil: 80 m^3 capacity tank
- Aqueous Ammonia (24.9%)

These tanks will be of double skinned construction in order to protect against the risk of catastrophic tank failure.

Any spills outside of bunded areas would be collected in the surface drainage systems at the site. The outfall from the site is fitted with an oil water separator to protect against elevated concentrations of oil in the surface water discharge. In the event of a spill of water soluble materials, Indaver can shut down the outfall and divert to a dedicated retention tank. This will be done automatically by fitting a TOC, conductivity and pH meter on the line, which will shut down the outfall when necessary. There will also be a switch which can be activated by Indaver personnel to manually shut down the outfall.

2.5.5 Weather Data

The range of weather conditions that were examined for the purposes of the consequence modelling work that was conducted in support of the HAZID&RA exercise depended on the type of scenario being considered, as follows:

- Fire scenarios: the consequence modelling exercise for the fire scenarios covered in this report use wind speeds of 5 m/s (to represent the impacts during normal weather conditions) and 10 m/s (to represent the impacts in high wind speeds, which can give rise to flame tilt).
- Explosion scenarios: any scenarios involving the evolution and dispersion of vapour to atmosphere were modelled in D5 weather conditions (5 m/s wind speed and normal levels of atmospheric stability) and F2 weather conditions (2 m/s and calm weather conditions).

individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

- Toxic releases: any scenarios involving the release of toxic materials to atmosphere were modelled in D5 weather conditions (5 m/s wind speed and normal levels of atmospheric stability) and F2 weather conditions (2 m/s wind speed and calm weather conditions).

In each case, the approach was to model the scenario in normal weather conditions, which would be more likely to prevail at the time of an accident, and also in worst case conditions (in other words, low wind speeds and calm atmospheric conditions for toxic releases and high wind speeds for fires).

2.6 Credible Scenario Trail

2.6.1 Review of Accident Scenarios

The approach used to carry out the risk assessment exercise is described in Section 2.1. The resulting HAZID&RA worksheets are included in Appendix 3. These comprise the Accident Scenario sheets (AS), which describe the various end events that were identified for the site, and the Risk Assessment Register (RAR) and Risk Reduction Register (RRR), which identifies the various initiating events which could give rise to an accident and calculates the overall risk associated with each scenario. These worksheets also provide details of the various protection and mitigation measures that will be in place at the site, as well as any additional measures recommended in the course of the HAZID&RA exercise.

This exercise covered the full range of accident scenarios examined for each of the areas listed in Section 2.1.2 of this report.

In total the HAZID&RA exercise covered a total of 95 accident scenarios, many of which were slight variations of other scenarios. Of these, a small subset of representative worst case scenarios was identified for further assessment. These scenarios were primarily selected on the basis of their Risk Ratings, but additional consideration was also given to potentially catastrophic events. The scenarios selected for more detailed consideration were as follows:

- Bunker Fire, with potential evolution of toxic products of combustion to atmosphere.
- Loss of containment of aqueous Ammonia or Hydrochloric Acid.
- Fire following loss of containment from Aqueous Waste.

This sub-set was selected on the basis that they represent the credible worst case scenarios of the various categories or types of accident that could arise at the site, as identified by the HAZID&RA Team. They are described in more detail below.

2.7 Detailed Subset of Accident Scenarios

This section of the report describes the sub-set of accident scenarios that was selected for more detailed analysis. These represent the credible worst case scenarios that could arise at the Ringaskiddy facility. These scenarios have been selected for detailed discussion as they represent the worst case events at the various locations that were examined.

2.7.1 Bunker Fire

Smoke Plume

The risk assessment team examined a number of different bunker fire scenarios, ranging from a spot fire in the waste bunker area up to a fully developed bunker fire. Although the Seveso Regulations do not apply to the waste material within the bunker, nonetheless a fire in this area could give rise to a variety of potentially hazardous products of combustion. Based on the previous discussions with the HSA at the time of the 2008 report and on the findings of the 2015 HAZID&RA review, the primary hazard associated with a bunker fire of this type is the potential formation and emission to atmosphere of dioxins in the smoke plume, although there could also be other products of combustion such as CO, HCl and SO_2 in the emission.

The bunker will typically comprise c.4,000 tonnes of waste, based on a design calorific value of 9.6 MJ/kg, although it will have the capacity to accommodate up to 6,000 tonnes. The dimensions of the bunker are 18.2 m × 40.5 m.

Based on the analysis of the HAZID&RA Team, there are three categories of bunker fire examined:

- Minor fire – smouldering due to contaminants such as hot ashes in the incoming waste stream. In this scenario, Indaver can respond by using the grab crane to load the portion of smouldering waste to the hopper feeding the furnace. It is conservatively assumed that up to 1 tonne of waste could be burned in the bunker area for this scenario.
- Intermediate fire – this is a larger fire scenario requiring the implementation of Indaver's fire fighting response to extinguish the fire. It is assumed that up to 50 tonnes of waste could be consumed in this case.
- Fully developed fire – if the initial fire fighting response fails to deal with the scenario the fire could escalate to become a fully developed scenario. In this case the full inventory of waste in the bunker area (between 4,000 and 6,000 tonnes) is consumed.

A more detailed description of the approach used for the consequence modelling exercise for these potential bunker fire scenarios is included in Appendix 6.

Thermal Radiation

In addition to the potentially hazardous effects from the smoke plume arising from a bunker fire, there would also be significant thermal radiation to the surrounding area once the fire became fully developed. The software package that was used for this exercise does not include data on the burning rate and surface emissive power for the waste in the bunker and so a surrogate material was selected. The impacts of this scenario were modelled as a pool fire with a surface area equal to the cross sectional area of the bunker. Decane was selected as a surrogate material, as a longer chain hydrocarbon compound. This is considered to be conservative for the purposes of determining heat fluxes as Decane will burn at a higher rate and with a higher intensity than would the material in the bunker.

2.7.2 Loss of Containment of aqueous Ammonia or Hydrochloric Acid

There are several loss of containment events identified in the HAZID&RA worksheets. The primary such scenarios are as follows:

- Loss of containment of aqueous Ammonia from transfer pipeline. The flow rate in the transfer line is 0.4 m^3/hr. In the event of a major release (guillotine failure) Indaver personnel will be able to detect the loss of containment and to take the necessary measures to shut down the transfer. For the purposes of this assessment a response time of 15 minutes has been assumed. This is a conservative assumption when calculating the quantity of Ammonia that would be released in this scenario as, if the pipe line was to fail in this manner, the pumps would not be able to maintain the pressure in the line. In order to calculate the total quantity released in this period, we multiplied the flow rate by the response time and applied a factor of 2 to allow for additional material lost due to the reduced resistance against which the pump would be operating and for residual material in the line after the pumping ceased. The total volume spilled in this scenario is calculated to be 0.2 m^3.
- Full loss of containment from aqueous Ammonia tank. This is an extremely remote event as the ammonia tank will be a double-skinned tank. The tank will also be protected against impacts by elevating it on a plinth and by installing bollards to protect against impact. However, the HAZID team did not rule out the possibility of the tank being damaged due to mechanical impact. In this scenario the full inventory of the tank could be released (i.e. up to 100 m^3 of aqueous ammonia). The area to which the ammonia would spill in this scenario is comprised of concrete hard standing and graded towards an eco channel which is routed to the surface water network. As such, while the resulting pool could cover a large area, as per the consequence modelling results later in this report, it would not remain in place for a long duration. Once collected in the surface water network, the spill would be routed to a forecourt separator which can be used to retain spills rather than allowing it to discharge off site.
- Loss of containment during delivery of aqueous ammonia (rupture of transfer hose). This scenario involves a much higher flow rate than a release from a pipeline (40 m^3/hr). However, as the operation is manned locally, there is a much more rapid response time (taken to be 1 to 2 minutes). In this case a factor of 1.5 was also applied to allow for the increase in flow rate following failure of the hose line. The total quantity released in this scenario is 2 m^3.
- Loss of containment of HCl from IBC: HCl will be stored on site in a bunded IBC. For this scenario the full inventory of 1 m^3 is released into the bund tray that the IBC is housed in.
- Damage to side of IBC resulting in jet release of HCl outside of bund. This scenario involves a gradual release of HCl outside of the bund tray due to overjetting. The total quantity released in this case will be the full inventory of the container above the hole height. The resulting pool of liquid will increase in size, giving an increase in HCl evaporation rate over time. As an upper limit to this scenario the maximum evaporation rate of Hydrogen Chloride gas to atmosphere will be determined by the maximum release rate of HCl within the liquid solution being released from the hole in the container.
- Damage to IBC during delivery. This is the worst case event for the HCl container. It is assumed that the full 1 m^3 inventory is released to an unbunded area.

The loss of containment of an aqueous solution of these materials can give rise to the evolution of potentially toxic gas (Ammonia or Hydrogen Chloride). In each case we have modelled the evolution of gas from the liquid spill, based on the dimensions of the pool formed, the weather conditions (D5 or F2) and the properties of the material spilled.

2.7.3 Fire following Loss of Containment of Aqueous Waste

The aqueous waste stream at Indaver will comprise a variety of different materials, although the bulk of the mixture will comprise water (>70%). This will reduce the flammability of the mixture as the dilution effect will act to reduce the flash point. Nevertheless depending on the mixture of materials involved, this mixture could present a flammable hazard and so the HAZID Team identified the potential risk of a pool fire scenario arising following a loss of containment.

Aqueous waste will be brought on site by bulk tanker. These vehicles will park in a paved area and the waste will be transferred to the aqueous waste tank, from which the stream can be fed into the furnace.

Aqueous waste is transferred by pipeline at a rate of 2 m^3/hr. In the event of guillotine failure of the line to the aqueous waste tank, it is judged that Indaver would be able to take action to shut down the transfer within 15 minutes, during which time a quantity of up to 0.5 m^3 would be pumped. A factor of 2 has been applied to this figure, to account for the increased flow rate that could arise in the event of guillotine line failure, as well as residual material in the pipeline, giving a total release quantity of 1 m^3 in this scenario. This would be released to an unbunded area. However it should be noted that this is a paved area which will drain to a holding tank which in turn discharges to the surface water drainage network at the site. These measures help to reduce the potential atmospheric impacts from the release. For a spill of this quantity over flat ground, it could spread to a representative pool thickness of 10 mm, giving a total pool area of 100 m^2.

2.8 Consequence Assessment

The consequence modelling results for the various scenarios described above are set out in this section.

2.8.1 Bunker Fires

Dioxin Emissions from Bunker Fire – Human Health

The modelling exercise for the impacts of the dioxin emissions from a bunker fire are described in Appendix 6. The focus of this aspect of the assessment is to examine the combined dose that could be experienced over the course of the fire event, as follows:

- Initial phase with smouldering waste: this is characterised by lower emission rates but also has a less buoyant smoke plume
- Intermediate phase: this involves a fire in the bunker, but one which is extinguished before it can become fully developed.
- Fully developed fire: this involves a fire in the full inventory in the bunker. It is characterised by higher emission rates but it also has a higher buoyancy smoke plume which helps to reduce ground level impacts.

Each phase is progressively less likely to occur, due to the controls and response plans that Indaver will have in place for a fire in the bunker, but the combined impacts of all three phases have been examined.

Table 2.5 sets out the findings of the expected maximum contribution to dioxin intake to the closest vulnerable receptors to the site – the closest residences at Ringaskiddy, the adjacent Hammond Lane facility, the DePuy Wind Energy Project and the National Maritime College of Ireland.

Table 2.5: Impacts of Potential Dioxin Intake (combined risk from all Bunker Fire Scenarios)

Parameter	Ringaskiddy	Hammond Lane	DePuy	Maritime College
Dist. from Bunker (m)	650 m	125 m	350 m	250 m
Average intake (µg/day)	1.26×10^{-8}	3.49×10^{-8}	2.02×10^{-8}	2.29×10^{-8}
Body weight (kg)	70	70	70	70
Average Intake (µg/day per kg)	1.80×10^{-10}	4.99×10^{-10}	2.89×10^{-10}	3.27×10^{-10}
Average Intake (pg/day per kg)	1.80×10^{-4}	4.99×10^{-4}	2.89×10^{-4}	3.27×10^{-4}
Safety Margin compared with TDI	5,570	2,005	3,459	3,060

This shows that there is a very wide margin of safety between the expected dioxin intake to people at these locations when compared with the WHO's Tolerable Daily Intake (TDI) for lifetime exposure of 1-4 pg/kg/day (taken as 1 pg/kg/day for the purposes of this calculation). As such the overall exposure to dioxins in the surrounding area as a result of the Indaver facility would be very low (over three orders of magnitude less than the overall TDI established by WHO).

The closest Protected Site to the Indaver facility is Lough Beg, which is part of the Cork Harbour SPA and is also a pNHA. This is located c.500 m from the facility. Applying the same calculations as used in Table 2.5, the resulting factor of safety works out as 4,390, based on the WHO criteria for human health.

Dioxin Emissions from Bunker Fire – Environmental Impacts

At the time of the previous risk assessment, in 2008, Indaver arranged for a study to be conducted by AWN to predict the increase in soil PCDD/F (Polychlorinated Dibenzo Dioxin and Polychlorinated Dibenzo Furan) concentrations as a result of potential fire scenarios at the Ringaskiddy facility.

Based on the results of this assessment, the increase in soil PCDDD/F concentrations over a 30-year period was calculated to be 0.0001337 ng I-TEQ/kg, applying an assumption of one small fire (1-tonne) per annum, and 0.0004445 ng I-TEQ/kg, applying an assumption of two 50-tonne fires over the 30-year period. These were very conservative assumptions when compared with Indaver's operational experience at other plants.

Based on this approach the total contribution to soil concentrations within the zone of influence (a 20 km radius around the site) was calculated to be 0.000577 ng I-TEQ/kg. This was found to be significantly lower (three orders of magnitude) than the lowest background soil concentration measured in the Ringaskiddy area, which was 0.55 ng I-TEQ/kg.

Based on this assessment, the calculated values for the PCDD/F contribution made by the Indaver facility were found to be insignificant.

While the assessment shows that the contribution made by the Indaver facility to the existing dioxin levels in the soil would be negligible, it is also important to check the significance of the existing dioxin levels. The EPA conducts regular surveys of dioxin levels and we have examined the most recent such study (2012) available on their website[12].

The EPA's survey involved an assessment of the concentrations of dioxin in cows' milk for various locations throughout Ireland. The EPA's report states that, given that the primary mechanism for dioxins to enter the food chain is through atmospheric dispersion, cows' milk is considered to be a particularly suitable matrix for assessing their presence in the environment, since cows tend to graze over relatively large areas and these compounds will, if present, concentrate in the fat content of the milk.

The EPA's study comprised 24 samples from Type A stations (these are background stations covering the entire country) and 14 samples from Type B stations (these are stations in areas of perceived potential risk). Ringaskiddy was included in the survey as one of the Type B stations and the results for Ringaskiddy were comparable to those at the other locations.

The results for the survey as a whole found that the dioxin concentrations varied from 0.158 to 0.583 pg WHO-TEQ/g, with an average value of 0.196 pg WHO-TEQ/g. The results for Ringaskiddy showed a dioxin concentration of 0.21 pg WHO-TEQ/g.

Based on the EPA's findings, the results of the survey were in line with the historical data from previous EPA surveys (conducted between 1995 and 2011). The dioxin concentrations in the samples were found to be well below the EU limit for milk and milk products (2.5 pg WHO-TEQ/g). The results of the EPA's survey also compared favourably with those taken from a random selection of similar studies in the EU and other countries.

The low impact on soil dioxin levels predicted by AWN and the findings of the EPA's surveys support the conclusion that there will be no impact of significance to the soils and/or the food chain from dioxins released in the event of accidental fires in the solid waste bunkers at Indaver.

Thermal Radiation from Bunker Fire

In addition to the potential impacts of the smoke plume, a fire scenario at the bunker could also give rise to significant levels of thermal radiation to the surrounding area. In the case of the first two fire scenarios considered here, the structure of the bunker building would remain intact or largely intact and so the impacts to the surrounding area would be minor. However in the escalation event, involving a fully developed fire at the bunker, it is assumed that the structure of the building could be damaged by the fire and so this shielding effect would no longer be provided.

The consequence modelling results for this scenario are shown in Table 2.6.

Table 2.6: Consequence Modelling – Thermal Radiation from Fully Developed Bunker Fire

Parameter	Wind Speed of 5 m/s	Wind Speed of 10 m/s
Distance to 25 kW/m^2	19 m	21 m
Distance to 8 kW/m^2	39 m	38 m
Distance to 6.3 kW/m^2	43 m	41 m
Distance to 4 kW/m^2	52 m	46 m

[12] "Dioxin Levels in the Irish Environment: Tenth Assessment (Summer 2012), based on levels in Cows milk"

All distances are expressed as distances from the edge of the bunker. For the purposes of this assessment, the fire is taken to be fully developed and so no shielding effect from the structure of the bunker building is taken into account.

Each of the off-site receptors examined previously (Ringaskiddy, Hammond Lane, DePuy and the Maritime College) are comfortably outside of the hazard distances reported in Table 2.6. The closest off site receptor is the Hammond Lane site. At its closest point, the distance from the flame front following a fire in bunker area to the boundary of the Hammond Lane site is over 100 m. At this distance the resulting heat fluxes would be much less than 4 kW/m^2 and there would be negligible impacts at Hammond Lane. As such there is no risk of adverse impacts to any off site receptors arising from the thermal radiation emitted in this scenario.

2.8.2 Loss of Containment of aqueous Ammonia or Hydrochloric Acid

The consequence modelling results for the loss of containment events described above involving aqueous Ammonia are shown in Table 2.7.

Table 2.7: Consequence Modelling for Aqueous Ammonia Releases

Parameter	Loss of containment from Pipeline		Loss of containment from Tank		Loss of containment during delivery	
Weather	D5	F2	D5	F2	D5	F2
Pool Area (m^2)	20	20	1,000	1,000	100	100
Distance to AEGL-2	52 m	109 m	326 m	876 m	215 m	435 m
Distance to 1% lethality	6 m	15 m	45 m	110 m	20 m	70 m
Distance to 50% lethality	-		23 m	56 m	-	25 m

- indicates that the model did not generate this concentration at any location downwind from the release. However, it should be noted that there would be elevated concentrations directly above the liquid surface.

The primary point to note in this instance is the relatively long hazard distances that are generated following a major release from the ammonia tank. Consideration should be given to these hazard distances when implementing any emergency response efforts to a major release scenario.

The closest off site receptor is at Hammond Lane. At its closet point the site boundary at Hammond Lane lies within c.100 m of the Ammonia tank. As such, there is the potential for the 1% concentration to extend as far as the eastern boundary of Hammond Lane in the absolute worst case scenario (i.e. full loss of containment from the ammonia tank, in calm atmospheric conditions and with the wind blowing in an unfavourable direction). This calculation is based on an assumed exposure time of 30 minutes, in accordance with HSA guidance. However, this is likely to be a very conservative assumption in this case as the site's drainage system will collect the spill, thereby reducing the duration for which the pool would be present. Furthermore the impacts could be mitigated by having people evacuate the area or taking shelter.

The results indicate that there is no risk of lethal impacts at any of the other off-site receptors (Ringaskiddy, DePuy or the Maritime College), even in the worst case scenario.

Using the AEGL-2 concentrations rather than the lethality exposure levels result in longer hazard distances, as would be expected. In this case the results show that the AEGL-2 concentration could extend to several off site receptors, again depending on the atmospheric conditions and wind direction. In this case there is no significant risk of lethal effects, but persons downwind following a major release should either remain indoors or evacuate the area in order to protect against exposure effects.

The scenario involving a full loss of contents from the Ammonia tank was identified as the worst case scenario in terms of Severity Rating in the HAZID&RA exercise. However, the HAZID&RA Team found this scenario to have a low probability of occurrence (Frequency Rating), due to the controls in place, which include:

- The ammonia tank is of double-skinned construction.
- Provision of leak detection between skins to allow Indaver to detect any instances of a leak within the inner skin of the tank.
- Impact protection barriers at the tank.
- Speed limit on site.
- Preventative Maintenance regime to ensure tank integrity.
- Drainage system to collect spills in the vicinity of the ammonia tank.

The consequence modelling results for the loss of containment events described above involving aqueous Hydrochloric Acid are shown in Table 2.8.

Table 2.8: Consequence Modelling for Aqueous Hydrochloric Acid Releases

Parameter	Release from IBC to Bund		Overjetting from IBC		Full Release of IBC to	
Weather	D5	F2	D5	F2	D5	F2
Pool Area (m^2)	1.44	1.44	27	27	100	100
Distance to AEGL-2	< 10m	< 10m	< 10m	24 m	14 m	44 m
Distance to 1% lethality	-	-	-	5 m	-	8 m
Distance to 50% lethality	-	-	-	-	-	-

- indicates that the model did not generate this concentration at any location downwind from the release. However, it should be noted that there would be elevated concentrations directly above the liquid surface.

The results show that none of these release scenarios would give rise to any adverse impacts at the off-site receptors.

2.8.3 Fire following loss of containment of Aqueous Waste

The consequence modelling results for this scenario are shown in Table 2.9.

Table 2.9: Consequence Modelling – Fire of Aqueous Waste

Parameter	Wind Speed of 5 m/s	Wind Speed of 10 m/s
Distance to 25 kW/m^2	-	-
Distance to 8 kW/m^2	7 m	7 m
Distance to 6.3 kW/m^2	8 m	8 m
Distance to 4 kW/m^2	10 m	10 m

- indicates that the model did not generate this heat flux at any location downwind from the release. However, it should be noted that the flux would be in excess of this value for anything engulfed in the fire.

The results show that none of these fire scenarios would give rise to any adverse impacts at the off-site receptors.

2.9 Demonstration of ALARP

2.9.1 Overview of Scenarios

A total of 95 scenarios was examined in the HAZID&RA exercise, 91 of which were found to present credible accident hazards. These scenarios were assessed and a Severity Rating and Frequency Rating assigned to each, in accordance with the methodology described previously in this report.

The distribution of risk ratings based on risks to human health and to the environment are summarised in Table 2.10 and Table 2.11.

Table 2.10: Frequency Distribution of Risk Ratings (Human Health)

	Severity				
Frequency	**1**	**2**	**3**	**4**	**5**
1	0	0	0	0	0
2	10	14	9	0	1
3	22	17	8	0	0
4	4	3	1	0	0
5	0	1	0	0	0
6	0	0	0	0	0

Table 2.11: Frequency Distribution of Risk Ratings (Environment)

	Severity				
Frequency	**1**	**2**	**3**	**4**	**5**
1	0	0	0	0	0
2	6	23	5	0	0
3	11	35	1	0	0
4	2	5	1	0	0
5	2	0	0	0	0
6	0	0	0	0	0

Based on the findings of the HAZID exercise, there were no scenarios identified which presented a Priority Risk and there was one scenario which presented a Substantial Risk, which was the bunker fire scenario. This scenario received a Severity Rating of 3 for both Human Health and for the Environment and a Likelihood Rating of 4.

The risk associated with this scenario was considered by the HAZID Team to be ALARP, due to the variety of measures that are in place to protect against a fire scenario, either by reducing the likelihood of occurrence or mitigating the impacts if it did occur. These are listed below:

Prevention Measures

- Visual inspection of waste as it is unloaded at the reception hall, to check for any irregularities.
- Hot work permitting system – control on ignition sources in area.

- Trained operators.
- LEL monitoring in bunker.
- Where practicable, equipment is taken outside of the bunker for maintenance works to protect against risk of fire from maintenance activities.
- Due to the manner in which the activity is carried out, there is a quick throughput at the bunker which means that waste is not left in situ for a long period of time.
- Bunker Management Programme - once or twice per year the level in the bunker is lowered (as far as practicable) in the course of a lead in to plant shut down.
- Barrier in place at Tipping Hall, to protect against scenario in which a trailer falls into the bunker.

Mitigation Measures

- In the event of a fire in the bunker, the fire damper will close and air to boiler will be taken from elsewhere.
- The control room is manned area that has visibility on the bunker at all times via a large window that looks out onto it; this would facilitate rapid detection of smoke formation.
- Negative pressure at waste reception area.
- UV/IR detectors in the bunker.
- If smouldering waste is detected it is loaded directly to hopper and more waste is then placed on top to smother it.
- 4 x Fixed water cannons in place to douse spot fires.
- Sprinkler system on roof as back up to the water cannons.
- Bunker is concrete structure.
- Fire wrapping of cables to ensure continued function during fire event.

Furthermore, Indaver will conduct a fire water retention study for the site in order to ensure that there is adequate provision to retain fire fighting water applied at the site.

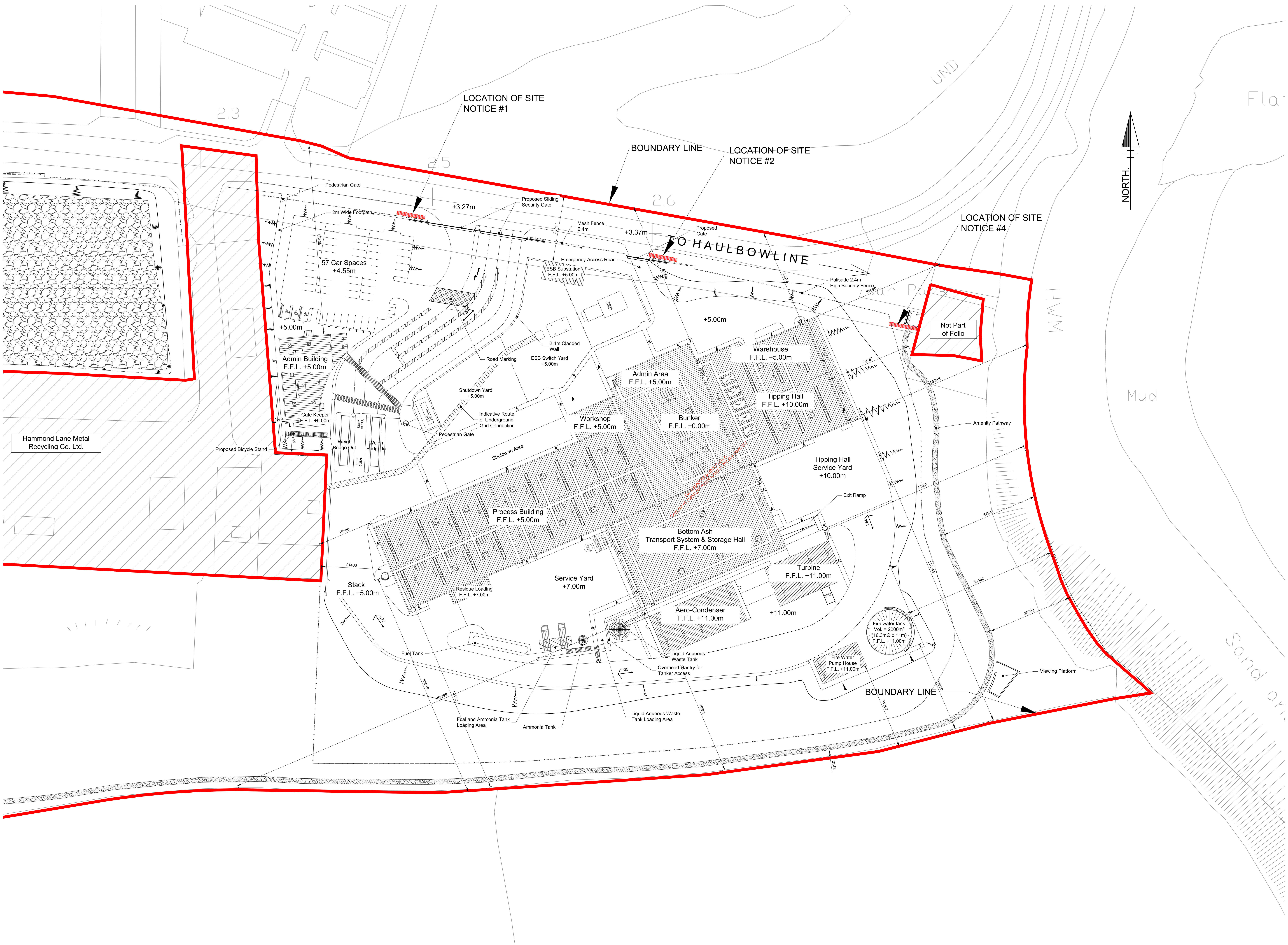
3 CONCLUSIONS

Based on the findings of this risk assessment exercise it is considered that with the control measures that will be put in place at the site, as detailed in the HAZID worksheets in Appendix 3 and the additional measures listed in Appendix 4, the risks associated with accident scenarios at the Indaver facility at Ringaskiddy will be reduced to ALARP (As Low As Reasonably Practicable).

Appendix 1: Site Drawings

NOTE:
- DO NOT SCALE. USE FIGURED DIMENSIONS ONLY
- THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT SPECIFICATIONS AND DRAWINGS.
- ALL DIMENSIONS TO BE CHECKED ON SITE.
- IN THE EVENT OF ANY DISCREPANCIES BETWEEN DRAWINGS THE CONTRACTOR IS TO INFORM THE ARCHITECT IMMEDIATELY

REV.	DATE	DESCRIPTION	DRWN	CH'KD.	APP'RD.



PROPOSED SITE LAYOUT PLAN

(SCALE 1:500 @A0)

LEGEND:

- LOCATION OF SITE NOTICE
- AREA TO WHICH APPLICATION RELATES OUTLINED IN RED
- +7.00m SITE PROPOSED LEVELS
- F.F.L. +7.00m FLOOR FINISHED LEVELS
- FOR DRAINAGE DETAILS REFER TO ENGINEERING DRAWINGS
- FOR ROAD DETAILS REFER TO ENGINEERING DRAWINGS
- FOR SACRIFICIAL MATERIAL DETAILS REFER TO ENGINEERING DRAWINGS
- FOR LANDSCAPE DETAILS REFER TO LANDSCAPE ARCHITECTS DRAWINGS
- FOR SERVICE DIVERTIONS DETAILS REFER TO ENGINEERING DRAWINGS

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RINGASKIDDY RESOURCE RECOVERY CENTRE
INDAVER
RINGASKIDDY, CO.CORK

PROPOSED SITE LAYOUT PLAN

SCALE	DATE	DRAWN BY	CHECKED	REVISION No.	DRAWING NO.
1:500 @A0	JAN'16	IS	FOM	11	1434 - 104

NOTE:
- DO NOT SCALE. USE FIGURED DIMENSIONS ONLY
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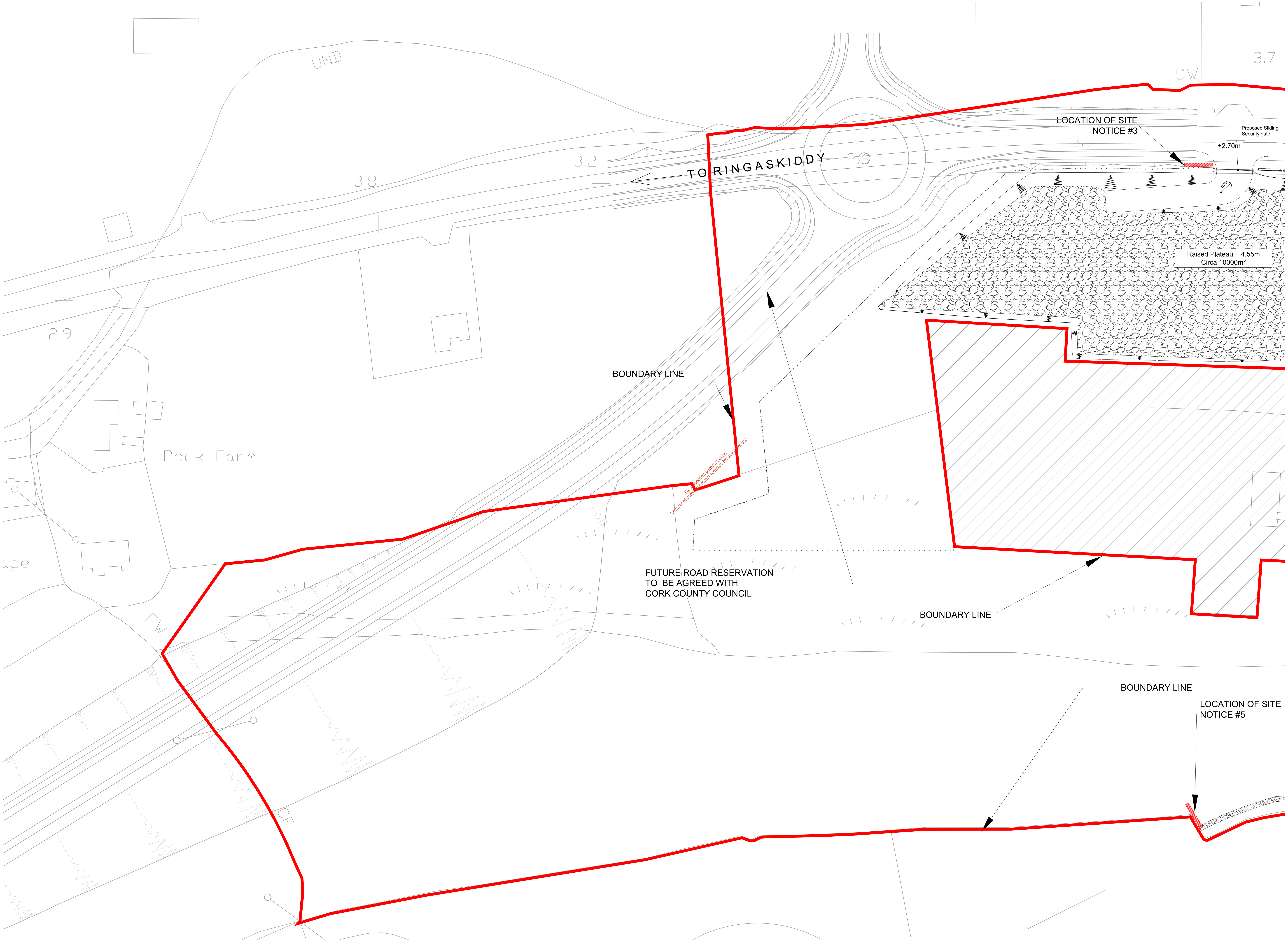
- IN THE EVENT OF ANY DISCREPANCIES BETWEEN DRAWINGS THE CONTRACTOR IS TO INFORM THE ARCHITECT IMMEDIATELY

REV.	DATE	DESCRIPTION	DRWN	CH'KD.	APP'RD.



LEGEND:

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- FOR LANDSCAPE DETAILS REFER TO LANDSCAPE ARCHITECTS DRAWINGS
- FOR SERVICE DIVERTIONS DETAILS REFER TO ENGINEERING DRAWINGS

PROPOSED SITE LAYOUT PLAN

(SCALE 1:500 @A0)

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RINGASKIDDY RESOURCE RECOVERY CENTRE INDAVER RINGASKIDDY, CO.CORK	PROPOSED SITE LAYOUT PLAN

SCALE	DATE	DRAWN BY	CHECKED	REVISION No.	DRAWING NO.
1:500 @A0	JAN'16	IS	FOM	11	1434 - 105

NOTE: - DO NOT SCALE. USE FIGURED DIMENSIONS ONLY
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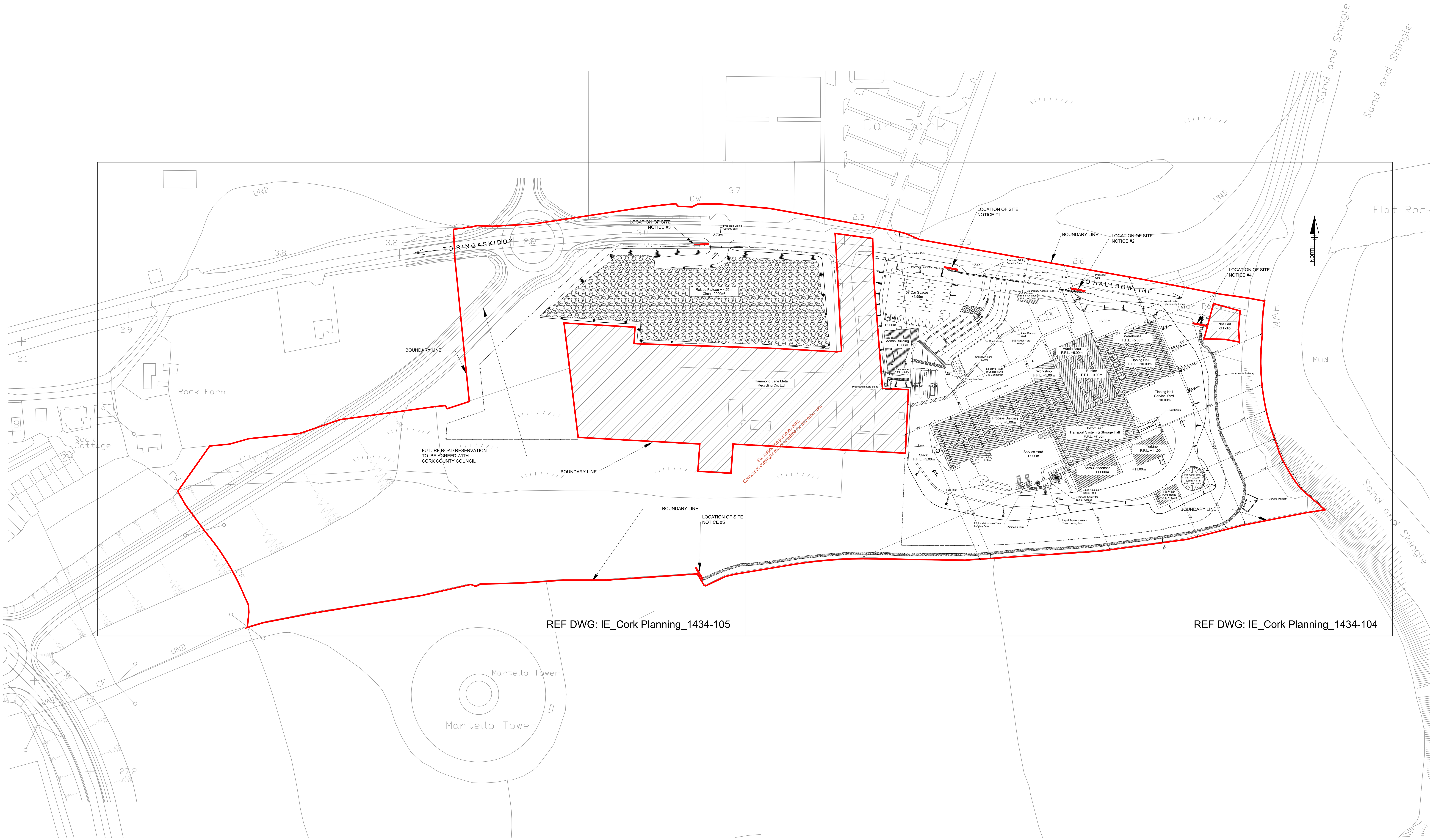
- IN THE EVENT OF ANY DISCREPANCIES BETWEEN DRAWINGS THE CONTRACTOR IS TO INFORM THE ARCHITECT IMMEDIATELY

REV.	DATE	DESCRIPTION	DRWN	CH'KD.	APP'RD.



LEGEND:

LOCATION OF SITE NOTICE

AREA TO WHICH APPLICATION RELATES OUTLINED IN RED

+7.00m SITE PROPOSED LEVELS

F.F.L. +7.00m FLOOR FINISHED LEVELS

FOR DRAINAGE DETAILS REFER TO ENGINEERING DRAWINGS

FOR ROAD DETAILS REFER TO ENGINEERING DRAWINGS

FOR SACRIFICIAL MATERIAL DETAILS REFER TO ENGINEERING DRAWINGS

FOR LANDSCAPE DETAILS REFER TO LANDSCAPE ARCHITECTS DRAWINGS

FOR SERVICE DIVERTIONS DETAILS REFER TO ENGINEERING DRAWINGS

DRAWING BASED ON THE FOLLOWING O.S MAP INFORMATION

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Map Series:
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SURVEY DATE = 31-Dec-1977

1:2500

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SURVEY DATE = 02-Jan-1997

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6511-A
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SURVEY DATE = 01-Feb-1997

6511-B
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SURVEY DATE = 30-Oct-2002

6473-C
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6512-A
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URX,URY = 580006,565136

Projection:
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ITM

ITM Centre Point Co-ordinate:
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X,Y = 578566,564071

Extraction Date:
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21-Oct-2015

Ní hionann bóthar, bealach nó cosán a bheith ar an léarscáil seo agus fianaise ar chead slí.
The representation on this map of a road, track or footpath is not evidence of the existence of a right of way.

Ní thaispeánann léarscail de chuid Ordanáis Shuirbheireacht na hÉireann teorann phointí dleathúil de mhaoin riamh, ná úinéireacht de ghnéithe fhisiciúla.
Ordnance Survey maps never show legal property boundaries, nor do they show ownership of physical features.

PROPOSED COMPOSITE SITE LAYOUT PLAN

(SCALE 1:1000 @A0)

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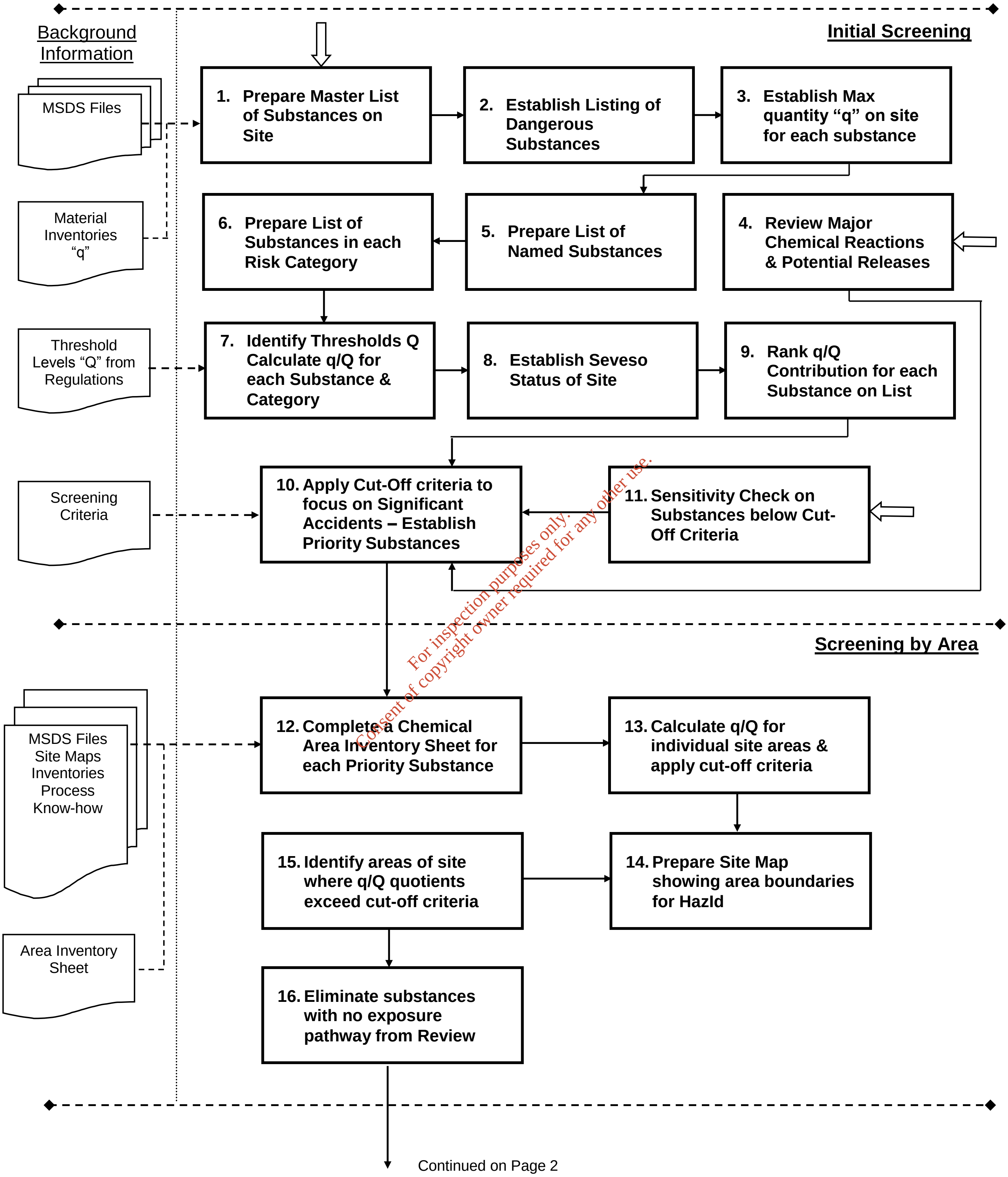
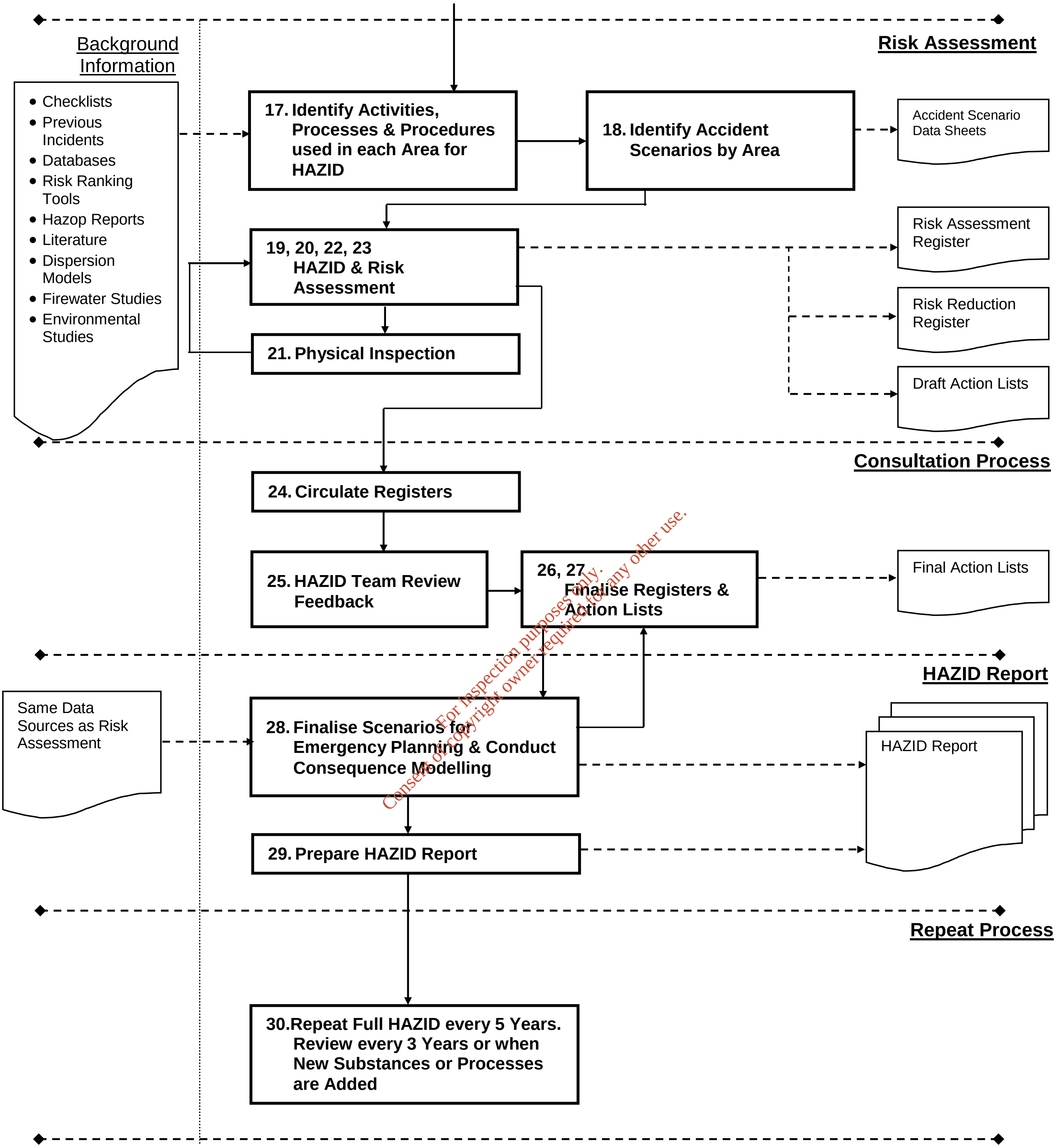
RINGASKIDDY RESOURCE RECOVERY CENTRE INDAVER RINGASKIDDY, CO.CORK				COMPOSITE PROPOSED SITE LAYOUT PLAN	
SCALE 1:1000 @A0	DATE JAN'16	DRAWN BY IS	CHECKED FOM	REVISION No. 11	DRAWING NO. 1434 - 106

Appendix 2 – HAZID&RA Flow Chart



Continued on Page 2


Background Information
Risk Assessment
Checklists
Previous Incidents
Databases
Risk Ranking Tools
Hazop Reports
Literature
Dispersion Models
Firewater Studies
Environmental Studies
17. Identify Activities, Processes & Procedures used in each Area for HAZID
18. Identify Accident Scenarios by Area
Accident Scenario Data Sheets
19, 20, 22, 23 HAZID & Risk Assessment
Risk Assessment Register
Risk Reduction Register
21. Physical Inspection
Draft Action Lists
Consultation Process
24. Circulate Registers
25. HAZID Team Review Feedback
26, 27 Finalise Registers & Action Lists
Final Action Lists
HAZID Report
Same Data Sources as Risk Assessment
28. Finalise Scenarios for Emergency Planning & Conduct Consequence Modelling
HAZID Report
29. Prepare HAZID Report
Repeat Process
30.Repeat Full HAZID every 5 Years. Review every 3 Years or when New Substances or Processes are Added

Appendix 3: Hazard Identification and Risk Assessment Worksheets

Accident Scenario Data Sheet (ASDS)												
Area		Date	Rev	Completed By		End Event Ref No.	Generic Category of End Event	Details of End Event	Consequence Description	Environ-mental Receptor	Severity (Health & Safety)	Severity (Environ-mental)
ID	Name											
02	Bunker	09-Apr-15	1.0	HazId Team	**01**	**2 - 1**	Fire (combustible solids)	Spot Fire in waste bunker area -	Spot smoking - in Bunker, HCl, smoke, some dioxins may be formed. Sucked into boiler as combustion air	Air	2	1
02	Bunker	09-Apr-15	1.0	HazId Team	**02**	**2 - 2**	Fire (combustible solids)	Escalation of spot fire to larger scale (intermediate bunker fire)	As above, but with greater emission of potentially toxic combustion products	Air	2	2
02	Bunker	09-Apr-15	1.0	HazId Team	**03**	**2 - 3**	Fire (combustible solids)	Fully developed Bunker Fire	As above, but with greater emission of potentially toxic combustion products Potenital escalation / knock on effects to other areas of site.	Air	3	3
02	Bunker	09-Apr-15	1.0	HazId Team	**04**	**2 - 4**	Fire (combustible solids)	Fire in Hopper	Similar consequences to 2-1 above. Possibility of spreading back to bunker	Air	2	1
02	Bunker	09-Apr-15	1.0	HazId Team	**05**	**2 - 5**	Fire (combustible solids)	Explosion at Hopper	LPG cylinders makes it through to waste pusher where it it crushed. Explosion resulting in waste being blown back out of hopper. Damage to furnace.	Air	2	2
04	Furnace	09-Apr-15	1.0	HazId Team	**01**	**4 - 1**	Explosion (flammable substance)	Explosion in furnace	Overpressure leading to explosion. Refractory damage	Air	2	2
04	Furnace	09-Apr-15	1.0	HazId Team	**02**	**4 - 2**	Gaseous (toxic) release	Flue gases back into boiler house building	Potential for inhalation of flue gases if someone is in vicinity at the time (SO2 exposure)	Air	3	2
04	Furnace	09-Apr-15	1.0	HazId Team	**03**	**4 - 3**	Liquid (toxic) release	Loss of containment from Fuel Oil Supply at Furnace Start up	Spill to building. Contained within building	Surface water	1	2
04	Furnace	09-Apr-15	1.0	HazId Team	**04**	**4 - 4**	Fire (flammable liquid / gas)	Loss of containment from Fuel Oil Supply at Furnace Start up - with ignition - not credible (high flash point liquid)	n.a.	None	0	0
04	Furnace	09-Apr-15	1.0	HazId Team	**05**	**4 - 5**	Liquid (toxic) release	Loss of containment from liquid waste supply to furnace	Spill to building. Contained within building	Surface water	1	2
04	Furnace	09-Apr-15	1.0	HazId Team	**06**	**4 - 6**	Liquid (toxic) release	Loss of containment from liquid waste supply to furnace - with ignition	Fire within building. Risk of damage to plant. Firewater run off	Surface Water, Air	3	2
07	Boiler	09-Apr-15	1.0	HazId Team	**01**	**7 - 1**	Gaseous (toxic) release	Ammonia slip (Incorrect temperature, excess volume)	Possible exceedance of licence due to high ammonia emissions to atmosphere	Air	0	1
07	Boiler	09-Apr-15	1.0	HazId Team	**02**	**7 - 2**	Liquid (toxic) release	Collection of oil below grate due to non firing of burners during startup	Oil collection below waste pit (on concrete floor), would be retained and collected - not a major accident scenario		0	0

Accident Scenario Data Sheet (ASDS)												
Area		Date	Rev	Completed By		End Event Ref No.	Generic Category of End Event	Details of End Event	Consequence Description	Environ-mental Receptor	Severity (Health & Safety)	Severity (Environ-mental)
ID	Name											
07	Boiler	09-Apr-15	1.0	HazId Team	**03**	**7 - 3**	Fire	Fire below grate due to ignition of oil pool. Scenario 7.2 without cleanup of oil before second firing of burners	Smoke plume inside building, equipment damage.	Air	2	1
07	Boiler	09-Apr-15	1.0	HazId Team	**04**	**7 - 4**	Liquid (toxic) release	Leak of oil at flanged connection to burner	Spill of oil to drip tray inside building		1	1
07	Boiler	09-Apr-15	1.0	HazId Team	**05**	**7 - 5**	Fire	Leak of oil at flanged connection to burner - with ignition	Small pool fire within drip tray		1	1
07	Boiler	09-Apr-15	1.0	HazId Team	**06**	**7 - 6**	Liquid (toxic) release	Complete failure at flange connection, spill of oil	Spill to ground. Retained within building.		1	2
11	Flue Gas Cooling Section Water Quench	07-May-15	1.0	HazId Team	**01**	**11 - 1**	No MAH identified in this area. Flue gas in chamber - water & lime					
12	Activated Carbon Silo	07-May-15	1.0	HazId Team	**01**	**12 - 1**	No MAH identified in this area.					
13	Bag House	07-May-15	1.0	HazId Team	**01**	**13 - 1**	Solid (toxic) release	Release of ash residue from bag filters	Accumulation of residue on floor Release of residue dust cloud through vents/open doorways	Groundwater, surface water	1	1
13a	Flue Gas Residue Storage	07-May-15	1.0	HazId Team	**01**	**13a - 1**	Solid (toxic) release	Release of ash residue from storage silos (2 No. silos - with a capacity of between 360m3 and 540m3)	Accumulation of residue on floor Release of residue dust cloud through vents/open doorways	Groundwater, surface water	1	2
14	Flue Gas Cooling Section Heat Exchanger	07-May-15	1.0	HazId Team	**01**	**14 - 1**	Dirty flue gases being mixed with clean flue gases - leak will be from clean to dirty - not a major accident scenario					
16	ID Fan	07-May-15	1.0	HazId Team	**01**	**16 - 1**	No MAH identified in this area.					
19	Stack	07-May-15	1.0	HazId Team	**01**	**19 - 1**	No MAH identified in this area.					
44	HCl Storage	07-May-15	1.0	HazId Team	**01**	**44 - 1**	Liquid (toxic) release	Loss of containent from IBC to bund tray	Spill to ground. Held within bund. Evolution of toxic vapour to atmosphere	Surface Water, Air	2	2

Area ID	Area Name	Date	Rev	Completed By		End Event Ref No.	Generic Category of End Event	Details of End Event	Consequence Description	Environ-mental Receptor	Severity (Health & Safety)	Severity (Environ-mental)
Accident Scenario Data Sheet (ASDS)												
44	HCl Storage	07-May-15	1.0	HazId Team	02	44 - 2	Liquid (toxic) release	Rupture of IBC and release to outside bund	Spill to ground. Collected in internal drainage system (leading to dirty water pit). Evolution of toxic vapour to atmosphere	Surface Water, Air	3	2
44	HCl Storage	07-May-15	1.0	HazId Team	03	44 - 3	Liquid (toxic) release	Loss of containment during IBC delivery	Loss of containment of 1m3 of HCl (30%) to unbunded area.	Surface Water, Air	3	2
102	Piperacks	07-May-15	1.0	HazId Team	01	102 - 1	Liquid (toxic) release	Leak of fuel oil from pipeline	Release of oil to ground collected in surface water drainage system. May be diverted to surface/firewater retention tank	Surface water, groundwater	1	1
102	Piperacks	07-May-15	1.0	HazId Team	02	102 - 2	Liquid (toxic) release	Rupture of fuel oil pipeline	Release of oil to ground collected in surface water drainage system. Diverted to surface/firewater retention tank	Surface water, groundwater	1	2
102	Piperacks	07-May-15	1.0	HazId Team	03	102 - 3	Liquid (toxic) release	Leak of ammonia solution from pipeline	Release of ammonia to ground collected in surface water drainage system. May be diverted to surface/firewater retention tank	Surface water, groundwater	2	2
102	Piperacks	07-May-15	1.0	HazId Team	04	102 - 4	Liquid (toxic) release	Rupture of ammonia solution pipeline	Release of ammonia to ground collected in surface water drainage system. Diverted to surface/firewater retention tank	Surface water, groundwater	3	2
102	Piperacks	07-May-15	1.0	HazId Team	05	102 - 5	Fire (flammable liquid / gas)	Leak of aqueous waste from pipeline	Spill giving rise to pool fire. Spill collected in surface water drainage along with fire fighting water	Surface water, groundwater	1	1
102	Piperacks	07-May-15	1.0	HazId Team	06	102 - 6	Fire (flammable liquid / gas)	Rupture of aqueous waste pipeline	Spill giving rise to pool fire. Spill collected in surface water drainage along with fire fighting water	Surface water, groundwater	2	2
104	General Storage Area	07-May-15	1.0	HazId Team	01	104 - 1	Liquid (toxic) release	Loss of containent from fuel oil tank connection (pipeline)	Spill of fuel to ground. Collected in drainage system.	Surface water	1	2
104	General Storage Area	07-May-15	1.0	HazId Team	02	104 - 2	Liquid (toxic) release	Rupture of fuel oil tank	Loss of full tank contents to bund	Surface water	1	2
104	General Storage Area	07-May-15	1.0	HazId Team	03	104 - 3	Liquid (toxic) release	Loss of containment of fuel oil tank during road tanker delivery	Spill of fuel to ground. Collected in drainage system.		1	2
104	General Storage Area	07-May-15	1.0	HazId Team	04	104 - 4	Liquid (toxic) release	Loss of containent from aqueous Ammonia tank connection (pipeline)	Spill to ground. Collected in drainage system. Evolution of toxic vapour to atmosphere	Surface Water, Air	2	2

Accident Scenario Data Sheet (ASDS)												
Area		Date	Rev	Completed By		End Event Ref No.	Generic Category of End Event	Details of End Event	Consequence Description	Environ-mental Receptor	Severity (Health & Safety)	Severity (Environ-mental)
ID	Name											
104	General Storage Area	07-May-15	1.0	HazId Team	**05**	**104 - 5**	Liquid (toxic) release	Rupture of aqueous Ammonia tank	Loss of full tank contents to ground. Evolution of toxic vapour to atmosphere. Potenital risk to operator if in vicinty. Potential emergency response implications off site.	Surface Water, Air	5	3
104	General Storage Area	07-May-15	1.0	HazId Team	**06**	**104 - 6**	Liquid (toxic) release	Loss of containment of aqueous ammonia during road tanker delivery	Loss of containment of of Ammonia to unbunded area delivery rate of 40m3/hr). Operator responds and shuts down transfer within 1-2 minutes	Surface Water, Air	3	2
104	General Storage Area	07-May-15	1.0	HazId Team	**07**	**104 - 7**	Liquid (toxic) release	Loss of containent from aqueous waste tank connection (pipeline)	Loss of containment of dilute solution to ground - collected in surface drainage system	Surface water	1	2
104	General Storage Area	07-May-15	1.0	HazId Team	**08**	**104 - 8**	Fire (flammable liquid / gas)	Loss of containent from aqueous waste tank connection (pipeline) - with ignition	Spill giving rise to pool fire. Spill collected in surface water drainage along with fire fighting water	Surface water	2	2
104	General Storage Area	07-May-15	1.0	HazId Team	**09**	**104 - 9**	Liquid (toxic) release	Rupture of aqueous waste tank	Spill of fuel to ground. Collected in drainage system.	Surface water	1	2
104	General Storage Area	07-May-15	1.0	HazId Team	**10**	**104 - 10**	Fire (flammable liquid / gas)	Rupture of aqueous waste tank - with ignition	Spill giving rise to pool fire. Spill collected in surface water drainage along with fire fighting water	Surface water	3	2
104	General Storage Area	07-May-15	1.0	HazId Team	**11**	**104 - 11**	Fire (flammable liquid / gas)	Loss of containment of aqueous waste during road tanker delivery	Spill giving rise to pool fire. Spill collected in surface water drainage along with fire fighting water	Surface water	1	2
104	General Storage Area	07-May-15	1.0	HazId Team	**12**	**104 - 12**	Fire (flammable liquid / gas)	Loss of containment of aqueous waste during road tanker delivery - with ignition	Spill giving rise to pool fire. Spill collected in surface water drainage along with fire fighting water	Surface water	2	2

Area		Risk Assessment Register (RAR)						Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Risk Reduction Register (RRR)						
ID	Name	Description of Activity	Description of Initiating Event	End Event Ref No.	Severity (Health & Safety) S	Severity (Environ-mental) SE	Frequency F			Description of Activity	Description of Initiating Event	End Event Ref No.	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Measures in Place	Additional Measures
2	**Bunker**	Waste receipt	Waste arrives on site smouldering in truck	**2 - 1**	**2**	**1**	**4**	**8**	**4**	**Waste receipt**	**Waste arrives on site smouldering in truck**	**2 - 1**	**8**	**4**	If fire is detected in bunker, the fire damper will close and air to boiler will be taken from elsewhere. Bunker is concrete structure and is compartmentalised (1 hr fire rating).. Visual inspection of waste as it is unloaded. Fire wrapping of cables to ensure continued function during fire event. Fire protection systems in Bunker.	
2	**Bunker**	Maintenance	Ignition due to hot works or smiilar activities in area	**2 - 1**	**2**	**1**	**3**	**6**	**3**	**Maintenance**	**Ignition due to hot works or smiilar activities in area**	**2 - 1**	**6**	**3**	Hot work permiting system. Trained operators. Where practicable, equipment is taken outside of the bunker for maintenance works	
2	**Bunker**	Waste receipt	Heating due to self-combustion of organic fraction in the waste	**2 - 1**	**2**	**1**	**5**	**10**	**5**	**Waste receipt**	**Heating due to self-combustion of organic fraction in the waste**	**2 - 1**	**10**	**5**	Relatively quick throughput, waste is not left to settle for long period of time. Bunker Management Programme - once or twice per year, prior to shutdown periods, the bunker invetnory is brought to low level (as far as practicable) to avoid situation where a waste batch is allowed sit for long period of time. Would be evident due to smoke formation as well as UV/IR detectors in the bunker. If smouldering waste is detected it is loaded directly to hopper and more waste is then dumped on top to smother it. 4 x Fixed water cannons in place to douse spot fires. Sprinkler system on roof as back up.	
2	**Bunker**	Waste receipt	Trailer falls into bunker. Loss of containment of high temperature fuel, with ignition	**2 - 1**	**2**	**1**	**2**	**4**	**2**	**Waste receipt**	**Trailer falls into bunker. Loss of containment of high temperature fuel, with ignition**	**2 - 1**	**4**	**2**	Barrier in place. SOP	
2	**Bunker**	Waste receipt	Container of flammable material in bunker, damaged by grab when collecting from bunker	**2 - 1**	**2**	**1**	**3**	**6**	**3**	**Waste receipt**	**Container of flammable material in bunker, damaged by grab when collecting from bunker**	**2 - 1**	**6**	**3**	Visual inspection of waste in tipping hall. LEL detector in bunker	
2	**Bunker**	Waste receipt	Methane formation due to anaerobic digestion in waste	**2 - 1**	**2**	**1**	**3**	**6**	**3**	**Waste receipt**	**Methane formation due to anaerobic digestion in waste**	**2 - 1**	**6**	**3**	LEL detector in bunker	Indaver are conducting an investigation of the atmospheric conditions in the bunker in Meath to see if there is any CH4 formation - in particular when process is stopped
2	**Bunker**	Waste receipt	Waste arrives on site smouldering in truck	**2 - 2**	**2**	**2**	**3**	**6**	**6**	**Waste receipt**	**Waste arrives on site smouldering in truck**	**2 - 2**	**6**	**6**	If fire is detected in bunker, the fire damper will close and air to boiler will be taken from elsewhere. Bunker is concrete structure and is compartmentalised (1 hr fire rating).. Visual inspection of waste as it is unloaded. Fire wrapping of cables to ensure continued function during fire event. Fire protection systems in Bunker.	

Area		Risk Assessment Register (RAR)								Risk Reduction Register (RRR)						
		Description of Activity	Description of Initiating Event	End Event Ref No.	Severity (Health & Safety)	Severity (Environ-mental)	Frequency	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Description of Activity	Description of Initiating Event	End Event Ref No.	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Measures in Place	Additional Measures
ID	Name				S	SE	F									
2	Bunker	Maintenance	Ignition due to hot works or smiilar activities in area	2 - 2	2	2	2	4	4	**Maintenance**	**Ignition due to hot works or smiilar activities in area**	2 - 2	4	4	Hot work permiting system. Trained operators. Where practicable, equipment is taken outside of the bunker for maintenance works	
2	Bunker	Waste receipt	Heating due to self-combustion of organic fraction in the waste	2 - 2	2	2	4	8	8	**Waste receipt**	**Heating due to self-combustion of organic fraction in the waste**	2 - 2	8	8	Relatively quick throughput, waste is not left to settle for long period of time. Bunker Management Programme - once or twice per year, prior to shutdown periods, the bunker invetnory is brought to low level (as far as practicable) to avoid situation where a waste batch is allowed sit for long period of time. Would be evident due to smoke formation as well as UV/IR detectors in the bunker. If smouldering waste is detected it is loaded directly to hopper and more waste is then dumped on top to smother it. 4 x Fixed water cannons in place to douse spot fires. Sprinkler system on roof as back up.	
2	Bunker	Waste receipt	Trailer falls into bunker. Loss of containment of high temperature fuel, with ignition	2 - 2	2	2	2	4	4	**Waste receipt**	**Trailer falls into bunker. Loss of containment of high temperature fuel, with ignition**	2 - 2	4	4	Barrier in place. SOP	
2	Bunker	Waste receipt	Container of flammable material in bunker, damaged by grab when collecting from bunker	2 - 2	2	2	2	4	4	**Waste receipt**	**Container of flammable material in bunker, damaged by grab when collecting from bunker**	2 - 2	4	4	Visual inspection of waste in tipping hall. LEL detector in bunker	
2	Bunker	Waste receipt	Methane formation due to anaerobic digestion in waste	2 - 2	2	2	2	4	4	**Waste receipt**	**Methane formation due to anaerobic digestion in waste**	2 - 2	4	4	LEL detector in bunker	Indaver are conducting an investigation of the atmospheric conditions in the bunker in Meath to see if there is any CH4 formation - in particular when process is stopped
2	Bunker	Waste receipt	Waste arrives on site smouldering in truck	2 - 3	3	3	3	9	9	**Waste receipt**	**Waste arrives on site smouldering in truck**	2 - 3	9	9	If fire is detected in bunker, the fire damper will close and air to boiler will be taken from elsewhere. Bunker is concrete structure and is compartmentalised (1 hr fire rating).. Visual inspection of waste as it is unloaded. Fire wrapping of cables to ensure continued function during fire event. Fire protection systems in Bunker.	FWR study to be conducted to confirm that bunker has capacity to retain the fire fighting water applied in this scenario
2	Bunker	Maintenance	Ignition due to hot works or smiilar activities in area	2 - 3	3	3	2	6	6	**Maintenance**	**Ignition due to hot works or smiilar activities in area**	2 - 3	6	6	Hot work permiting system. Trained operators. Where practicable, equipment is taken outside of the bunker for maintenance works	

Area		Risk Assessment Register (RAR)								Risk Reduction Register (RRR)						
ID	Name	Description of Activity	Description of Initiating Event	End Event Ref No.	Severity (Health & Safety) S	Severity (Environ-mental) SE	Frequency F	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Description of Activity	Description of Initiating Event	End Event Ref No.	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Measures in Place	Additional Measures
2	**Bunker**	Waste receipt	Heating due to self-combustion of organic fraction in the waste	**2 - 3**	**3**	**3**	**4**	**12**	**12**	**Waste receipt**	**Heating due to self-combustion of organic fraction in the waste**	**2 - 3**	**12**	**12**	Relatively quick throughput, waste is not left to settle for long period of time. Bunker Management Programme - once or twice per year, prior to shutdown periods, the bunker invetnory is brought to low level (as far as practicable) to avoid situation where a waste batch is allowed sit for long period of time. Would be evident due to smoke formation as well as UV/IR detectors in the bunker. If smouldering waste is detected it is loaded directly to hopper and more waste is then dumped on top to smother it. 4 x Fixed water cannons in place to douse spot fires. Sprinkler system on roof as back up.	
2	**Bunker**	Waste receipt	Trailer falls into bunker. Loss of containment of high temperature fuel, with ignition	**2 - 3**	**3**	**3**	**2**	**6**	**6**	**Waste receipt**	**Trailer falls into bunker. Loss of containment of high temperature fuel, with ignition**	**2 - 3**	**6**	**6**	Barrier in place. SOP	
2	**Bunker**	Waste receipt	Container of flammable material in bunker, damaged by grab when collecting from bunker	**2 - 3**	**3**	**3**	**2**	**6**	**6**	**Waste receipt**	**Container of flammable material in bunker, damaged by grab when collecting from bunker**	**2 - 3**	**6**	**6**	Visual inspection of waste in tipping hall. LEL detector in bunker	
2	**Bunker**	Waste receipt	Methane formation due to anaerobic digestion in waste	**2 - 3**	**3**	**3**	**2**	**6**	**6**	**Waste receipt**	**Methane formation due to anaerobic digestion in waste**	**2 - 3**	**6**	**6**	LEL detector in bunker	
2	**Bunker**	Waste processing	Smouldering material dumped into hopper in error	**2 - 4**	**2**	**1**	**3**	**6**	**3**	**Waste processing**	**Smouldering material dumped into hopper in error**	**2 - 4**	**6**	**3**	As above UV/IR at hopper. Dedicated deluge system above hopper.	
2	**Bunker**	Waste processing	Smouldering material dumped into hopper and not adequately smothered with more waste afterwards	**2 - 4**	**2**	**1**	**3**	**6**	**3**	**Waste processing**	**Smouldering material dumped into hopper and not adequately smothered with more waste afterwards**	**2 - 4**	**6**	**3**	Trained operators. Documented procedure in place to respond to this scenario by smothering the smouldering material with more waste	
2	**Bunker**	Waste processing	LPG cylinder in waste stream. Dropped into hopper and then crushed by the waste pusher	**2 - 5**	**2**	**2**	**3**	**6**	**6**	**Waste processing**	**LPG cylinder in waste stream. Dropped into hopper and then crushed by the waste pusher**	**2 - 5**	**6**	**6**	Customer segregation at source. Visual inspection prior to acceptance. For new customers, load is dumped on floor in receipt area and examined in more detail before admitting into the bunker	Indaver to review customer approval procedure for screening of waste streams
4	**Furnace**	Waste processing	LPG cylinder in waste stream. Makes its way to furnace and ruptures due to high temperatures	**4 - 1**	**2**	**2**	**3**	**6**	**6**	**Waste processing**	**LPG cylinder in waste stream. Makes its way to furnace and ruptures due to high temperatures**	**4 - 1**	**6**	**6**	System designed in accordance with EN 12952. Observations at simiilar sites indicate that the system can withstand this scenario without sustaining damage.	
4	**Furnace**	Waste processing	Emergency shutdown, combustion on grate, continues to emit CO. Or waste smouldering to generate CO. If not flushed before restart then can generate explosion on restart	**4 - 1**	**2**	**2**	**3**	**6**	**6**	**Waste processing**	**Emergency shutdown, combustion on grate, continues to emit CO. Or waste smouldering to generate CO. If not flushed before restart then can generate explosion on restart**	**4 - 1**	**6**	**6**	Interlocks on O2 level to ensure excess oxygen. Monitoring for CO at stack. Purge of system before restart	

Area		Risk Assessment Register (RAR)								Risk Reduction Register (RRR)						
ID	Name	Description of Activity	Description of Initiating Event	End Event Ref No.	Severity (Health & Safety) S	Severity (Environ-mental) SE	Frequency F	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Description of Activity	Description of Initiating Event	End Event Ref No.	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Measures in Place	Additional Measures
4	Furnace	Waste processing	Control loop pressure transmitter (set point -2mbar) goes out of action. Overpressure leading to induction fan failure, combustion continues. Flue gases back into building	4 - 2	3	2	3	9	6	Waste processing	Control loop pressure transmitter (set point -2mbar) goes out of action. Overpressure leading to induction fan failure, combustion continues. Flue gases back into building	4 - 2	9	6	Preventative Maintenance on ID fan. Vibration detection	
4	Furnace	Waste processing	Slag accumulation on furnace walls - drops off and impacts grate. Sudden impact of hot slag on water lock gives rise to overpressure with release flue of gases - not credible due to appropriate material selection to prevent slag accumulation in the first place	4 - 2	3	2	0	0	0	Waste processing	Slag accumulation on furnace walls - drops off and impacts grate. Sudden impact of hot slag on water lock gives rise to overpressure with release flue of gases - not credible due to appropriate material selection to prevent slag accumulation in the first place	4 - 2	0	0	Engineer hazard out: appropriate selection of materials for wall to protect against risk of slag accumulation. Cleaning once per year.	
4	Furnace	Combustion	Oil to furnace without burners activated. Oil passess through grate and is collected inside building	4 - 3	1	2	3	3	6	Combustion	Oil to furnace without burners activated. Oil passess through grate and is collected inside building	4 - 3	3	6	Purge step is carried out on start up of burners. Interlocks to prevent oil flow when burners are not firing. Contained building to retain spills. UV/IR and sprinkler system at burners. Flame scanners on system - would also activate shutdown if burners do not fire within timeframe	
4	Furnace	Combustion	Failure of pipeline resulting in leak. Spill is collected inside building or in surface water drains	4 - 3	1	2	3	3	6	Combustion	Failure of pipeline resulting in leak. Spill is collected inside building or in surface water drains	4 - 3	3	6	Oil water separator on drains. PM schedule. Pressure gauge at burner would detect major loss of containment and activate interlocks	
4	Furnace		Not credible	4 - 4	0	0					Not credible	4 - 4				
4	Furnace	Combustion	Oil to furnace without burners activated. Oil passess through grate and is collected inside building	4 - 5	1	2	3	3	6	Combustion	Oil to furnace without burners activated. Oil passess through grate and is collected inside building	4 - 5	3	6	Spill kits. Drainage / bund tray to restrict size of spill.	
4	Furnace	Combustion	Failure of pipeline resulting in leak. Spill is collected inside building or in surface water drains	4 - 5	1	2	3	3	6	Combustion	Failure of pipeline resulting in leak. Spill is collected inside building or in surface water drains	4 - 5	3	6	Welded pipe with flanged connection at entry to furnace	
4	Furnace	Combustion	Failure of pipeline resulting in leak. Spill is collected inside building or in surface water drains - with ignition	4 - 6	3	2	2	6	4	Combustion	Failure of pipeline resulting in leak. Spill is collected inside building or in surface water drains - with ignition	4 - 6	6	4	ATEX Zoning. Furnace is insulated with cladding, no external ignition source. Fire fighting system - hoses, extinguishers	
7	Boiler	Injection of ammonia	Failure of process controls - too much ammonia / incorrect chamber temperature	7 - 1	0	1	5	0	5	Injection of ammonia	Failure of process controls - too much ammonia / incorrect chamber temperature	7 - 1	0	5	Process control monitor temperature. Automatic control system linked to temperature monitors. Measurements for ammonia slip at the stack.	
7	Boiler	Oil firing	Oil sent to chamber without ignition & not purged prior to firing chamber again	7 - 3	2	1	3	6	3	Oil firing	Oil sent to chamber without ignition & not purged prior to firing chamber again	7 - 3	6	3	Infrequent firing from cold. Automatic purge control sequence programmed Trained operators	
7	Boiler	Post Combustion process	Operator error - not securing flange connection following maintenance works	7 - 4	1	1	4	4	4	Post Combustion process	Operator error - not securing flange connection following maintenance works	7 - 4	4	4	Trained fitters	

Area ID	Name	Description of Activity	Description of Initiating Event	End Event Ref No.	Severity (Health & Safety) S	Severity (Environ-mental) SE	Frequency F	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Description of Activity	Description of Initiating Event	End Event Ref No.	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Measures in Place	Additional Measures
		Risk Assessment Register (RAR)								Risk Reduction Register (RRR)						
7	Boiler	Post Combustion process	Mechanical failure of flange	7 - 4	1	1	3	3	3	Post Combustion process	Mechanical failure of flange	7 - 4	3	3	Piping designed to recognised standard/specification Visual inspection of pipes (daily shift walks) Preventative maintenance program (SAP)	
7	Boiler	Post Combustion process	Operator error - not securing flange connection following maintenance works	7 - 5	1	1	3	3	3	Post Combustion process	Operator error - not securing flange connection following maintenance works	7 - 5	3	3	see 7.4 for controls to prevent loss of containment	
7	Boiler	Post Combustion process	Mechanical failure of flange	7 - 5	1	1	2	2	2	Post Combustion process	Mechanical failure of flange	7 - 5	2	2	Fire detection system Control of ignition sources Fire protection Sprinkler system	
7	Boiler	Post Combustion process	Operator error - not securing flange connection following maintenance works	7 - 6	1	2	4	4	8	Post Combustion process	Operator error - not securing flange connection following maintenance works	7 - 6	4	8	Lock out, tag out procedure. Permit to work sign off by authoised party Trained fitters	
7	Boiler	Post Combustion process	Mechanical failure of flange	7 - 6	1	2	3	3	6	Post Combustion process	Mechanical failure of flange	7 - 6	3	6	Piping designed to recognised standard/specification Visual inspection of pipes (daily shift walks) Preventative maintenance program (SAP)	
13	Bag House		Major mechanical damage to bag house due to impact	13 - 1	1	1	3	3	3		Major mechanical damage to bag house due to impact	13 - 1	3	3	Impact protection Inside a building Restricted vehicle access Trained operators Process controls to detect pressure drops. Alarms.	
13a	Flue Gas Residue Storage	Storage of residue	Major mechanical damage to silo(s) due to impact	13a - 1	1	2	3	3	6	Storage of residue	Major mechanical damage to silo(s) due to impact	13a - 1	3	6	Impact protection Inside a building Restricted vehicle access Trained operators Process controls - temperature/weight detection	
13a	Flue Gas Residue Storage	Storage of residue	Catastrophic failure of silo	13a - 1	1	2	2	2	4	Storage of residue	Catastrophic failure of silo	13a - 1	2	4	Silos designed to recognised standard/specification (designed for external use, housed internally) Visual inspection of silos (daily shift walks) Preventative maintenance program (SAP)	
44	HCl Storage	HCl storage	Corrosive/wear & tear causing leak	44 - 1	2	2	2	4	4	HCl storage	Corrosive/wear & tear causing leak	44 - 1	4	4	UN approved containers / packaging for materials. Bunded IBCs Regular site inspection (as above) Screening / assessing deliveries to site Investigations / follow up if supplier provides faulty IBC	
44	HCl Storage	HCl storage	Leak at outlet/tap	44 - 1	2	2	3	6	6	HCl storage	Leak at outlet/tap	44 - 1	6	6	as above	
44	HCl Storage	HCl storage	Mechanical impact	44 - 1	2	2	3	6	6	HCl storage	Mechanical impact	44 - 1	6	6	Speed limit / traffic management controls on site. Trained operators Permit to work system Caged IBCs	

Area ID	Area Name	Risk Assessment Register (RAR): Description of Activity	Description of Initiating Event	End Event Ref No.	Severity (Health & Safety) S	Severity (Environ-mental) SE	Frequency F	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Risk Reduction Register (RRR): Description of Activity	Description of Initiating Event	End Event Ref No.	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Measures in Place	Additional Measures
44	**HCl Storage**	HCl storage	Mechanical impact	**44 - 2**	**3**	**2**	**3**	**9**	**6**	**HCl storage**	**Mechanical impact**	**44 - 2**	**9**	**6**	Speed limit / traffic management controls on site. Trained operators Permit to work system Caged IBCs	
44	**HCl Storage**	HCl storage	Catastrophic failure	**44 - 2**	**3**	**2**	**2**	**6**	**4**	**HCl storage**	**Catastrophic failure**	**44 - 2**	**6**	**4**	UN approved containers / packaging for materials. Bunded IBCs Regular site inspection (as above) Screening / assessing deliveries to site Investigations / follow up if supplier provides faulty IBC	
44	**HCl Storage**	Delivery of HCl IBC	Mechanical impact	**44 - 3**	**3**	**2**	**3**	**9**	**6**	**Delivery of HCl IBC**	**Mechanical impact**	**44 - 3**	**9**	**6**	Speed limit / traffic management controls on site. Trained operators Caged IBCs	
44	**HCl Storage**	Delivery of HCl IBC	Operator drops IBC	**44 - 3**	**3**	**2**	**2**	**6**	**4**	**Delivery of HCl IBC**	**Operator drops IBC**	**44 - 3**	**6**	**4**	Speed limit / traffic management controls on site. Trained operators Caged IBCs	
102	**Piperacks**	Transfer of fuel oil by pipeline	Wear & tear / corrosive	**102 - 1**	**1**	**1**	**3**	**3**	**3**	**Transfer of fuel oil by pipeline**	**Wear & tear / corrosive**	**102 - 1**	**3**	**3**	Piping designed to recognised standard/specification (piperacks welded / flanged at end) Visual inspection of pipes (daily shift walks) Preventative maintenance program (SAP)	
102	**Piperacks**	Transfer of fuel oil by pipeline	Mechanical Impact	**102 - 1**	**1**	**1**	**3**	**3**	**3**	**Transfer of fuel oil by pipeline**	**Mechanical Impact**	**102 - 1**	**3**	**3**	Speed limit / traffic management controls on site. Trained operators Protection barriers Maximum height warning signs at piperack crossovers	
102	**Piperacks**	Transfer of fuel oil by pipeline	Overpressure due to blockage in line	**102 - 1**	**1**	**1**	**2**	**2**	**2**	**Transfer of fuel oil by pipeline**	**Overpressure due to blockage in line**	**102 - 1**	**2**	**2**	Pressure relief valve at pump Pipe lines pressure tested to 1.5 times operating pressure	

Area		Risk Assessment Register (RAR)								Risk Reduction Register (RRR)						
		Description of Activity	Description of Initiating Event	End Event Ref No.	Severity (Health & Safety)	Severity (Environ-mental)	Frequency	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Description of Activity	Description of Initiating Event	End Event Ref No.	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Measures in Place	Additional Measures
ID	Name				S	SE	F									
102	**Piperacks**	Transfer of fuel oil by pipeline	Mechanical Impact	**102 - 2**	**1**	**2**	**3**	**3**	**6**	**Transfer of fuel oil by pipeline**	**Mechanical Impact**	**102 - 2**	**3**	**6**	Speed limit / traffic management controls on site. Trained operators Protection barriers Maximum height warning signs at piperack crossovers	
102	**Piperacks**	Transfer of fuel oil by pipeline	Catastrophic Failure	**102 - 2**	**1**	**2**	**3**	**3**	**6**	**Transfer of fuel oil by pipeline**	**Catastrophic Failure**	**102 - 2**	**3**	**6**	Piping designed to recognised standard/specification (piperacks welded / flanged at end) Visual inspection of pipes (daily shift walks) Preventative maintenance program (SAP)	
102	**Piperacks**	Transfer of ammonia by pipeline	Wear & tear / corrosive	**102 - 3**	**2**	**2**	**3**	**6**	**6**	**Transfer of ammonia by pipeline**	**Wear & tear / corrosive**	**102 - 3**	**6**	**6**	Piping designed to recognised standard/specification (piperacks welded / flanged at end, stainless steel pipeline for ammonia) Visual inspection of pipes (daily shift walks) Preventative maintenance program (SAP)	
102	**Piperacks**	Transfer of ammonia by pipeline	Mechanical Impact	**102 - 3**	**2**	**2**	**3**	**6**	**6**	**Transfer of ammonia by pipeline**	**Mechanical Impact**	**102 - 3**	**6**	**6**	Speed limit / traffic management controls on site. Trained operators Protection barriers Maximum height warning signs at piperack crossovers	

Area		Risk Assessment Register (RAR)								Risk Reduction Register (RRR)						
ID	Name	Description of Activity	Description of Initiating Event	End Event Ref No.	Severity (Health & Safety) S	Severity (Environ-mental) SE	Frequency F	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Description of Activity	Description of Initiating Event	End Event Ref No.	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Measures in Place	Additional Measures
102	**Piperacks**	Transfer of ammonia by pipeline	Overpressure due to blockage in line	**102 - 3**	**2**	**2**	**2**	**4**	**4**	**Transfer of ammonia by pipeline**	**Overpressure due to blockage in line**	**102 - 3**	**4**	**4**	Pressure relief valve at pump Pipe lines pressure tested to 1.5 times operating pressure	
102	**Piperacks**	Transfer of ammonia by pipeline	Mechanical Impact	**102 - 4**	**3**	**2**	**3**	**9**	**6**	**Transfer of ammonia by pipeline**	**Mechanical Impact**	**102 - 4**	**9**	**6**	Speed limit / traffic management controls on site. Trained operators Protection barriers Maximum height warning signs at piperack crossovers	
102	**Piperacks**	Transfer of ammonia by pipeline	Catastrophic Failure	**102 - 4**	**3**	**2**	**3**	**9**	**6**	**Transfer of ammonia by pipeline**	**Catastrophic Failure**	**102 - 4**	**9**	**6**	Piping designed to recognised standard/specification (piperacks welded / flanged at end) Visual inspection of pipes (daily shift walks) Preventative maintenance program (SAP)	
102	**Piperacks**	Transfer of aqueous waste by pipeline	Wear & tear / corrosive	**102 - 5**	**1**	**1**	**2**	**2**	**2**	**Transfer of aqueous waste by pipeline**	**Wear & tear / corrosive**	**102 - 5**	**2**	**2**	Controls to prevent loss of containment as per 102-3 Control on ignition sources (Permit to Work) Fire fighting systems / water main Spill kits ERT team	
102	**Piperacks**	Transfer of aqueous waste by pipeline	Mechanical Impact	**102 - 5**	**1**	**1**	**2**	**2**	**2**	**Transfer of aqueous waste by pipeline**	**Mechanical Impact**	**102 - 5**	**2**	**2**	as above	
102	**Piperacks**	Transfer of aqueous waste by pipeline	Overpressure due to blockage in line	**102 - 5**	**1**	**1**	**2**	**2**	**2**	**Transfer of aqueous waste by pipeline**	**Overpressure due to blockage in line**	**102 - 5**	**2**	**2**	as above	
102	**Piperacks**	Transfer of aqueous waste by pipeline	Mechanical Impact	**102 - 6**	**2**	**2**	**2**	**4**	**4**	**Transfer of aqueous waste by pipeline**	**Mechanical Impact**	**102 - 6**	**4**	**4**	Controls to prevent loss of containment as per 102-4 Control on ignition sources (Permit to Work) Fire fighting systems / water main Spill kits ERT team	

Area ID	Area Name	Risk Assessment Register (RAR): Description of Activity	Description of Initiating Event	End Event Ref No.	Severity (Health & Safety) S	Severity (Environ-mental) SE	Frequency F	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Risk Reduction Register (RRR): Description of Activity	Description of Initiating Event	End Event Ref No.	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Measures in Place	Additional Measures
102	Piperacks	Transfer of aqueous waste by pipeline	Catastrophic Failure	102 - 6	2	2	2	4	4	Transfer of aqueous waste by pipeline	Catastrophic Failure	102 - 6	4	4	as above	
104	General Storage Area	Fuel oil supply to Furnace	Impact to line	104 - 1	1	2	4	4	8	Fuel oil supply to Furnace	Impact to line	104 - 1	4	8	CE certified equipment.	Design to incorporate measure to protect against siphoning of the tank contents (e.g. a hole in pipeline at top point on tank outlet or a check valve) in the event of line failure.
104	General Storage Area	Fuel oil supply to Furnace	Corrosion /erosion of line	104 - 1	1	2	3	3	6	Fuel oil supply to Furnace	Corrosion /erosion of line	104 - 1	3	6	No flange connections, all welded. Carbon steel line. PM regime on site.	
104	General Storage Area	Fuel oil supply to Furnace	Maintenance error, line breaking	104 - 1	1	2	3	3	6	Fuel oil supply to Furnace	Maintenance error, line breaking	104 - 1	3	6	Permit to work system for maintenance. Trained operators	
104	General Storage Area	Fuel Oil storage	Mechanical impact to tank	104 - 2	1	2	2	2	4	Fuel Oil storage	Mechanical impact to tank	104 - 2	2	4	Impact protection. Speed limit on site. Trained operators.	
104	General Storage Area	Fuel Oil storage	Mechanical failure	104 - 2	1	2	3	3	6	Fuel Oil storage	Mechanical failure	104 - 2	3	6	PM regime. Double skinned tank with leak detection.	
104	General Storage Area	Fuel Oil delivery	Failure of transfer hose	104 - 3	1	2	3	3	6	Fuel Oil delivery	Failure of transfer hose	104 - 3	3	6	Trained operators. Manned activity. Hose inspection prior to use	
104	General Storage Area	Fuel Oil delivery	Road tanker in poor condition - corrosion	104 - 3	1	2	2	2	4	Fuel Oil delivery	Road tanker in poor condition - corrosion	104 - 3	2	4	Visual inspection of tankers prior to acceptance on site	
104	General Storage Area	Fuel Oil delivery	Overfilling of tank	104 - 3	1	2	3	3	6	Fuel Oil delivery	Overfilling of tank	104 - 3	3	6	Overfill protection systems in place (gauging, level switches etc.)	
104	General Storage Area	Ammonia to SNCR for scrubbing	Impact to line	104 - 4	2	2	4	8	8	Ammonia to SNCR for scrubbing	Impact to line	104 - 4	8	8	CE certified equipment.	Design to incorporate measure to protect against siphoning of the tank contents (e.g. a hole in pipeline at top point on tank outlet or a check valve) in the event of line failure.
104	General Storage Area	Ammonia to SNCR for scrubbing	Corrosion /erosion of line	104 - 4	2	2	3	6	6	Ammonia to SNCR for scrubbing	Corrosion /erosion of line	104 - 4	6	6	No flange connections, all welded. Stainless steel line. PM regime on site.	
104	General Storage Area	Ammonia to SNCR for scrubbing	Maintenance error, line breaking	104 - 4	2	2	3	6	6	Ammonia to SNCR for scrubbing	Maintenance error, line breaking	104 - 4	6	6	Permit to work system for maintenance. Trained operators	
104	General Storage Area	Ammonia storage	Mechanical impact to tank	104 - 5	5	3	2	10	6	Ammonia storage	Mechanical impact to tank	104 - 5	10	6	Impact protection. Speed limit on site. Trained operators.	
104	General Storage Area	Ammonia storage	Catastrophic failure of tank - not credible as double skinned	104 - 5	5	3	0	0	0	Ammonia storage	Catastrophic failure of tank - not credible as double skinned	104 - 5	0	0	PM regime Double skinned Leak detection between skins on all double skinned tanks	
104	General Storage Area	Ammonia delivery	Failure of transfer hose	104 - 6	3	2	3	9	6	Ammonia delivery	Failure of transfer hose	104 - 6	9	6	Trained operators. Manned activity. Hose inspection prior to use	PPE for delivery drivers
104	General Storage Area	Ammonia delivery	Road tanker in poor condition - corrosion	104 - 6	3	2	2	6	4	Ammonia delivery	Road tanker in poor condition - corrosion	104 - 6	6	4	Visual inspection of tankers prior to acceptance on site	
104	General Storage Area	Ammonia delivery	Overfilling of tank	104 - 6	3	2	3	9	6	Ammonia delivery	Overfilling of tank	104 - 6	9	6	Overfill protection systems (gauging, level switches etc)	

Area ID	Area Name	Risk Assessment Register (RAR): Description of Activity	Description of Initiating Event	End Event Ref No.	Severity (Health & Safety) S	Severity (Environmental) SE	Frequency F	Risk Rating (Health & Safety)	Risk Rating (Environmental)	Risk Reduction Register (RRR): Description of Activity	Description of Initiating Event	End Event Ref No.	Risk Rating (Health & Safety)	Risk Rating (Environmental)	Measures in Place	Additional Measures
104	General Storage Area	Operation of aqueous waste tank	Impact to line	104 - 7	1	2	4	4	8	Operation of aqueous waste tank	Impact to line	104 - 7	4	8	CE certified equipment.	Design to incorporate measure to protect against siphoning of the tank contents (e.g. a hole in pipeline at top point on tank outlet or a check valve) in the event of line failure.
104	General Storage Area	Operation of aqueous waste tank	Corrosion /erosion of line	104 - 7	1	2	3	3	6	Operation of aqueous waste tank	Corrosion /erosion of line	104 - 7	3	6	No flange connections, all welded. Stainless steel line. PM regime on site.	
104	General Storage Area	Operation of aqueous waste tank	Maintenance error, line breaking	104 - 7	1	2	3	3	6	Operation of aqueous waste tank	Maintenance error, line breaking	104 - 7	3	6	Permit to work system for maintenance. Trained operators	
104	General Storage Area	Operation of aqueous waste tank	Impact to line	104 - 8	2	2	3	6	6	Operation of aqueous waste tank	Impact to line	104 - 8	6	6	Controls to protect against loss of containment, as described in 104-7. Dilute waste stream (>70% water), which reduces fire hazard. Fire fighting / fire protection systems on site.	
104	General Storage Area	Operation of aqueous waste tank	Corrosion /erosion of line	104 - 8	2	2	2	4	4	Operation of aqueous waste tank	Corrosion /erosion of line	104 - 8	4	4	No flange connections, all welded. Stainless steel line. PM regime on site.	
104	General Storage Area	Operation of aqueous waste tank	Maintenance error, line breaking	104 - 8	2	2	2	4	4	Operation of aqueous waste tank	Maintenance error, line breaking	104 - 8	4	4	Permit to work system for maintenance. Trained operators	
104	General Storage Area	Operation of aqueous waste tank	Mechanical impact to tank	104 - 9	1	2	2	2	4	Operation of aqueous waste tank	Mechanical impact to tank	104 - 9	2	4	Impact protection. Speed limit on site. Trained operators.	
104	General Storage Area	Operation of aqueous waste tank	Catastrophic failure of tank - not credible as double skinned	104 - 9	1	2	0	0	0	Operation of aqueous waste tank	Catastrophic failure of tank - not credible as double skinned	104 - 9	0	0	PM regime Double skinned Leak detection between skins on all double skinned tanks	
104	General Storage Area	Operation of aqueous waste tank	Mechanical impact to tank	104 - 10	3	2	2	6	4	Operation of aqueous waste tank	Mechanical impact to tank	104 - 10	6	4	Controls to protect against loss of containment, as described in 104-9. Dilute waste stream (>70% water), which reduces fire hazard. Fire fighting / fire protection systems on site.	
104	General Storage Area	Operation of aqueous waste tank	Catastrophic failure of tank - not credible as double skinned	104 - 10	3	2	0	0	0	Operation of aqueous waste tank	Catastrophic failure of tank - not credible as double skinned	104 - 10	0	0	-	
104	General Storage Area	Operation of aqueous waste tank	Wear & tear / corrosive	104 - 11	1	2	3	3	6	Operation of aqueous waste tank	Wear & tear / corrosive	104 - 11	3	6	Trained operators. Manned activity. Hose inspection prior to use	
104	General Storage Area	Operation of aqueous waste tank	Mechanical Impact	104 - 11	1	2	3	3	6	Operation of aqueous waste tank	Mechanical Impact	104 - 11	3	6	Visual inspection of tankers prior to acceptance on site	
104	General Storage Area	Operation of aqueous waste tank	Overpressure due to blockage in line	104 - 11	1	2	2	2	4	Operation of aqueous waste tank	Overpressure due to blockage in line	104 - 11	2	4	Overfill protection systems (gauging, level switches etc)	
104	General Storage Area	Operation of aqueous waste tank	Wear & tear / corrosive	104 - 12	2	2	2	4	4	Operation of aqueous waste tank	Wear & tear / corrosive	104 - 12	4	4	Controls to protect against loss of containment, as described in 104-11. Dilute waste stream (>70% water), which reduces fire hazard. Fire fighting / fire protection systems on site.	
104	General Storage Area	Operation of aqueous waste tank	Mechanical Impact	104 - 12	2	2	2	4	4	Operation of aqueous waste tank	Mechanical Impact	104 - 12	4	4	Visual inspection of tankers prior to acceptance on site	

Area		Risk Assessment Register (RAR)								Risk Reduction Register (RRR)						
Area		Description of Activity	Description of Initiating Event	End Event Ref No.	Severity (Health & Safety)	Severity (Environ-mental)	Frequency	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Description of Activity	Description of Initiating Event	End Event Ref No.	Risk Rating (Health & Safety)	Risk Rating (Environ-mental)	Measures in Place	Additional Measures
ID	Name				S	SE	F									
104	General Storage Area	Operation of aqueous waste tank	Overpressure due to blockage in line	104 - 12	2	2	2	4	4	**Operation of aqueous waste tank**	**Overpressure due to blockage in line**	104 - 12	4	4	Overfill protection systems (gauging, level switches etc)	

Appendix 4: Recommendations Arising from HAZID&RA Exercise

The HAZID Team made the following recommendations for the Indaver facility at Ringaskiddy:

1. Indaver are conducting an investigation of the atmospheric conditions in the bunker in Meath to determine the extent of any gas formation in the waste and to determine what gases are being formed, if any, in particular when process is stopped and ventilation is switched off. The findings of this assessment should also be reviewed in the context of the Ringaksiddy site to see if there is a potential hazard here also.

2. Indaver to review procedures for emergency response. This will be done to confirm whether there is a documented procedure to instruct operators on how to assess the risks associated with smouldering material present in the bunker. This should provide instructions to the operator on determining when it would be appropriate to use the crane to load this material into the hopper and when this could not be done and the fire fighting systems should be deployed.

3. Indaver to conduct a fire water retention study for the site. This will be conducted in accordance with the EPA guidelines for fire water retention studies in order to protect against the risk of contaminated run-off water being released to the environment in the event of a major fire at the site. This review will also determine the required flow rates and foam stocks required to adequately deal with the fire scenario in the course of the emergency response, which will allow Indaver to determine the adequacy of the fire protection systems for the site.

4. Indaver to review the customer approval procedure for screening of incoming waste streams to ensure that there are appropriate checks for unsuitable waste being fed to the hopper (for example, an LPG cylinder in the waste stream).

5. Indaver to review the arrangements for the provision of personal protective equipment (PPE) for drivers / operators engaged in the delivery of aqueous Ammonia to site. Suitable respiratory protection should be provided (by reference to the Safety Data Sheet) to ensure that the personnel are protected from inhalation of toxic gas in the event of a major release.

A full list of the measures that will be put in place at the Indaver facility (aside from these specific measures identified in the course of the HAZID&RA meeting) is contained within the HAZID&RA Worksheets in Appendix 3.

Appendix 5: Assessment of Flue Gas Residue and Boiler Ash

1 Introduction

This note sets out the findings of an assessment conducted by Byrne Ó Cléirigh (BÓC) of the boiler ash and flue gas residue at Indaver's site in order to determine if there could be any potential scope for the site to qualify under the Seveso III Regulations (SI 290 of 2015).

Hazardous ash residue contains heavy metal content which, if present in sufficiently high concentrations, would result in the material becoming classed as Hazardous to the Aquatic Environment and thereby qualifying under the Seveso Regulations.

The presence of these heavy metal compounds within a residue stream does not present any potential for the ash to qualify under Seveso under any other of the other categories set out in Schedule 1 of the Seveso III Regulations.

- Health Hazards: Compounds of these materials can also present an acute toxic hazard to people, but to a lesser extent than the environmental hazard that they present. This means that they would need to be present in the waste in much larger quantities in order to qualify as a Seveso substance by this route when compared with the criteria for environmental hazards.
- Physical Hazards: Compounds of these materials do not generally present any of the hazards that fall under this heading under the Seveso Regulations (e.g. flammable, explosive, oxidising, pyrophoric)
- Other Hazards: Compounds of these materials do not generally present any of the Hazard Statements listed under this section of the Regulations

Based on the above details, it is the assessment against the thresholds for environmental criteria that will determine whether or not the residue will qualify under the Regulations.

2 Background

As the Ringaskiddy facility is not yet built, there are no samples of ash available to assess. We have therefore referred to data from Indaver's Carranstown site, which treats a similar waste stream and using a similar technology to the one planned at Ringaskiddy.

There are two distinct ash residue streams under consideration – flue gas residue and boiler ash. Analytical data of spot samples collected from both ash streams are set out in Table 1, Table 2 and Table 3.

Table 1: Heavy Metal Content of Flue Gas Residues

Date	13/10/2011	17/01/2012	16/08/2012	18/01/2013	15/08/2013	22/01/2014	20/08/2014	19/02/2015	09/06/2015
Al	4100	9500	7700	7600	9200	9300	7200	6300	7100
As	7.6	26	28	38	26	42	25	27	26
Ba	120	250	240	290	240	300	220	210	210
Ca	410000	310000	64000	280000	270000	320000	310000	380000	360000
Cd	46	130	150	160	140	110	100	72	98
Co	4	8.3	11	7.7	8.4	8.5	8	5.7	6.5
Cu	130	380	330	680	380	280	350	240	340
Cr	19	32	38	32	47	31	40	29	35
Fe	2600	5200	5200	5400	4000	6100	4000	4500	4100
K	11000	32000	65000	37000	40000	27000	32000	22000	29000
Mn	140	320	10	280	250	330	230	250	240
Mo	2.2	6.4	6.8	10	12	18	9.6	7.7	7
Ni	13	32	31	35	19	40	22	34	23
Pb	390	1700	2400	3600	2000	1200	1500	920	1300
Sb	140	280	450	420	460	350	280	160	330
Se	10	10	10	10	5	8.3	3.9	5.8	5
Sn	95	400	360	620	460	420	350	260	280
Tl	6	6	6	6	6	6	6	6	6
V	12	47	27	49	13	71	6	63	37
Zn	2300	6600	6100	12000	8600	7000	7400	5000	6000
Hg	2.5	6.2	5.8	14	8.8	6.2	20	8.8	8.1

Table 2: Heavy Metal Content of Boiler Ash (part 1)

Sample ref	2012-10-10-1	2012-01-09-01	2012-04-23-01	2012-07-12-01	2012-11-30-01	2013-01-18-02	2013-06-05-01	2013-08-15-01	2013-10-31-01
Al	620000	54000	41000	47000	42000	48000		47000	
As	18	40	33	20	38	44	38	26	33
Ba	920	440	740	270	380	350	380	640	670
Ca	180000	190000	170000	37000	200000	200000		190000	
Cd	26	37	31	27	39	36	32	36	28
Co	28	43	34	38	54	50	33	38	39
Cu	430	410	520	520	550	660	430	350	340
Cr	190	140	130	190	160	140	140	170	160
Fe	27000	27000	24000	30000	28000	35000		19000	
K	10000	22000	14000	40000	17000	24000		24000	
Mn	1200	1600	1300	1100	1200	1500	1100	1100	1300
Mo	22	22	27	22	24	37	22	29	31
Ni	150	180	140	130	180	220	150	95	140
Pb	260	640	1000	610	880	1400	1100	620	580
Sb	290	370	440	400	420	290	440	580	420
Se	10	10	10	10	10	10	10	1.9	2.4
Sn	180	350	240	260	280	380	330	380	270
Tl	6	6	6	6	6	6	6	6	6
V	110	290	150	74	160	340	160	55	150
Zn	5200	6400	6400	6700	9500	10000	8100	6800	5600
Hg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.3

Table 3: Heavy Metal Content of Boiler Ash (part 2)

Sample ref	2014-01-23-01	2014-04-08-01	2014-08-20-03	2014-09-19-02(ECO)	2014-09-19-03(2/3)	2014-09-19-01(SH)	2014-10-31-02	2015-02-09-01	2015-04-24-03
Al	38000	52000	42000	45000	60000	35000	48000	44000	40000
As	74	46	29	30	30	57	34	52	41
Ba	260	290	620	650	560	450	470	450	120
Ca	140000	230000	200000	210000	200000	180000	220000	200000	200000
Cd	42	31	42	29	26	52	33	31	42
Co	57	36	47	41	83	42	44	36	31
Cu	320	340	390	420	460	480	480	450	450
Cr	180	130	160	150	180	150	140	130	140
Fe	28000	34000	20000	19000	19000	16000	26000	34000	23000
K	27000	17000	21000	19000	17000	34000	18000	18000	21000
Mn	1500	1200	1100	1100	1100	1100	1400	1400	1200
Mo	45	26	28	20	17	23	22	29	25
Ni	280	180	110	95	120	95	140	210	140
Pb	1000	460	900	400	450	980	470	570	660
Sb	790	310	490	410	380	910	460	400	490
Se	3.7	2.9	2.1	1.9	1.6	5.5	2.2	3.5	3.8
Sn	630	250	350	250	220	490	270	310	310
Tl	6	1	6	6	6	6	6	6	6
V	310	350	81	96	100	86	210	420	280
Zn	11000	5500	6600	4500	4200	7400	5500	5900	6300
Hg	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

3 Classification of Residue

In order to determine the appropriate hazard classification of the ash residue stream, we have referred to the Classification Labelling and Packaging (CLP) Regulation[1], which is the basis for determining whether a material qualifies under Seveso III and which also describes the approach to determine if a mixture or preparation containing multiple hazardous constituents should be classed as hazardous to the environment.

Referring to the CLP Regulation, many of the heavy metals identified in flue gas and boiler ash residues are capable of forming compounds that are classed as H410 (very toxic to aquatic life with long lasting effects), i.e. Chronic Category 1. The basic rule for determining the appropriate classification for a mixture containing constituents that present this hazard classification is set out in Table 4.1.2 of the CLP Regulation, which we reproduce here as Table 4.

Table 4: Classification of a mixture for chronic (long term) hazards, based on a summation of classified components

Sum of Components Classified as	Mixture is Classified as
Chronic Category 1 × M* ≥ 25%	Chronic Category 1
(M × 10 × Chronic Category 1) + Chronic Category 2 ≥ 25%	Chronic Category 2
(M × 100 × Chronic Category 1) + (10 × Chronic Category 2) + Chronic Category 3 ≥ 25%	Chronic Category 3
Chronic Category 1 + Chronic Category 2 + Chronic Category 3 + Chronic Category 4 ≥ 25%	Chronic Category 4

* The M-factor is a multiplying factor which may be applied where there are mixtures containing highly toxic components. This is discussed in more detail below

If the entire mixture is classed as Chronic Category 1 or 2, then it qualifies under the Seveso III Regulations. Referring to Table 4 it is clear that the determination of the status of the ash residue will depend on the quantities and on the relative toxicities of the various components present.

We have conducted a screening assessment of the entries of various heavy metal compounds under the CLP Regulation in order to determine the degree of toxicity to the aquatic environment that these components, or compounds containing these components, present.

[1] Regulation (EC) No 1272/2008 of the European Parliament and of the Council on classification labelling and packaging of substances and mixtures

Table 5: Overview of Classifications of Compounds containing Heavy Metals (CLP Regulation)

Component	Classification of Compounds of this Material	M-Factor	Other Comments
Aluminium (Al)	n.a.		
Arsenic (As)	Cat 1	-	
Barium (Ba)	Cat 2	n.a.	
Calcium (Ca)	n.a.		The Calcium content in the ash comprises lime (Calcium carbonates, oxides and hydrides).
Cadmium (Cd)	Cat 1	-	
Cobalt (Co)	Cat 1	M-10	A Multiplication factor of 10 applies more often than not to Cobalt compounds.
Copper (Cu)	Cat 1	-	
Chromium (Cr)	Cat 1	-	
Iron (Fe)	n.a.		
Potassium (K)	n.a.		
Manganese (Mn)	Cat 1		
Molybdenum (Mo)	Cat 1		
Nickel (Ni)	Cat 1	-	
Lead (Pb)	Cat 1	-	
Antimony (Sb)	Cat 2	n.a.	
Selenium (Se)	Cat 1		
Tin (Sn)	Cat 1	-	Multiplication factors do not generally apply to compounds containing Tin. The exception to this is in the case of organotin compounds.
Thallium (Tl)	Cat 2	n.a.	
Vanadium (V)	Cat 2	n.a.	
Zinc (Zn)	Cat 1	-	Zinc compounds vary in classification from non-ecotoxic up to ecotoxic materials to which M-factors are applied
Mercury (Hg)	Cat 1	-	

- based on our review, M-Factors do not apply to compounds containing this Heavy Metal

For most of the heavy metal compounds present in ash, they can form compounds for which the H400 and/or H410 hazard statements apply, i.e. Category 1 materials. However in most cases they do not form compounds to which an M-factor would apply. The exceptions to this are as follows:

- Cobalt: For most cobalt compounds listed in the CLP Regulation, an M-factor of 10 applies. We have therefore applied this factor to the total inventory of Cobalt in the ash residue.
- Tin: Multiplication factors do not generally apply to compounds containing Tin. The exception to this is in the case of organotin compounds. It is not considered credible that there would be any significant quantities of organotin compounds in the waste residue. These compounds were formerly used as anti-foulants on ships' hulls but have since largely been banned from use. Furthermore, even if any such materials were present in the intake to the plant, they would be destroyed and converted into more straightforward compounds, such as Tin Oxide.
- Zinc: Many Zinc compounds are not classed as ecotoxic, while others are eco-toxic and have additional M-factors applied to them also. For the purposes of this assessment we have conducted the assessment on the basis that all of the Zinc compounds present would be H400 and/or H410 materials, but with no M-factor. This is considered to be a representative approach to the overall inventory of Zn in the waste. It also corresponds to the classification of Zinc Oxide, which is expected to be the most prevalent zinc compound in the waste stream.

There are also several materials identified which predominantly present Category 2 hazards, i.e. Barium, Antimony, Thallium and Vanadium.

4 Assessment of Flue Gas Residue / Boiler Ash Samples

Using the approach described above, we have examined the results for each sample collected from the flue gas residue in turn in order to determine if the Category 2 classification could be applied to the waste stream as a whole, by applying the equation

$$M \times 10 \times \text{Chronic Category 1}) + \text{Chronic Category 2} \geq 25\%$$

If the combined inventory works out as being greater than or equal to 25%, then the Category 2 classification applies to the waste stream as a whole, which would be sufficient for the waste to qualify as a Seveso substance.

A sample calculation for the first sample of flue gas residue is shown in Table 6.

The total value in this case is calculated to be 3.58%, which is significantly less than the threshold of 25% which would need to be reached in order for the mixture to qualify as Category 2. On this basis the waste residue would not qualify under the Seveso Regulations. (It should be noted here that in falling short of the criteria for Category 2, it automatically follows that the residue does not qualify as Category 1 either because there are higher concentration thresholds for qualifying under Category 1, as shown in Table 4).

Table 6: Assessment of Carranstown Flue Gas Residue Sample

Metal	Content (%)	Class	M-Factor	(M x 10 x Cat 1) + Cat 2
Aluminium (Al)	0.410%	-	-	0.00%
Arsenic (As)	0.001%	Cat 1	-	0.01%
Barium (Ba)	0.012%	Cat 2	-	0.01%
Calcium (Ca)	41.000%	-	-	0.00%
Cadmium (Cd)	0.005%	Cat 1	-	0.05%
Cobalt (Co)	0.000%	Cat 1	10	0.40%
Copper (Cu)	0.013%	Cat 1	-	0.13%
Chromium (Cr)	0.002%	Cat 1	-	0.02%
Iron (Fe)	0.260%	-	-	0.00%
Potassium (K)	1.100%	-		0.00%
Manganese (Mn)	0.014%	Cat 1	-	0.14%
Molybdenum (Mo)	0.000%	Cat 1	-	0.00%
Nickel (Ni)	0.001%	Cat 1	-	0.01%
Lead (Pb)	0.039%	Cat 1	-	0.39%
Antimony (Sb)	0.014%	Cat 2	-	0.01%
Selenium (Se)	0.001%	Cat 1	-	0.01%
Tin (Sn)	0.010%	Cat 1	-	0.10%
Thallium (Tl)	0.001%	Cat 2	-	0.00%
Vanadium (V)	0.001%	Cat 2	-	0.00%
Zinc (Zn)	0.230%	Cat 1	-	2.30%
Mercury (Hg)	0.000%	Cat 1	-	0.00%
Total				**3.58%**

Table 7, Table 8 and Table 9 show the results of similar assessments based on the other flue gas residue and boiler ash data available for the reference site at Carranstown. The results show that in each case the metals content in the sample are below the 25% threshold for the waste stream to qualify under the Seveso Regulations.

Table 7: Assessment of Carranstown Flue Gas Residues – Cat 2 Determination

Date	13/10/2011	17/01/2012	16/08/2012	18/01/2013	15/08/2013	22/01/2014	20/08/2014	19/02/2015	09/06/2015
As	0.01%	0.03%	0.03%	0.04%	0.03%	0.04%	0.03%	0.03%	0.03%
Ba	0.01%	0.03%	0.02%	0.03%	0.02%	0.03%	0.02%	0.02%	0.02%
Cd	0.05%	0.13%	0.15%	0.16%	0.14%	0.11%	0.10%	0.07%	0.10%
Co	0.40%	0.83%	1.10%	0.77%	0.84%	0.85%	0.80%	0.57%	0.65%
Cu	0.13%	0.38%	0.33%	0.68%	0.38%	0.28%	0.35%	0.24%	0.34%
Cr	0.02%	0.03%	0.04%	0.03%	0.05%	0.03%	0.04%	0.03%	0.04%
Mn	0.14%	0.32%	0.01%	0.28%	0.25%	0.33%	0.23%	0.25%	0.24%
Mo	0.00%	0.01%	0.01%	0.01%	0.01%	0.02%	0.01%	0.01%	0.01%
Ni	0.01%	0.03%	0.03%	0.04%	0.02%	0.04%	0.02%	0.03%	0.02%
Pb	0.39%	1.70%	2.40%	3.60%	2.00%	1.20%	1.50%	0.92%	1.30%
Sb	0.01%	0.03%	0.05%	0.04%	0.05%	0.04%	0.03%	0.02%	0.03%
Se	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.00%	0.01%	0.01%
Sn	0.10%	0.40%	0.36%	0.62%	0.46%	0.42%	0.35%	0.26%	0.28%
Tl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
V	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.01%	0.00%
Zn	2.30%	6.60%	6.10%	12.00%	8.60%	7.00%	7.40%	5.00%	6.00%
Hg	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.02%	0.01%	0.01%
Total	**3.58%**	**10.53%**	**10.64%**	**18.33%**	**12.86%**	**10.41%**	**10.90%**	**7.47%**	**9.07%**

Table 8: Assessment of Carranstown Boiler – Cat 2 Determination (part 1)

Ref	2012-10-10-1	2012-01-09-01	2012-04-23-01	2012-07-12-01	2012-11-30-01	2013-01-18-02	2013-06-05-01	2013-08-15-01	2013-10-31-01
As	0.02%	0.04%	0.03%	0.02%	0.04%	0.04%	0.04%	0.03%	0.03%
Ba	0.09%	0.04%	0.07%	0.03%	0.04%	0.04%	0.04%	0.06%	0.07%
Cd	0.03%	0.04%	0.03%	0.03%	0.04%	0.04%	0.03%	0.04%	0.03%
Co	2.80%	4.30%	3.40%	3.80%	5.40%	5.00%	3.30%	3.80%	3.90%
Cu	0.43%	0.41%	0.52%	0.52%	0.55%	0.66%	0.43%	0.35%	0.34%
Cr	0.19%	0.14%	0.13%	0.19%	0.16%	0.14%	0.14%	0.17%	0.16%
Mn	1.20%	1.60%	1.30%	1.10%	1.20%	1.50%	1.10%	1.10%	1.30%
Mo	0.02%	0.02%	0.03%	0.02%	0.02%	0.04%	0.02%	0.03%	0.03%
Ni	0.15%	0.18%	0.14%	0.13%	0.18%	0.22%	0.15%	0.10%	0.14%
Pb	0.26%	0.64%	1.00%	0.61%	0.88%	1.40%	1.10%	0.62%	0.58%
Sb	0.03%	0.04%	0.04%	0.04%	0.04%	0.03%	0.04%	0.06%	0.04%
Se	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.00%	0.00%
Sn	0.18%	0.35%	0.24%	0.26%	0.28%	0.38%	0.33%	0.38%	0.27%
Tl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
V	0.01%	0.03%	0.02%	0.01%	0.02%	0.03%	0.02%	0.01%	0.02%
Zn	5.20%	6.40%	6.40%	6.70%	9.50%	10.00%	8.10%	6.80%	5.60%
Hg	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	**10.62%**	**14.24%**	**13.36%**	**13.46%**	**18.36%**	**19.53%**	**14.85%**	**13.54%**	**12.51%**

Table 9: Assessment of Carranstown Boiler – Cat 2 Determination (part 2)

Ref	2014-01-23-01	2014-04-08-01	2014-08-20-03	2014-09-19-02(ECO)	2014-09-19-03(2/3)	2014-09-19-01(SH)	2014-10-31-02	2015-02-09-01	2015-04-24-03
As	0.07%	0.05%	0.03%	0.03%	0.03%	0.06%	0.03%	0.05%	0.04%
Ba	0.03%	0.03%	0.06%	0.07%	0.06%	0.05%	0.05%	0.05%	0.01%
Cd	0.04%	0.03%	0.04%	0.03%	0.03%	0.05%	0.03%	0.03%	0.04%
Co	5.70%	3.60%	4.70%	4.10%	8.20%	4.20%	4.40%	3.60%	3.10%
Cu	0.32%	0.34%	0.39%	0.42%	0.46%	0.48%	0.48%	0.45%	0.45%
Cr	0.18%	0.13%	0.16%	0.15%	0.18%	0.15%	0.14%	0.13%	0.14%
Mn	1.50%	1.20%	1.10%	1.10%	1.10%	1.10%	1.40%	1.40%	1.20%
Mo	0.05%	0.03%	0.03%	0.02%	0.02%	0.02%	0.02%	0.03%	0.03%
Ni	0.28%	0.18%	0.11%	0.10%	0.12%	0.10%	0.14%	0.21%	0.14%
Pb	1.00%	0.46%	0.90%	0.40%	0.45%	0.98%	0.47%	0.57%	0.66%
Sb	0.08%	0.03%	0.05%	0.04%	0.04%	0.09%	0.05%	0.04%	0.05%
Se	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
Sn	0.63%	0.25%	0.35%	0.25%	0.22%	0.49%	0.27%	0.31%	0.31%
Tl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
V	0.03%	0.04%	0.01%	0.01%	0.01%	0.01%	0.02%	0.04%	0.03%
Zn	11.00%	5.50%	6.60%	4.50%	4.20%	7.40%	5.50%	5.90%	6.30%
Hg	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	**20.91%**	**11.86%**	**14.53%**	**11.21%**	**15.11%**	**15.18%**	**13.01%**	**12.81%**	**12.50%**

Sensitivity Analysis

As a final check, we note that these metals are present in compounds rather than as pure elements in the waste. As such the quantities of the metallic compounds present in the wastes by mass will be slightly greater than in the values calculated above, which are based on the assumption that the metals are present in elemental form. Based on literature data provided by Indaver[2] these materials are most commonly present as metallic oxides and so we have recalculated the values for all three waste streams based on the assumption that 100% of each of these metals are present as metallic oxides.

A sample of this calculation is shown in Table 10. This is for the first of the flue gas residue samples (i.e. the sample on 13/10/2011). The full set of results is shown in Table 11, Table 12 and Table 13.

Table 10: Recalculation to allow for contribution to Mass by other Elements in Metallic Compounds

Parameter	% Molecular Mass to Heavy Metal Element	Metal Content	Metal Oxide Conten t
Arsenic Oxide (As2O3)	76%	0.01%	0.01%
Barium Oxide (BaO)	90%	0.01%	0.01%
Cadmium Oxide (CdO)	88%	0.05%	0.05%
Cobalt Oxide (Co2O3)	71%	0.40%	0.56%
Copper Oxide (Cu2O)	89%	0.13%	0.15%
Chromium Oxide (Cr2O3)	68%	0.02%	0.03%
Manganese Dioxide (MnO2)	63%	0.14%	0.22%
Molybdenum Oxide (MoO2)	75%	0.00%	0.00%
Nickel Oxide (NiO)	79%	0.01%	0.02%
Lead Oxide (Pb3O4)	91%	0.39%	0.43%
Antimony Oxide (Sb2O3)	84%	0.01%	0.02%
Selenium Oxide (SeO2)	71%	0.01%	0.01%
Tin Oxide (SnO2)	79%	0.10%	0.12%
Thallium Oxide (Tl2O3)	89%	0.00%	0.00%
Vanadium Oxide (V2O5)	56%	0.00%	0.00%
Zinc Oxide (ZnO)	80%	2.30%	2.86%
Mercury Oxide (HgO)	93%	0.00%	0.00%
Total		**3.58%**	**4.50%**

[2] "Combustion and Incineration Processes" (4th edition)

Table 11: Sensitivity Analysis – Recalculation to allow for contribution to Mass by other Elements in the Metallic Compounds (All Samples of Flue Gas Residue)

Date	13/10/2011	17/01/2012	16/08/2012	18/01/2013	15/08/2013	22/01/2014	20/08/2014	19/02/2015	09/06/2015
As	0.01%	0.03%	0.04%	0.05%	0.03%	0.06%	0.03%	0.04%	0.03%
Ba	0.01%	0.03%	0.03%	0.03%	0.03%	0.03%	0.02%	0.02%	0.02%
Cd	0.05%	0.15%	0.17%	0.18%	0.16%	0.13%	0.11%	0.08%	0.11%
Co	0.56%	1.17%	1.55%	1.08%	1.18%	1.20%	1.13%	0.80%	0.92%
Cu	0.15%	0.43%	0.37%	0.77%	0.43%	0.32%	0.39%	0.27%	0.38%
Cr	0.03%	0.05%	0.06%	0.05%	0.07%	0.05%	0.06%	0.04%	0.05%
Mn	0.22%	0.51%	0.02%	0.44%	0.40%	0.52%	0.36%	0.40%	0.38%
Mo	0.00%	0.01%	0.01%	0.01%	0.02%	0.02%	0.01%	0.01%	0.01%
Ni	0.02%	0.04%	0.04%	0.04%	0.02%	0.05%	0.03%	0.04%	0.03%
Pb	0.43%	1.88%	2.65%	3.97%	2.21%	1.32%	1.65%	1.01%	1.43%
Sb	0.02%	0.03%	0.05%	0.05%	0.06%	0.04%	0.03%	0.02%	0.04%
Se	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Sn	0.12%	0.51%	0.46%	0.79%	0.58%	0.53%	0.44%	0.33%	0.36%
Tl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
V	0.00%	0.01%	0.00%	0.01%	0.00%	0.01%	0.00%	0.01%	0.01%
Zn	2.86%	8.21%	7.59%	14.94%	10.70%	8.71%	9.21%	6.22%	7.47%
Hg	0.00%	0.01%	0.01%	0.02%	0.01%	0.01%	0.02%	0.01%	0.01%
Total	**4.50%**	**13.07%**	**13.05%**	**22.45%**	**15.91%**	**13.01%**	**13.53%**	**9.32%**	**11.26%**

Table 12: Sensitivity Analysis – Recalculation to allow for contribution to Mass by other Elements in the Metallic Compounds (Boiler Ash – Part 1)

Date	2012-10-10-1	2012-01-09-01	2012-04-23-01	2012-07-12-01	2012-11-30-01	2013-01-18-02	2013-06-05-01	2013-08-15-01	2013-10-31-01
As	0.02%	0.05%	0.04%	0.03%	0.05%	0.06%	0.05%	0.03%	0.04%
Ba	0.10%	0.05%	0.08%	0.03%	0.04%	0.04%	0.04%	0.07%	0.07%
Cd	0.03%	0.04%	0.04%	0.03%	0.04%	0.04%	0.04%	0.04%	0.03%
Co	3.94%	6.06%	4.79%	5.35%	7.60%	7.04%	4.65%	5.35%	5.49%
Cu	0.48%	0.46%	0.59%	0.59%	0.62%	0.74%	0.48%	0.39%	0.38%
Cr	0.28%	0.20%	0.19%	0.28%	0.23%	0.20%	0.20%	0.25%	0.23%
Mn	1.90%	2.53%	2.06%	1.74%	1.90%	2.37%	1.74%	1.74%	2.06%
Mo	0.03%	0.03%	0.04%	0.03%	0.03%	0.05%	0.03%	0.04%	0.04%
Ni	0.19%	0.23%	0.18%	0.17%	0.23%	0.28%	0.19%	0.12%	0.18%
Pb	0.29%	0.71%	1.10%	0.67%	0.97%	1.54%	1.21%	0.68%	0.64%
Sb	0.03%	0.04%	0.05%	0.05%	0.05%	0.03%	0.05%	0.07%	0.05%
Se	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.00%	0.00%
Sn	0.23%	0.44%	0.30%	0.33%	0.36%	0.48%	0.42%	0.48%	0.34%
Tl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
V	0.02%	0.05%	0.03%	0.01%	0.03%	0.06%	0.03%	0.01%	0.03%
Zn	6.47%	7.97%	7.97%	8.34%	11.82%	12.45%	10.08%	8.46%	6.97%
Hg	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	**14.04%**	**18.88%**	**17.47%**	**17.66%**	**24.00%**	**25.42%**	**19.24%**	**17.75%**	**16.57%**

Table 13: Sensitivity Analysis – Recalculation to allow for contribution to Mass by other Elements in the Metallic Compounds (Boiler Ash – Part 2)

Date	2014-01-23-01	2014-04-08-01	2014-08-20-03	2014-09-19-02(ECO)	2014-09-19-03(2/3)	2014-09-19-01(SH)	2014-10-31-02	2015-02-09-01	2015-04-24-03
As	0.10%	0.06%	0.04%	0.04%	0.04%	0.08%	0.04%	0.07%	0.05%
Ba	0.03%	0.03%	0.07%	0.07%	0.06%	0.05%	0.05%	0.05%	0.01%
Cd	0.05%	0.04%	0.05%	0.03%	0.03%	0.06%	0.04%	0.04%	0.05%
Co	8.03%	5.07%	6.62%	5.77%	11.55%	5.91%	6.20%	5.07%	4.37%
Cu	0.36%	0.38%	0.44%	0.47%	0.52%	0.54%	0.54%	0.51%	0.51%
Cr	0.26%	0.19%	0.23%	0.22%	0.26%	0.22%	0.20%	0.19%	0.20%
Mn	2.37%	1.90%	1.74%	1.74%	1.74%	1.74%	2.22%	2.22%	1.90%
Mo	0.06%	0.03%	0.04%	0.03%	0.02%	0.03%	0.03%	0.04%	0.03%
Ni	0.36%	0.23%	0.14%	0.12%	0.15%	0.12%	0.18%	0.27%	0.18%
Pb	1.10%	0.51%	0.99%	0.44%	0.50%	1.08%	0.52%	0.63%	0.73%
Sb	0.09%	0.04%	0.06%	0.05%	0.05%	0.11%	0.06%	0.05%	0.06%
Se	0.01%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.01%
Sn	0.80%	0.32%	0.44%	0.32%	0.28%	0.62%	0.34%	0.39%	0.39%
Tl	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
V	0.06%	0.06%	0.01%	0.02%	0.02%	0.02%	0.04%	0.08%	0.05%
Zn	13.69%	6.85%	8.21%	5.60%	5.23%	9.21%	6.85%	7.34%	7.84%
Hg	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	**27.37%**	**15.71%**	**19.09%**	**14.93%**	**20.45%**	**19.80%**	**17.30%**	**16.94%**	**16.38%**

Based on these results, all samples of the flue gas residue that have been analysed show a total content of heavy metals which is less than the threshold required to qualify the overall mixture as Category 2. On this basis the flue gas residue does not qualify as a Seveso substance.

Of the eighteen samples of boiler ash, the results for 16 of them showed the levels of heavy metals were below the threshold and so the mixture would not qualify as Category 2. However, in two cases, the calculation based on the sensitivity analysis resulted in values slightly greater than 25%, indicating that these samples qualified as Category 2.

However it should be noted here that these ash / residue streams are not homogenous and do not have consistent characteristics that would apply throughout the c.150 tonnes of boiler ash that may be present on site at any one time. For a representative picture of the average metals content level through the 150 tonne pile of boiler ash, it is more accurate to look at the average of the data samples. Taking the averages of the data presented in Table 12 and Table 13, the overall calculation works out as 18.8%, which is below the 25% threshold. Even applying one standard deviation upwards to this data, the figure works out as 22.4%. Two standard deviations upwards would have to be applied in order to bring the figure above 25%. Even if this extreme case was found to be representative of the boiler ash at Ringaskiddy, the overall site would still not qualify under the Seveso Regulations as the maximum inventory of boiler ash (150 tonnes) is below the threshold in the regulations for qualifying as a lower tier establishment (200 tonnes).

Based on the above data, neither the flue gas residue nor the boiler ash qualifies under the Seveso Regulations. It should be borne in mind that these findings are based on an analysis of what is considered to be an analogous waste collected from another site. Indaver will conduct a similar programme of monitoring of the waste streams at Ringaskiddy in order to ensure that these findings remain valid for the site once it is in operation.

Appendix 6: Consequence Modelling for Fires in Bunker Area

1 Introduction

The purpose of this Appendix is to determine the impacts associated with an accidental fire in the solid waste bunker area of the Indaver facility at Ringaskiddy and examine the potential impacts to the surrounding area.

The Hazard Identification and Risk Assessment (HAZID&RA) Team identified a fire in this location as a credible accident scenario. The primary hazards for a fire in this location are the potential impacts associated with products of combustion (CO, HCl, SO_2 and Dioxins).

The waste bunker has dimensions of 18.2 m × 40.5 m and will typically store c.4,000 tonnes of waste, with a capacity to store up to 6,000 tonnes.

2 Overview of Fire Scenarios

BÓC and Indaver have examined this scenario previously, at the time of the 2008 Planning Application in order to assess the development of the various stages of a fire at this location.

Indaver's operational experience is that smouldering of the incoming wastes can be occasionally caused e.g. by hot ashes in dustbins. The normal response in such cases is that the crane operator would remove any smouldering material using the grab crane and load it into the hopper feeding the furnace, where it would be burned under controlled conditions. The grab crane has the capacity to lift approximately 3 cubic metres of waste, equivalent to 1.2 tonnes at one time. This response would help to protect against escalation of the fire event. Nonetheless, the HAZID&RA team considered the possibility that a fire could escalate to larger sizes. The fire scenarios that have been examined for the bunker area are therefore as follows:

- Fire of 1 tonne of waste. This involves smouldering of the waste rather than a major fire event and it is conservatively assumed that up to 1 tonnes could be consumed in this scenario.
- Fire in bunker, extinguished by the fixed fire protection systems. This is a more remote event, which would involve failure of the initial response using the grab crane but the fire is extinguished by the fire protection systems at the bunker area. Based on the properties of the waste and the anticipated spread of fire in this instance, it is estimated that the fire could continue for a maximum of 2 hours, with up to 26.7 tonnes of waste being burned in this scenario.
- Full bunker fire. This is the most unlikely fire scenario at the bunker, requiring failure of both the initial response and of the fire protection systems. It is assumed for the purposes of this assessment that if the fire escalates to this extent that it would no longer be practicable to extinguish it and instead the response would be to allow it to burn down while focus of the fire fighting efforts would be to protect nearby plant and equipment.

3 Emissions from a Bunker Fire

In mass emission terms, the primary emissions in the smoke plume in the event of a fire in the bunker would be by-products of combustion as a result of the Carbon, Chlorine and Sulphur content of the waste. There could also be the potential for emissions of Dioxins from a fire in this area of the plant.

The waste in the bunker will comprise 30-35% water and 65-70% solids. Of this solids content, it will comprise c.80% Carbon, 0.4% Chlorine and 0.1% Sulphur.

3.1 Rate of Burning

As mentioned above, the waste in the bunker will comprise 30-35% water and 65-70% solids. Based on Indaver's operational experience at other facilities involved in the storage and handling of similar waste streams, the average calorific value of this waste is expected to be 9.6 MJ/kg.

In the initial stages of a fire in the bunker, this would involve a slow smouldering burn within the waste stream. Based on the assessments that were carried out for the 2008 Planning Application a representative burning rate of 1 tonne of waste being consumed within 30 minutes was used. This slow burn would result in a correspondingly low emission rate to atmosphere. However, it is also expected that the resulting smoke plume would have lower buoyancy and there would be less plume rise than for a fully developed fire.

In the event that the scenario escalates into a fully developed fire, the rate of burning will be determined by the properties of the waste and (in the worst case scenario) by the dimensions of the bunker.

The Yellow Book[1] provides data on typical burning rates for a variety of materials. We have extracted the data for a selection of these materials in Table 1. We have also included details of the energy content of these materials, for reference.

[1] "Methods for the calculation of physical effects due to releases of hazardous materials (liquids and gases)"

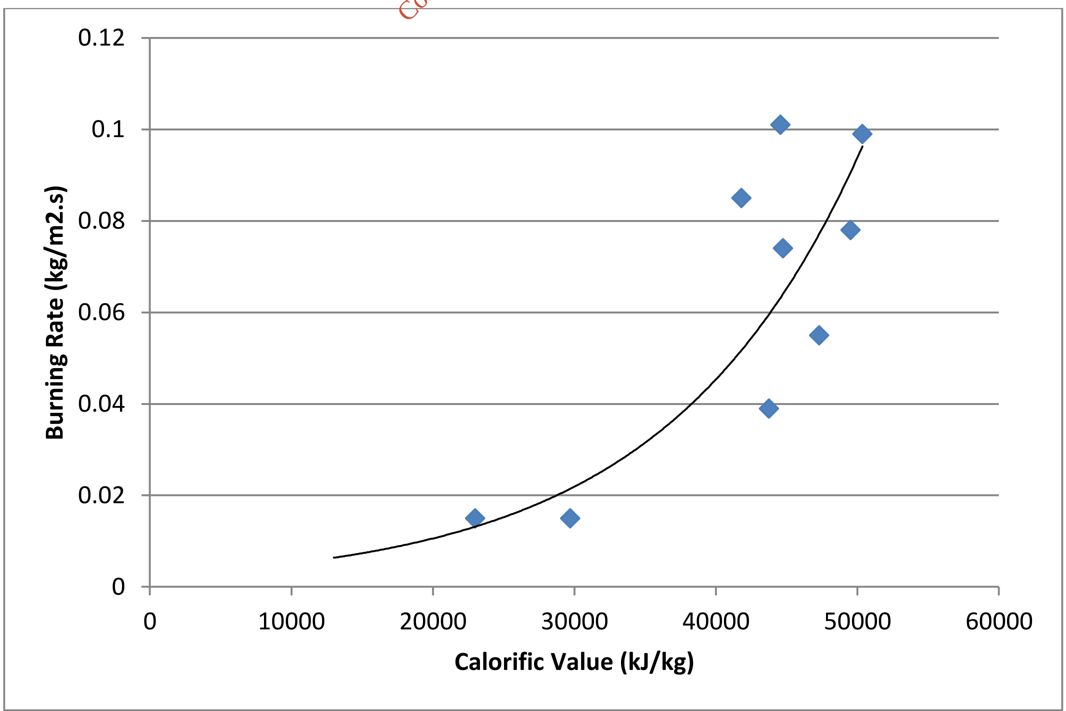
Table 1: Data on Burning Rates and Energy Content of Fuels

Fuel	Calorific Value (kJ/kg)	Rate of Burning (kg/m².s))
Propane	50,350	0.099
Butane	49,510	0.078
Hexane	44,752	0.074
Heptane	44,566	0.101
Benzene	41,800	0.085
Gasoline	47,300	0.055
Kerosene	43,750	0.039
Methanol	23,000	0.015
Ethanol	29,700	0.015

Figure 1 shows a plot of Burning Rate vs. Calorific values for these materials. This indicates that there is a relationship between the two parameters and we have added a best-fit line to this data.

Applying this assessment to the bunker waste, which has a calorific value of 9,600 kJ/kg, this would give a rate of burning of 0.005 kg/m^2.s. However we are conscious that this assessment involves extrapolation outside of the data range and so in order to ensure a conservative approach, we have doubled this figure in order to determine a maximum burning rate of 0.01 kg/m^2.s. This works out as a slightly lower burning rate for an equivalently sized pool of methanol or ethanol.

Figure 1: Plot of Burning Rate vs. Energy Content



The surface area of the bunker is 18.2 m × 40.5 m = 737 m^2. Based on the calculations shown above, this means that the maximum burning rate in the bunker would be of the order of 0.45 tonnes per minute, or 26.7 tonnes per hour. This rate of burning would only arise where the fire is fully developed and covers the full areas of the bunker. For a typical inventory of 4,000 tonnes these results indicate that a fully developed bunker fire could continue for c.6 days and in the event that the bunker was filled to capacity at 6,000 tonnes, it could continue for over a week.

For the intermediate fire scenario, i.e. where the fire escalates beyond the initial smouldering phase but has not spread to the full extent of the bunker area, we have applied a burning rate of 50% of the calculated maximum value.

The details of the three fire scenarios are summarised in Table 2.

Table 2: Burning Rates for different Fire Scenarios at the Bunker

Parameter	Minor Fire, Smouldering Waste in Bunker	Intermediate Fire, extinguished by Emergency Response	Fully Developed Bunker Fire
Total quantity of waste burned (tonnes)	1	26.7	4,000
Rate of burning (t/hr)	2	13.4	26.7

Based on data provided by Indaver, the rate of evolution of flue gas to atmosphere arising from a fire in the bunker area would be c.6000 Nm^3 per tonne of waste consumed.

For the purposes of this assessment we have also made the following assumptions about the smoke plume. For a scenario involving a smouldering 1 tonne fire, the resulting smoke plume would exhibit low thermal buoyancy as the fire would be in the early stages of development. A temperature of 50°C was used for modelling the impacts of this scenario. For the more developed bunker fire scenarios, the temperature of the gases would be much higher. A figure of 300°C has been used for the smoke plume from the intermediate fire and 500°C for the fully developed fire.

3.2 By Products of Combustion of Carbon, Chlorine and Sulphur

Based on data provided by Indaver, the bunker waste will comprise up to 65% solid matter. This solid fraction will typically comprise c.80% Carbon, 0.4% Chlorine and 0.1% Sulphur, by weight. In other words, for every tonne of waste burned, there would be 0.52 tonne Carbon, 0.0026 tonne Chlorine and 0.0007 tonne Sulphur consumed.

Referring to the HSA's guidance document for Land Use Planning (LUP) provides conversion factors for the purposes of calculating combustion products from a fire. The relevant details are summarised below:

- Carbon Monoxide (CO): 9.7% C to CO
- Hydrogen Chloride (HCl): 100% Cl to HCl
- Sulphur Dioxide (SO_2): 100% S to SO_2

There would also be Carbon Dioxide formed in the fire, but the toxic impacts of this component of the smoke plume would be negligible when compared with the Carbon Monoxide emission.

On this basis, we have calculated the emission rates to atmosphere for these products of combustion for the three fire scenarios identified for the bunker. These are set out in Table 3.

Table 3: Emission Rates of Products of Combustion for Bunker Fire Scenarios

Parameter	Minor Fire, Smouldering Waste in Bunker	Intermediate Fire, extinguished by Emergency Response	Fully Developed Bunker Fire
Rate of burning (t/hr)	2	13.4	26.7
Emission rates			
Carbon Monoxide	0.103 kg/s	0.687 kg/s	1.374 kg/s
Hydrogen Chloride	0.0015 kg/s	0.0099 kg/s	0.0199 kg/s
Sulphur Dioxide	0.0007 kg/s	0.0048 kg/s	0.0097 kg/s

In order to assess the impacts of these emissions on the surrounding area, we have used the Probit function which is used to determine the relationship between dose exposure and potential lethal effects (see main report for more details on this function). The scenarios have been modelled to determine the maximum hazard distances to the AEGL-2 endpoint[2] and to a 1% lethality dosage level.

These model runs were conducted using AERSCREEN, a software package developed by the USEPA. This software is used to model the impacts of the release in order to calculate the worst case impacts at distance, based on worst case weather conditions.

It should be noted that it is possible that there would be no emissions to atmosphere for the smaller fire scenarios as the Reception Hall is kept under negative pressure. Combustion air for the incinerators is drawn into the process via the reception hall in order to suppress odours. As such it is possible that the smoke plume arising from the fire would be drawn into the incinerator and treated in the abatement system, which includes filters. As such this assessment has been conducted on a conservative basis.

3.2.1 Carbon Monoxide

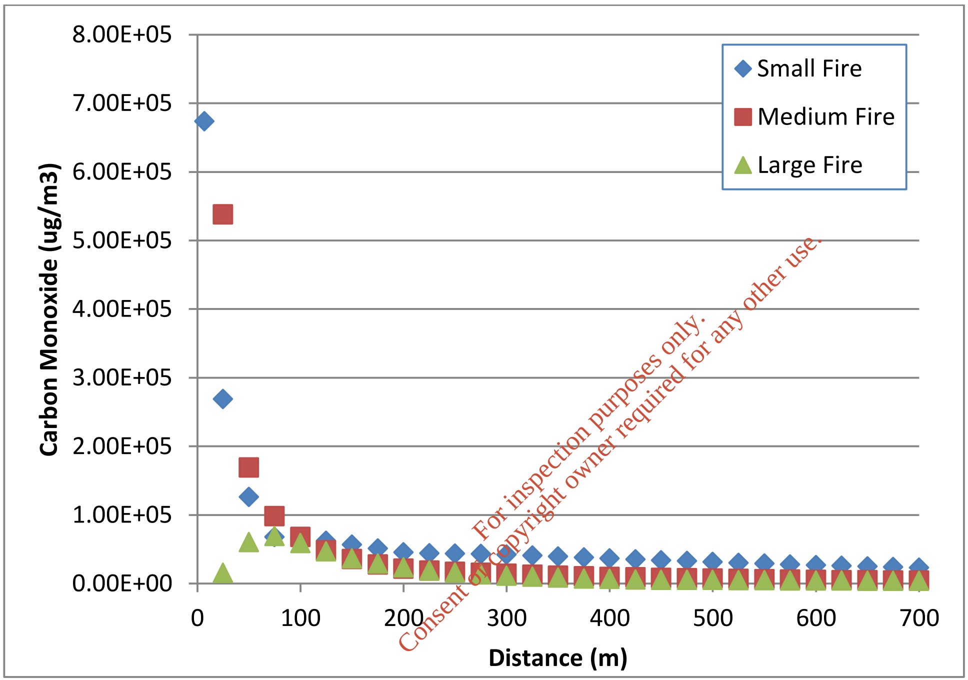
The model results for the Carbon Monoxide emissions are shown in Figure 2. This plot shows how the concentration profile varies with distance for each of the fire scenarios. Comparing the results, the impacts to the surrounding area are broadly comparable in the case of the minor fire and the

[2] Acute Exposure Guideline Level 2 – this is defined by the US EPA as the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

intermediate fire. The impacts are less significant in the case of the fully developed fire due to the high plume buoyancy that arises in this scenario.

The maximum concentrations in the immediate vicinity of the fire tend to arise in conditions of high wind speed, as this can give rise to grounding of potentially buoyant plumes. However at longer distances, the worst case impacts arise in calm conditions. As mentioned above, the model determines the worst case impacts at each distance, based on worst case weather conditions.

Figure 2: Consequence Modelling Results – Atmospheric Dispersion of CO following Bunker Fire



The AEGL-2 concentration for CO is 83 ppm or 96.6 mg/m^3. Referring to the model results for these fires, the maximum distances to this endpoint are as follows:

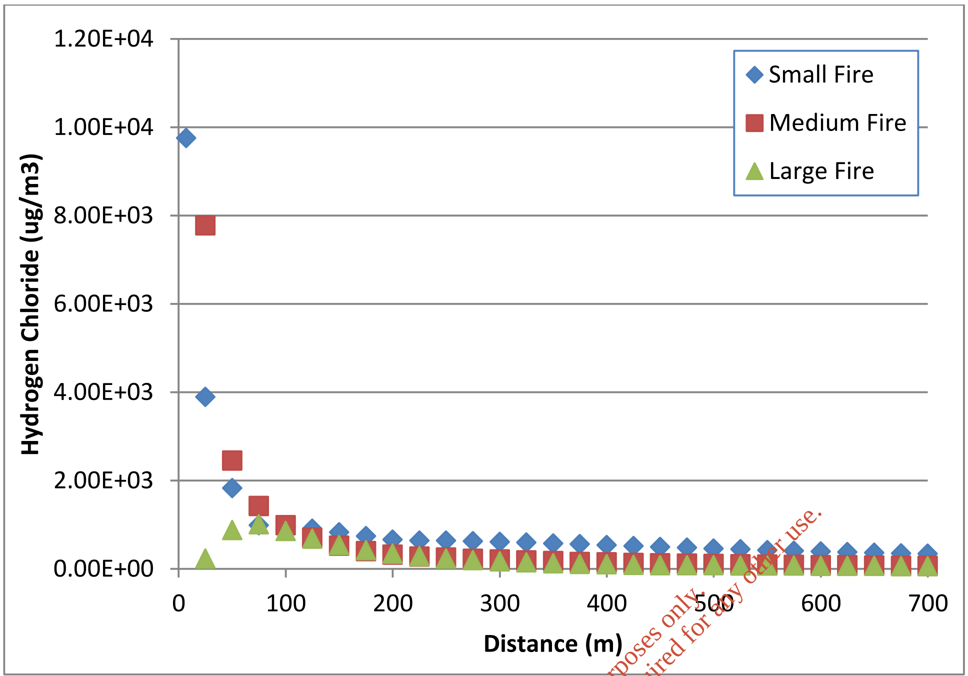
- Small Fire: 70 m
- Intermediate Fire: 80 m
- Major Fire: n.a. this concentration is not reached at any downwind receptor

Assessing the results using the Probit function in order to determine the potential for lethal effects from CO exposure, the results show that the 1% Dangerous Dose could be experienced in the immediate vicinity of the fire only and would not extend to any other buildings on site or to any off-site locations.

3.2.2 Hydrogen Chloride

The consequence modelling results for Hydrogen Chloride emissions from the bunker fire are shown in Figure 3.

Figure 3: Consequence Modelling Results – Atmospheric Dispersion of HCl following Bunker Fire

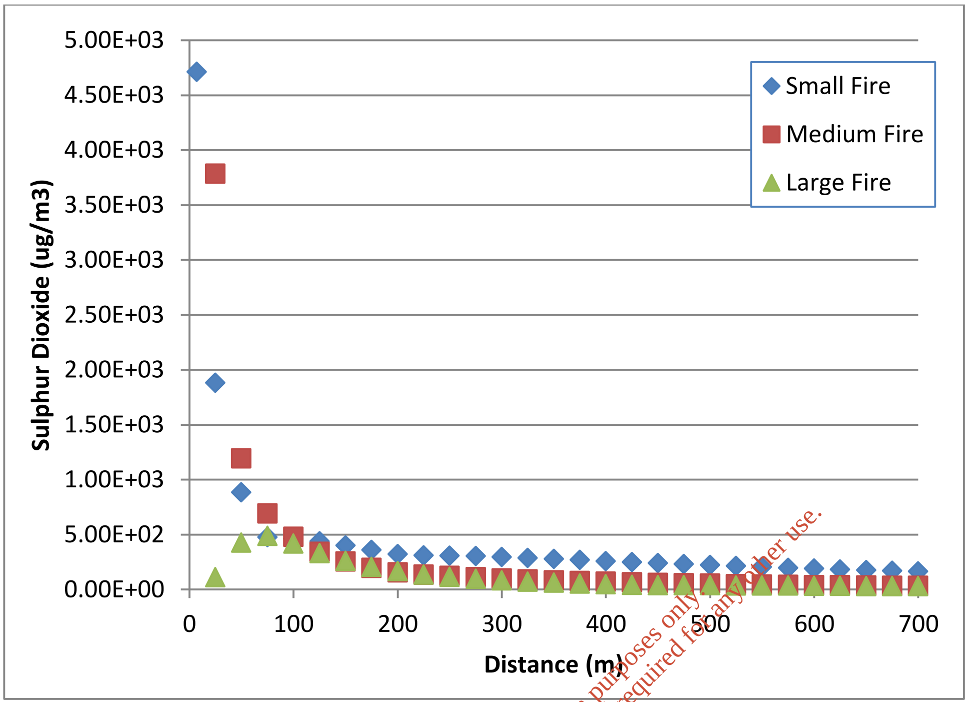


The AEGL-2 concentration for HCl is 22 ppm or 33 mg/m^3. This concentration is not reached at any location downwind of the fire. Similarly the results show that there is no risk of exposure to a dangerous dose of HCl from this scenario.

3.2.3 Sulphur Dioxide

The consequence modelling results for Sulphur Dioxide emissions from the bunker fire are shown in Figure 4.

Figure 4: Consequence Modelling Results – Atmospheric Dispersion of SO_2 following Bunker Fire



The AEGL-2 concentration for SO_2 is 0.75 ppm or 2 mg/m^3. Referring to the model results for these fires, the maximum distances to this endpoint are as follows:

- Small Fire: 24 m
- Intermediate Fire: 40 m
- Major Fire: n.a. this concentration is not reached at any downwind receptor

Using the probit function, the results show that there is no risk of exposure to a dangerous dose of HCl from this scenario at any buildings in the surrounding area, either on site or off site.

3.3 Dioxins

There are a number of reports in the literature, which quote the quantity of dioxins that could be emitted from various types of accidental fires. These included reports on emissions from house fires, building fires, chimney fires, forest fires, and vehicle fires. Having conducted an extensive review of the literature for the 2008 Planning Application on the data available for dioxin releases from accidental fires, the HAZID Team from BÓC and Indaver selected a figure of 72.8 ng of dioxins I-TEQ per kg of material combusted as likely to be the most representative of the dioxin emissions from an MSW fire.

This figure was selected as the most suitable analogue for a bunker fire because it is the reported average result from 7 trial burns involving open burning of municipal wastes in the USA. The trials were conducted by the US EPA as a means of estimating the portion of the US national dioxin burden caused by back yard burning of domestic refuse (trash) in barrels. This method of disposing of domestic waste is reported to be very common outside urbanised areas in the US. The measurements conducted showed dioxin emissions which ranged from 10 to 6000 ng I-TEQ dioxins per kg of waste burned. However it should be noted that the highest figures recorded were from fires involving wastes which had been deliberately "spiked" with high chlorine contents e.g. a prepared waste containing 7.5% by weight of PVC. This figure of 72.8 ng of dioxins I-TEQ per kg of material combusted is considered to still be valid for a fire scenario at the bunker.

The emission rates to atmosphere for the three fire scenarios at the bunker are shown in Table 4.

Table 4: Emission Rates of Dioxins for Bunker Fire Scenarios

Parameter	Minor Fire, Smouldering Waste in Bunker	Intermediate Fire, extinguished by Emergency Response	Fully Developed Bunker Fire
Rate of burning (t/hr)	2	13.4	26.7
Duration of fire (hr)	0.5	2	150
Dioxin Emission factor (ng I-TEQ per kg)	72.8	72.8	72.8
Dioxin emission rates	4.04×10^{-8} g/s	2.70×10^{-7} g/s	5.41×10^{-7} g/s

The potential impacts of these emissions on the surrounding area were assessed by dispersion modelling. In this case we have focused the assessment on the closest potentially vulnerable off-site receptors.

- Closest Residential Houses at Ringaskiddy: c.650 m from bunker (max conc: 1×10^{-5} ug/m^3)
- Maritime College: c.250 m from bunker at nearest point (max conc: 1.75×10^{-5} ug/m^3)

The impacts are summarised in Table 5.

In order to determine the impacts of these emissions in the short-term, a comprehensive literature survey was conducted for the 2008 assessment, which found that the US EPA had established a maximum 8-hr average exposure to workers on remediation sites of 0.2 ng/m^3 I-TEQ. The results in Table 5 show that this concentration level would not be reached at either location, even in the worst case weather conditions. However, the concentrations in the immediate vicinity of the fire would be elevated and it would be necessary for emergency responders to wear appropriate respiratory protection to protect from the smoke fumes.

In addition to assessing the concentrations in the surrounding area, and assessment was also made on the potential dioxin intake to people in the vicinity based on these potential accident scenarios.

Table 5: Impacts of Dioxin Emissions (Dioxin intake)

Impacts at Downwind Receptors	Minor Fire		Intermediate Fire		Fully Developed Fire	
	Ringaskiddy	Maritime College	Ringaskiddy	Maritime College	Ringaskiddy	Maritime College
Distance (m)	650	250	650	250	650	250
Max conc (ug/m^3)	1.0×10^{-5}	1.75×10^{-5}	2.0×10^{-6}	6.84×10^{-6}	1.74×10^{-6}	6.37×10^{-6}
Exposure time (hr)	0.5	0.5	2	2	4	4
Daily inhalation (m^3/day)	20	20	20	20	20	20
Inhalation per event (m^3)	0.42	0.42	1.67	1.67	3.33	3.33
Representative intake (ug)	4.2×10^{-6}	7.3×10^{-6}	3.3×10^{-6}	1.1×10^{-5}	5.8×10^{-6}	2.1×10^{-5}
Cumulative intake (ug)	4.2×10^{-6}	7.3×10^{-6}	6.7×10^{-6}	1.6×10^{-5}	9.6×10^{-6}	2.7×10^{-5}
Frequency (years)	1	1	20	20	100	100
Average intake (per annum)	4.2×10^{-6}	7.3×10^{-6}	3.3×10^{-7}	7.9×10^{-7}	9.6×10^{-8}	2.7×10^{-8}
Average intake (per day)	1.14×10^{-8}	2.0×10^{-8}	9.12×10^{-10}	2.17×10^{-9}	2.62×10^{-10}	7.25×10^{-10}

The following assumptions were made in this calculation:

- In the event of a fully developed fire, it is assumed that the emergency response approach would be to evacuate the area in the vicinity. An upper figure of 4 hours has been selected as the maximum exposure time.
- Based on typical respiration rates, a person at either receptor would inhale 20 m^3 of air over a 24-hour period.
- As the fire event escalates, the calculated overall dioxin exposure is cumulative (e.g. for the fully developed fire, persons in the vicinity would be exposed to concentrations typical of minor fires for the first ½ hour, of concentrations typical to an intermediate fire for the following 1.5 hours and of a fully developed fire for the remaining 2 hours.
- The following conservative assumptions were made to the analysis of the frequency of these scenarios, for the purposes of the dioxin intake calculation:
  - Instances involving smouldering waste could arise every few years. For the purposes of this assessment it has been assumed that such a fire could arise on an annual basis.
  - The intermediate fire is assumed to occur once in 20 years.
  - The fully developed fire is assumed to occur once in 100 years.

Combining the overall, the expected annual intake of Dioxins at the two locations is calculated by summing the figures for all three fires:

- Dioxin intake at nearest residence at Ringaskiddy: 1.26×10^{-8} per day

- Dioxin intake at closest point at Maritime College: 2.29 × 10^{-8} per day

The impacts of this intake are assessed further in Table 6.

Table 6: Impacts of Potential Dioxin Intake

	Ringaskiddy	Maritime College
Average intake (ug/day)	1.26 × 10^{-8}	2.29 × 10^{-8}
Body weight (kg)	70	70
Average Intake (ug/day per kg)	1.80 × 10^{-10}	3.27 × 10^{-10}
Average Intake (pg/day per kg)	1.80 × 10^{-4}	3.27 × 10^{-4}
Safety Margin compared with WHO ceiling	5,570	3,060

It has been assumed that the same people are present each year, for the purposes of calculating their potential cumulative exposure.

The combined intake is compared with a figure of 1.0 pg I-TEQ per day per kg body weight, which is a ceiling value established by the WHO. The results show that the expected dioxin intake to people in the vicinity of the site would be several orders of magnitude less than this figure.

Sensitivity Analysis

As a final sensitivity analysis on the results, we have also calculated the effects if the dioxin emission rate was higher than had been assumed here. The figure of 72.8 ng/kg for the dioxin emission was a mean value taken from a US EPA study. However, due to the variety of sources examined by the US EPA there was a large degree of scatter in the emissions data. The highest emission rate cited in the US EPA study was an emission rate of 2,769 ng/kg of waste. This was exhibited by a stream involving household wastes with a high recycling effort, resulting in a high PVC content (4.5%). If this figure was applied to the emissions from a bunker fire, the overall dioxin intake to people in the vicinity would increase proportionately. Even in this case, the total intake would still be significantly lower than the WHO ceiling; the factors of safety would be reduced to:

- Nearest residence at Ringaskiddy: Factor of Safety = 147
- Closest point at Maritime College: Factor of Safety = 80

Even based on this conservative emission rate, there would still be a significant factor of safety for any people located at either potentially sensitive location.