Derby Digesters and Sludge Tanks

IED Containment Assessment-Risk Identification Report

September 2022

Severn Trent

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1.0	10/12/21	Draft	MH	SH	SG	RB
1.1	23/09/22	Final for issue	HR	PG	PG	RB

Contents

i. Background and Executive Summary

Following initial audits by the Environment Agency (EA) in 2019 that examined the primary, secondary, and tertiary containment provisions for Severn Trent's anaerobic digestion (AD) process and associated tanks, the EA reported *"there is no provision of secondary containment for the AD process at any of Severn Trent's sites. Catastrophic tank failure may impact nearby receptors and the operation of adjacent sewage treatment activities".* Jacobs were appointed to carry out an initial risk assessment of all 33 sites to establish a) the sites that pose the highest risk, and b) the highest individual risk factors at any individual site. The risk assessment and its outcomes have been reported on separately. Once all risk factors had been considered, the assessment identified Derby as presenting a high risk.

This report addresses the site-specific risks at Derby and determines the design containment volume based on a credible failure scenario.

Figure i Satellite view of Derby Sewage Treatment Works

Derby Sewage Treatment works is in the eastern region of Derby; the River Derwent lies on the south side and around the site. The boundary of the site has industrial parks. Figure i shows an aerial view of the site in the context of its nearby surroundings. An initial visit to Derby Sewage Treatment Works occurred for the purpose of site assessment and data collection.

This document should be read in conjunction with; Derby Digesters and Sludge Tanks, IED Containment Assessment-Proposed Option Report, revision 1.1 dated 23/09/2022. This report outlines the options to contain a spill from the tanks within the IED permit boundary.

Chapter 1 outlines the site-specific risks at Derby for sludge holding and digestion assets and discusses the CIRIA/ ADBA containment classification assessment.

Chapter 2 describes the site contouring, derivation of overland flow paths and any significant sludge holding tanks.

Chapter 3 determines the design containment volume based on a credible failure scenario and commentary on rainfall allowances.

Chapter 4 discusses the risks to the site from jetting.

Chapter 5 discusses the risks to the site from external flooding.

Chapter 6 discusses the potential high-level options for containment.

Chapter 7 presents the main conclusions of this assessment.

Chapter 8 (Appendix 1) presents the ABDA site hazard risk assessment completed for this site.

1. Site Specific Risks at Derby

To model the event of a credible and catastrophic tank failure resulting in loss of containment of sludge at Derby, the assets on site must be evaluated to identify the most hazardous failure events.

The principal sludge holding and digestion tanks at Derby are detailed below:

- 3 digesters, concrete of the following capacity; 3159m^3 (Digester No. 7), 3000 m^3 (Digester No. 8) and 3000m^3 (Digester No. 9)

2 Pathogen Kill Tanks (PKT), steel, each with a capacity 3663m^3

There are a number of smaller tanks each <2500 m3 within the IED permit area.

- 1 thickening sludge blending tank, steel, capacity 2245m^3
- 2 Acid Phase Digesters (APD), concrete, each with a capacity 1600m^3
- 1 Surplus Activated Sludge (SAS) Buffer Tank, steel, capacity *600m^3
- 1 primary sludge storage tank, steel, capacity 683m^3

*Estimated

For clarity, the capacities given above are the total tank capacities, i.e., the maximum volume that a particular tank could hold. In practice the operational volumes are less due to freeboard and headspace, but for the purpose of this assessment the maximum volume is used to represent worst case scenario.

The plan in Figure 1.1 below indicates the boundary of the permitted IED area and the assets contained within.

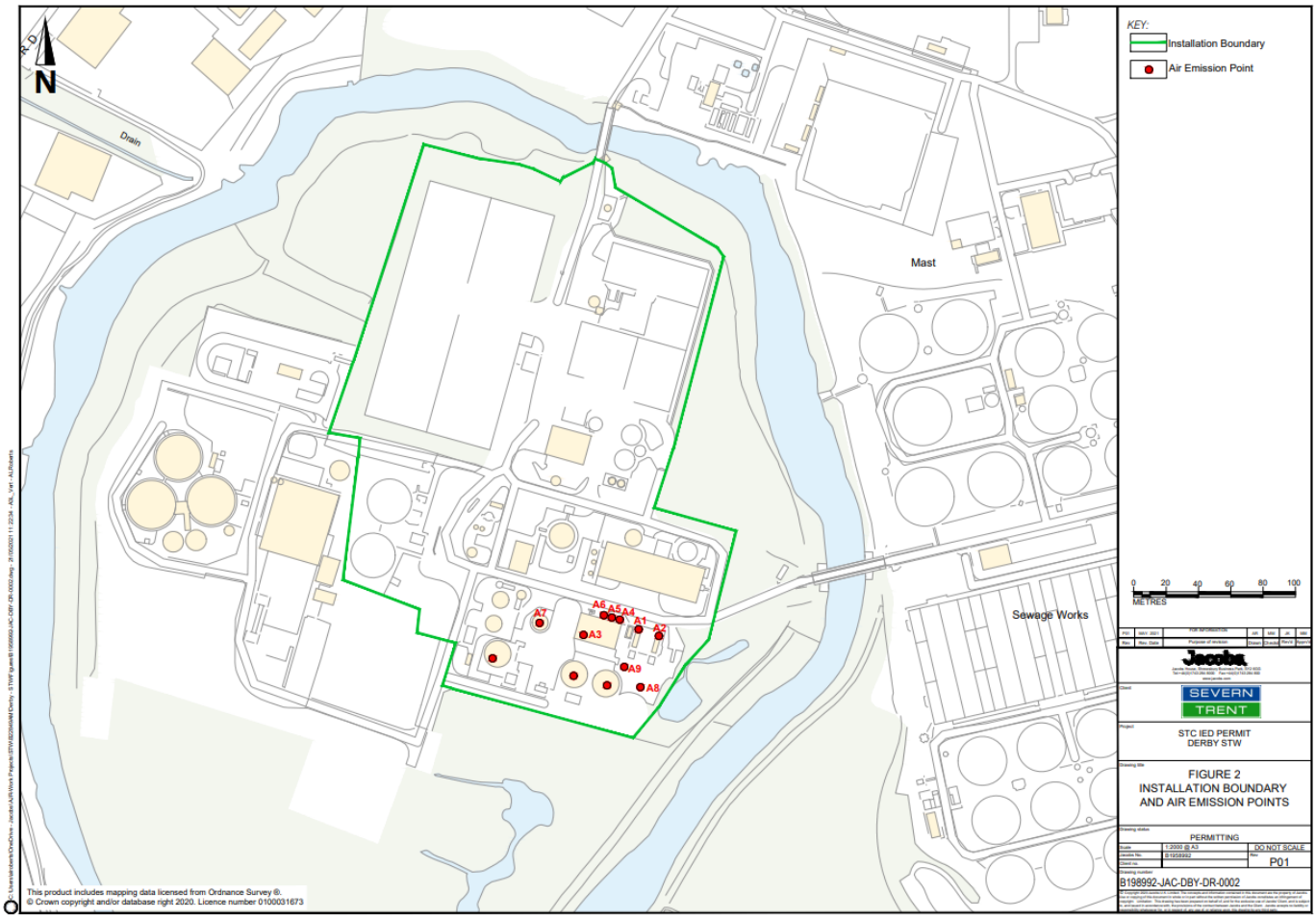

Figure 1.1 Boundary of the permitted IED area and the assets contained in Derby.

1.1 Containment Classification Assessment

CIRIA C736 states how the site hazard rating and, the site risk and classification are calculated. A summary of the hazard risks for Derby are as follows:
Source – There are two sources that have been identified:

1. Domestic and trade effluent Wastewater sludges, both in a raw, semi-treated and treated state.
2. Polyelectrolyte chemicals for sludge thickening.

The Source Hazard rating was determined as **High**.

Pathway – There are three pathways that have been identified:

1. The process and site drains take any liquid to the head of the works which would negatively impact the process stability on site and would eventually impact on the receiving watercourse.

2. The site is surrounded by River Derwent therefore in any case any spill will gravitate towards the river.

3. To the south side of the site there are several areas where a sludge spill could pass over permeable ground.

Consequently, the Pathway Hazard rating was determined as **High.**

Receptor – There are three potential receptors that have been identified

1. The site drainage system and the head of the works.

2. The River Derwent is in close proximity to the site.

3. There is a secondary aquifer present in this location.

The Receptor Hazard rating was determined as **High.**

Likelihood

A review was completed with Severn Trent Bioresources staff and the likelihood for mitigated and unmitigated risks were calculated. The probabilities outlined in CIRIA C736 section 2.5, table 2.3 were used. Scoring was completed on the basis of a loss of containment which was not necessarily a total loss through a catastrophic failure but could in fact be a partial loss through a leak of minor spillage.

Pre-mitigation measures, operational failures were highlighted as a high risk, shortfalls in design (provision of alarms and monitoring) together with structural failure were highlighted as a high risk also.

Following the implementation of Post-mitigation measures the risk was scored as **Low.**

The overall Likelihood Hazard rating was determined as **Low.**

Based on the information above the overall site risk rating was calculated to be medium which means that class 2 secondary containment is required.

Source Risk	**Pathway Risk**	**Receptor Risk**	**Site Hazard Rating**	**Likelihood**	**Overall Site Risk Rating**
High	High	High	High	Low	Medium (Class 2)

2. Flow Paths

2.1 Site Characterisation

To understand the topography of the site, LiDAR (Light detection and ranging) data was utilised from the Environment Agency (EA) National LiDAR Programme. This dataset was captured aerially and can be used to accurately measure the terrain or objects on the surface using a series of laser pulses. There are several products available as part of this programme, this project has utilised the DSM (Digital Surface Model) and DTM (Digital Terrain Model) alongside aerial imagery. The DSM was used with aerial imagery to locate any buildings or tanks within the site so these could be removed from the process. The 1m resolution DTM uses the last return of the LiDAR pulse, classified as the ground, and as part of the EA National Programme has been manually filtered to improve accuracy of the ground model.
The DTM was observed for the entire site as shown in Figure 2.1.

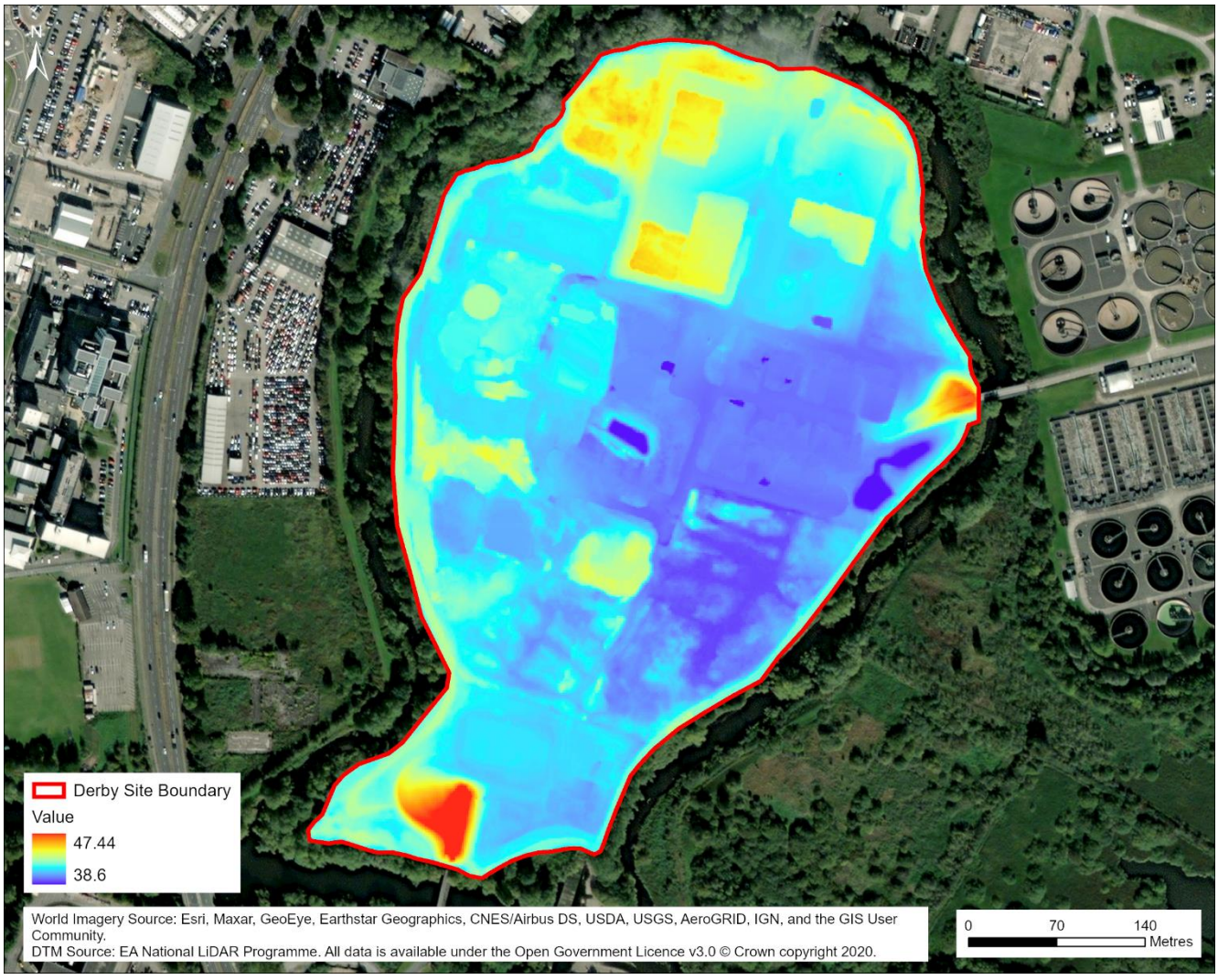

Figure 2.1 DEM/DTM Hill shade model of Derby Sewage Treatment Works Site

2.2 Uncontained spill mapping and flow paths

In order to demonstrate the location of the flow paths and the area sludge is deposited too following the catastrophic failure of the largest volumetric tank on site, uncontained flood mapping has been completed utilising Flood modeller software.

Modelling limitations

The software models the spill with a single density, a modelling tool is not available that can model all the variables associated with sludge storage and sludge spill ie. Sludge density in the tank will vary from day to day, sludge density will be different at every level in the tank and again change daily, it is likely that solids separation will occur in the area closest to the spill, but again this is variable depending upon the velocity of the liquid and the variability of the surface the sludge is travelling over.

Hydraulic modelling has been used to assess the uncontained spill following a catastrophic failure of the largest digester tank within the site. The 2D model generated uses the TUFLOW software package (Version 2020-10-AC), which can be used for simulating depth-averaged, one and two-dimensional free-surface flows exhibited with floods and tides. TUFLOW's implicit 2D solver, solves the full two-dimensional, depth averaged, momentum and continuity equations for free-surface flow using a 2nd order semi-implicit matrix over a regular grid of square elements. Furthermore, it includes the viscosity or sub-grid scale turbulence term that other mainstream software omit.

The DTM used in the model was of 1m resolution and the footprints of buildings and tanks were omitted from the model. The dimensions of the tank were used to calculate a constant flow of liquid in all directions from the circumference until it was emptied. Areas with different roughness coefficients were delineated using aerial imagery e.g., liquid would flow more easily over roads and paths as opposed to vegetated ground. The model outputs are 2m resolution with a timestep of one second. The model was run until the liquid front was no longer moving. Default parameters were used in the simulation and the model was stable with a mass balance error below the acceptable 1%.

This modelling has been completed using the tank volume only, with no allowance for rainfall.

Figure 2.2 below indicates the pathways and depths of sludge applicable to Derby.

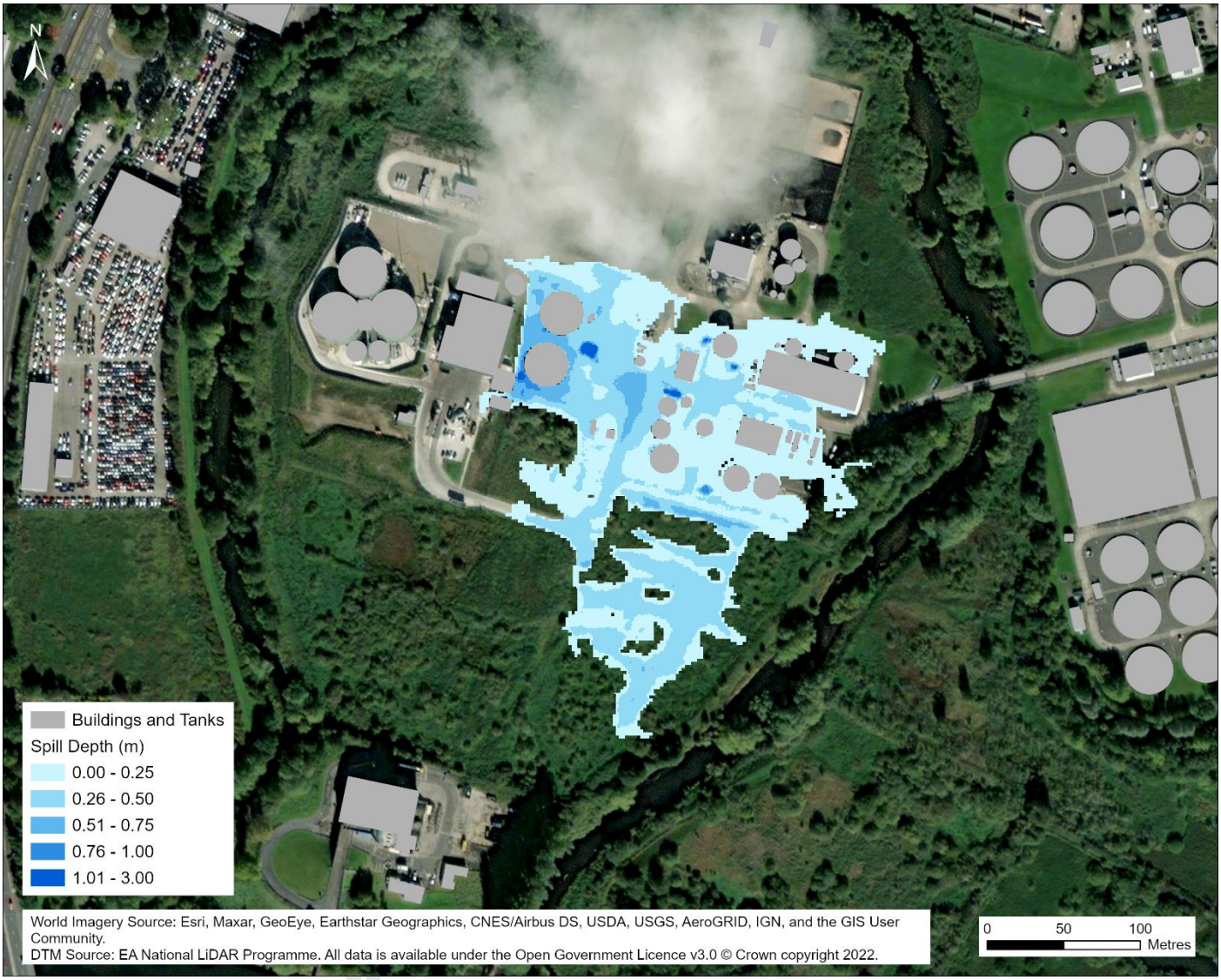

Figure 2.2 Uncontrolled spill of Derby Sewage Treatment Works

2.3 Assets impacted by the spill

In the event of losing the full contents of the largest tank on site, the following assets will be impacted:

- 3 x Sludge Digesters
- 2 x Pathogen Kill Tanks (PKTs), also known as Secondary Digesters
- 3 x Acid Phase Digesters (ADPs)
- 1 x Sludge Thickening Building
- 1 x Sludge Blending Tank
- 1 x Surplus Activate Sludge (SAS) Buffer Tank with the proposed containment area

Spill modelling indicate that the spill contents would be fully retained within Severn Trent's boundary and doesn't reach the river Derwent. Figure 2.3 illustrates the site annotated with principal sludge holding and digestion tanks, significant buildings, and boundary for the area of study.

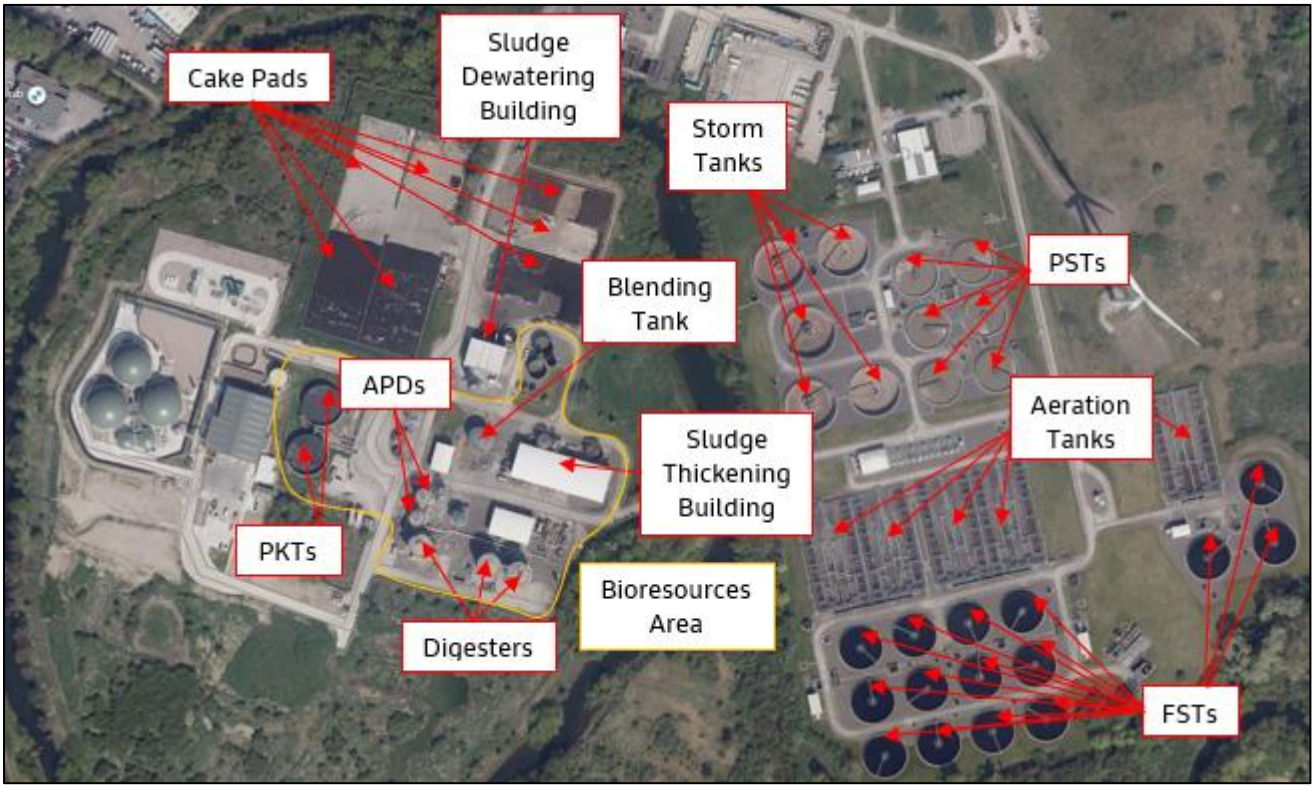

Figure 2.3 Labelled image of Derby Sewage Treatment Works

3. Loss of stock from most credible failure scenario

CIRIA C736 states that in determining containment requirements, the volume of spill should be based on the loss from a credible scenario, this need not necessarily involve the entire site inventory. To determine the most credible failure scenario the existing assets need to be considered.

3.1 Condition of Assets within the IED permit boundary

The principal sludge holding and digestion tanks at Derby are detailed below:

- Two Pathogen Kill Tanks (PKT):
    - Steel Tanks with maximum 3663 m^3 capacity, subject to weekly operational inspections.

- Three Digesters of concrete construction:
    - Concrete Digester No.7, with 3159 m^3 capacity. Mott McDonald asset and structural inspection completed 25th Aug 2021 and certified as structurally sound, next inspection August 2022.
    - Concrete Digester No.8, with 3000 m^3 capacity. Mott McDonald asset and structural inspection completed 25th Aug 2021 and certified as structurally sound, next inspection August 2023.
    - Concrete Digester No.9, with 3000 m^3 capacity. Mott McDonald asset and structural inspection completed 25th Aug 2021 and certified as structurally sound, next inspection August 2023.

There are several smaller tanks each <2500 m^3 within the IED permit area which are subject to weekly operational inspections.

- One Steel Surplus Activated Sludge (SAS) Buffer Tank.
- One Steel primary Sludge Storage Tank.
- Two Concrete Acid Phase Digesters (APD).
- One Steel thickening Sludge Blending Tank

3.2 Most credible failure scenario

When considering the most credible failure scenario to the principal sludge tanks on site, the most credible catastrophic failure scenario is failure of a single steel Pathogen Kill Tank (PKT). Since, the tanks are not hydraulically linked the maximum spill volume is 3663 m^3.

3.3 Design allowance for rainfall

In addition to the maximum volume of sludge spill in the event of catastrophic failure of the tanks, an additional allowance needs to be made for rainfall that may accumulate within the contained area before and after a spill.

The CIRIA guidance recommends that the containment volume should allow for the total rainfall accumulated in response to a 1 in 10-year return period events for the 24 hours preceding an incident and for an eight-day period following an incident, or other time periods as dictated by a site-specific assessment.

Given that Derby is a large, manned sewage works with ready access to pumps and tankers, and with a (controlled) disposal route via the sewage treatment system being available, it is considered unlikely that even a catastrophic spillage would take more than 48 hours to be pumped and drained away, therefore a 2-day post-event period has been selected.
The average 48 hours rainfall depths for a 1 in 10-year storm for Derby is 58.49 mm. It should be noted that the rainfall depths for Derby have been estimated using the depth-duration-frequency rainfall model contained on the Flood Estimation Handbook (FEH), which provides location specific rainfall totals for given durations and return periods.

4. Spill through Jetting

4.1 Jetting Flows

In addition to the analysis of spill maps for containment assessed in this report, jetting effects have also been considered to better understand the flow paths for a potential spill. Jetting is the phenomenon whereby the failure of a tank through rupture or corrosion results in the escape of a jet of liquid with sufficient force causing projection out of the tank.

Due to the location and construction of the tanks and provision of impermeable surfaces and their distance from the boundary of the containment area, there is a risk of jetting therefore jetting needs to be considered in the proposed containment option. Moving the containment boundary away from the tank stock is an option to be considered in detail design.

Figure 4.1 below details the method for determining the necessary height and distance of a bund wall from a given tank to prevent jetting.

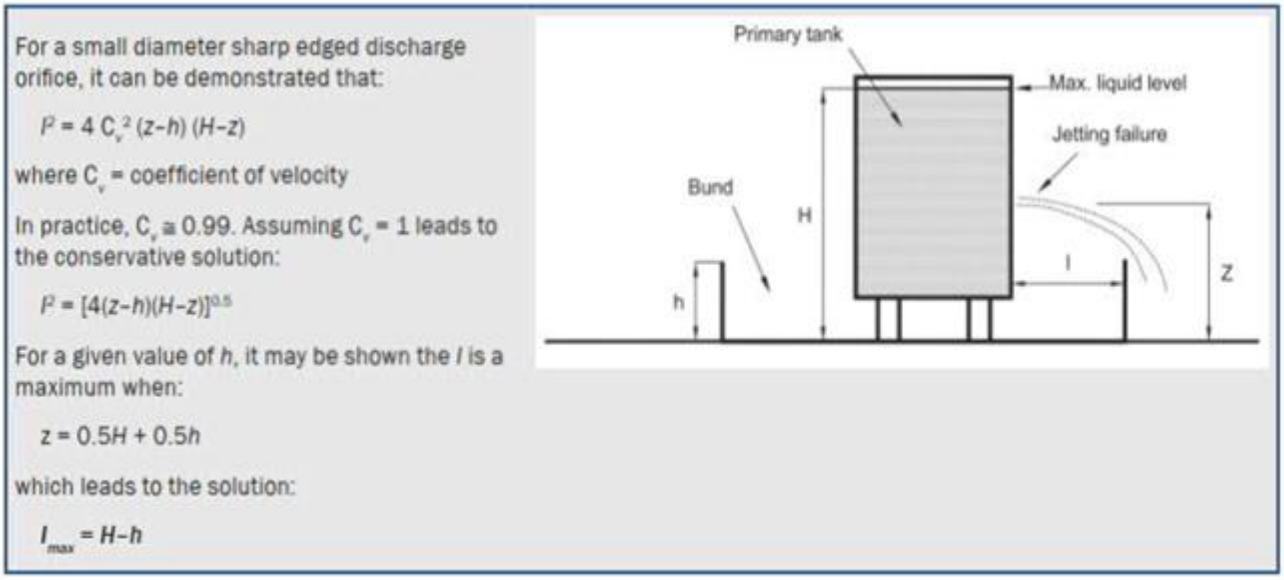

Figure 4.1 Extract for tank jetting consideration, CIRIA guidance document C736 (Containment systems for the prevention of pollution – Secondary, tertiary, and other measures for industrial and commercial premises, 2014)

5. Flooding

According to the UK Government's Flood Map for Planning, the Bioresources Area is in Flood Zone 2 as shown in Figure 5.1. The Flood Zone definitions shown in Table 5.1 detail the likelihood of the Bioresources Area flooding, which has between a 1 in 100 and 1 in 1000 probability of river flooding. Based on the location of the river and Zone 3 flooding shown in Figure 5.1, it can be inferred flooding would approaches from all sides. This can be mitigated in the design of the containment solution. Additionally, in the Flood Risk Vulnerability Classification, sewage works are classified as 'less vulnerable,' if adequate measures to control pollution and manage sewage during flooding events are in place.

The provision of containment to the sludge assets in this area does impact on the available area available for flooding. It is proposed to provide pipe penetrations through the containment bunding / walls in strategic locations, together with the provision of non-return valves or slam shut valves, simply allowing flood water in, stopping sludge flowing out in the event of a major spill. This option will be progressed during detailed design and the relevant EA permissions sought.

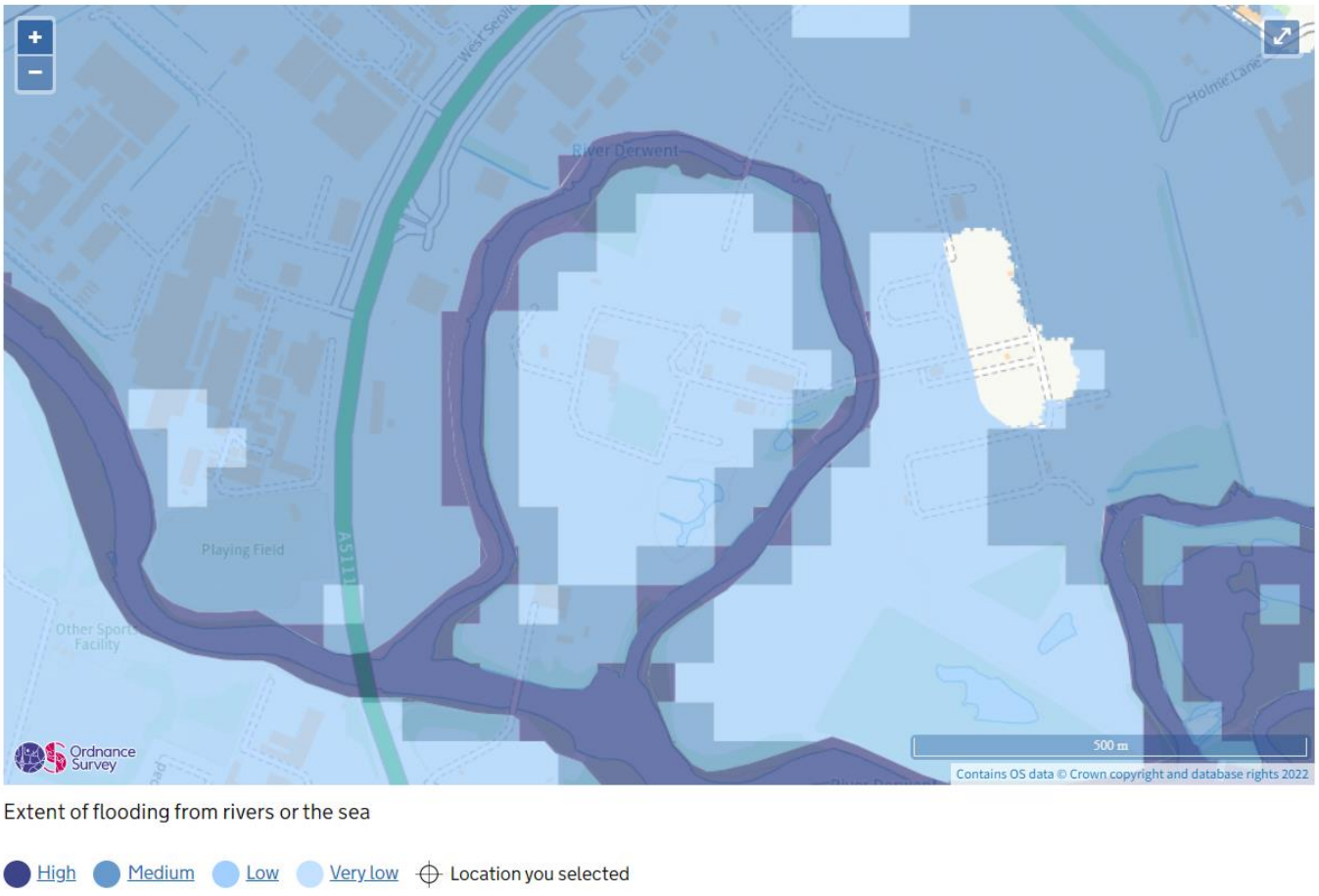

Figure 5.1 Extent of Fluvial flooding due to extreme weather events

Table 5.1 Flood Zone Definitions from GOV.UK Flood Map for Planning

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding.(Land shown in dark blue on the Flood Map)

6. Potential Options

There are several options which need to be considered as part of the optioneering to deliver containment at the Sludge Treatment Centre. This optioneering has not yet been carried out and hence some of the proposed options may not be appropriate for the site on a cost, engineering, space or practicality basis.

Some of these options are applicable across several sites, while others are site and location specific. It is possible that more than option may be appropriate at a single site, on an asset specific basis, rather than using a single concept at the site.

If any of the incoming power supply and combustion assets are impacted by a potential spill which would impact on their ability to function, Severn Trent will seek to either re-locate or protect them with a specific containment solution

The high-level containment options are tabulated below, followed by an overview of some of the options, with regards to their practicality at the specific site. Some options may not relate to specific tanks but involve the movement of other assets such as pumps, pipework, or the biogas systems to minimise the risk of damage to these in the event of a spill. This may involve relocating assets or raising them above their current level, which may alter available volumes close to tanks impacting upon bunding requirements with regards to location and height.

6.1 Potential Option of containment

High Level Option	Details	Scope	Applicability
Replacement of tanks	Existing tanks replaced by assets which are double skinned or integrally bunded.	May apply to all tanks or a subset of tanks	Will depend upon the assessed current asset lifespan. Integral bunding practicality may be influenced by tank volume
Replacement of tanks	Resizing of existing tanks to reduce either the overall number of tanks, or potential volume in a containment failure scenario	May apply to all tanks or a subset of tanks	Will depend upon the assessed current asset lifespan. May increase overall number of tanks on site. May reduce site resilience due to reduced storage volumes
Installation of tank farm bunding	Bunding of tanks on either an individual basis	May apply to all tanks or a subset of all tanks	May be used on all tanks, however, likely to involve changes to existing pipe

	or for a group of closely spaced tanks		runs and pumping requirements, to reduce the requirement for bund penetrations by pipes. May impact on access to individual tanks For some assets, may lead to potential confined space or DSEAR concerns
Use of Tertiary containment	Remote bunding of tanks, which may include use of existing assets to capture spillages, such as roadways or open space	May apply to all tanks or a subset of all tanks	Likely to be applicable to all sites. However, may lead to increased requirement for impermeable surfacing to reduce infiltration in designated spill containment areas. Will depend on existing site infrastructure and may lead to land sterilisation issues
Installation of increased diameter drains and wet wells	Installation of increased diameter drainage locally to capture more of a spillage, linked to wet wells to hold spillages, prior to return to works inlet	May be possible for some tanks but will depending on existing drainage infrastructure.	May be applicable for single or multiple tanks, but the larger the covered area, the greater the potential volume needed to account for rainwater May be limited in use due to ground conditions and subsurface asset locations May have carbon related impacts due to increase in pumping requirements
Construction of sumps	Construction of engineered, sealed, sumps, to increase storage capacity locally in the event of a loss of containment	May be possible for some tanks, but likely to only have potential for a limited storage volume	Likely to be applicable mainly for smaller tanks May be limited in use due to ground conditions and subsurface asset locations

			May create confined spaces or raise DSEAR concerns.
Tank construction	Change to asset standards to reduce the potential risk of tank failure	May apply to tanks if they are being replaced	Will not remove need for containment, but may alter the failure mode, impacting on the speed of a spillage occurring and volume involved. Potential carbon related impacts
Process changes	Changes to process technology and techniques to reduce the requirement for post digestion storage duration to achieve the required pathogen kill level	Applicable to sites without advanced digestion techniques	May reduce to the overall volume of sludge stored reducing containment requirements. However, may increase dewatering requirements and associated storage volumes May have wider impact on works, such as changes to gas yield or requirement for liquor treatment
Movement or raising of ancillary assets	Movement of assets such as pumps, pipework and the biogas system in order to raise it above the potential spill level local to those assets.	All assets which may be impacted by a sludge spillage within the spill mapped area	Applicable to all assets which may be impacted by a loss of containment. May involve raising levels locally through installation of plinths or similar, altering the existing spill mapping. May have carbon related impacts due to increase in pumping requirements
Site closure	Closure of sludge assets, with transfer of sludge to alterative treatment location	Would apply to all permitted assets. Likely to only be applicable at treatment centers with lower throughputs	Will depend upon the assessed current asset lifespan. Requires sufficient capacity at alternative treatment location

			Potential for carbon impact due to transfer of sludge

7. Conclusions

This section summarises the findings of the site assessment at Derby STW for event of a credible catastrophic failure scenario of a pathogen kill tank.

Sludge spill mapping was undertaken for an event of uncontained sludge spill which showed that the spill does not reach the river Derwent, instead spreading out across the operational site.

A hazard risk assessment was carried out for Derby STW, with the site hazard rating estimated to be High and the likelihood of a spillage being classed as Low. Based on these risks, an overall site risk rating was determined to be Medium, resulting in the requirement for class 2 containment.

Digital terrain models generated show the topography of the site and identify low point where sludge spills would collect on site, namely the area immediately surrounding the Pathogen Kill Tanks. This area was subsequently identified as area of interest to perform spill mapping. The volume for sludge spills in this area was calculated and spill maps were generated. The effect of jetting has also been considered as part of this containment assessment in order to understand flow paths of a potential sludge spills in the event that damage to one of the tanks was to occur. Top water level of 40.72mAOD was estimated for the Bioresources Area. The Bioresources Area is in Flood Zone 2 according to the UK Government's Flood Map for Planning.

In the instance of a credible catastrophic failure of a sludge holding tank at Derby STW, to prevent sludge from entering the ground water or the head of the works a remote secondary containment system should be designed and implemented.

8. Appendix 1 ABDA Site Hazard Risk assessment for Derby STW

Site Name	Derby STW Containment Classification Assessment					
Revision	Date	Description	Author	Checked	Reviewed	Approved
1.0	28/09/2022	Final	P. Grant	H Rani	H Rani	R Bainbridge

Jacobs

Material	Physical properties	Quantity	units	Storage	Flammability	Corrosive	Ecotoxicity (based on LD and quantity)	Environmental hazard rating	Justifications
Feedstock									
Barley	Solid	1000	tonnes	Covered clamp	Not flammable	No	Low	L	
Chicken manure	Solid	<1500	tonnes	Covered clamp	Not flammable	Possibly	Low	M	
	Solid	>1500	tonnes	Covered clamp	Not flammable	Possibly	Low	M	
Cow manure	Liquid	<10000	tonnes	Covered tank	Not flammable	No	Low	H	
	Liquid	>10000	tonnes	Covered tank	Not flammable	No	Low	H	
Potatoes	Solid	2000	tonnes	Covered	Not flammable	No	Low	L	
Clamp Leachate	Liquid	1000	m3	Collected by	Not flammable	Possibly	Moderate	H	
Condensate from gas line	Liquid	1	m3	condensate trap	Not flammable	No	Low	L	
Slurry	Liquid	<-1000	tonnes	Covered tank	Not flammable	No		H	
Slurry	Liquid	>1000	tonnes	Covered tank	Not flammable	No	Medium	H	
Energy Crops	Solid	<50000	tonnes		Not flammable	No		L	
Energy Crop silage	Solid		tonnes	Pad	Not flammable	No		M	
Energy crop silage effluent	Liquid		m3	Covered tank	Not flammable	No		H	
Food waste	Solid		tonnes	Pad	Not flammable	No		H	
Green waste	Solid		tonnes	Pad	Possibly	No		L	
							Feedstock Overall Rating	L	Section not relevant
Process									
Digestate (fermenter)	Liquid	<1000	m3	Covered Tank or lagoon				H	Based on latest aquatic toxicity results from REA
	Liquid	1000 < X < 5000	m3	Covered Tank or lagoon				H	Based on latest aquatic toxicity results from REA
Separated digestate solids	Cake			Concrete pad				M	Largely immobile therefore presents only a medium risk.
Separated digestate liquid	Liquid			Covered tank				H	
							Process Overall Rating	H	Justification: Digestate is stored within a number of tanks
Additives and site chemicals									
Ferric Chloride	Liquid	1	IBC	IBC	Not flammable	No	Low	L	
Glycol	Liquid	1	IBC	IBC	Not flammable	No	Low	L	
Cleaning products	Liquid	1	IBC	Consumables container	Not flammable	No	Low	L	
Lab consumables	Liquid	20	litres	Consumables container	Not flammable	No	Low	L	
							Chemicals Overall Rating	L	Section not relevant
Fire fighting agents and cooling water									
Fire Fighting Agents harmful in their own right or contaminated by inventory	Liquid	>25	m3	NA	Not flammable	No	Low	L	
Fire fighting and cooling water contaminated by	Liquid	>25	m3	NA	Not flammable	No	Low	L	
							Spillages Overall Rating	L	All the hazards are "Low" therefore the overall rating is low
							Sources Overall Hazard Rating	**H**	

Pathway - the route from primary containment to receptor		Environmental hazard rating	Notes
Site layout and drainage			
If any of the site inventory has a runoff time of a few minutes...		H	Runoff time is an estimate of how long it would take to flow to the nearest receptor
If any of the site inventory has a runoff time of a few hours....		H	
If any of the site inventory has a runoff time of a few days...		M	
If any of the site inventory has a runoff time of a few weeks...		L	
Topography, geology and hydrology			
Site is raised above a nearby receptor		M	Receptors include watercourses and the underlying geology
Chalk		H	
Fractured chalk		H	
Principal Aquifer		H	
Groundwater protection zone 1		H	
etc			
Mitigation - do these apply?			
If a secondary containment system is present...		L	
If the rain water drainage system in the secondary containment fails safe...		L	
	Path & Mitigation Overall Rating	H	Justification: Estimated runoff time to receptor will be minutes/hours rather than days.
Climatic conditions			
Annual rainfall < 1000 mm		L	
Annual rainfall > 1000 mm		M	
Snow accumulation is possible		M	
Fire Fighting Water			
Inflammable materials normally present on site in large quantities?		M	
Location			
Site is in a flood plain		M	
Site is at bottom of a hill		M	
Site is connected to a sewage treatment works		M	
	Site Considerations Overall Rating	M	Justification: site is mostly within flood zone 2.
	Pathway Overall Hazard Rating	**H**	

Receptors	Within	units					Environmental hazard rating	Notes
Watercourses and								
Rivers above potable water supplies	100	m					H	
Aquifers used for public supply	150	m					H	
High quality waters	1000	m					H	
Agricultural abstraction points	50	m					M	
High value ecosystems	1000	m					M	
Recreational waters	50	m					M	
Small treatment works	50	m					M	
None of the above							L	
						Water Overall Rating	H	Justification: Site is within 200m of the River Derwent
Habitation								
Dwelling	250	m					M	
Workplace	250	m					L	
None of the above							L	
						Habitation Overall Rating	L	No dwellings within 250m, workplace within this distance but L hazard rating
Other								
SSSI/SPA/SAC	1000						L	
RAMSAR Site	1000						L	
None of the above							L	
						Other Overall Rating	L	Justification: None of the above apply
						Receptors Overall Hazard	H	

Calculated hazard ratings:			
Source	Pathway	Receptor	**Site Hazard Rating**
H	H	H	**High**

Possible Combination			Site Hazard Rating
L	L	L	Low
M	M	L	Low
H	L	L	Low
M	M	M	Medium
H	M	L	Medium
H	H	L	Medium
H	M	M	High
H	H	M	High
H	H	H	High

Risk #	Description of Risk	UNMITIGATED LIKELIHOOD	Mitigation applied	MITIGATED LIKELIHOOD
1	Operational failures, such as failure of plant, or human failure by operators	H	Annual HAZOPs and operator training	L
2	Shortfalls in design – lack of alarms and fail-safe devices	M	Pre-construction HAZOP identified measures - see P&IDs	L
3	Structural failure – materials, components, detailing, corrosion or when exposed to heat and flame	M	Inspection of vessels, asset management	L
4	Abuse – inappropriate change of use or other misuse	L		L
5	Impact, eg from a vehicle	L	Armco barriers and concrete bollards installed	L
6	Vandalism, terrorism, force majeure etc	L		L
7	Fire or explosion	L		L
8	Geological factors -subsidence etc	L		L
9	Ageing or deteriorating assets/sub-components.	M	Inspection of vessels, asset management	L
10	Lightning strike	L		L
11				
12				

Low	Site Overall Likelihood

Site Hazard Rating	Likelihood	Overall Site Risk Rating
High	Low	**Medium**