Derby Digesters and Sludge Tanks

IED Containment Assessment-Proposed Option Report

September 2022

Severn Trent

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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 containment report addresses the site-specific risks at Derby and outlines the options available for providing remote secondary containment of a catastrophic tank or digester failure.

This document should be read in conjunction with; Derby Digesters and Sludge Tanks, IED Containment Assessment-Risk Report (Revision 1.0 dated 15/08/2022) which outlines the impact of an uncontained spill and the risk assessment completed.

Figure i Satellite view of Derby Sewage Treatment Works

Derby Sewage Treatment works is located 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.

Chapter 1 provides an overview of the differing options for containment as outlined in CIRIA guidance document C736 *(Containment systems for the prevention of pollution – Secondary, tertiary and other measures for industrial and commercial premises, 2014)* and the importance of this work at Derby.

Chapter 2 details the recommended solutions to provide remote secondary containment considering containment and transfer areas for each area investigated and discusses the optimal solution at the Derby site.

Chapter 3 evaluates the surface water site drainage. Automated isolation valves linked to level indicators in the tanks are discussed to prevent shock loadings from being returned to the head of the works or sludge discharging into the river in the event of a sludge tank failure.

Chapter 4 addresses the site-specific risks identified in Derby Digesters and Sludge Tanks IED Containment Assessment - Risk Identification Report, namely jetting and fluvial flooding.

Chapter 5 presents the main conclusions of the containment assessment.

Chapter 6 (Appendix 1) presents the ABDA site hazard risk assessment completed for this site.

1. Proposed Containment at Derby

1.1 CIRIA C736

CIRIA guidance document C736 *(Containment systems for the prevention of pollution – Secondary, tertiary and other measures for industrial and commercial premises, 2014)* describes various options for containment of spillages from a credible failure scenario. It makes reference to a key plan, reproduced below;

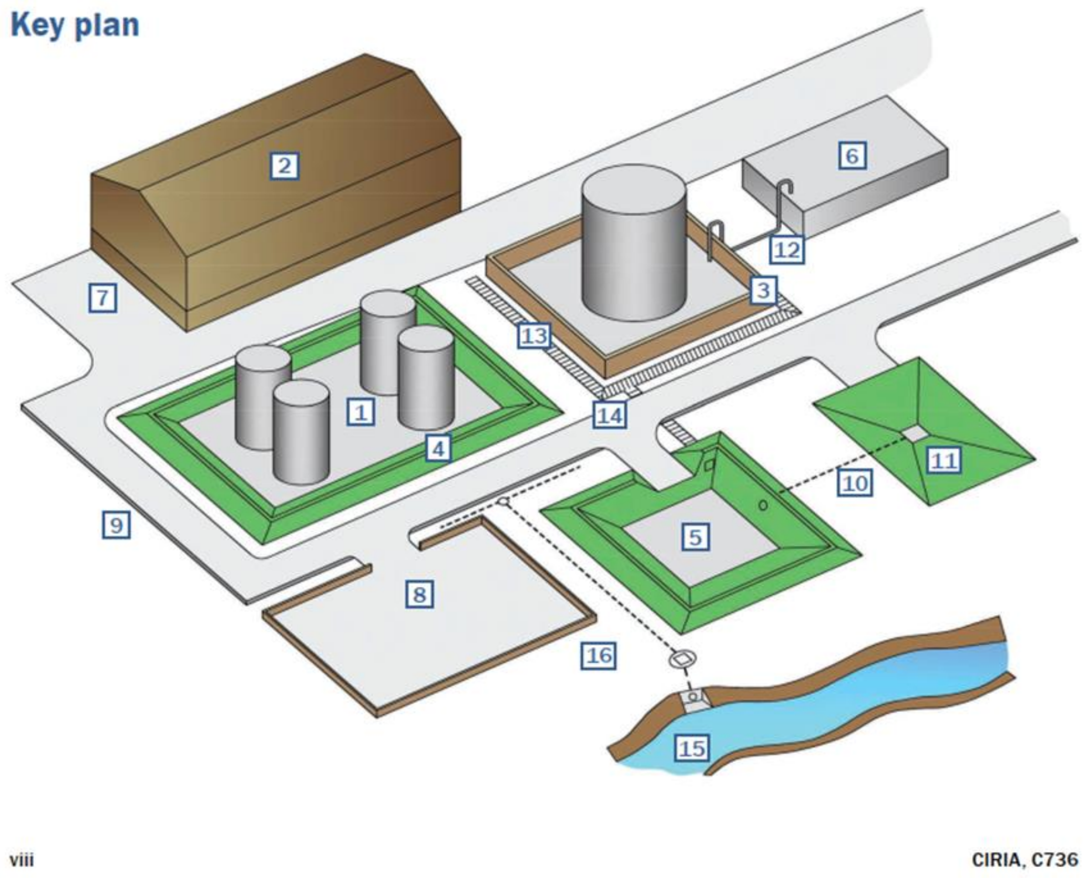


Figure 1.1 Diagram of primary, secondary and tertiary containment examples

-**Primary containment** is provided by the actual tank or vessel [1]

-**Secondary containment** is provided by a bund immediately surrounding the primary vessel e.g. [3] and [4], or by a lagoon [5] or tank [6]. If containment is provided away from the primary vessels this is known as **remote containment** and may be considered as either **remote secondary** or **tertiary containment**.

-**Tertiary containment** can be provided by a number of means including lagoons [5], or impermeable areas such car parks [8]. Roadways with high kerbing of sufficient height [9] can also form part of a tertiary containment system, or the **transfer system** to the remote containment.

-The distinction between *remote secondary* and *tertiary* containment is not always clear but, if properly designed, a combined system can be provided that is capable of providing the necessary degree of environmental protection. The overriding concern is not the terminology but the robustness and reliability of the system which depends on a number of factors such as.

- Its complexity – the more there is to go wrong, the greater the risk. Passive systems relying solely on gravity are more reliable than pumped.
- Whether manual intervention is relied on to make the system work or whether the system can be automated to include fail-safes and interlocks.
- The ease of maintenance and monitoring of the system's integrity, and repair of any defects.

During and after an incident any rainfall runoff from the remote secondary storage areas, from the spillage catchment areas and from the transfer systems must also be prevented from reaching any outfall(s) to surface water by closure of control valve(s).

1.2 Site specific risks at Derby

Based on the use of the ABDA risk assessment, considering the source, pathway and receptor risk Derby site hazard rating is deemed to be High. When considering the mitigated likelihood as low a 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)

The detailed ABDA risk assessment tool is attached in Appendix 1.

1.3 Objectives of remote secondary containment

The objectives of the remote secondary containment measures proposed in this report are to safely contain spillages from credible failure scenarios and prevent them from:

- escaping off site
- entering surface waters
- percolating into groundwater
- being pumped back to the inlet of the sewage works in an uncontrolled manner.

The remote secondary containment will be provided by maximising use of existing impermeable surfaced areas to provide a fail-safe passive system that relies on gravity rather than pumps. A means of leak detection that will automatically trigger isolation valves at key locations in the drainage system is also proposed.

1.4 Derby STW Spill Volume Summary

There are two components that contribute to the required capacity of secondary containment, the source spill volume requiring containment and rainfall. Section 4 of CIRIA 736 forms the basis of this assessment. Section 4.2 reviews current industry practice related to source spill volume, section 4.2.8 summarises current industry practice related to source spill volume in a tabular form. It can be seen from section 4.2.8 that sewage sludges and associated regulations / guidance are not listed.

Within section 4.2.1, there is detailed reference to the use of 110% of the largest tank or 25% of the total tank inventory volume, whichever is greater, and the rationale for this. CIRIA recognises that this approach is not quantitative or based on a risk assessment and are arbitrary methods. Section 4.3 and 4.4 provide guidance on a quantitative risk assessment methodology and this is what is being used for the calculation of the required capacity for containment in this report.

1.4.1 Design allowance for rainfall

In addition to the maximum volume arising from a credible failure scenario, extra allowance for rainfall that may accumulate within the contained area before and after an incident has been made. The CIRIA guidance recommends that the containment volume should include an allowance 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.

1.4.2 Total Spill Volumes

Considering a 26620 m^2 catchment area for the Bioresources Area with 58.49 mm rainwater depth, the total design containment volume comprises 3663 m^3 from catastrophic tank failure, and 1557 m^3 from 48-hr rainfall event, giving a total volume of **5220 m^3**. This volume equates to 143 % of the largest tank spill volume on site.

2. Remote Secondary Containment

The constituent parts of remote secondary containment are:

- The contained area itself.
- The transfer system.
- Isolation of the drainage from both the contained area and from the transfer system.

For Derby, where possible, existing features of the site (e.g., building structures and impermeable surfaces) are used as much as possible to provide the remote secondary containment to reduce cost. The options considered, modifications and their functionality at Derby STW are listed below:

- Impermeable linings to prevent percolation into groundwater on permeable surfaces. Existing impermeable surfaces will be utilised preferentially to provide secondary containment. The lining material could be concrete or bituminous material, or clay or a flexible membrane such as HDPE or Geosynthetic Clay Liner (GCL).
- Bund/walls to contain liquid. The heights of bund/walls given in Section 2.1 of this report are the minimum heights required such that the top of the bund/wall is equal to the top water level plus a 250mm freeboard consideration. This includes 100mm freeboard in accordance with CIRIA and 150mm to account for LiIDAR software vertical accuracy. As the topography of the area varies, the minimum required height along each bund/wall varies. Practicalities of their installation and use on site is at Severn Trent's discretion.
- Containment ramps provide a barrier for the liquid on roads that still need to be accessible to vehicles for site operation. Their heights also include a 250mm freeboard allowance. Obvious practicalities exist for containment ramps over 0.3m. Self-closing flood barriers provide an alternative if containment ramps are deemed impractical on site.
- Local infill of concrete to raise the elevation and re-direct the spill.
- Raised kerbs on roadways to channel spill to the remote containment area.

  All buildings within the containment and transfer areas must either have doors that lie above the top water levels detailed in Section 2.1 or any equipment inside must be raised off the ground to level above the top water level.

2.1 The Containment Area

2.1.1 Bioresources Area Spill topography

The topography of the Bioresources area from the highest elevations look to be on north and east side at around 41.8 mAOD. The contouring shows the lowest regions in blue. The vegetation near the east boundary of the area corresponds with the boundary of the river Derwent, that surrounds the site from every direction. The topography also slopes upwards from south to north of the area although the gradient is gentle in this direction. The lowest point in the area looks closer to the south side of the site.

Figure 2.1 Contouring map of Derby Bioresources Area

2.2.2 Containment Option

To provide sufficient secondary containment for the Bioresources Area, a total design containment volume of 5220 m^3 needs to be provided. LiDAR spill modelling predicted the top water level (TWL) when 5220 m^3 is contained in this area to be at 40.72 mAOD. Figure 2.2 below shows the physical works necessary to the Bioresources Area to enable the effective secure remote secondary containment of a spill.

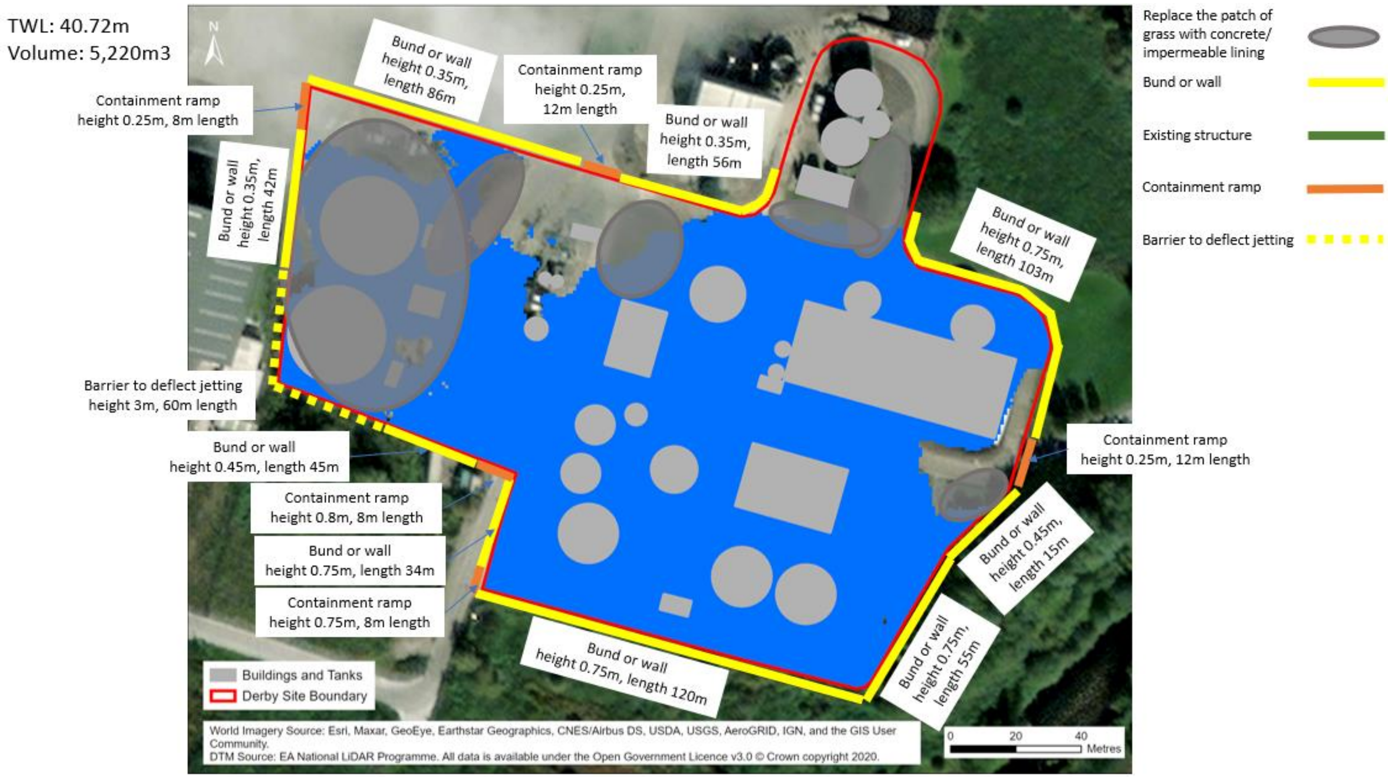


Figure 2.2 Recommended site modifications to provide remote secondary containment for Bioresources Area

This solution requires a variety of materials including impermeable lining on all grass areas, containment walls/bunding and containment ramps where the containment area perimeter crosses roads. The proposed installations aim to prevent a spill from escaping uncontrolled from the containment area.

This option has been proposed based on containing the spill to as many existing impermeable areas as possible. It is recognised that this option results in the need for significant containment ramps, bunds and walls up to 0.75m in height. The spill depth and consequently the height of any containment assets can be reduced by moving the Southern boundary further South but this would require this additional area to be provided with impermeable surfacing. It is suggested that the costs associated with ese two options are considered during detailed design.

2.2 The Transfer System

Due to the topography of the site, the transfer of liquid to the remote secondary containment occurs under gravity. At the Bioresources Area, no additional elements are needed to encourage the spill volume to transfer under gravity to a remote area, spill modelling shows most of the Bioresources Area acts as the containment area therefore no additional modifications are required.

Remote Secondary Containment Summary

A summary of the recommended containment for Bioresources Area is listed in Table 2.1. A 250mm freeboard allowance has been made in all the heights listed.

Table 2.1 Recommended containment for Bioresources Area

	Impermeable Lining /m^2	Walls/Barriers	Ramps*	Other (Isolation Valves/Building Protection/Local infill)
Bioresources Area	5 areas require impermeable lining (Total area of 2937m^2)	9 sections: • height 0.35m, length 86m. • height 0.35m, length 56m. • height 0.75m, length 103m. • height 0.45m, length 15m. • height 0.75m, length 55m. • height 0.75m, length 120m. • height 0.75m, length 34m. • height 0.45m, length 45m. • height 0.35m, length 42m. Jetting barrier: height 3m, length 60m.	5 containment ramps: • height 0.8m, length 8m. • height 0.75m, length 8m. • height 0.25m, length 8m. • height 0.25m, length 12m. • height 0.25m, length 12m.	

***self-rising flood barriers are an alternative**

Site Drainage

Site drainage assessments are based on Derby Sewage Works Layout Plan Drawing Numbers R783/001 and R783/002.

2.3 Foul, Process and Effluent Drainage

The Sewage Works Layout Plan for Derby shows all Foul/ Combined/ Process/ Effluent drainage pipes, indicated by red lines, are understood to go to the head of the works shown in Figure 3.1. In the event that sludge was to enter the head of the works, the shock load could impact the sewage works treatment process. These lines should therefore be isolated in the event of a catastrophic loss of containment and/or pumps being inhibited.

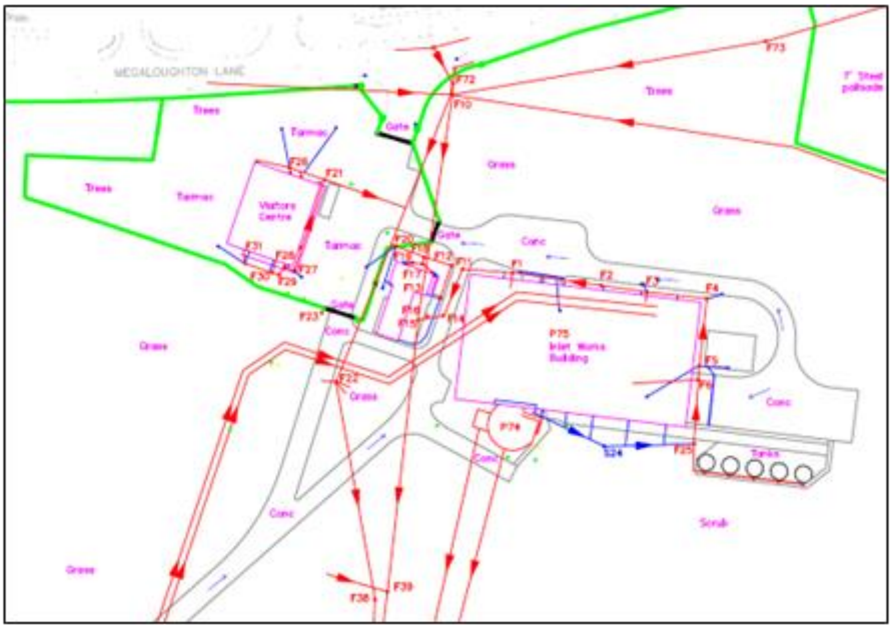


Figure 3.1 Drainage line to head of works

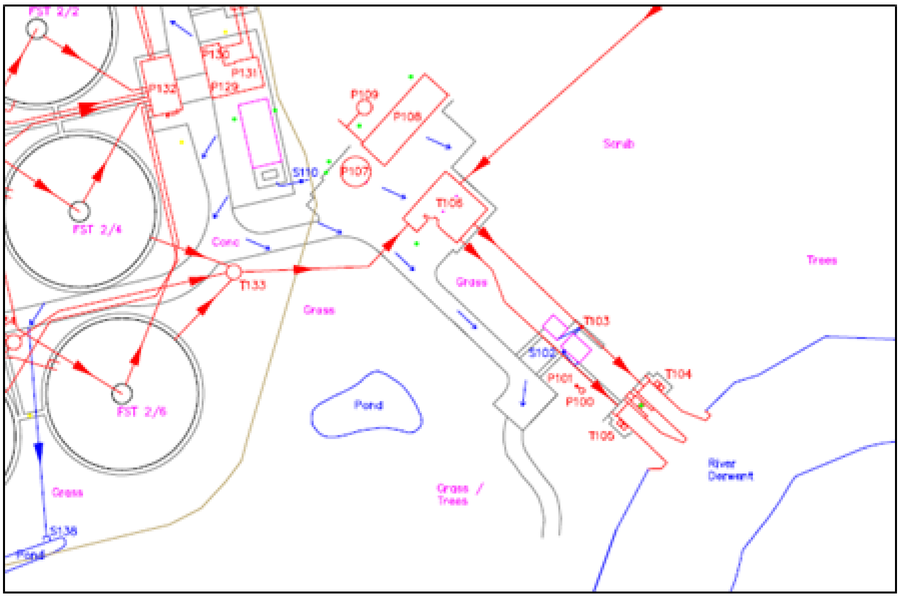


Figure 3.2 Discharge line to River Derwent

2.4 Surface Water Drainage

Surface water drainage, shown by blue lines on the sewage works layout plan for Derby, drains into the combined drainage pipes, indicated by red lines, which then would be pumped to the head of the works. For the loss of containment events explored in this report, any of the surface water manholes within the transfer and containment areas that are below the top water levels of 40.72mAOD, will be sending sludge to the head of the works. A potential means of isolation and protection from filling with sludge for these lines should be considered as part of this containment assessment (details in Section 3.3).

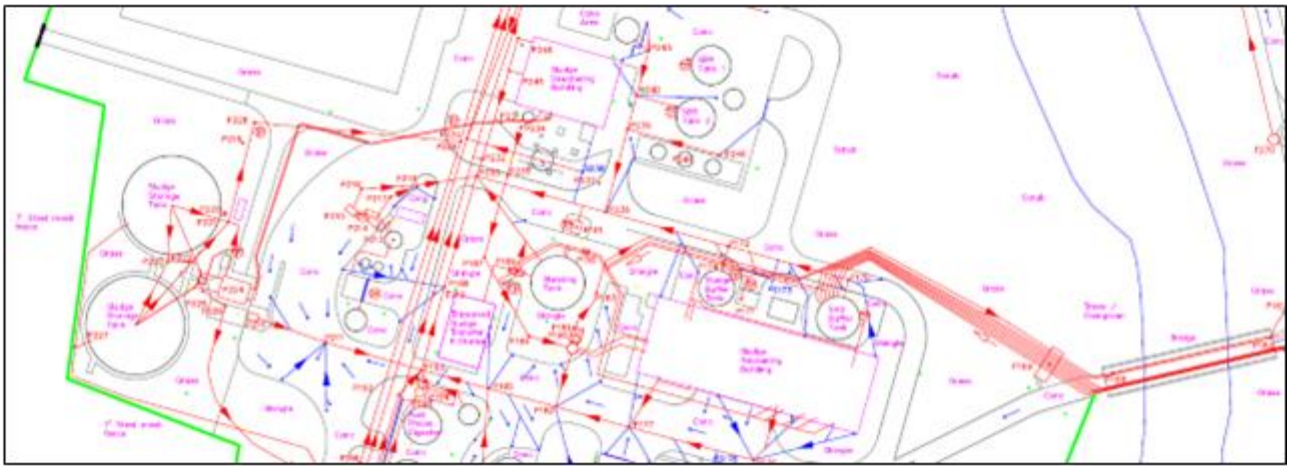


Figure 3.3 Bioresources Area surface water drainage – Plan 1 of 2

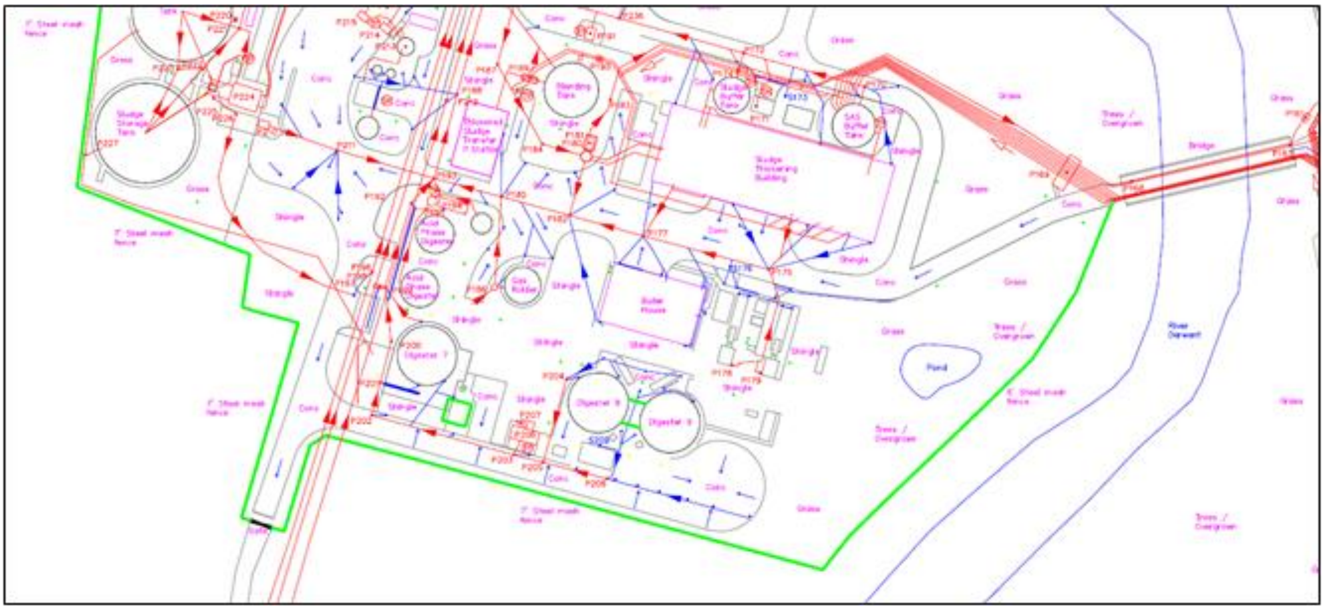


Figure 3.4 Bioresources Area surface water drainage – Plan 2 of 2

2.5 Automatic Isolation Valves

For the catastrophic loss of containment scenarios discussed, such a loss could be automatically detected by the level sensors in the tanks. A catastrophic failure would be identified by the rate of change in tank level being larger than expected at normal operation. The signal from the sensors would be used to automatically prevent any adverse impact on sewage treatment. There are two options for this;

A. Level signal automatically isolates the at-risk pipes. This would prevent large flows of digestate from entering the drainage lines to the inlet channel or river. This option requires an automatically actuated isolation valve to be installed on each of these pipes.

B. Level signal automatically inhibits sludge being returned back to the head of the i.e., allow catastrophic spillages to enter the inlet channel but prevent it from being pumped back to the head of the works. This option requires no hardware or infrastructure, only software modifications.

Option B is cheaper and easier to implement. Operators on site should however be consulted to further understand the surface water drainage system to explore any automatic isolation solutions that involve software modifications only in tripping pumps that pump from the Bioresources Area to the inlet works.

The option of the level sensor signal from an abnormal rate of change triggering an alarm system for an operator has been considered. However, the response time, particularly for nights and weekends when operators may not be on site, was deemed too slow to manually close isolation valves in a timely manner to prevent river pollution or sludge entering the head of the works having adverse consequences on its function.

Once the spillage has been stopped and contained, any sludge in the drainage system can be released back into the head of the work in a controlled manner therefore, not creating adverse effects at the inlet.

3. Mitigation of Site-Specific Risks

3.1 Jetting and Surge Flows

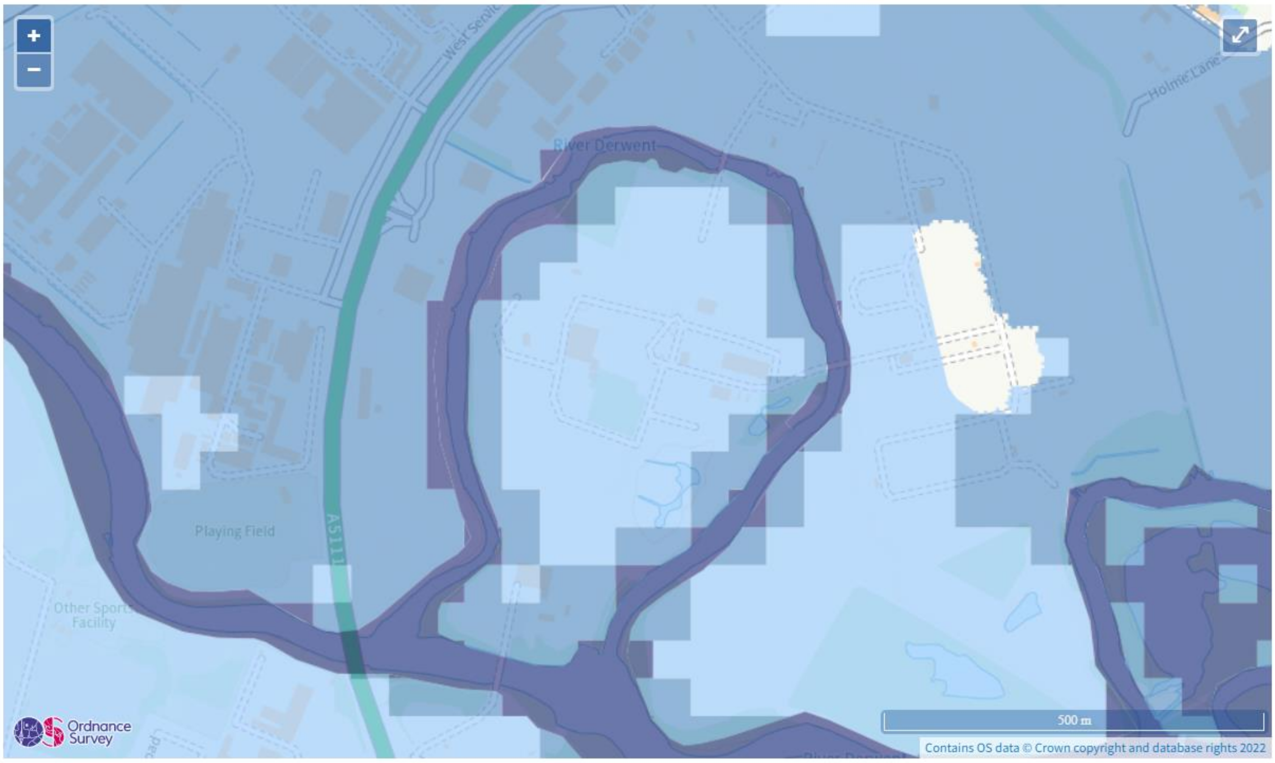
For the Bioresources Area, the spill mapping in Figure 2.2 shows that jetting flows can be of concern for the Pathogen Kill Tanks, PKT, located to the south.

This means a jetting barrier of 60m length on the south-west corner of the fence line around the PKT will be required in order to contain the sludge spilled in the event that one of the PKT fails. The PKT has a height of 6m and is a distance of 3m from the containment area perimeter, this means the jetting barrier would need to be 3m high. An alternative solution could be to utilise the grass area in front of the Severn Trent AD Power Facility and the existing building as additional containment area for jetting. However, in order for this option to be considered further confirmation of the installation of membrane lining at area beyond the boundary of the STW will require confirmation by Severn Trent AD Power Facility.

3.2 Flooding

Fluvial flooding was identified as a risk in *Derby Digesters and Sludge Tanks IED Containment Assessment - Risk Identification Report* as the Bioresources Area lies in Flood Zone 2. Considering the recommended containment structures for the Bioresources Area shown in Figure 2.2, the proposed bund/walls would prevent flooding from entering this area, however this could compromise flooding in the area downstream. It is recommended to undertake further analysis, where possible, to locate a containment flooding area which would contain the equivalent volume that has potentially been detracted from the proposed secondary containment area.

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.



Extent of flooding from rivers or the sea

High   Medium   Low   Very low   Location you selected

Figure 4.1 Extent of Fluvial flooding due to extreme weather events

4. Conclusions

This section summarises the findings of the containment assessment at sludge and bioresources areas, located at Derby sewage treatment works.

In the Risk Identification Report for Derby a containment classification report was carried out. An overall site risk rating of high was determined meaning that class 2, section 1.1 containment is needed. The detailed requirements for class 2 containment have been outlined in the Risk Identification Report in section 1.1 .

The assessment focuses on site-specific risks and outlines the options available for providing remote secondary containment of a catastrophic tank or digester failure. A list of the containment solutions proposed for containment of spills at the Bioresources Area are:

- Provision of impermeable lining (Total surface area of 2937m^2).
- Provision of walls/barriers (heights ranging from 0.35m-0.75m and a total length of 556m).
- Provision of containment ramps (heights ranging from 0.25m-0.8m and 8m long).
- Provision of a jetting barrier (3m high and 60m long). Alternatively, utilise Severn Trent AD Power Facility existing building and additional impermeable lining if an agreement can be achieved as this option, is the most cost-effective solution.
- Provision of other containment equipment including isolation valves on surface drain manholes below 40.72mAOD for the Bioresources Area.
- Raising of doors or equipment within nearby buildings and structures to 40.72mAOD.

Finally, assessment of the risk of flooding at Derby sewage treatment works based on the UK Government's Flood Map for Planning, showed that the Bioresources Area is in Flood Zone 2, which means this area has between a 1 in 100 and 1 in 1000 probability of river flooding.

5. 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

Material	Physical properties	Quantity	units	Storage	Flammability	Corrosive	Ecotoxicity (based on LD and quantity)	Environmental hazard rating	Justification
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	IVC	IVC	Not flammable	No	Low	L	
Glycol	Liquid	1	IVC	IVC	Not flammable	No	Low	L	
Cleaning products	Liquid	1	IVC	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" threfore 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**