Barnhurst STW Digesters and Sludge Tanks

IED Containment Assessment – Risk Identification Report

June 2023

Severn Trent Water Limited

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Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
1.0	17/12/21	Draft	BNB	SH	SG	RB
1.1	18/02/22	Draft – Hazard Assessment Included	BNB	SG	SG	RB
1.2	08/06/23	Final Report	HR	WL	CS	KC

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i. Background

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 was appointed to assess site risks and outline the options available for providing remote secondary containment of a catastrophic tank or digester failure across multiple Severn Trent sites. This report details the site-specific risks at Barnhurst Sewage Treatment Works (STW), the illustration of the uncontained spill event and the containment classification.

Barnhurst Sewage Treatment works is in the North region of Wolverhampton; Shropshire Union Canal lies on the north side of the site and the Autherley Canal Junction on the east side. The site is surrounded by housings from every side of the site. Figure i iFigure i i shows an aerial view of the site in the context of its nearby surroundings. An initial visit to Barnhurst Sewage Treatment Works occurred for the purpose of site assessment and data collection.

Figure i i Satellite view Barnhurst Sewage Treatment Works

This document precedes 'Barnhurst STW Digesters and Sludge Tanks, IED Containment Assessment- Option and Recommendations Report, revision 1.2' and informs the containment classification required. 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 Barnhurst STW 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 analyses the spill mapping for the Digester Area that was achieved using ArcGIS and ArcPy coding of LiDAR data and digital topographic imagery.

Chapter 4 discusses the risks to the site from external flooding.

Chapter 5 discusses the potential options of sludge containment.

Chapter 6 presents the main conclusions of this assessment.

Appendix A presents the ADBA site hazard risk assessment completed for this site.

1. Site specific risks at Barnhurst STW

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

The principal sludge holding and digestion tank at Barnhurst STW is as detailed below:

- Three digesters, in concrete construction each with 2,800 m^3 capacity;
- One pre-digestion thickening blending tank in steel construction with 900 m^3 capacity;;
- Two centrifuge feed tanks in steel construction each with 600 m^3 capacity;
- One primary buffer tank in steel construction with 300 m^3 capacity;
- One imported digested sludge holding tank in steel construction with 300 m^3 capacity (disused);
- One discharge tank in concrete construction with 300 m^3 capacity;
- One SAS Buffer tank in steel construction with 600 m^3 capacity;

For clarity, in each case the capacities given above are the total tank capacity, i.e., the nominal volume that a particular tank could hold. In practice the operational volumes are less due to freeboard and headspace, but the maximum volume is used to represent worst case scenario. The plan in Figure 1.1 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 Barnhurst STW.

The site-specific risk factors that were identified at Barnhurst STW are as follows:

- The total digester volume onsite and the number of large tanks and their individual tank capacities.
- Groundwater vulnerability is ranked as "Medium-High", information retrieved from Ground Water Vulnerability Map.
- Principal aquifer is located at this site.
- The Shropshire Union Canal Main Line is within 214m from the site is situated to the north boundary of the site. The distance between the IED permitted area and Canal is within 225m in the north east direction of the site.
- Proximity to Oxley Moor Road– the site is within 125m of this road.
- There are residentials dwellings within 250m of the site to the west and south of the site to the north-east is surrounded by fields.
- Smestow Valley is a Local Nature Reserve located within 150m to the south of the site; Four Ashes is Site of Specific Scientific Interest located within 6.22 Km to the north of the site.

Table 1.1 Designated site review

Site Name	Designation	Distance	Direction
Smestow Valley	LNR	150m	South
South Staffordshire Railway Walk	LNR	3920m	South
Waddens Brook, Noose Lane	LNR	5860m	East
Four Ashes	SSSI	6220m	North

Abbreviations:. LNR – Local Nature Reserves. SSSI – Site of Specific Scientific Interest

(Table 1.1 Reference: MAGIC.gov.uk website, accessed in May 2023)

For habitat sites, the relevant distance for consideration are: International designations (SAC, MPA, SPA and Ramsar - 10km); National designations (SSSI – 2km); Nature reserves and ancient woodland (2km). (Reference: Environment Agency pre-application conservation and screening report issued March 2023).

1.1. Containment Classification Assessment

CIRIA C736 states how the site hazard rating and, the site risk and classification are to be calculated. The ADBA risk assessment tool was used and is attached in Appendix 1. A summary of the hazard risks for Barnhurst STW are as follows:

Source – There is a source that has been identified:

1. Domestic and trade effluent Wastewater sludges, both in a raw, semi treated and treated state.

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

Pathway – There are three pathways that have been identified:

1. In event of uncontained spill. The sludge would cross site boundary in 5 minutes.

2. 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.

3. The Groundwater Vulnerability is classified as Medium-High according to Ground Water Vulnerability Map.

4. The site inclines from West to East, towards the Canal to the north side.

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

Receptor – There are two receptors that have been identified:

1. Residential area is within 250m of the site.

2. Principal aquifer is present at this site.

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 medium risk also.

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

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

Based on the information above the overall site risk rating was calculated to be high 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, open-source LiDAR (Light detection and ranging) imaging data from the Environment Agency (EA) National LiDAR Programme, was utilised. This dataset was captured aerially and used to accurately measure the terrain or objects on the surface using a series of laser pulses on 1m pulse laser beam intervals and 1km grid tiles across the whole site. ArcGIS 10.8.1 modelling software was used to analyse LiDAR Digital Surface Model (DSM)/Digital Terrain Model (DTM) and formulate coloured hill shading and contour models. 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. DTM model for Barnhurst STW shows that the site gradually slopes from south-west to north-east. Higher elevation is to the west boundary of the site, reaching 121.04 mAOD. The site slopes gradually, the central area is relatively around 111.105 mAOD high with site sloping to the north of the side reaching 101.17 mAOD.

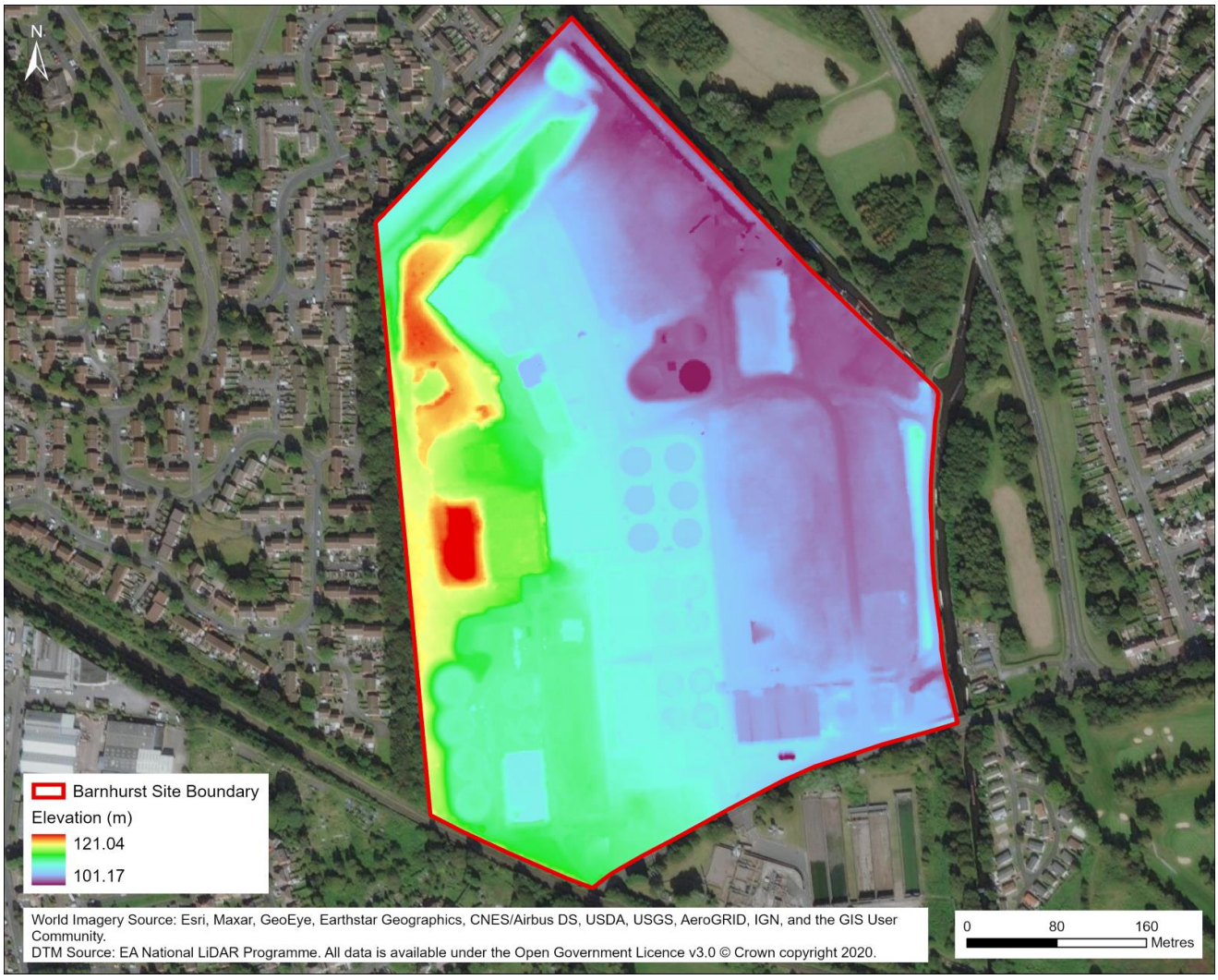

Figure 2.1 DEM/DTM imagery of Barnhurst Sewage Treatment Works Site

Figure 2.2 shows the site annotated with Gas Holder, Digesters, Solar Panels, Thickening Blending tank, SAS Buffer tank, Digested Sludge Holding tank, Pre- Thickening sludge tank, dewatering tanks, Sludge Holding tanks and significant buildings and the IED area.

Figure 2.2 Labelled image of Barnhurst Sewage Treatment Works

2.2. Uncontained spill mapping and flow paths

In order to demonstrate the location of the flow paths and the area sludge is deposited to following the catastrophic failure of sludge tank(s) onsite, uncontained flood mapping has been completed utilising Flood modeller software.

This modelling has been completed using a spill volume of 2983 m^3, which is 110% of the largest sludge asset volume onsite. This value is larger than 25% of all above ground sludge assets in the containment area. This volume had excluded the SAS Buffer tank in the calculation as this contained unthicken SAS and does not need to be considered in the IED containment assessment.

Figure 2.3 below indicate the pathway and depths of sludge applicable to Barnhurst STW. The sludge asset where spill originated is indicated on the models.

Modelling limitations

The software models the spill using a single density, a modelling tool is not available that can model all the variables associated with sludge storage and sludge spill i.e. Sludge density in the tank will vary from day to day, sludge density will be different at different levels in the tank and again different every day, 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%.

Figure 2.3 Uncontrolled spill of Barnhurst Sewage Treatment Works (Depth profile)

2.3. Assets impacted by the spill

In the event of a spill event on site at Barnhurst Sewage Treatment Works, the assets that will be impacted are three digesters, sludge holding tank and solar panels and other significant buildings and assets at the Barnhurst Sewage Treatment site, for more details please refer to Figure 2.3.

The sludge spill mapping of an uncontained event in Barnhurst STW (Figure 2.3) showed that a potential sludge spill from three digestion tanks will not be contained within the site and therefore passive containment needs to be implemented to safeguard the nearby receptors. According to the model, the spill will leave the site boundary in the north in approximately 5 minutes following failure of the tanks.

The spillage would run to the north boundary and spread into the local boat hire Service unit, Napton Narrowboats (Autherley) and consequently flow into the Shropshire Union Canal, the sludge would continue on and spread in the Canal carried by the flow of water.

3.Spill through Jetting

3.1. Jetting and surge flows

In addition to analysis of spill maps for the areas, jetting effects should also be considered to understand 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.

In the instance that tanks lie near the boundary of the containment areas discussed in the chapter, jetting may have implications on where spills accumulate. The surrounding area of the tanks, where the spill could accumulate is the impermeable area, if the sludge assembles outside the bund the sludge will penetrate the permeable area. Both the digesters and containment tanks lie near the area boundaries.

Figure 3.1 below details the method for determining the necessary height and distance of a bund wall from a given tank to prevent jetting.

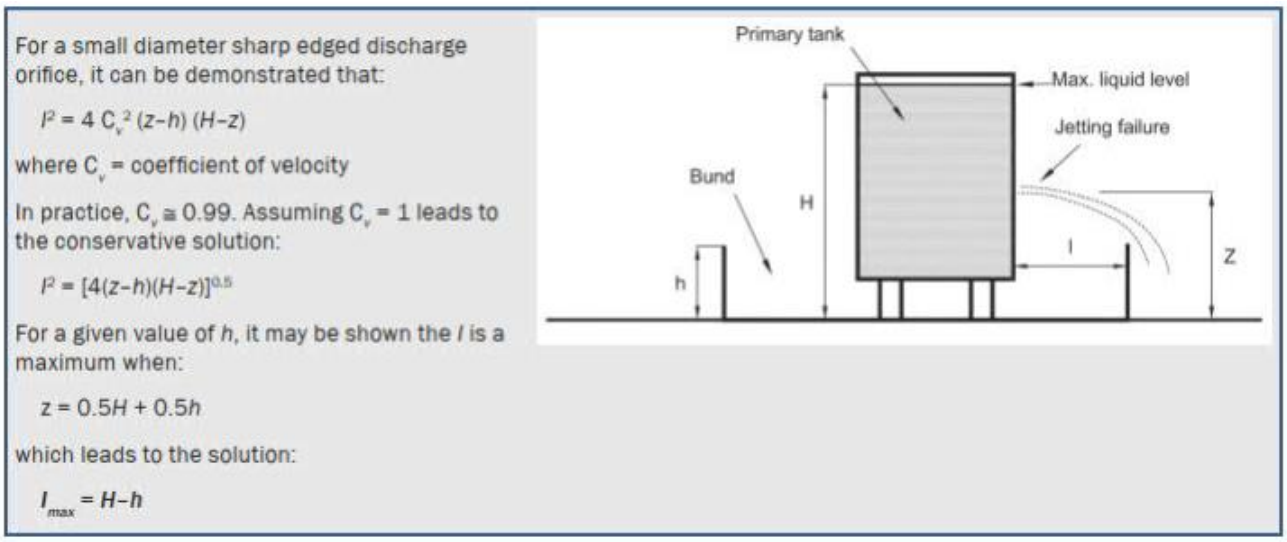

Figure 3.1 Extract for tank jetting consideration, *CIRIA guidance document C736 (Containment systems for the prevention of pollution – Secondary, tertiary, and other measures for industrial and commercial premises, 2014)*

3.2. Surge Flows

Surge effects of a catastrophic failure of the primary storage vessel will be considered in the design of the containment solution. This will consider the distance of the tanks from the bund walls and also the profile of the bund structure.

The surge allowance requirements (in the absence of detailed analysis) for different type of bund/containment structure are detailed in Table 4.7 of CIRIA C736.

- In situ reinforced concrete and blockwork bunds – 250mm surge allowance.
- Secondary containment tanks – 250mm surge allowance.
- Earthwork bunds – 750mm surge allowance.

4. Flooding

According to the UK Government's Flood Map for Planning, Barnhurst STW is not within any potential flooding zone (Flood Zone 1) as shown in Figure 4.1. The Flood Zone definitions listed in Table 4.1 provide additional detail of the areas of concern, which in the case of Barnhurst STW, have less than 1 in 1000 annual probability of river flooding. Given that the probability of flooding in the area is low, further mitigation measures are not required. 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.

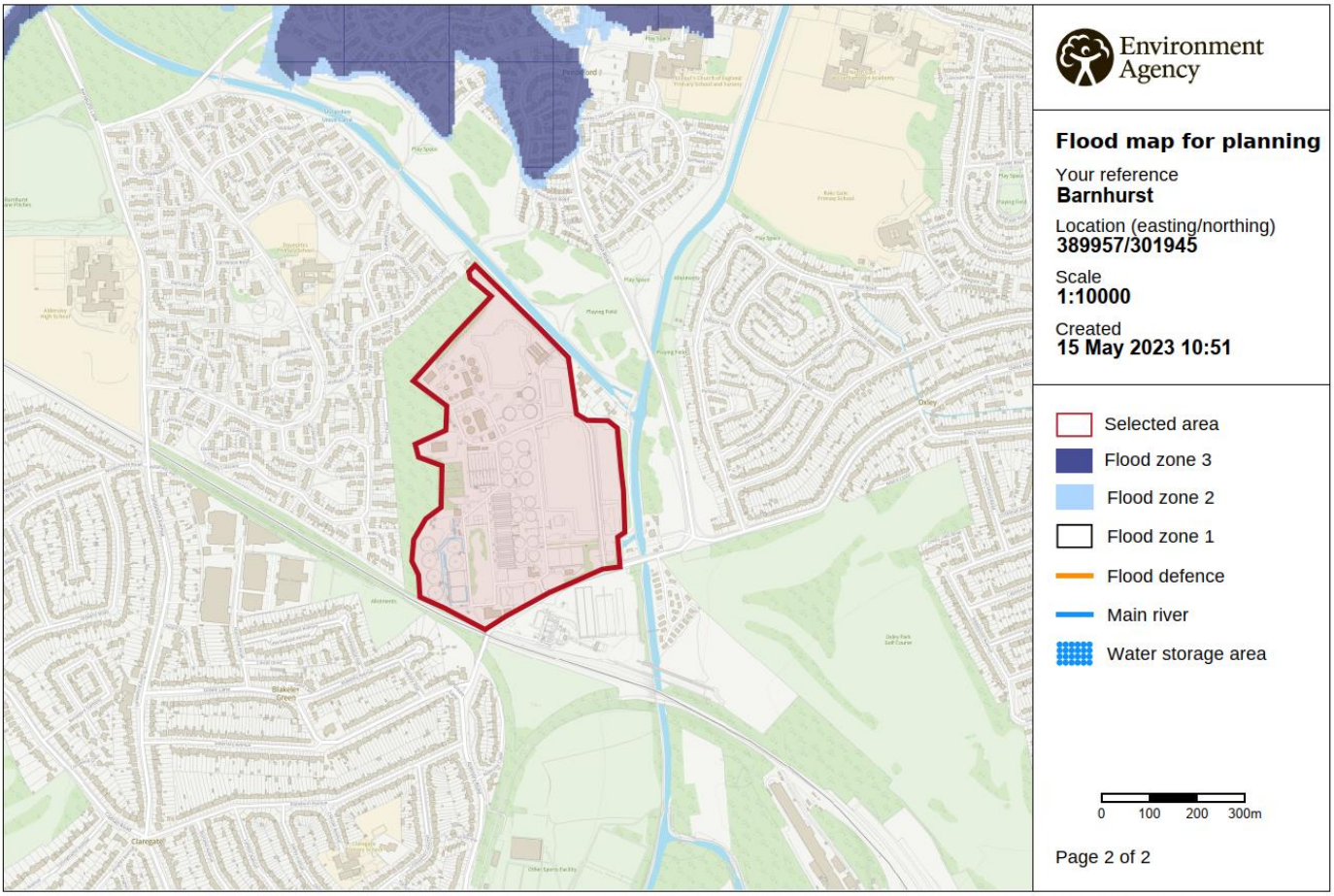

Figure 4.1 Extent of Fluvial flooding due to extreme weather events

Table 4.1 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)

5. 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 a number of 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. Potential options of containment are listed in the Table 5.1.

Table 5.1 Potential Options 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
Resizing 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 or for a group of closely spaced tanks	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 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	May apply to all tanks or a subset of all tanks	Likely to be applicable to all sites. However, may

High Level Option	Details	Scope	Applicability
	existing assets to capture spillages, such as roadways or open space		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

High Level Option	Details	Scope	Applicability
			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 centres 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

6. Conclusions

This section summarises the findings of the site assessment at Barnhurst STW for event of a credible failure of a sludge holding tank.

Sludge spill mapping was undertaken for an event of an uncontained sludge spill which showed that the spill does not self-contain within the site. According to the model the spill would leave site in 5 minutes and run to the north side and impact the local businesses and flow into the Shropshire Union Canal.

A hazard risk assessment was carried out for the site. A site hazard rating was calculated to be high, with the likelihood of a spillage being classed as low. Based on these risks an overall site risk rating was determined to be medium, meaning that class 2 containment is required.

In addition to the analysis of spill maps for the areas, jetting effects should also be considered to understand flow paths for a potential spill. In the instance that tanks lie near the boundary of the containment areas, jetting may have implications on where spills accumulate.

The site is in Flood Zone 1 according to the UK Government's Flood Map for Planning and therefore additional measures for flooding are not required.

Digital terrain models generated show the topography of the site and identify low point where sludge spills would collect on site, or flow to the north side into the Canal. The Digesters were subsequently identified as areas of interest to perform spill mapping. The uncontained sludge spill modelling shows that a potential digester failure spill will leave the site boundaries and contaminate the surroundings of the site by blocking ways of ingress to the sewage treatment works and pathways.

In the instance of a credible failure scenario at Barnhurst STW, to prevent sludge from spreading into the canal and to prevent sludge from possibly entering the groundwater, the provision of a secondary containment system should be considered.

Appendix A. ADBA Site Hazard Risk assessment for Barnhurst STW

Site Name	**Barnhurst STW Containment Classification Assessment**					
Revision	Date	Description	Author	Checked	Reviewed	Approved
1.0	08/06/2023	Final Draft	H. Rani	W Liu	C.Sfynia	K.Chiu
1.1	09/06/2023	Update following review	O. Fishwick	C.Sfynia	C.Sfynia	K.Chu

Material	Physical properties	Quantity	units	Storage	Flammability	Corrosive	Ecotoxicity (based on LD and quantity)	Environmental hazard rating	Justification
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	Three Digesters; Two dewatering Tanks; One Thickening Blending Tank; One Primary Sludge Pre-Thickening Tank; One digested Sludge Holding tank with total capacity of 10835 m3.
Additives and site chemicals									
Ferric Chloride	Liquid	1	IVC	IVC	Not flammable	No	Low	L	Not present
Glycol	Liquid	1	IVC	IVC	Not flammable	No	Low	L	Not present
Cleaning products	Liquid	1	IVC	Consumables container	Not flammable	No	Low	L	Not present
Lab consumables	Liquid	20	litres	Consumables container	Not flammable	No	Low	L	Not present
							Chemicals Overall Rating	L	Section not relevant
Fire fighting agents and cooling water spillages									
Fire Fighting Agents harmful in their own right or contaminated by inventory	Liquid	>25	m3	NA	Not flammable	No	Low	L	Not present
Fire fighting and cooling water contaminated by inventory	Liquid	>25	m3	NA	Not flammable	No	Low	L	Not present
							Spillages Overall Rating	L	Not Present
							Sources Overall Hazard Rating	**H**	Justification: Digesters, dewatering Tanks, Thickening Blending Tank, Primary Sludge Pre-Thickening Tank, Digested Sludge Holding tank are present at the site which contain digestate .

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	Sludge would leave site boundary in 5 minutes.
If any of the site inventory has a runoff time of a few hours….		H	Not applicable
If any of the site inventory has a runoff time of a few days…		M	Not applicable
If any of the site inventory has a runoff time of a few weeks…		L	Not applicable
Topography, geology and hydrology			
Site is raised above a nearby receptor		M	Site slopes from West to North- East therefore is raised above the Staffordshire and Worcestershire Canal.
Chalk		H	According to the British Geological Survey the site is not in the chalk aquifer area.
Fractured chalk		H	Not Applicable
Principal Aquifer		H	on top of a principle aquifer
Groundwater protection zone 1		H	Groundwater Vulnerability is Medium-high according to Ground Water Vulnerability Map.
etc			
Mitigation - do these apply?			
If a secondary containment system is present…		L	Not present at the moment
If the rain water drainage system in the secondary containment fails safe…		L	Not applicable
	Path & Mitigation Overall Rating	H	Justification: in event of uncontained spill the sludge would leave sites within a few minutes. The site also sits on top of the principle aquifer.
Climatic conditions			
Annual rainfall < 1000 mm		L	Annual Rainfall within 691.86 mm - 809.9 mm
Annual rainfall > 1000 mm		M	Not applicable
Snow accumulation is possible		M	Yes
Fire Fighting Water			
Inflammable materials normally present on site in large quantities?		L	Not applicable
Location			
Site is in a flood plain		M	according to UK Government's Flood Map for Planning the site is low risk from flooding
Site is at bottom of a hill		M	The site inclines from West to East, towards the Canal
Site is connected to a sewage treatment works		M	IED permitted Area is connected to a sewage treatment works
	Site Considerations Overall Rating	M	Justification: The site is a sewage treatment works
	Pathway Overall Hazard Rating	H	Justification: in the event of uncontained spill the sludge would leave site within a few minutes. The sits site on top of a principle aquifer.

Receptors	Within	units						Environmental hazard rating	Notes
Watercourses and bodies									
Rivers above potable water supplies	100	m						H	Shropshire Union Canal Main Line is within 100m from the site but is not used for potable water purpose.
Aquifers used for public supply	150	m						H	Principal aquifer is present at the site location.
High quality waters	1000	m						L	Not applicable
Agricultural abstraction points	50	m						L	No Agricultural abstraction identified via desktop analysis
High value ecosystems	1000	m						M	Smestow Valley LNR is within 200m from the site.
Recreational waters	50	m						L	Not applicable
Small treatment works	50	m						L	Not applicable
None of the above								L	Not applicable
							Water Overall Rating	H	Justification: Principal aquifer present at the site location
Habitation									
Dwelling	250	m						H	Housing is within 250m from the IED site.
Workplace	250	m						M	Small business are present within 250m from the IED site.
None of the above								L	Not applicable
							Habitation Overall Rating	H	Justification: Housing within 250 m of the STW
Other									
SSSI/SPA/SAC	1000	m						L	Four Ashes Pit SSSI 6220m north;
RAMSAR Site	1000	m						L	Not found
LNR Local Nature Reserve	1000	m						L	Smestow Valley LNR 150m south; South Staffordshire Railway Walk LNR 3920m south; Waddens Brook, Noose Lane LNR 5860m east.
None of the above								L	Not applicable
							Other Overall Rating	L	Justification: There are LNRs within 1000m, but this does not effect Hazard rating of this site
							Receptors Overall Hazard Rating	**H**	Justification: Principal aquifer present at the site location

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	Low	Site Overall 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		

Site Hazard Rating	Likelihood	Overall Site Risk Rating	Indicated Class of Secondary Containment Required
High	Low	**Medium**	**Class 2**