J840 – STC IED Containment

Beddington STC – Containment Options Report

November 2023

Thames Water

Project No: J840
Document Title: Beddington STC – Containment Options Report

Document No.:
Revision: P03
Date: 8/11/2023
Client Name: Thames Water
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File Name: B22849AZ Beddington STC – Containment Options Report

Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
P01	31/03/2023	First Issue	JH	SMNS	SC	SC
P02	20/09/2023	Updated to include overflow tanks	KG	SMNS	SC	HG
P03	8/11/2023	Coordination amendments	KG	SMNS	SC	HG

Contents

Jacobs

1. Executive Summary

Thames Water is required by the Environment Agency to provide secondary containment to their sludge treatment centres to satisfy provisions of the Industrial Emissions Directive and to safeguard the operation of the adjacent sewage treatments works. Twenty-five sludge treatment centres have been identified where containment proposals are required. This report deals with the proposals for Beddington.

Beddington STW is in the London Borough of Sutton and serves a population equivalent of 420,000. The sludge treatment centre shares the same site as the sewage treatment works.

CIRIA Report 736 – Containment systems for the prevention of pollution sets out principles and direction. This report sets out options to apply the CIRIA 736 principles within the accepted constraints of a retrofitted solution.

There are 13 tanks containing sludge of varying construction (steel, concrete plastic), the total operational sludge volume of 14,030m^3, with individual volumes varying between 25 to 2750m^3, refer to Section 3.4.1 for details on tanks and volumes. The site is generally low lying and flat with a raised embankment area enclosing the digesters up to a height around 5m above ground level. The containment volumes are split between 4 individual areas. Area 1 is driven by largest tank plus an allowance for rainfall with a spill volume of 965m^3 rather than the 25% rule (25% of total of tank volumes) or 110% (of the largest single tank). Area 2 is driven by the 25% rule with a spill volume of 2375m^3. Area 3 is driven by the 110% of the largest tank with a spill volume of 3025m^3. Area 4 is driven by largest tank plus an allowance for rainfall with a spill volume of 37m^3 rather than 110% (of the largest single tank).

An initial review, together with TW Site Operations, was carried out to confirm that the working of the sewage treatment works would not be compromised by any proposal. In the review closed containment and wide containment options were discussed. Within the discussions, failure of a primary digester tank (largest spilled tank) was addressed by adopting a wide containment area for all sludge assets as well as looking at 4 separate close containment options, with the latter seen as the most practicable in limiting interference with normal site operations. This also reduced the overall spill volume as each area could be isolated from one another. The volume of the disused digester tank has been utilized as storage volume, with minor excess spill being contained by the existing embankment shell around the operational and disused digesters. Refer to Section 4.1 for details on the options reviewed and Section 4.3 for the preferred option. Below is a summary of the preferred option:

Table 1 - Summary of preferred containment option

Containment Area	Description of containment
Sludge Buffer Tank area (Area 1)	300mm bund walls to contain initial jetting flows. Any jetting spill that is not contained by the ramps will be diverted back to the head of the works by the drainage network. Drainage sump located in northwest corner at the lowest ground level of the containment area, that is connected to a transfer pipeline to the disused digester tank in Area 2. The pipeline will have a non-return valve installed to prevent any backflows from the other containment areas. 2 large ramps will provide access for vehicles as the area is frequently visited during the day. Reprofiling of grass areas and replace with concrete as the impermeable material to a 33mAOD.
Digester Tank area (Area 2)	There are 5 operational digesters and 1 disused digester tank within a raised embankment. Transfer pipework will be connected between containment Areas 1 and 3 with a non-return valve on the pipework from Area 1 to stop back flow. To allow spills from a failing digester into the disused tank, cores through the walls within the internal chamber would be required. Any additional spill that cannot be contained by the disused tank will be self-contained by the raised embankment shell. No additional bunding is being proposed for this area.
Emergency Sludge Tank area (Area 3)	300mm bund walls to contain initial jetting flows. Drainage sump located in northwest corner that is connected to a transfer pipeline to the disused digester tank in Area 2. The pipeline will have a non-return valve installed to prevent any backflows from the other containment areas. Some ground resurfacing to concrete and reprofiling in these areas to direct flow towards the sump. Any existing concrete area will not be reprofiled and any local spill pooling in these areas are assumed to be contained by the low bunding and drainage network that returns to the head of the works. 4 ramps to provide access for vehicles and steps for pedestrians to access equipment behind containment area.
Overflow Tank (Area 4)	500mm bund walls to contain spill. Ground resurfacing to concrete. Steps for pedestrian access to overflow tank. Access is maintained in this area by the provision of two sets of stoplogs at the entrance to the containment area as well as at the entrance to the structure. As the frequency of access is very low, stoplogs (with locking bar over) are incorporated instead of gates to reinforce the planned nature of any entry into the area.

Summary	Option 1 reduces impact to operational access as ramps can be used to allow passage across containment boundaries. Minimal additional infrastructure and project cost by utilising the disused digester tank and the enclosed embankment area as storage volume. Splitting the areas into 4 allow the spill volume of each area to be isolated from each other and optimise the disused digester tank volume.

Float valves will also be installed onto surface water drains to prevent spilled sludge from returning immediately to the head of the works.

Bund heights are being set to provide freeboard considering both static conditions when the containment has been filled and during the transient condition at initial failure. There is the potential for some flow to overtop the access ramps during the conditions of the initial burst which is addressed by tertiary containment and conveyance to the site drainage system which discharges to the inlet works.

In addition to the creation of bunds, which due to space constraints are likely to be formed from concrete, existing grass or gravelled areas will be replaced with a bound impermeable material (high cement replacement concrete) to provide a surface that can be cleared of sludge to meet a four-day recovery period. Vehicular access into the containment areas is by ramps (speed humps) restricted to nom 250-300mm in height; traffic movements on site make the use of permanent flood gates impracticable. Whilst the site is identified as requiring Class 2 containment (impermeable soil with a liner), the proposed solution is intending to concrete (with no liner) on the basis of the impermeability of the concrete, inherent strength, and long-term mechanical resistance.

The general layout of the proposed solution is presented below:

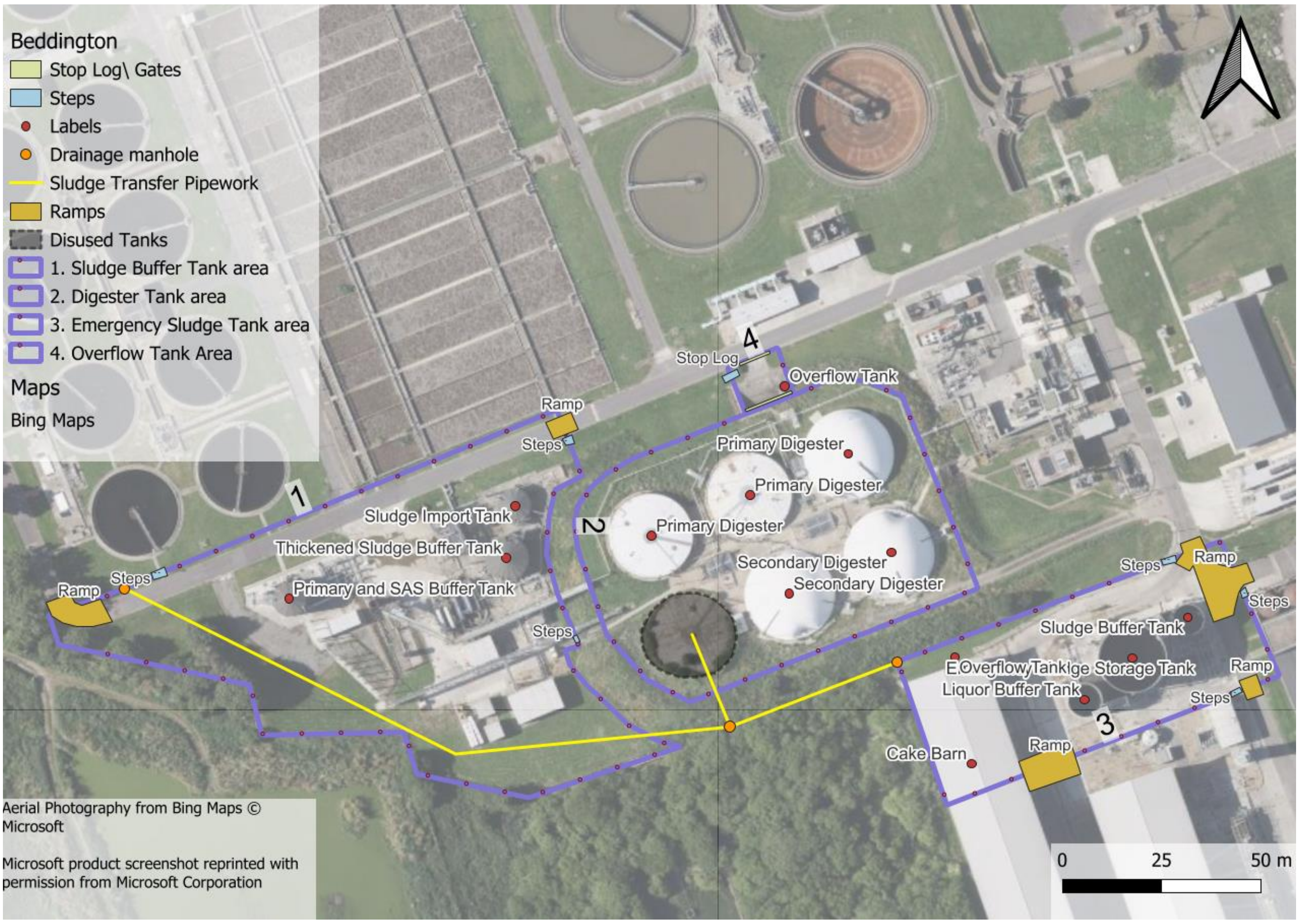

Figure 1-1 General layout of containment for Beddington STW

2. Background

Following initial audits by the Environment Agency (EA) in 2019 that examined the primary, secondary, and tertiary containment provisions for Thames Water'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 Thames Water's sites. Catastrophic tank failure may impact nearby receptors and the operation of adjacent sewage treatment activities".* Jacobs were appointed to assess site risks and outline the options available for providing remote secondary containment of a catastrophic tank or digester failure across 25 Thames Water sites. Based on CIRIA C736 and ADBA risk assessment tools this containment report addresses the site-specific risks at Beddington and outlines the options available for providing remote secondary containment in the event of a catastrophic tank or digester failure.

The current assessment identified gaps between the existing conditions of the sludge assets in Beddington STW and the requirements to meet the industrial standard (i.e., CIRIA C736 and The Anaerobic Digestion and Bioresources Association Limited (ADBA)). Site-specific risks, credible failure scenario and design containment volume for the Beddington STW were identified through a desktop study, Light Detection and Ranging Analysis (LiDAR) analysis and a site visit.

Beddington STC, contained within Beddington Sewage Treatment Works (Figure 2-1), is located between the towns of Carshalton (to the west) and Croydon (to the east). Immediately to the east of the site is the B272 Beddington Lane and then a large industrial/commercial estate. To the south are former sludge lagoons associated with the STW and residential properties. To the south-west and west are open green spaces of Beddington Park and Beddington Farmland (a potential nature site with land managed by Viridor) and to the north is the Beddington Energy from Waste facility.

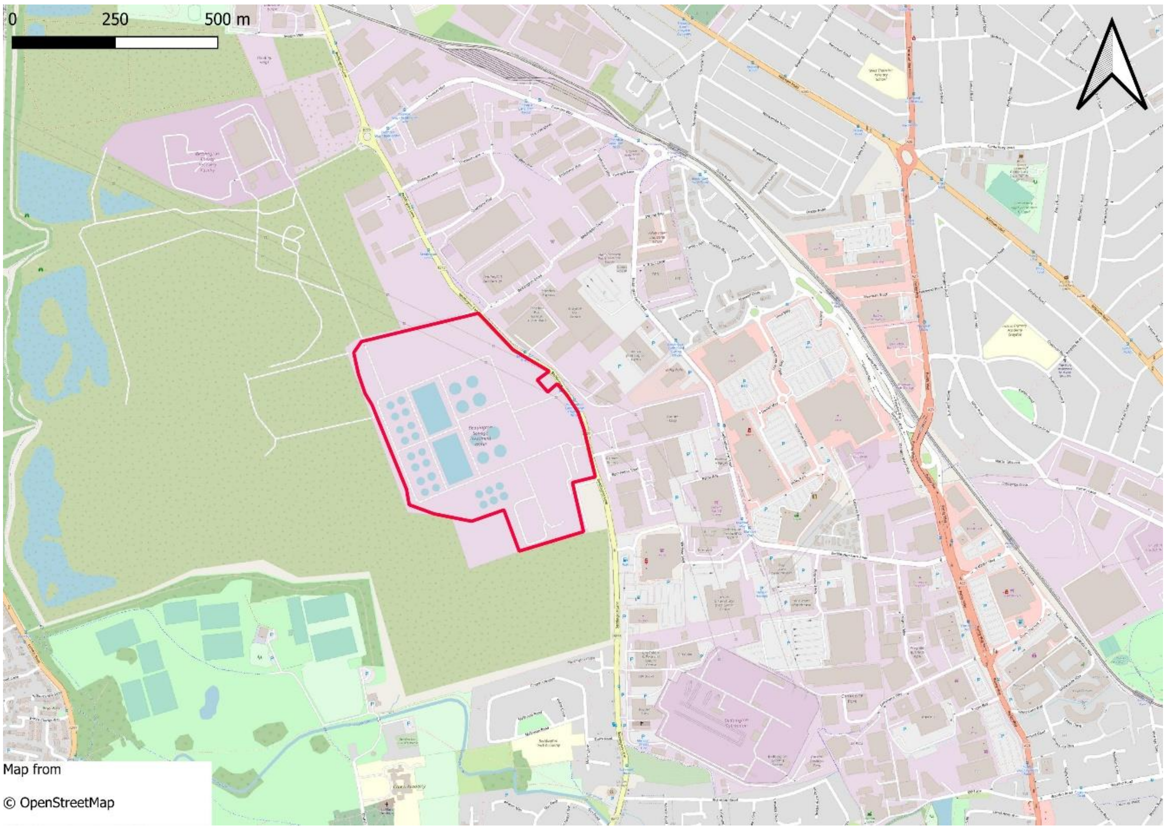

Figure 2-1 Location of Beddington STW

Figure 2-2 Satellite image of Beddington STW location next to industrial estate

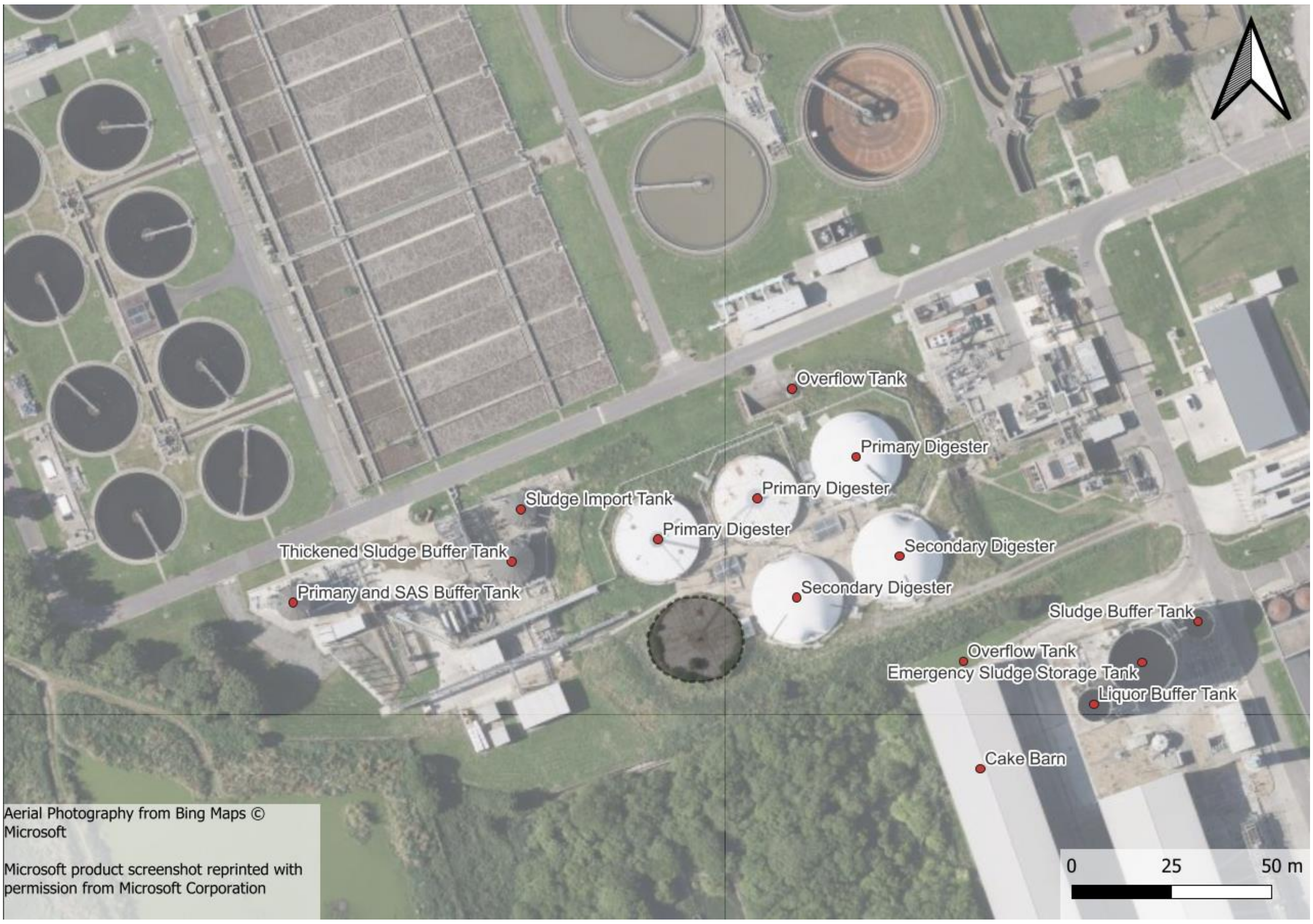

Figure 2-3 Labelled image of the assets within Beddington STW

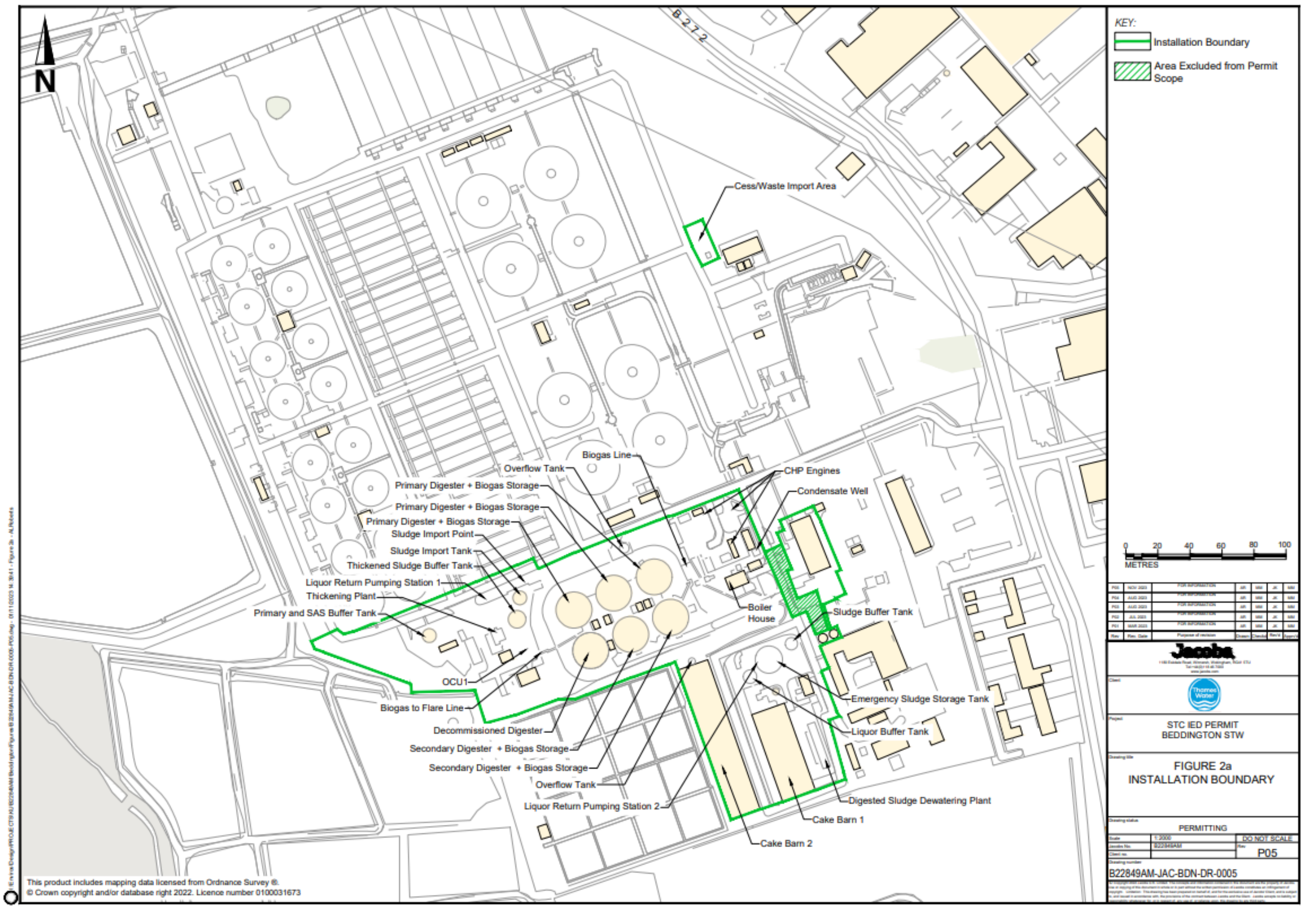

Figure 2-4 Boundary of permitted IED area and the assets

3. Proposed Containment at Beddington STW

3.1 CIRIA C736

This containment option report has been prepared using CIRIA C736 as the basis of design and guidelines. Where a deviation from C736 has been recommended it is highlighted in the text.

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;

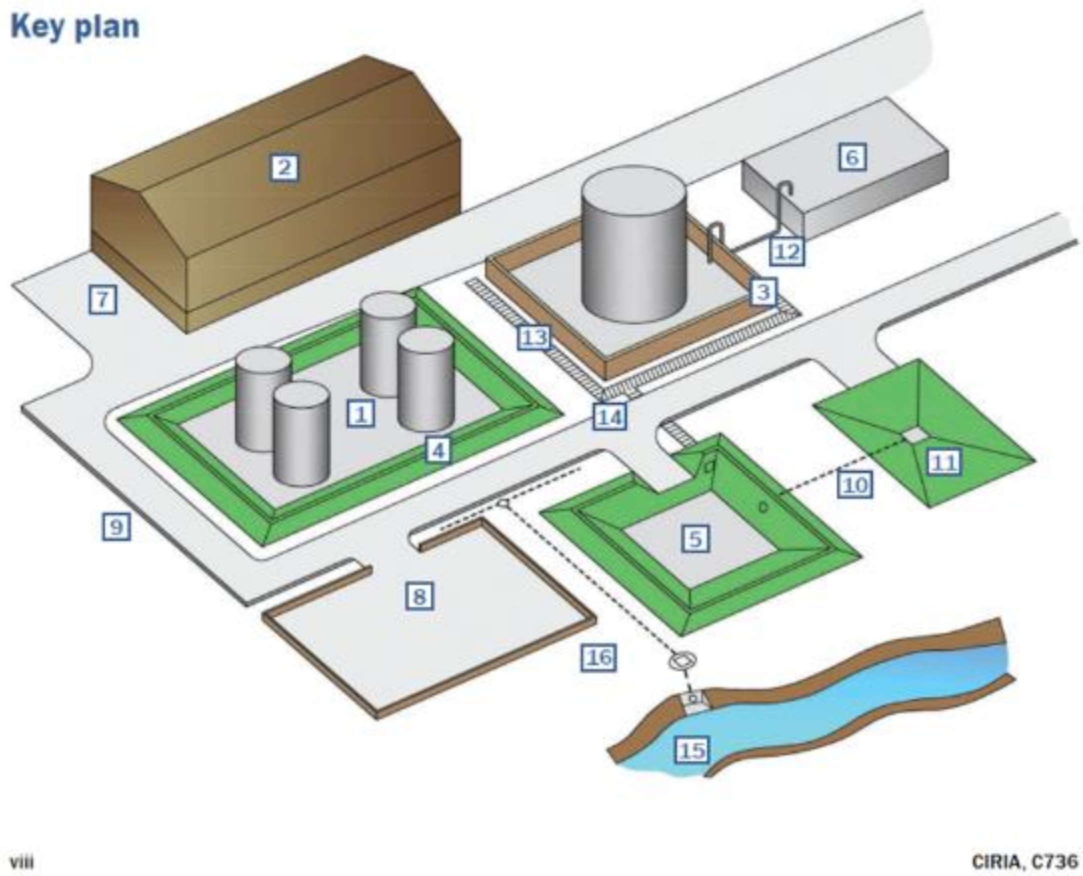

Figure 3-1 Diagram of primary, secondary and tertiary containment examples

-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).

3.2 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 the 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.

3.2.1 Uncontained Spill modelling

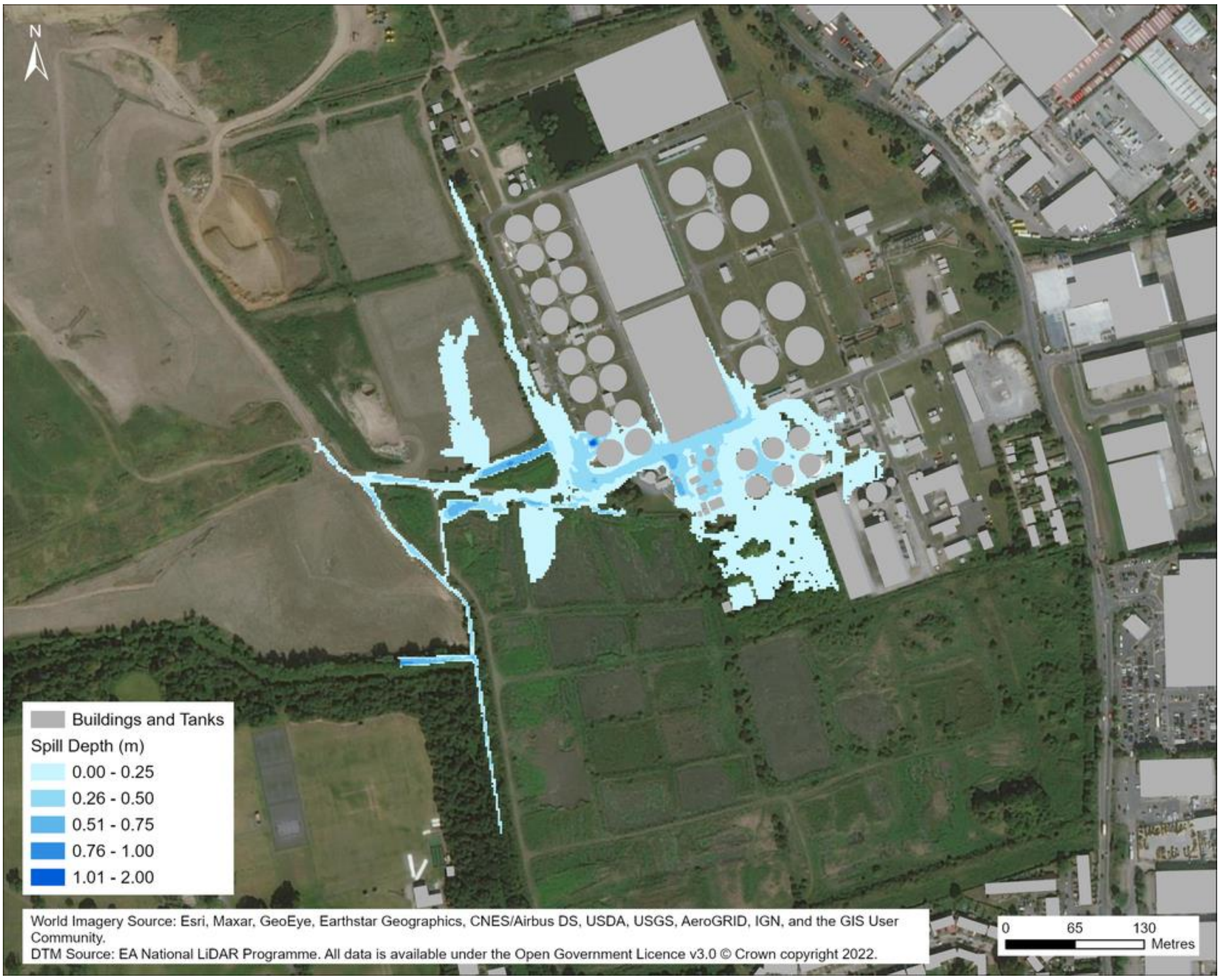

Figure 3-2 Uncontained Spill Model Results

Figure 3-2 shows the sludge spill mapping of an uncontained event in Beddington STW. The Modelling results show that a potential sludge spill from one of the primary digesters will not be self-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 west and south site boundaries in approximately 5 minutes after the failure of one of the digesters. The spilled content will travel northwest of the digesters before it flows south, due to the area in northwest side of the digesters being the lowest point on site.

The sludge travelling north, will then flow westward and will pass the Aeration lanes and the Final Settlement tanks before it leaves the site onto the footpath by Beddington Farmland. Part of the sludge may follow the path and flow to the north, but most of the sludge will remain within the southwest corner of the STW entering the Beddington Farmland area. This area consists of the remains of the old sewage treatment work and a landfill site. The site is to be upgraded to a nature reserve, and the topography of the site may undertake changes which could potentially affect how future spillages settle in this area, in the event of catastrophic failure of one of the tanks on site.

Generally, the spilled sludge would travel following the existing footpath and occasionally be directed towards the ditch and the old lagoons surrounding the pathway. Part of the sludge may flow south towards the border with Beddington Park while the rest of the sludge will leave the primary digester and flow southwards into the disused lagoons and the Cake pad area. It is expected that sludge will also flow to the east of the site where the Combined Heat and Power engines and Boiler house are located.

3.3 Site Classification Beddington

Based on the use of the ADBA risk assessment, considering the source, pathway and receptor risk Beddington site hazard rating is deemed to be high. When considering the mitigated likelihood as low a Class 2 secondary containment is required.

Table 2 - Risk rating

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

Refer to Appendix 1 for summary of the ADBA risk assessment tool.

3.4 Beddington STW Summary of Containment Requirements and assets

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 of the guidance reviews current industry practice relating to source spill volume, Section 4.2.8 then summarises current industry practice relating to source spill volume in a tabular form. It can be seen from Section 4.2.8 of the CIRIA guidance 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. Sections 4.3 and 4.4 of CIRIA 736 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.

3.4.1 Assets for Containment

The tanks for which containment is required are summarised in Table 3 overleaf:

Table 3 - List of tanks and volumes

Tank Purpose	No.	Operational Volume (m^3)	Total Volume (m^3)	Material
Primary and SAS Buffer Tank	1	443	443	Steel
Thickened Sludge Buffer Tank	1	471	471	Steel
Primary Digester Tanks	3	1900	5700	Concrete

Secondary Digester Tanks	2	1900	3800	Concrete
Sludge Buffer Tank	1	312	312	Steel
Emergency Sludge Storage Tank	1	2750	2750	Steel
Liquor Buffer Tank	1	350	350	Steel
Overflow Tank	2	25	50	Plastic
Sludge Import Tank	1	157	157	Steel
		Overall Total	14030	

3.4.2 Design allowance for rainfall

The containment volume, when not dictated by the 110% or 25% containment rules includes an 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 period as dictated by site specific assessment. Thames Water has indicated that the clean-up and return to operation is feasible in 3 to 4 days. Therefore, a three-day period following an incident has been allowed for in the design allowance for rainfall following the incident. The arising average rainfall depths for a 1 in 10-year storm over the event period for Beddington is 76.33mm. It should be noted that the rainfall depths for Beddington 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.

3.5 Identified Constraints

3.5.1 Operational constraints

3.5.1.1 Clean-up time

The time to recovery and return site back to operation has been set at 3-4 days following direction by Thames Water. The containment volume, when not dictated by the 110% or 25% containment rules allows for three days of rain during the recovery period and one day of rain immediately preceding an event.

3.5.1.2 Surface cleaning

The existing ground surfaces around the sludge treatment tanks consist mainly of grass and gravel that will need to be replaced with an impermeable surface, such as concrete, to facilitate the clean-up. The impermeable surface will be gently sloped where possible to aid with the sludge spill flow path towards the drainage network. Particularly for Area 3, the slope will direct flow towards the drainage sump and connecting pipework to the Area 2 and the disused digester tank.

It is noted that concreting these areas may slow emergency access to underground services and there is a trade-off between the advantages of digging up existing surfaces (in grass or gravel) vs. decreasing the clean-up effort required in the event of a sludge spill.

Whilst the site is identified as requiring Class 2 containment (impermeable soil with a liner and leakage detection system), the proposed solution is intending to use concrete (with no liner) based on the impermeability of the concrete, inherent strength, and long-term mechanical resistance. Remedial works to existing concrete slabs/roads will be undertaken to ensure that they provide a competent surface, for example resealing of joints.

3.5.1.3 Access and Traffic Thoroughfare

Vehicular access through the flow guiding walls will be via ramps (speed humps) restricted to nom 300mm in height and 1:15 slope.

Access is maintained in Area 4 by the provision of two sets of stoplogs at the entrance to the containment area as well as at the entrance to the structure.

To allow access on foot, steps with handrails will be constructed to allow workers to traverse the walls at Area 1 and 3. Refer to Figure 4-6 for an illustration of the step access to these areas.

3.5.1.4 Existing Services

Several above ground pipes can be seen from aerial images which may need to be relocated during construction/excavation.

3.5.2 Geotechnical and Environmental constraints

Much of the site is composed of made-up ground from previous civil works, these mounds can be seen in the map of the sites topography and will need to be considered when placing foundations for the bunding.

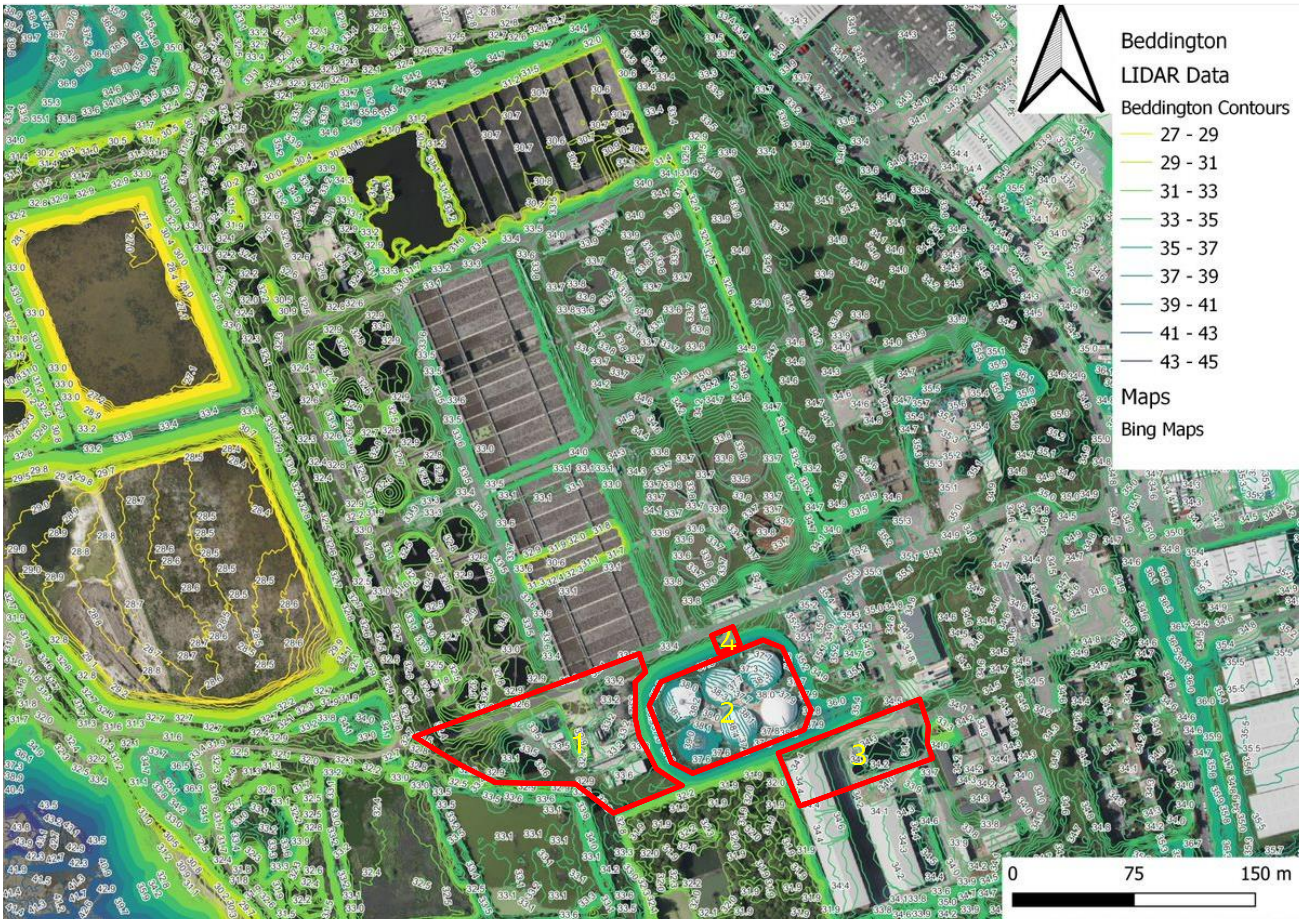

Figure 3-3 Map of Beddington STW showing areas where natural environment will be disturbed

The existing grass and shrubbery within containment Areas 1 and 3 shall be removed and area infilled with concrete. To compensate for the loss of shrubbery, alternative areas shall be identified onsite for compensation planting or planting containers installed onsite.

3.5.3 Topographical Constraints

Figure 3-4 Digital Terrain Model of Beddington Sewage Treatment Works

The STW effluent channel, which is discharging to River Wandle, is located on the northwest corner of the STW. Considering the topography of the sludge area(Figure 3-4), the high-resolution contouring revealed that the digesters are on higher ground relative to its surroundings, with the lowest ground to the northwest of these digesters, therefore the spilled sludge would flow down towards the north and west direction.

The nearest residential receptors are approximately 130m to the east of the site boundary. The site is otherwise bordered by the Beddington Farmland and Beddington Park to the west and southwest. A surface water body which is a small stream, Oily Brook, can be found approximately 20 m to the west of the installation and flows into the River Wandle, which is approximately 420 m south of the installation.

3.5.4 Other constraints

None

3.6 Planned Site Upgrade

Thames Water Operations noted minor upgrades to the site including a new Sludge Import area and Sludge Holding tank in Area 1.

- Containment construction as part of the preferred option may interfere with planned upgrades and connections. The interference is only likely to occur during construction if they are planned around a similar time. Area 1 and Area 3 consists of a low-bund wall of 300mm and this is unlikely to interfere with the location of planned upgrade works.
- The planned construction of major storage assets could potentially be combined or repurposed with sludge containment construction for a more cost-effective solution, but at this point the containment proposals seek to avoid sterilising areas with potential to accommodate new construction.

4. Secondary Containment

The constituent parts of 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 Beddington, where possible, existing features of the site (e.g., building structures, existing embankment 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 Beddington STW are listed below:

- Bund/walls to contain liquid. The heights of bund/walls given in Section 4.1 are the minimum heights required such that that top of the bund/wall is equal to the top water level plus a 250mm freeboard consideration for potential surge (to reflect the planned use of concrete walls with a recurved profile to return flow back on itself) in accordance with CIRIA.
- Containment ramps to provide a barrier for the liquid on roads that still need to be accessible to vehicles for site operation. The maximum height of these will be 250-300mm to avoid issues with vehicle passage. The risk of spill at the ramps is mitigated by conveyance of the flow to site drainage and return to the head of the works.
- Local infill of grass/gravel to create an impermeable surface and facilitate containment and conveyance.
- Steps will provide a containment barrier and allow access in and out of the containment area where foot traffic is high, but vehicular access is not needed. These steps will have handrails to facilitate safe passage over them.
- Flood gates\ stop logs to be installed where areas with foot traffic are low, but where vehicular access may be necessary.
- All buildings within the containment and transfer areas must either have doors that lie above the top water levels detailed in Section 4.1 or any equipment inside must be raised off the ground to level above the top water level.

4.1 Containment Options

Two options were investigated and developed with operations.

4.1.1 Option 1- Close Containment for 4 Individual Sludge Tank Areas

Option 1 splits the Sludge Treatment Centre into four individual areas. Listed below:

- Area 1 – Sludge Buffer Tanks Area
- Area 2 – Digester Tanks Area
- Area 3 - Emergency Sludge Tank Area
- Area 4 – Overflow Tank Area

This option aims to repurpose the disused digester tank in Area 2 to provide storage to 3 of the 4 Areas proposed. This will be achieved by providing a sump in the low point of Areas 1 and 3 allowing spills to be piped to the disused digester. The pipework from each area will be fitted with non-return valves to prevent backflow into the area.

For Area 2, penetrations will be made in the disused digester to allow any spill from the remaining digester tanks to gravitate into the tank. In addition, where required additional storage capacity can be provided within the internal chamber below the bund with the digesters.

4.1.1.1 Total Spill Volumes

Table 4 - Estimating critical spill volumes

Sludge Buffer Tank Area Containment (Area 1)		
25% Rule	286	
110% Rule	518	
Largest + rainfall	1019	Emerging critical case
Digester Tank Area Containment (Area 2)		
25% Rule	2375	Emerging critical case
110% Rule	2090	
Largest + rainfall	2307	
Emergency Storage Tank Area Containment (Area 3)		
25% Rule	853	
110% Rule	3025	Emerging critical case
Largest + rainfall	3004	
Overflow Tank Area Containment (Area 4)		
25% Rule	n/a	
110% Rule	28	
Largest + rainfall	37	Emerging critical case

For each containment area, the containment volume has been checked against the largest tank plus rainfall, the 110% and 25% rule. The largest tank plus rainfall applies to Areas 1 and 4, 25% rule applies to Area 2 and110% rule applies to Area 3.

The total design contained volumes comprise:

1. Sludge buffer tank area: 1019m^3
2. Digester tank area: 2375m^3
3. Emergency storage tank area: 3025m^3
4. Overflow tank area: 37m^3

4.1.1.2 Contained Model Output and Contour Maps

Figure 4-1 shows that the all the spills from Area1 will be contained in the disused tank at a level of 30.70mAOD. This is also below the level at the entrance to digesters internal chamber access.

Figure 4-2 and Figure 4-3 show that spills from Area 2 will fill the disused digester until around 75% of the spill volume is stored. At this point the spill starts to spread into the internal chamber settling at a level of 33.29mAOD. As with spills from Area1 this is below the level at the entrance to the digesters internal chamber access.

Figure 4-4 and Figure 4-5 show that spills from Area 3 will fill the disused digester until around 75% of the spill volume is stored. At this point the spill starts to spread into the internal chamber settling at a level of 33.67mAOD.

Manual calculations were undertaken for Area 4, due to small area and small spill volume. This has indicated that the spill level will be 34.23mAOD assuming an average ground level in the area of 34mAOD.

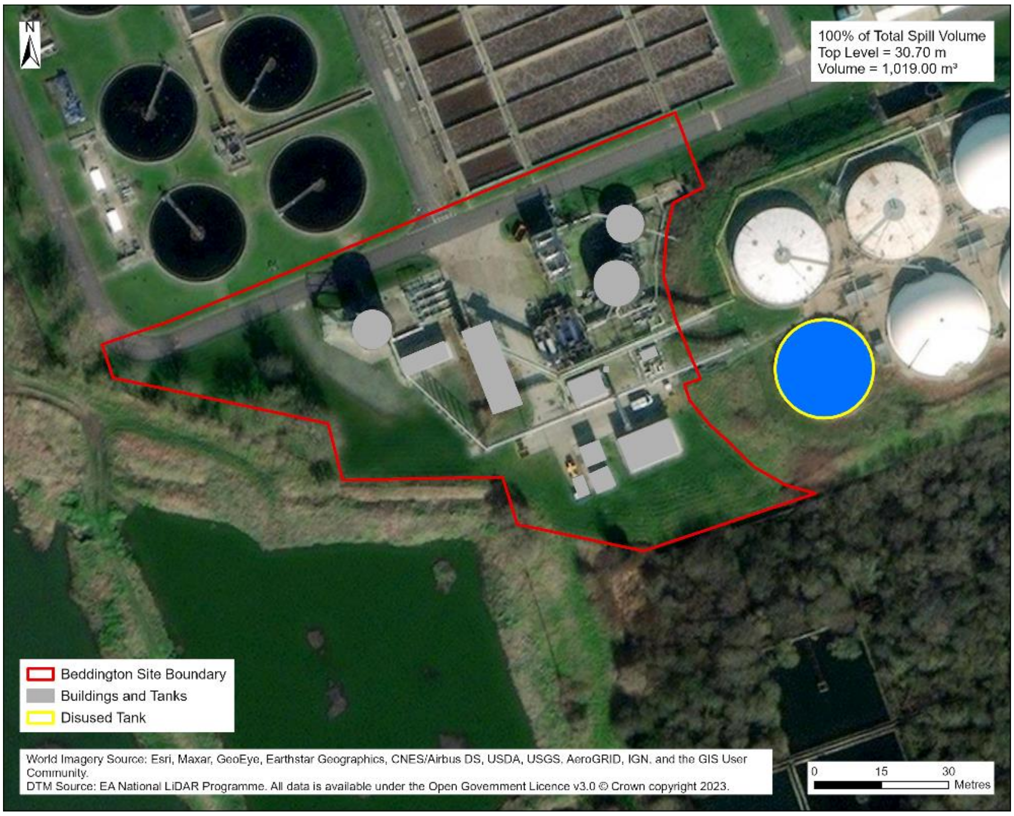

Figure 4-1 – Contained model output for Area 1

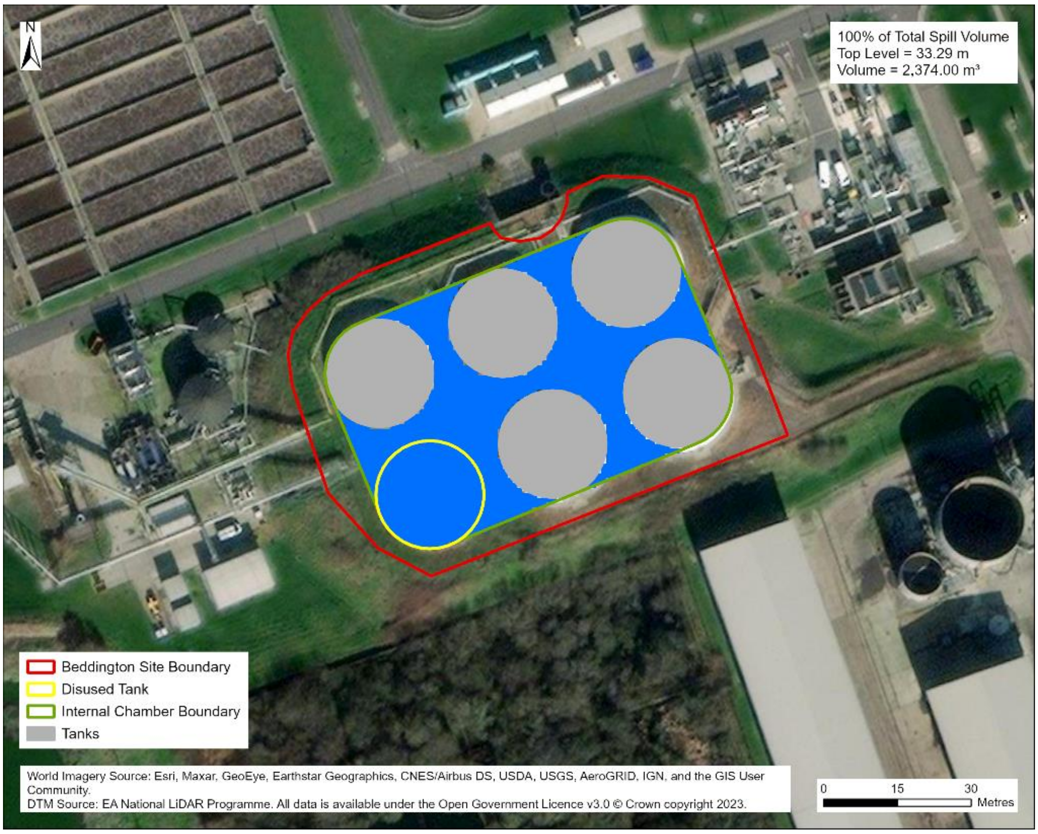

Figure 4-2 - Contained model output for Area 2 showing top level of liquid at 33.29mAOD

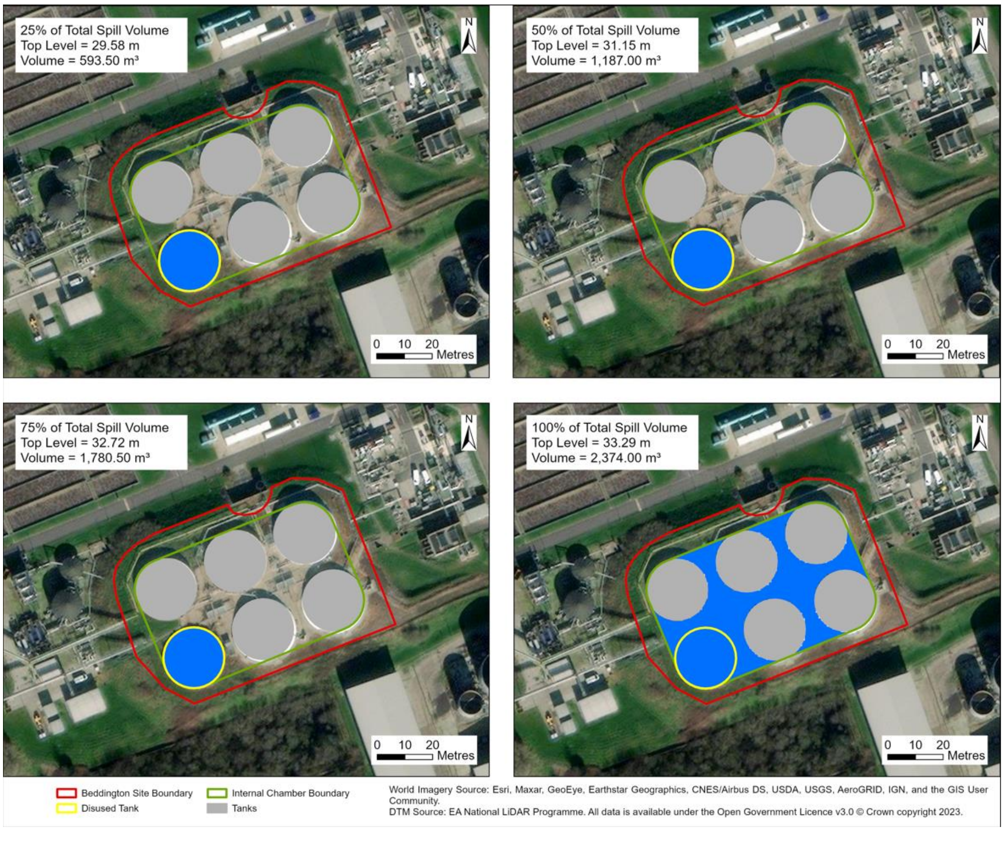

Figure 4-3 - Contained model output for Area 2 with 25, 50, 75 and 100% Spill Levels

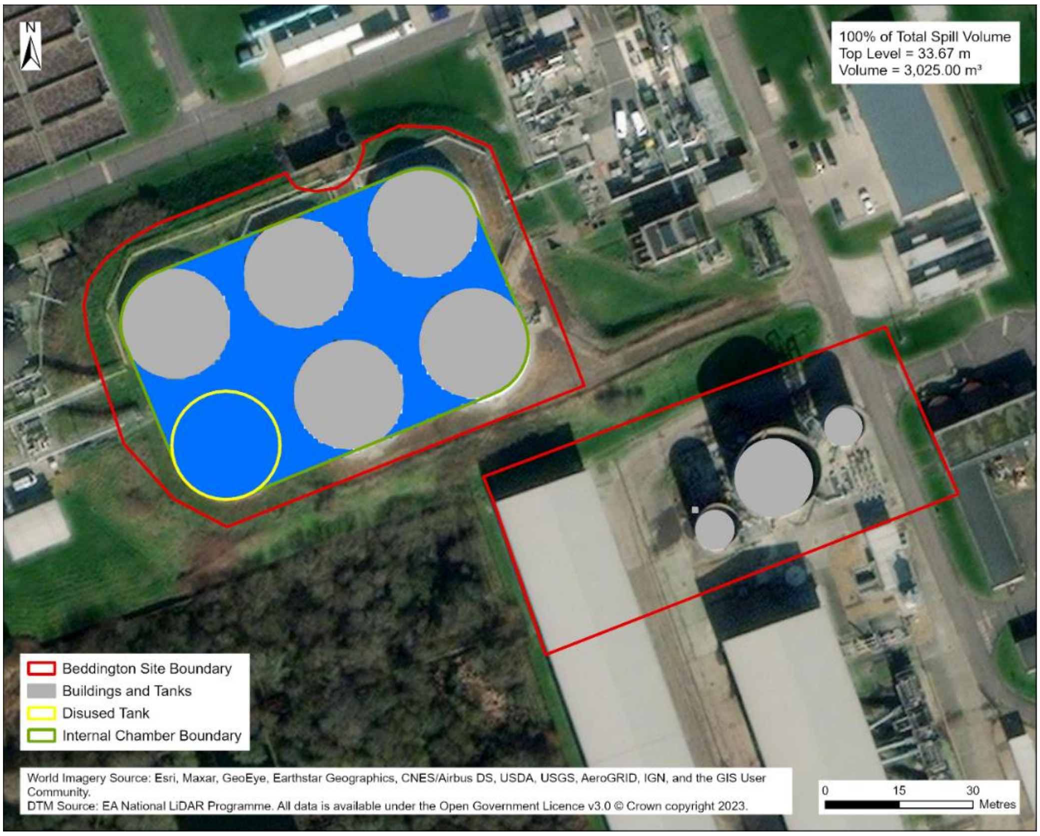

Figure 4-4 - Contained model output for Area 3

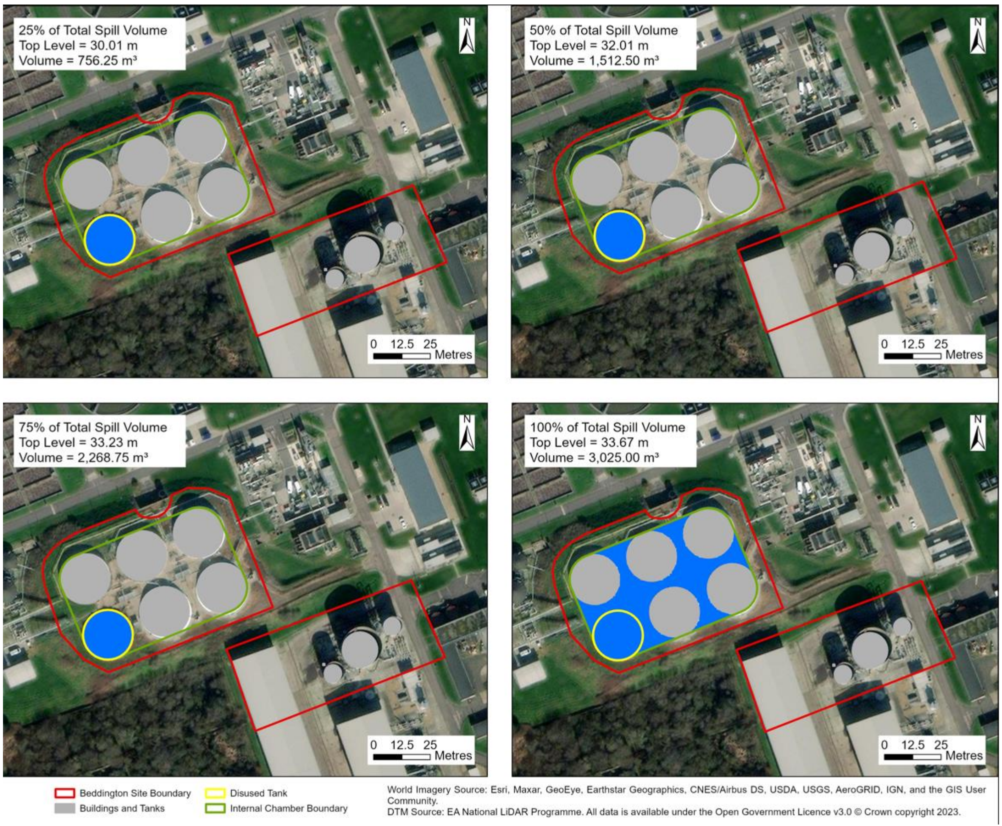

Figure 4-5- Contained Model Output for Area 3 showing 25, 50, 75 and 100% Spill Levels

Table 5 – Levels associated to each containment area

Area	Top Water Level arising in Area 2 (mAOD)	Nom GL for area (mAOD)*	Resilience Note
Sludge buffer tank area (Area 1)	30.70	32.5	Non-return valve required on feed pipe to storage tank
Digester tank area (Area 2)	33.29	33.0	
Emergency storage tank area (Area 3)	33.67	34.1	
Overflow tank (Area 4)	33.23	34.0	

*The existing embankment, that encloses the digesters (Area 2) has a top level of nom 38mAOD and will contain any additional spill from the repurposed storage tank that enters the valve gallery. The valve gallery has a floor level of 33mAOD.
Area 1 and 3 will have a drainage sump and connecting pipework to the disused tank. Any additional spill once the disused tank volume is exceeded will be contained by the digester embankment structure. Therefore, the only bunding that is needed around Area 1 and 3 is low-bunding of 300mm to guide flows to the sump.

Table 5 above compares the top water level once the full volume of the disused tank is reached against the internal embankment walls. The median depth against the boundary wall is then calculated within the area 2 embankment.

Please note that these values are derived from 1m LIDAR data which has an accuracy of +/- 150mm.

Table 6 provides a summary of Option 1 and Figure 4-6 illustrates the option.

Table 6 – Summary of each containment area option

Containment Area	Description of containment
Sludge Buffer Tank area (Area 1)	300mm bund walls to contain initial jetting flows. Any jetting spill that is not contained by the ramps will be diverted back to the head of the works by the drainage network. Drainage sump located in north west corner at the lowest ground level of the containment area, that is connected to a transfer pipeline to the disused digester tank in Area 2. The pipeline will have a non-return valve installed to prevent any backflows from the other containment areas. 2 large ramps will provide access for vehicles as the area is frequently visited during the day. Reprofiling of grass areas and replace with concrete as the impermeable material to a 33mAOD.

Digester Tank area (Area 2)	There are 5 operational digesters and 1 disused digester tank within a raised embankment. Transfer pipework will be connected between containment Areas 1 and 3 with a non-return valve on the pipework from Area 1 to stop back flow. To allow spills from an operational digester into the disused tank cores through the walls within the internal chamber would be required. Any additional spill that cannot be contained by the disused tank will be self-contained by the raised embankment shell. No additional bunding is being proposed for this area.
Emergency Sludge Tank area (Area 3)	300mm bund walls to contain initial jetting flows. Drainage sump located in north west corner that is connected to a transfer pipeline to the disused digester tank in Area 2. The pipeline will have a non-return valve installed to prevent any backflows from the other containment areas. Some ground resurfacing to concrete and reprofiling in these areas to direct flow towards the sump. Any existing concrete area will not be reprofiled and any local spill pooling in these areas are assumed to be contained by the low bunding and drainage network that returns to the head of the works. 4 ramps to provide access for vehicles and steps for pedestrians to access equipment behind containment area.
Overflow tank (Area 4)	500mm bund walls to contain spill. Ground resurfacing to concrete. Steps for pedestrian access to overflow tank. Access is maintained in this area by the provision of two sets of stoplogs at the entrance to the containment area as well as at the entrance to the structure. As the frequency of access is very low, stoplogs (with locking bar over) are incorporated instead of gates to reinforce the planned nature of any entry into the area.
Summary	Option 1 reduces impact to operational access as ramps can be used to allow passage across containment boundaries. Minimal additional infrastructure and project cost by utilising the disused digester tank and the enclosed embankment area as storage volume. Splitting the areas into 4 allow the spill volume of each area to be isolated from each other and optimise the disused digester tank volume.

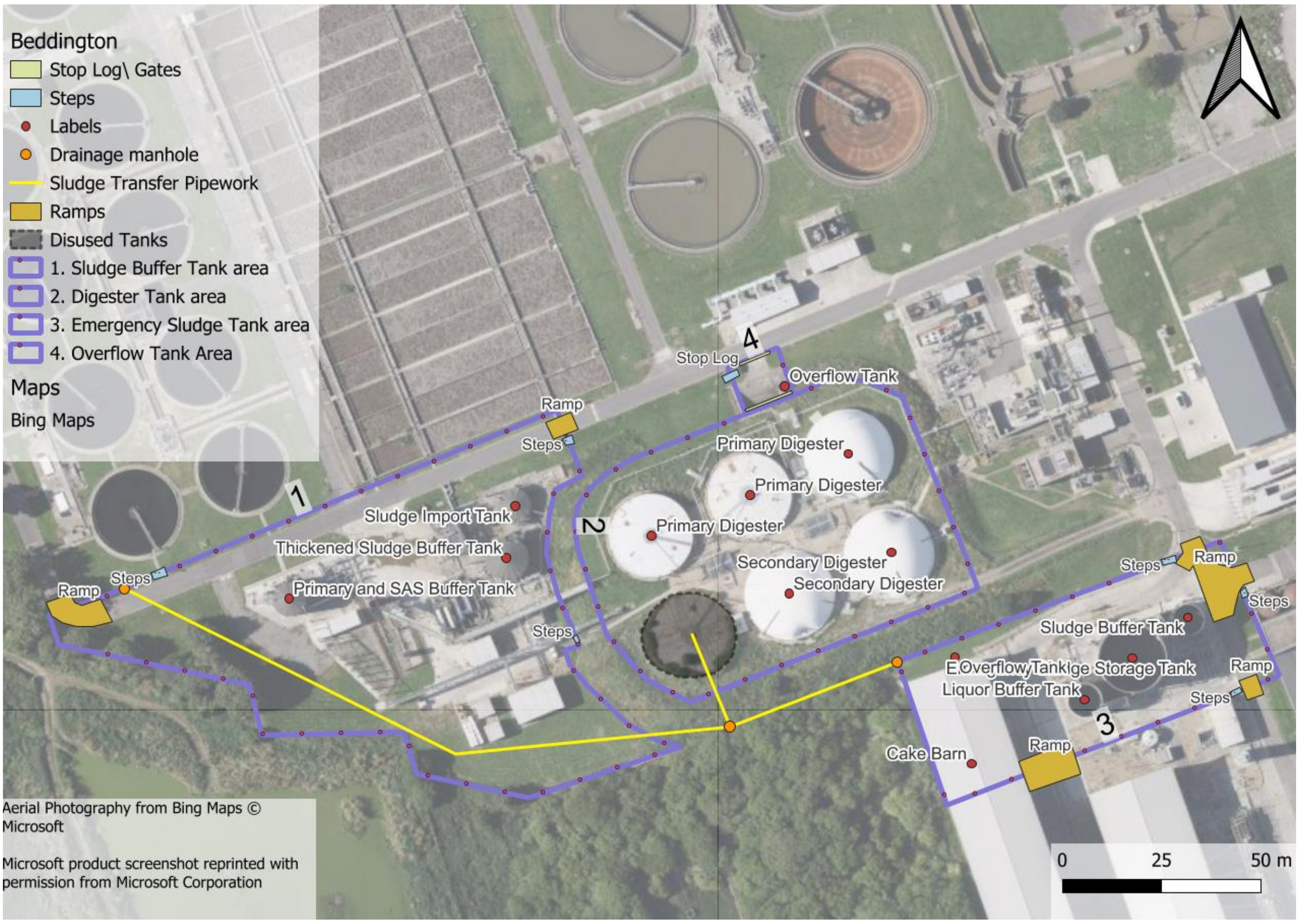

Figure 4-6 - Option 1 – Close containment solution utilising the disused digester and the raised embankment area for storage of each area.

4.1.2 Option 2 – Wide area containment using additional site area

Option 2 in Figure 4-7 comprises of a wide containment area that encompasses all the recorded sludge tanks. This option was discussed with Thames Water Operations and ruled out as operatives preferred minimising obstructing site operations and maximising the use of the disused digester tank.

Splitting the single area into 3 separate areas reduced the design spill volume considerably so the disused tank could be utilised for better effect. A minimum bunding of 300mm would be constructed to mitigate initial surge flows immediately after a spill scenario. The estimated containment height for Option 2 was above 300mm meaning vehicles would not be able to enter the area as easily as required. Modelling and costings associated with this option did not progress.

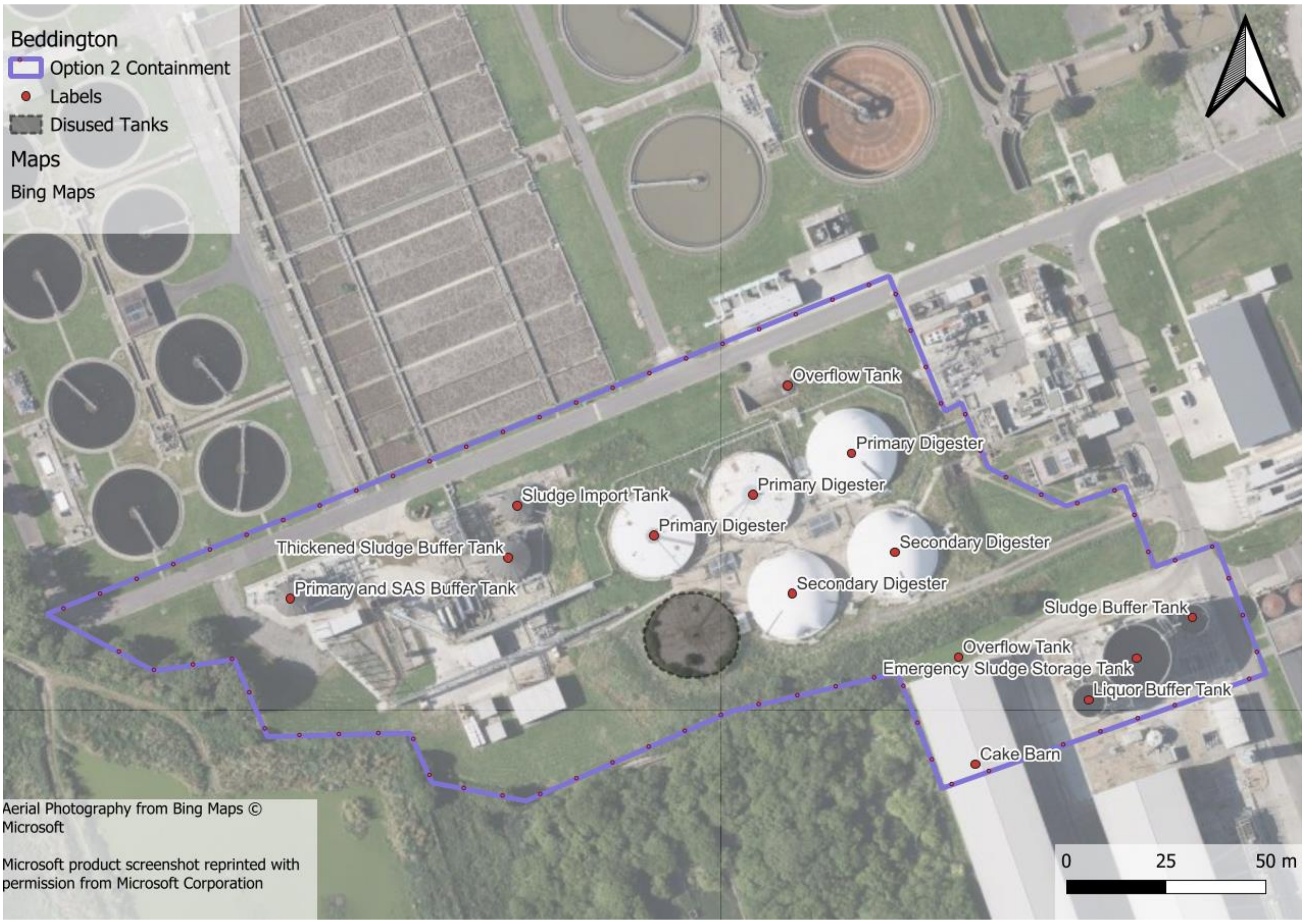

Figure 4-7 – Option 2 - Wide containment area

4.2 Mitigation of Site-Specific Risks

4.2.1 Jetting and Surge Flows

Due to the location of the tanks and their distance from the boundary of the containment area, the likelihood of jetting occurring is deemed low. Failure is more likely to begin with major seeping from the tanks which would be spotted during routine site walkabout tours each day.

The natural topography of the site and the distance to the boundaries of the containment area results in a low risk of surge overwhelming the containment.

4.2.2 Flooding

According to the UK Government's Flood Map for Planning, the site is substantially Flood Zone 1. Three tanks at the southern end of the STC fall into Flood Zone 2, as shown in Figure 4-8. Flood Zone 2 is defined as areas with between a 1 in 100 and 1 in 1000 probability of river flooding and areas defined as Flood Zone 1 has a probability of less than 1in1000 of river flooding.

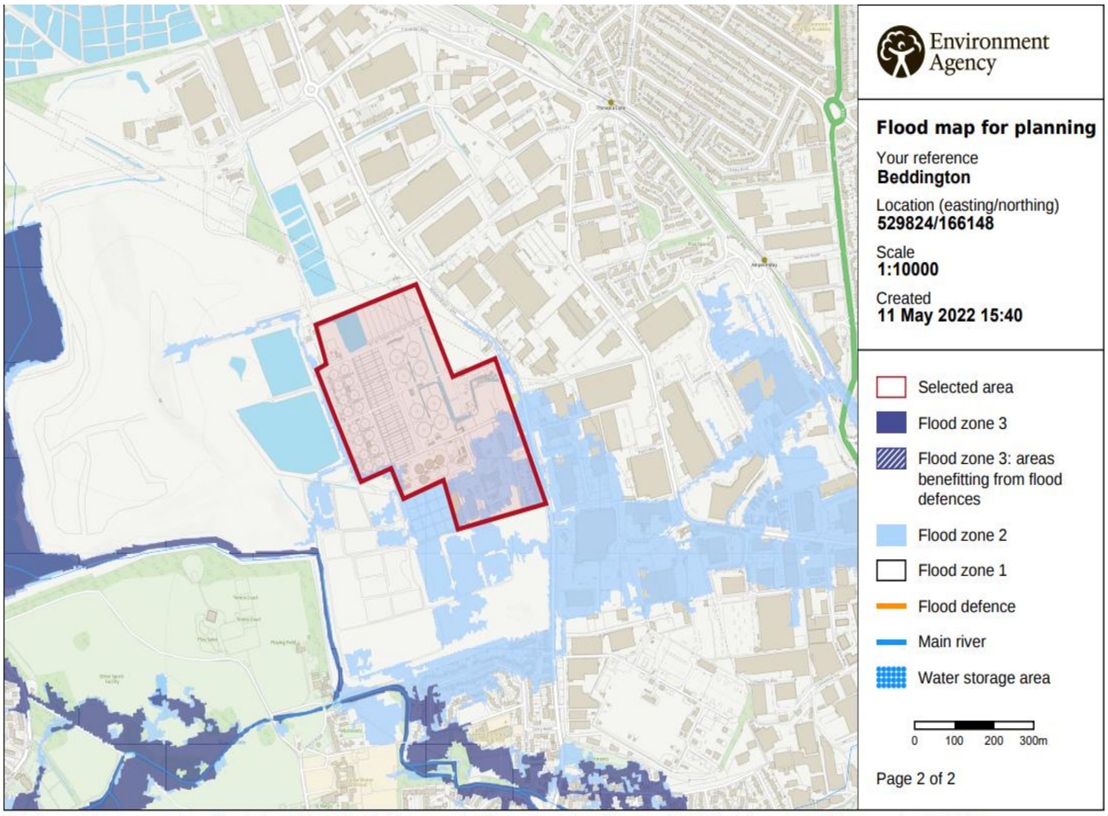

Figure 4-8 Extent of Fluvial flooding in Beddington due to extreme weather events

4.3 Identification of Preferred Option

The preferred containment proposal is Option 1 which considers the following advantages:

- Efficient use of assets/space (using disused digester as storage volume and any excess volume contained within the embankment shell that encloses the operational digesters)
- Practicality of installation (lower containment bund construction required)
- A lower bund wall will minimise long term site operational impacts including line of sight and ease of access.
- Access road operation simplified along higher traffic routes, by use of ramps to cross containment lines rather than by the use of floodgates

4.3.1 H&S and CDM risks

- Flood gates not suitable for areas of high traffic movement
- Cable ducts and fibre ducts act as conduit to transport sludge around site.
- Confirm that the containment walls do not impact the existing DSEAR equipment rating.
- Confirm all electrical equipment within the containment walls site above the top water level.

5. Site Drainage and liquor returns

5.1 Process flow diagram

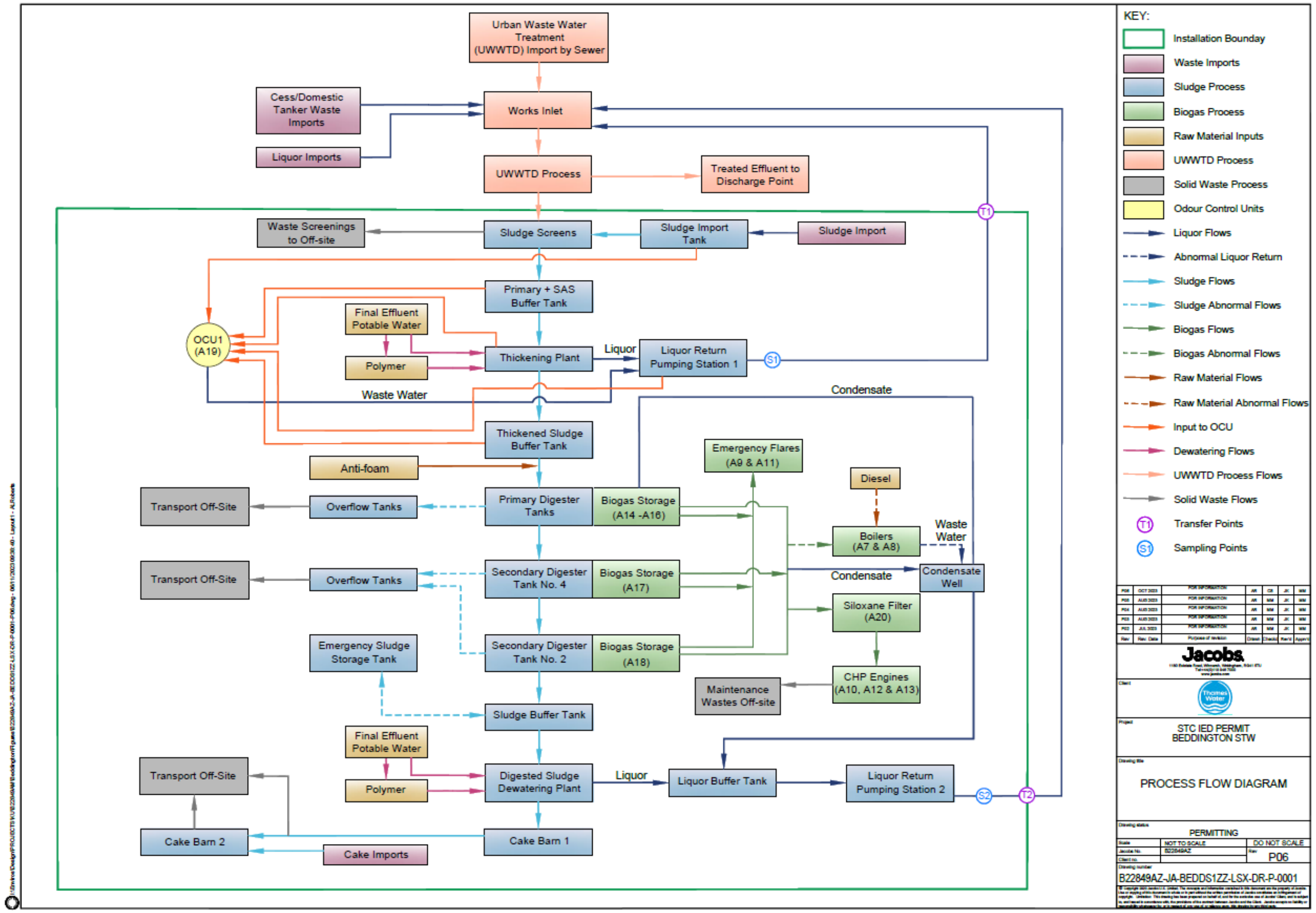

Figure 5-1 - Process Flow Diagram for Beddington STW

5.2 Foul Process and Effluent Drainage

There are no existing site drainage plans. From a site visit with the Performance Manager on site, they confirmed that the site drains fully to the works inlet. Supplementary survey work has been undertaken to confirm the discharge at Beddington.

Containment options onsite involve replacing existing impervious areas with concrete. This will result in a small increase in site surface waters, which are likely to have a negligible additional effect on the head of the works given the scale of flow to full treatment at Beddington.

5.3 Liquor Returns

The existing liquor return system is not being altered by the containment system, other than the control modifications proposed in Section 5.4.

Details of the liquor returns sampling are being developed outside of this report for incorporation within the permit submission.

5.4 Automatic Isolation Valves

For the catastrophic loss of containment scenarios, 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 generate an alarm.

In the event of a catastrophic sludge spill, flows entering the head of the works via the drainage pipes could adversely impact the sewage works treatment process. Therefore, in the event of a catastrophic loss of containment, this line should be isolated.

It is recommended that float operated isolation valves are installed on all outgoing drainage lines from the containment area. These valves will remain normally open but will close when high levels in the existing drainage system are encountered. This drainage configuration will have the following impacts:

- In heavy or intense rain events these drainage isolation valves may be triggered, and operators onsite will need to manual operate these valves to release flows into the existing drainage network.
- In minor or slow flow tank spill events, the sludge spill will flow into the existing drainage network (and into the head of the works) unless operators intervene to isolate the drainage networks. Due to the flow to full treatment at Beddington being large, minor spill flows will not adversely impact the process.
- In most locations, to accommodate the new isolation valves, new sealed manholes need to be constructed over the existing drainage lines.

6. Conclusions

This section summarises the findings of the containment assessment options report for Beddington Sewage Treatment Works.

Based upon the Advanced Digestion Biosolids Association (ADBA) containment assessment tool; the site carries an overall site risk rating of Medium meaning that Class 2 containment is needed.

The total contained volumes comprise:

Table 7 – Summary table of contained volumes for each area

Containment Area	Volume	Rule
Sludge buffer tank area	1019m^3	Largest tank plus rainfall
Digester tanks area	2375m^3	25%
Emergency sludge storage tank area	3025m^3	110%
Overflow tank area	37m^3	Largest tank plus rainfall

The contained spill modelling retains the tank contents and associated rainfall withi n the site boundary and the flows can be managed by TW operations for return to treatment.

Existing gravelled and grass areas within the containment will be replaced with concrete. Elements of the site roads will be replaced/repaired to allow them to present an impermeable surface.

In addition to the containment elements, isolation of the site drainage system linked to the containment area will be required to mitigate the risk of unmanaged flows impacting the sewage treatment works.

Freeboard allowances and the profile of the containment bund wall provides mitigation against surge effects. Jetting escape is mitigated due to the location of the tanks being remote to the containment boundary.

Option 1 reduces impact to operational access as ramps can be used to allow passage across containment boundaries. This option reduces the additional infrastructure and project cost by utilising the disused digester tank and the enclosed embankment area as storage volume. Splitting the areas into 4 allow the spill volume of each area to be isolated from each other and optimise the disused digester tank volume.

Appendix 1 ADBA Site Hazard Risk assessment summary for Beddington STW

The ADBA Industry Guidance and CIRIA C736 state how the site hazard rating, of the site risk and classification are to be calculated. A summary of the hazard risks for Beddington STW 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 (Ferric Sulphate) 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 both process and surface water to the head of the works which would negatively impact the process stability on site and would eventually impact on the receiving watercourse.
2. There are several areas where a sludge spill could pass over permeable ground.
3. The site inventory has a runoff time of 5 minutes.

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

Receptor – There are seven potential receptors which have been identified:

1. The site drainage system and the head of the works.
2. There is a "medium-high" and "medium-low" groundwater vulnerability in this location.
3. The B242 adjacent to the east of Beddington STW, and all the businesses and industrial estate that the B242 feeds into.
4. The habitation of large populaces nearby, the nearest of which is south of the STW.
5. The River Wandle directly to the southwest, with tributaries into it located west.
6. Roman bathhouses on an archaeological site to the southwest.
7. Beddington Farmland and Beddington Park to the southwest.

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

Likelihood – The mitigated likelihood is **low**, which reflects the use of materials, the tank systems do not have a history of failure, the tanks are designed to British Standards and installed by competent contractors and Thames Water undertake regular site tours giving the opportunity to identify early indications of potential issues.

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