J840 – STC IED Containment

Riverside STC – Containment Options Report

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1.0	16/12/2022	First Issue	CR	SMNS	SC	HG
2.0	5/12/2023	Updated PFD, boundary plan, tank table	CR	SMNS	SC	HG

Contents

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 (STC) have been identified where containment proposals are required. This report deals with the proposals for Riverside.

Riverside STW is located in Rainham, London Borough of Havering and serves a population equivalent of 397,000. 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 26 tanks containing sludge that fall within the IED permitting area, constructed in both steel and concrete, the total operational sludge volume is 28,205 m^3, with individual volumes varying between 13 to 4,863m^3, refer to section 3.4.1 for details on tanks and volumes. The containment volume to consider at Riverside is set by the largest tank + rainfall rule and is 6,817m^3.

An initial review, together with TW Site Operations, was carried out to confirm that the working of the sewage treatment work would not be compromised by any proposal. Within the discussions, failure of a primary digester tank (largest spilled tank) was addressed by adopting a wide containment area for all sludge assets. A second option was considered comprising 4 separate close containment areas, with the former seen as the most feasible for the site due to its lower impact on operations as it requires less access installations, such as flood gates or ramps. Refer to Section 4.1 for details on the options reviewed and Section 4.3 for the preferred option. Below a summary of the preferred option:

Table 1 Summary of preferred containment option

Containment Area	Description of containment
Wide containment area	• Wide containment with bund walls between 0.30-0.95m high that will contain a spillage within the site. • 3 large ramps will provide access for vehicles as main access routes are included within the containment area. • Steps to be installed for access to foot traffic. • 3 floodgates will be installed to allow infrequent access to vehicles where space precludes the use of ramps.
Summary	• Option reduces impact to operational access as no individual tanks are isolated within a high bund. • Minimal conveyance routes that require regular and onerous maintenance.

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 an eight-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:

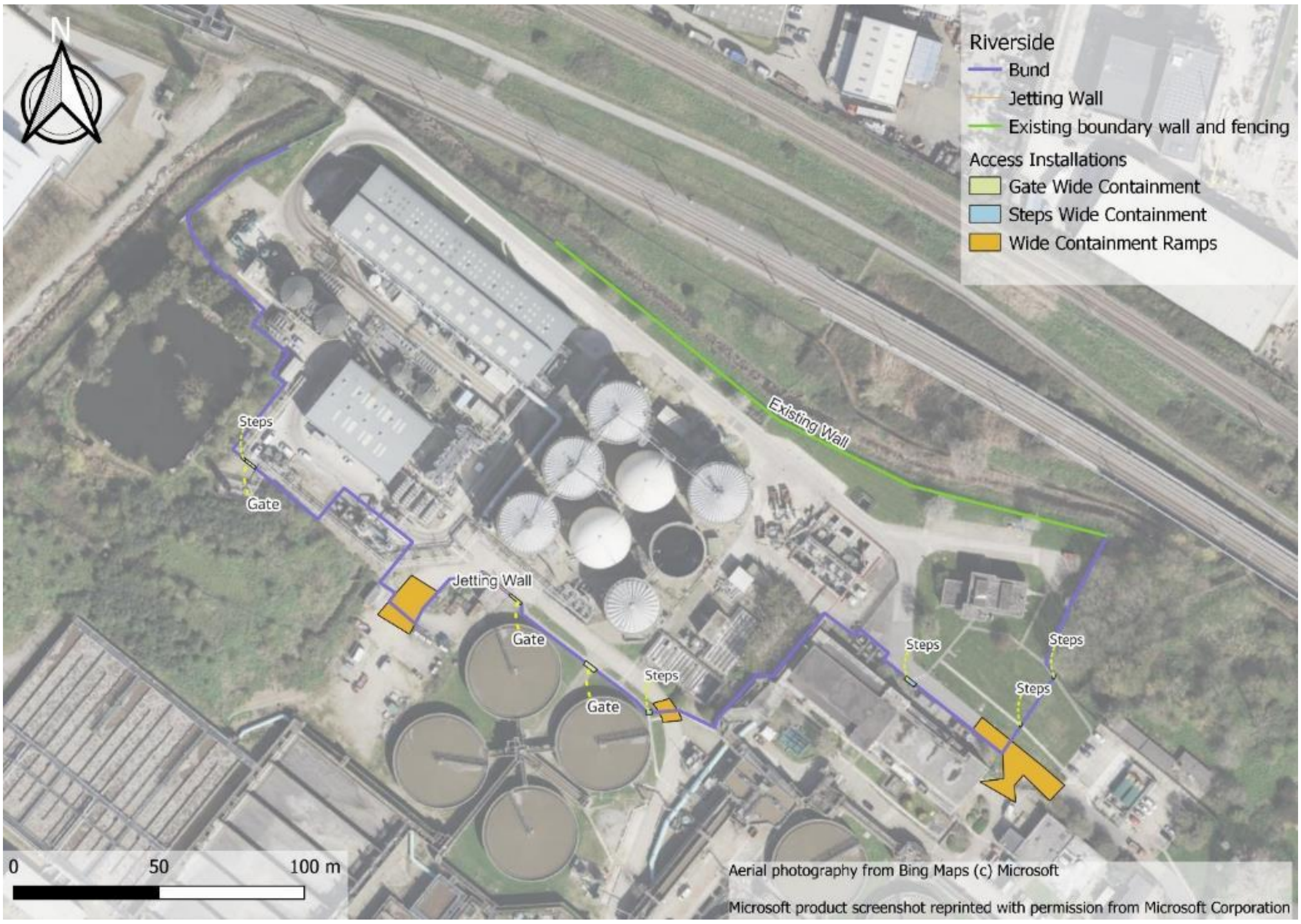

Figure 1.1 General layout of containment for Riverside STW

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 28 Thames Water sites. Based on CIRIA C736 and ADBA risk assessment tools this containment report addresses the site-specific risks at Riverside 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 Riverside 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 Riverside STW were identified through a desktop study, Light Detection and Ranging Analysis (LiDAR) analysis and a site visit.

Riverside STC, contained within Riverside Sewage Treatment Works (Figure 2.1) is between the A13 to the south, and a mainline railway to the north. There is an industrial area surrounding the site and River Thames at one kilometer distance to the South of the site.

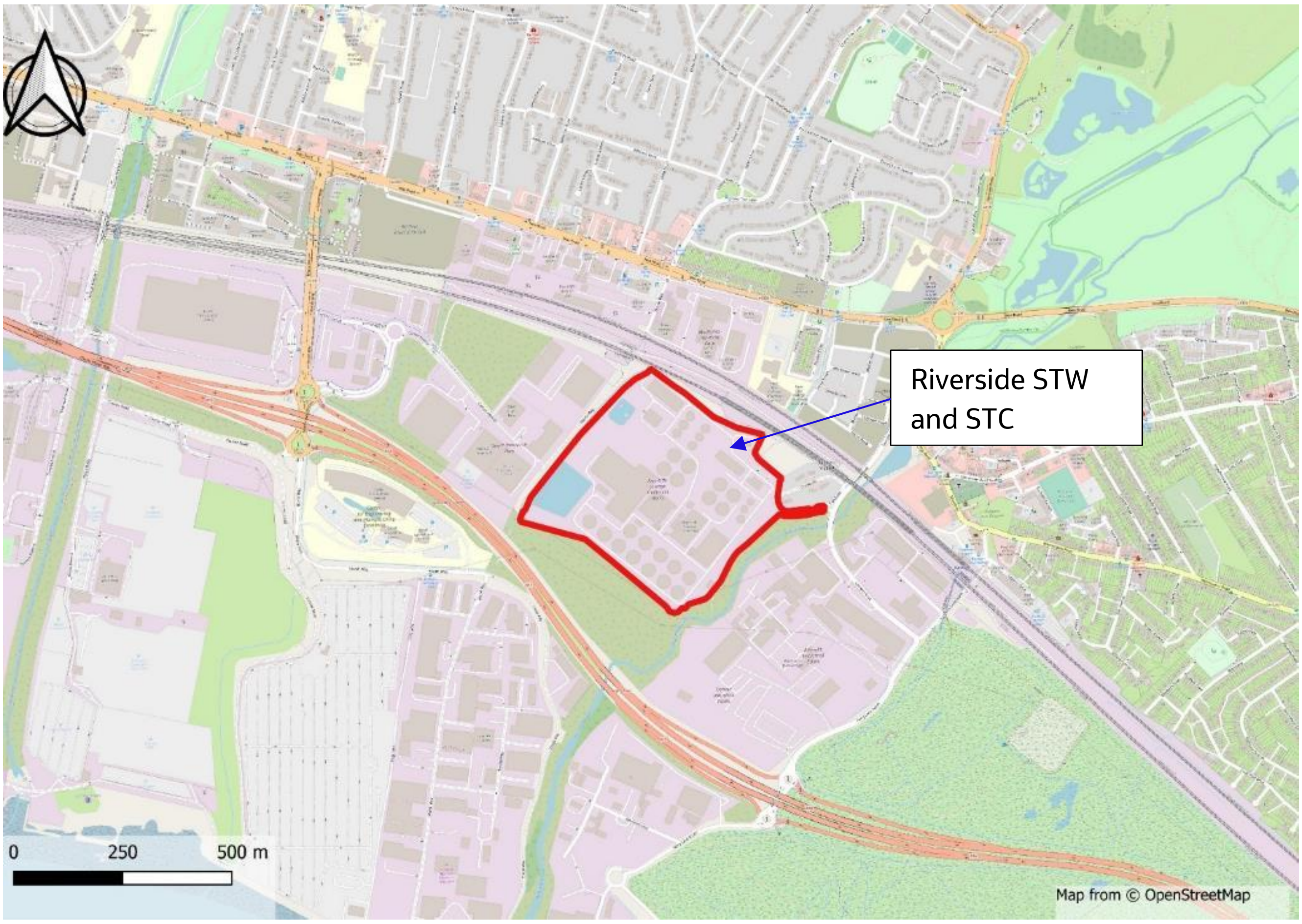

Figure 2.1 Location of Riverside STW

Figure 2.2 Satellite image of Riverside STW location next to industrial estate

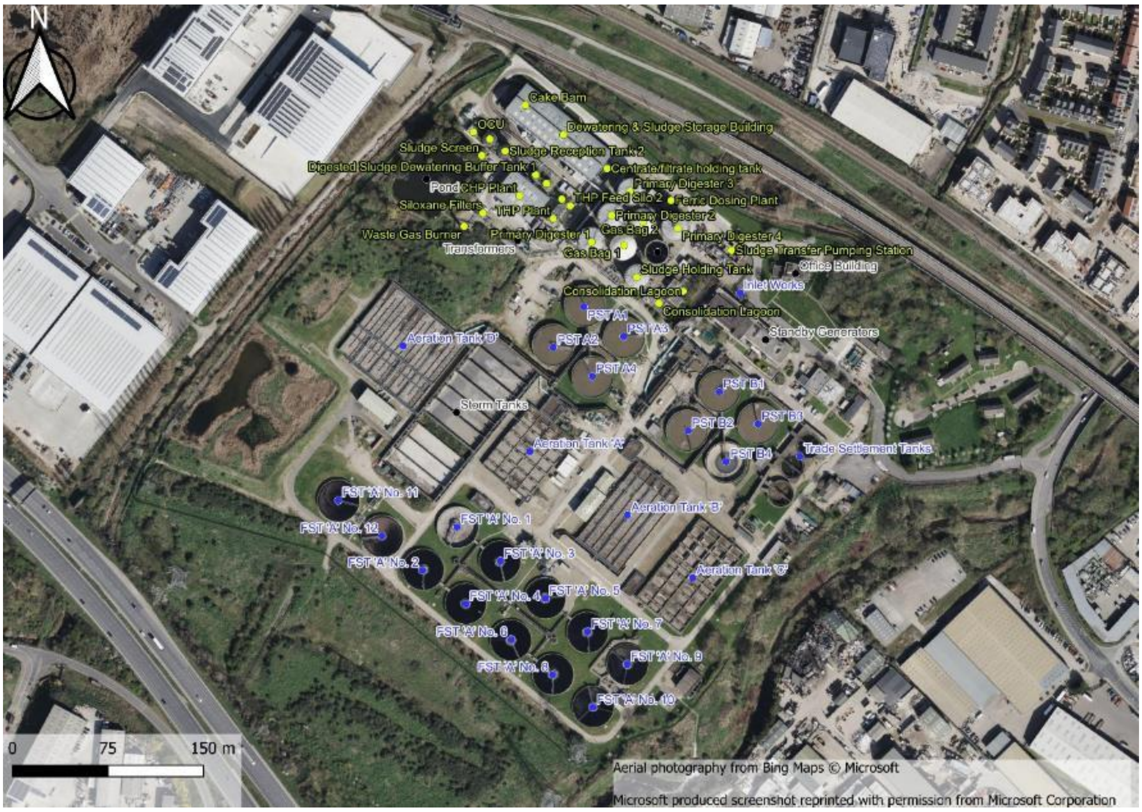

Figure 2.3 Labelled image of the assets within Riverside STW

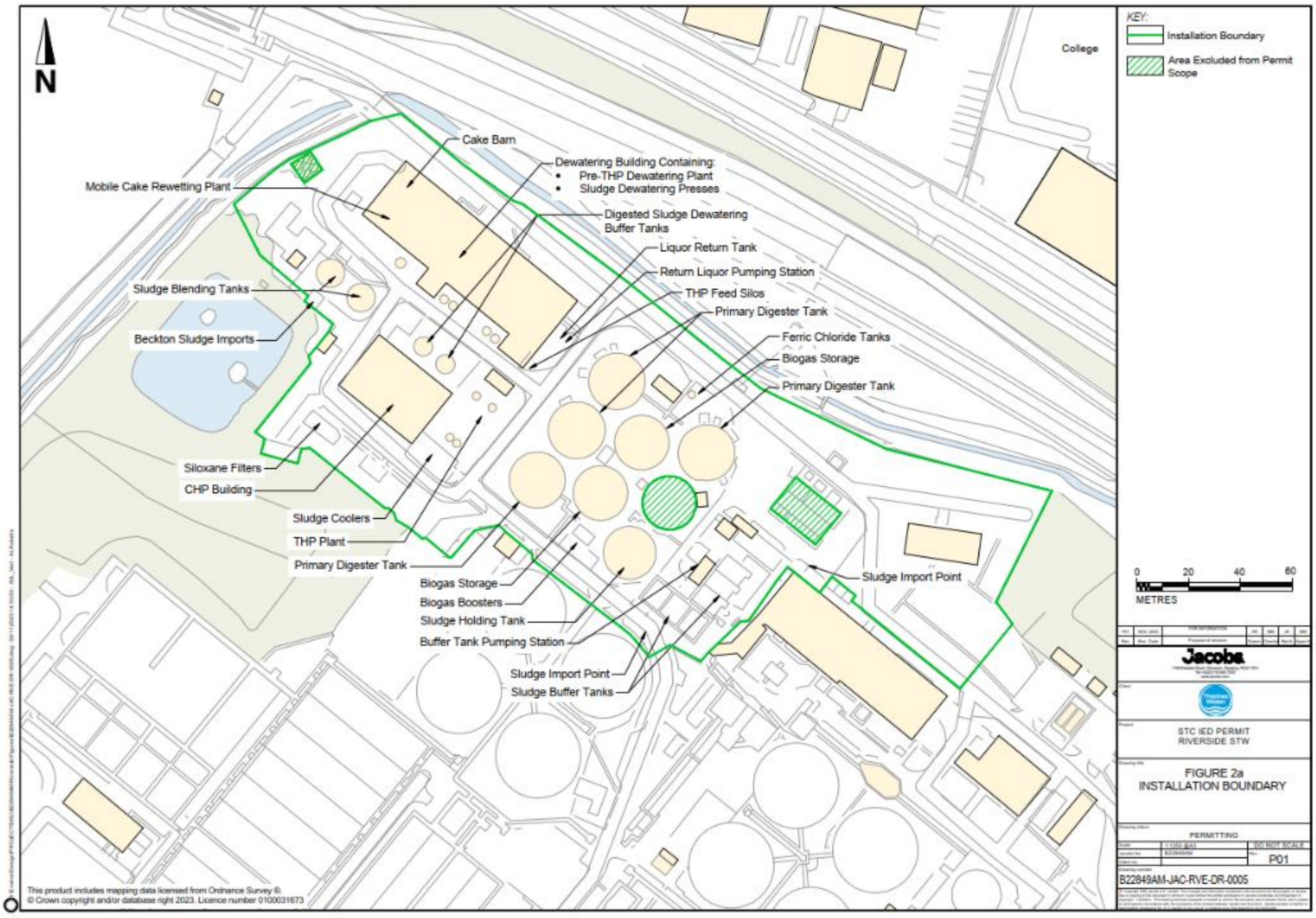

Figure 2.4 Boundary of permitted IED area and the assets

3. Proposed Containment at Riverside 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;

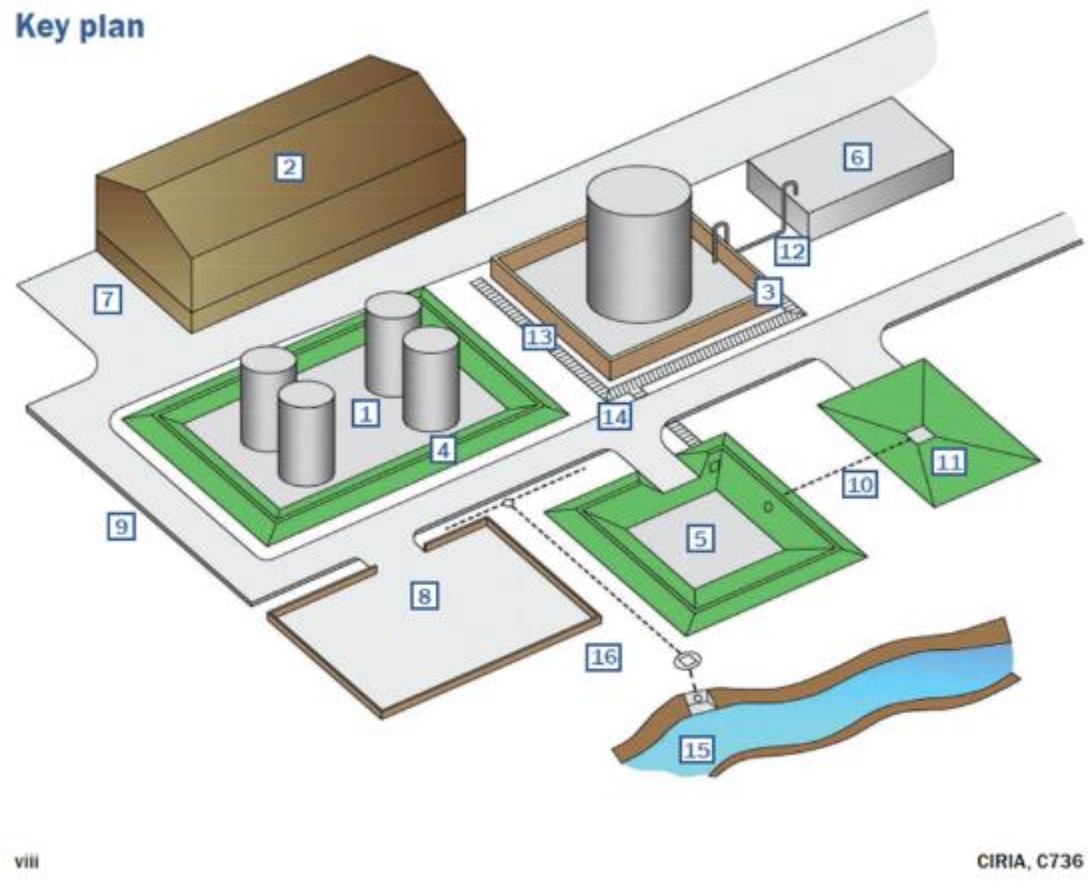

Figure 3.1 Diagram of primary, secondary and tertiary containment examples

-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

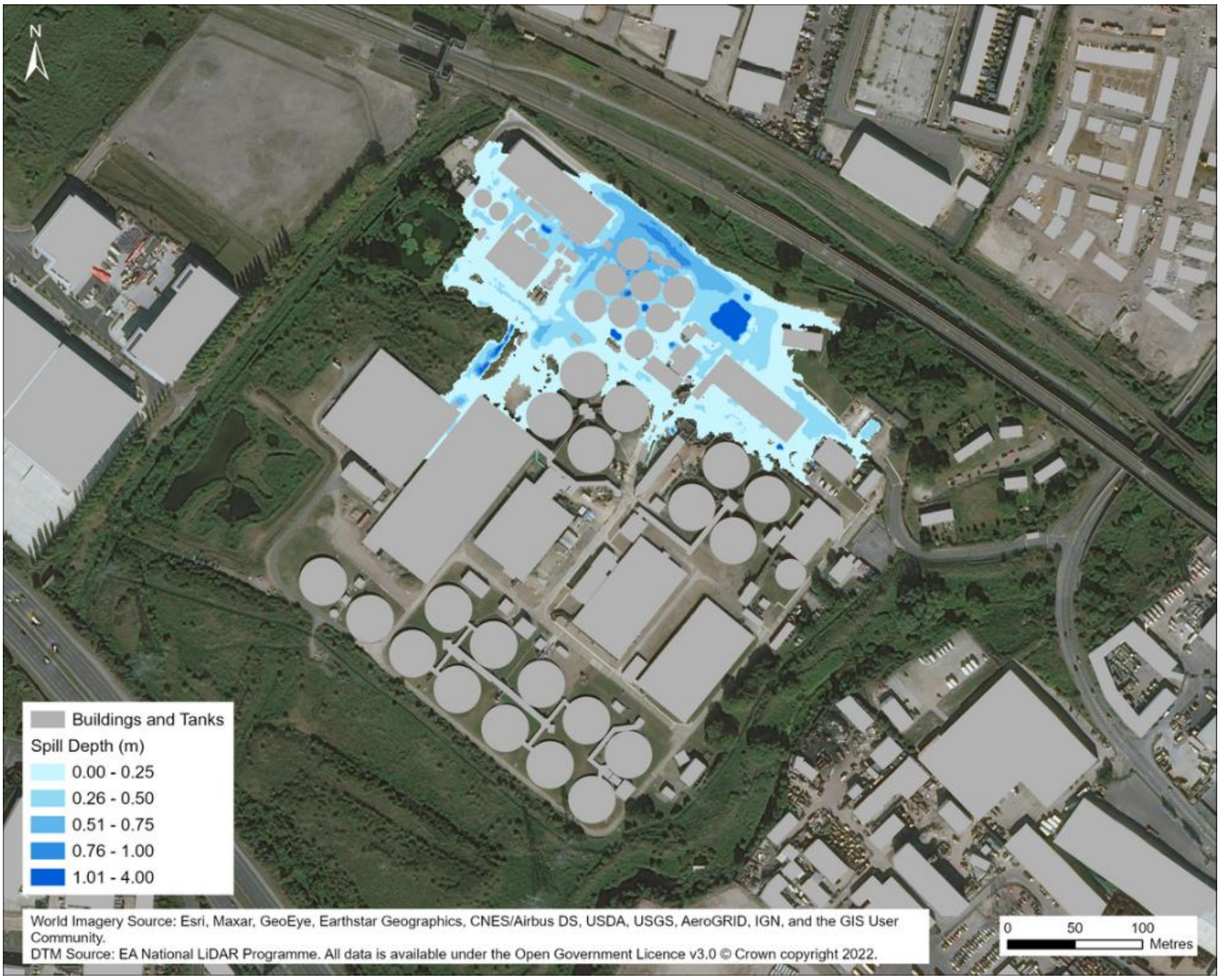

Figure 3.2 Uncontained Spill Model Results

Figure 3.2 the sludge spill mapping of an uncontained event in Riverside STC. The modelling results showed that a potential sludge spill from one of the Primary Digesters will be self-contained within the site however, passive containment should still be considered to safeguard the receptors on site. According to the model, the spill will reach the maximum level within the site boundary in approximately 1 minute following failure of one of the Primary Digesters and would travel northwest surrounding the Digested Sludge Dewatering Plant, Sludge Reception Tanks, the Combined Heat and Power Building, Thermal Hydrolysis Plant, Sludge Coolers, Cake barn and siloxane filters. Sludge, would further spread southeast, surrounding the gas holders, sludge holding and sludge consolidation tanks. Given that the area on the east of the digesters is the lowest point on site, it is expected that in the event of failure of the digester's sludge would also settle in this area.

3.3 Site Classification Riverside

Based on the use of the ADBA risk assessment, considering the source, pathway and receptor risk Riverside 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	Medium	High	Low	Medium (Class 2)

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

3.3.1 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 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 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.

3.3.2 Total Spill Volumes

For each containment area assessed, the containment volume has been checked against the largest tank + rainfall, the 110% and 25% rule and for the preferred option the largest tank + rainfall rule applies.

Table 3 Estimating critical spill volumes for the preferred option

Wide containment area		
25% Rule	5,176m^3	
110% Rule	5,349m^3	
Largest + rainfall	6,817m^3	Emerging critical case

3.4 Riverside STW Summary of Containment volumes and assets

3.4.1 Assets for Containment

The tanks for which containment is required are summarised below:

Table 4 List of tanks and volumes

Tank Purpose	No.	Operational Volume (m^3)	Total Volume (m^3)	Material
Sludge Blending Tanks	2	745	1,490	Steel
Primary Digester Tanks	4	4,863	19,450	Steel
Digested Sludge Dewatering Buffer Tanks	2	166	332	Steel
Liquor Return tank	1	54	54	Concrete
Sludge Buffer Tanks	2	1,700	3,400	Concrete
Sludge Holding Tank	1	3,173	3,173	Concrete
THP Feed Silos	2	25	50	Steel
THP Streams	2	Consisting of the following (in total):		
THP Streams THP Pulper Tank	2	34	68	Steel
THP Streams THP Reactor Tank	8	13	104	Steel
THP Streams THP Flash Tank	2	42	84	Steel
		Overall Total	**28,205**	

3.4.2 Digital Terrain Model

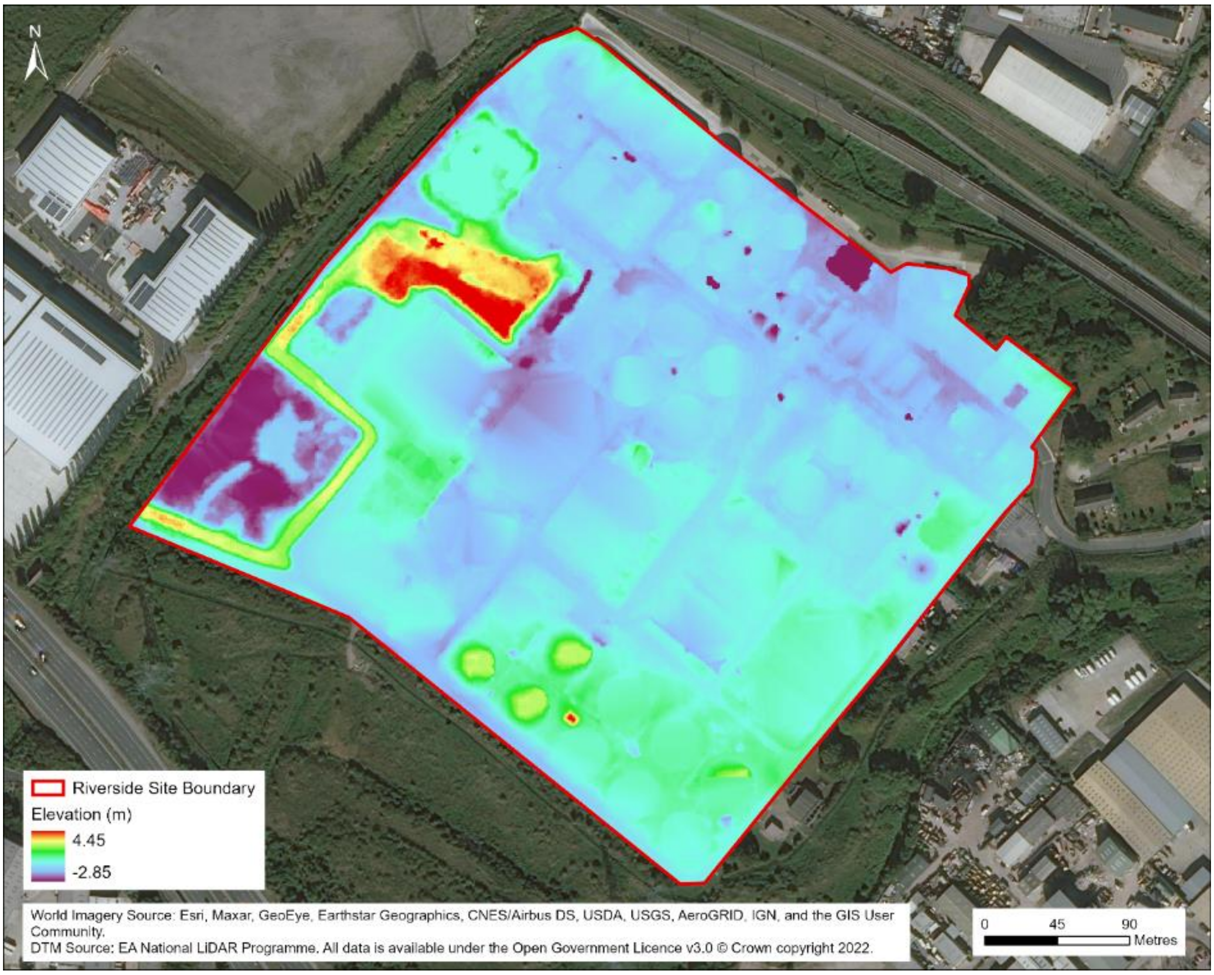

Figure 3.3 Digital Terrain Model of Riverside Sewage Treatment Works

The sludge holding and digestion tanks are located across the northern part of the site. The topography of the sludge area where the digesters are located, is generally on the lower end of the elevation of the site. Most of the site and the sludge assets including the sludge reception tanks, THP Buffer silos, generators appear to be on the same elevation plane with the lowest points being the area slightly east of the primary digesters, and the far southwest of the site. The paths and internal roads in Riverside STW are concreted, however in between those and the digesters/other structures, there is vegetation which would be directly impacted in the event of catastrophic failure of one of the digesters, as sludge would have direct access to and could potentially seep into a medium-high groundwater vulnerability area.

3.4.3 Contained Model Output and Contour Maps

Figure 3.5 and Figure 3.6 show the modelling results for a catastrophic spill of a primary digester within the preferred containment boundary. The spillage will be contained within the boundary, flooding all but the north-western corner of the site with the existing bund to the north of the site stops the spillage from exiting the site. The top water-level of the contained spillage will sit at a level of approximately 1.53m meaning flood depths could reach up to 0.75m at specific areas within the site.

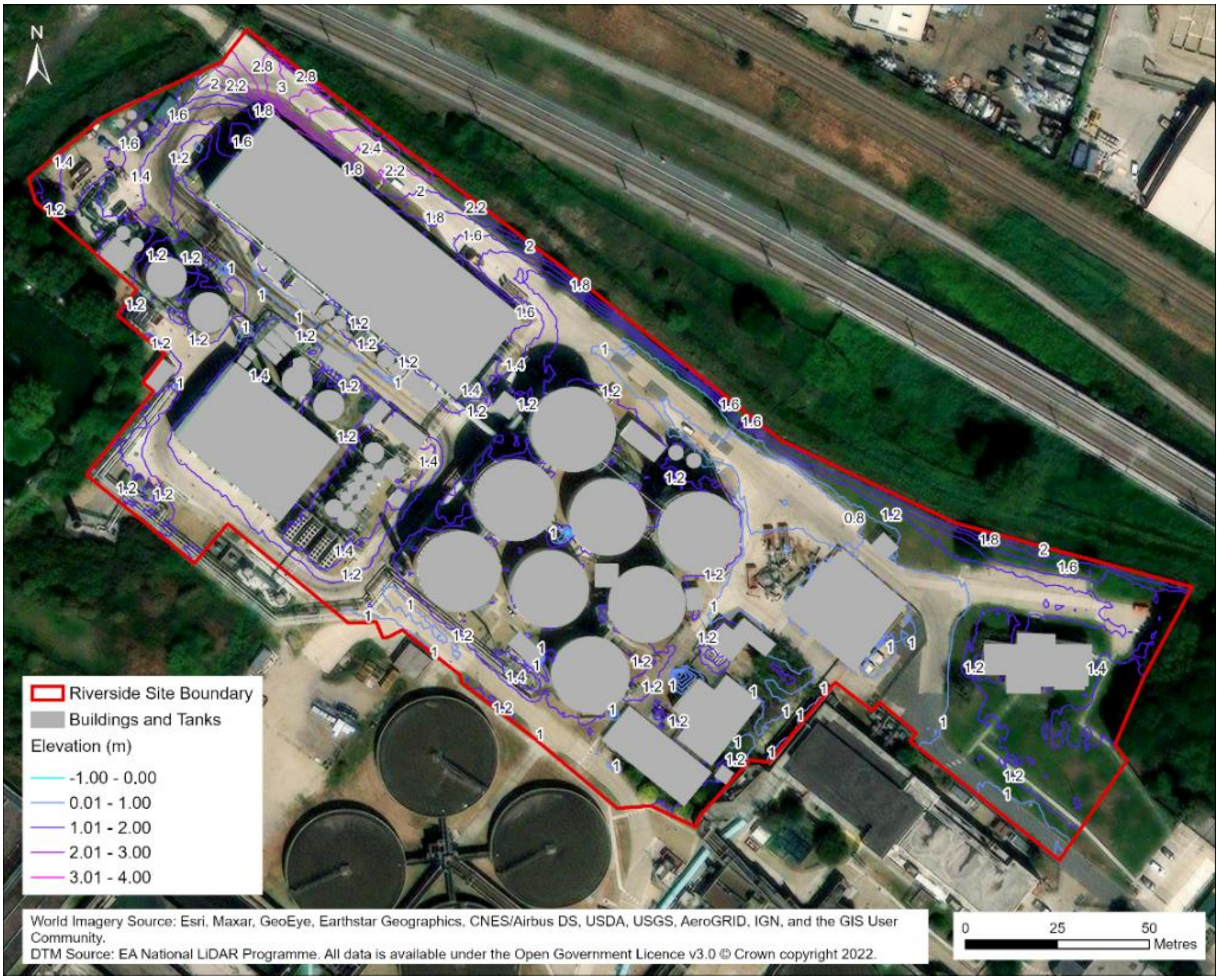

Figure 3.4 Contour lines within containment area

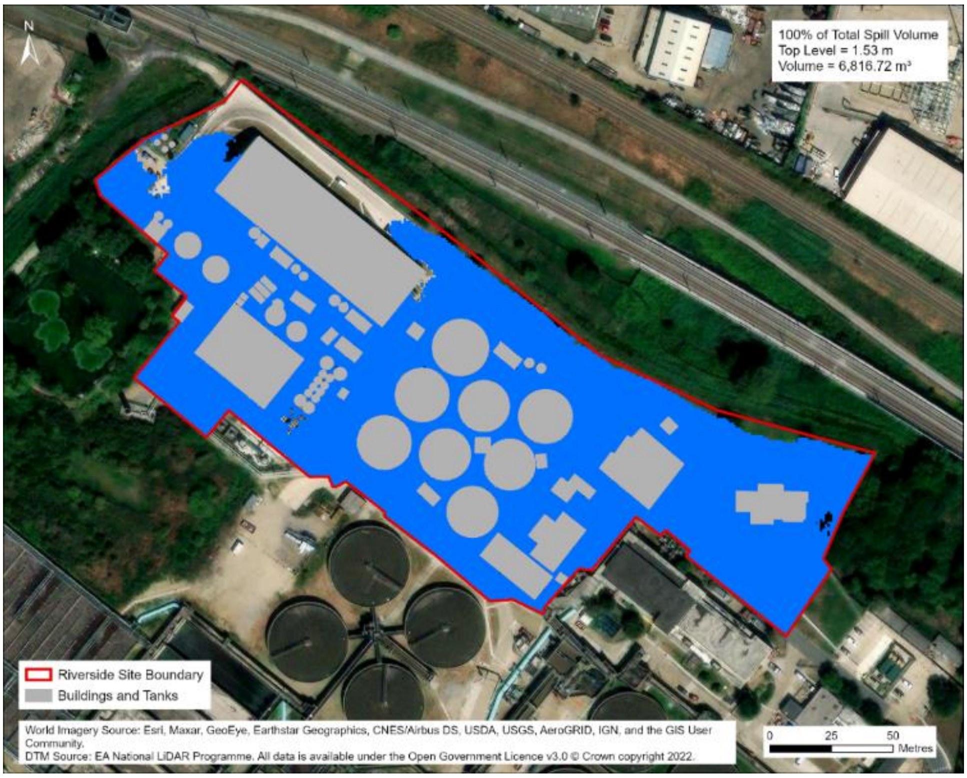

Figure 3.5 – Contained model output for wide containment area showing top level of liquid at 1.53mAOD

Figure 3.6 - Contained model output for wide containment area showing ground elevations at boundary

Table 5 – Levels associated to each containment area

Table 5 above compares the top water level with the typical ground level from the modelling results. The average depth against the boundary wall is then calculated within the containment area. It also shows the proposed height of any containment bunding according to the top water level. The containment bunding is set by adding 250mm to the top water level to provide freeboard to prevent overtopping from the surge effects. Some local low spots may be reprofiled to prevent operational issues.

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

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 cleanup. The impermeable surface will be gently sloped to aid with the sludge spill flow path towards the drainage network.

It is noted that concreting these areas may slow emergency access to underground surfaces 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, reprofiling of some local low spots may be necessary in order to achieve the 300mm height of the ramps.

Flood gates have been included at the proposed entry points into the close containment areas around the secondary digesters, where there is a need for non-frequent access need and where geometry precludes the use of ramps.

To allow access on foot, steps with handrails will be constructed to allow workers to traverse the walls.

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

The existing shrubbery within the containment area 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 Other constraints

None

3.6 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 a three-day period following an incident. The arising average rainfall depths for a 1 in 10-year storm over the event period for Riverside is 69.5 mm. It should be noted that the rainfall depths for Riverside 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.

3.7 Planned Site Upgrade

Thames Water Operations did not note any major works in the sludge treatment area. However, should new major works be considered:

- Containment construction as part of the preferred option may interfere with planned upgrades and connections.
- 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 Riverside, 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 Riverside 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 nom 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 to installed where areas with foot traffic are low, but where vehicular access may be necessary.

4.1 Containment Options

Two options were investigated with operations.

4.1.1 Option 1 – Wide containment area

The first option considers a wide containment solution for the whole sludge treatment area. Table 6 provides a summary of Option 1.

Table 6 – Summary of option 1 containment area option

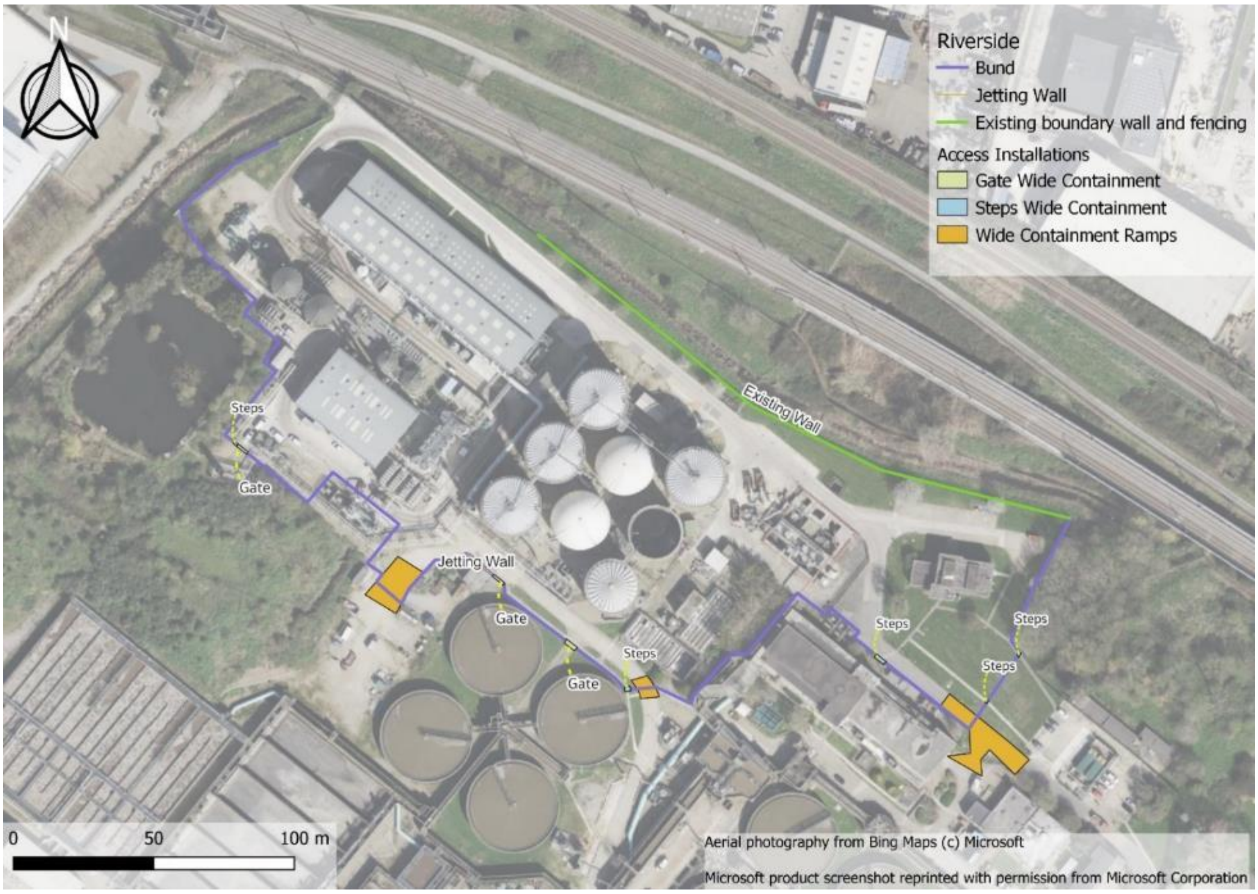

Figure 4.1 - Option 1 Wide Containment Area

4.1.2 Option 2 – Three close containment areas

Figure 4.2 – Option 2 - 1 wide and 3 close containment areas

Option 2 in Figure 4.2 comprises of 1 wide containment area and 3 smaller, close containment area. This option was discussed with Thames Water Operations and ruled out as operations preferred that fewer access routes would be installed with ramps, gates, or steps. The estimated containment height was also above 300mm for the wide containment area meaning vehicles would be at risk of floating in a spill event and be unable to enter. Modelling and costings associated with this option did not progress.

4.2 Mitigation of Site-Specific Risks

4.2.1 Jetting and Surge Flows

There is a potential for jetting from the southern primary digester to overshoot the bund wall. The impact of any flow should be mitigated by the operation of the site's road drainage providing a conveyance pathway to the head of the works.

The likelihood of jetting occurring however is deemed low as 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 sludge area is in Flood Zone 3, as shown in Figure 4.3. The Flood Zone definitions listed in Figure 4.3 provide additional detail of the areas of concern, which in the case of Riverside STW, have a 1-in-100 or less probability of river flooding. Mitigation measures are necessary for fluvial flooding given that the probability of flooding in the area is high. It is to be noted that some parts of the main site (humus tanks & site ditch) are in Flood Zone 2 and have medium risk of surface water flooding. Overall, the site would benefit from flood defence measures at the northern boundary.

Also, 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.

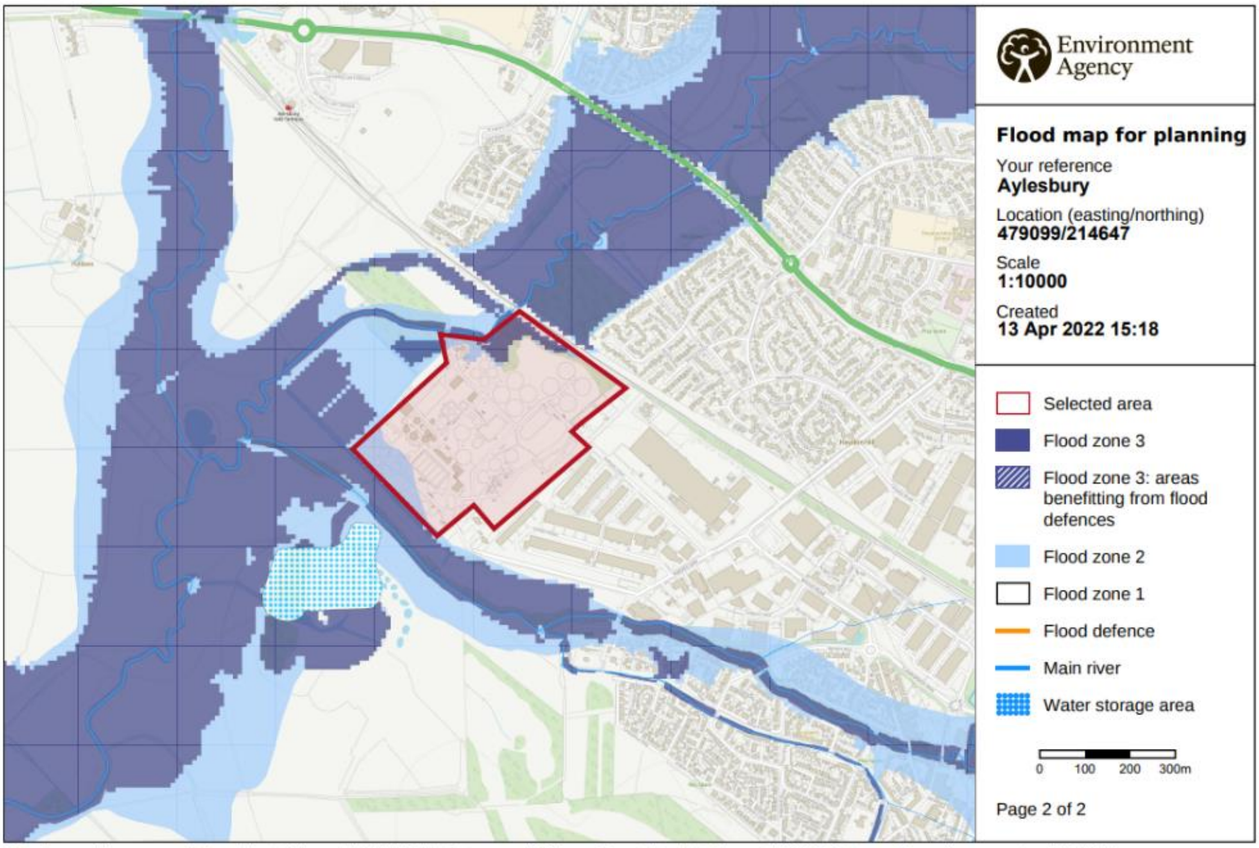

Figure 4.3 Extent of Fluvial flooding in Riverside due to extreme weather events

4.3 Identification of Preferred Option

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

- Efficient use of assets/space (using roads and elevated areas to act as natural bunding).
- 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 by use of ramps to cross containment lines rather than by the use of floodgates.
- High ground provides natural barrier to spilt sludge reducing need for bunding

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.
- Numerous float valves will be installed in surface water drains that will need regular maintenance checks.

5. Site Drainage and liquor returns

5.1 Process flow diagram

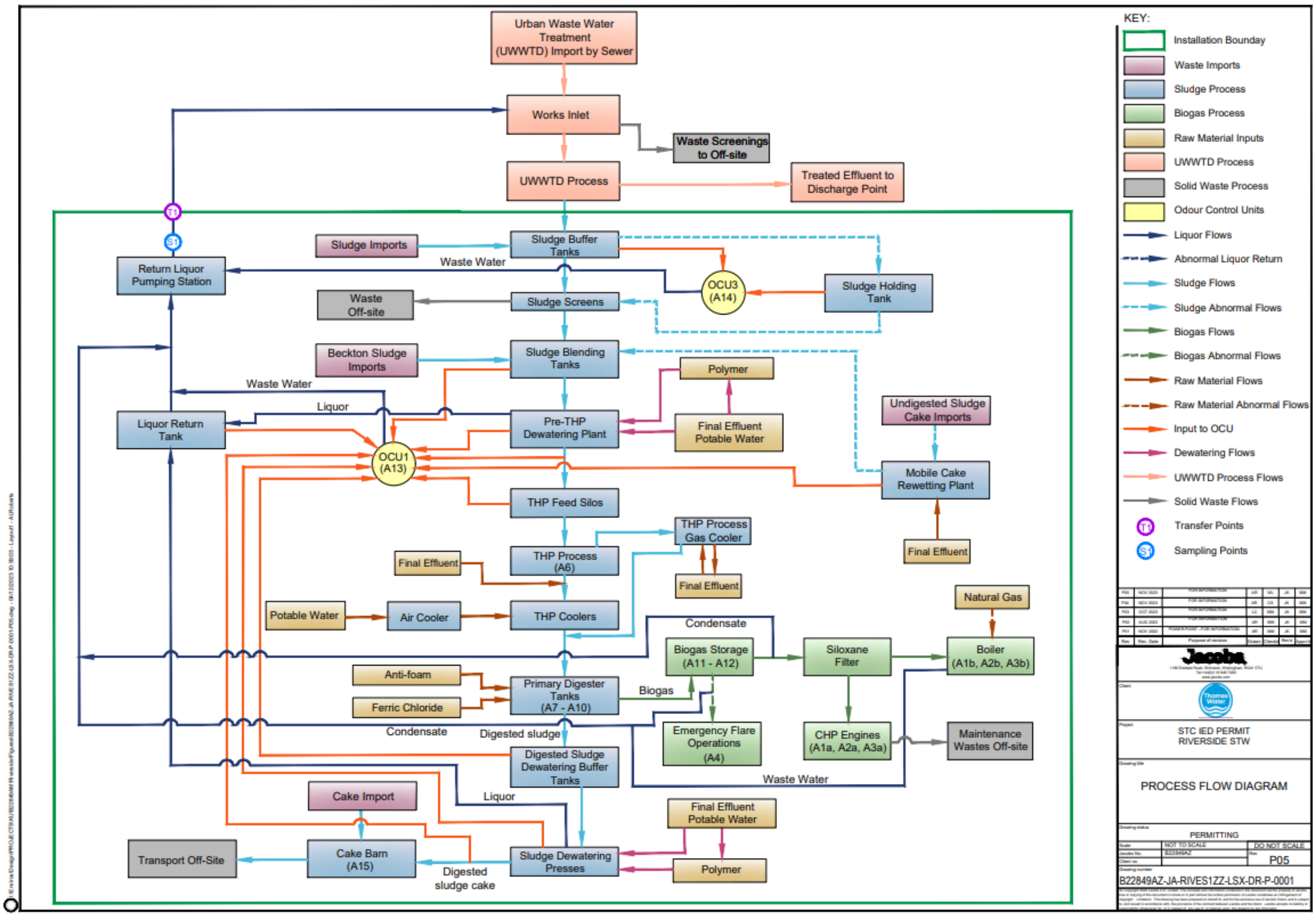

Figure 5.1 Process flow diagram for Riverside STW

5.2 Foul Process and Effluent Drainage

Site drainage plans were updated at the end of March 2021. The drawings indicate that the site drains fully to the works inlet. See drawing references: RIVES1ZZ-SSP-001-C, RIVES1ZZ-SSP-002-B and RIVES1ZZ-SSP-003-B.

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 Riverside.

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 for digester area 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 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 Riverside being large, minor spill flows will not adversely impact the process.
- In most locations, to accommodate the new isolation valves, new manholes need to be constructed over the existing drainage lines.

6. Conclusions

This section summarises the findings of the containment assessment options report for Riverside 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 report outlines the options available for providing secondary containment of a catastrophic tank or digester failure within the sludge treatment centre in which the tanks sit.

The total contained volumes comprise:

Containment Area	Volume	Rule
Wide containment area	**6,817m^3**	largest tank plus rainfall

Containment Area	Description of containment
Wide containment area	• Wide containment with bund walls between 0.30-0.95m high that will contain a spillage within the site. • 3 large ramps will provide access for vehicles as area is frequently visited during the day. • Steps installed for access to foot traffic. • 3 gates will be installed to allow infrequent access to vehicles where space precludes the use of ramps.

The contained spill modelling retains the tank contents and associated rainfall within the site boundary and the flows can be managed by TW operations for return to treatment. Some reprofiling of the containment area has been identified otherwise water may pond in isolated locations to a depth of 0.75m.

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 low and the potential impact is mitigated by the action of the site drainage system conveying flow to treatment.

Appendix 1 ADBA Site Hazard Risk assessment summary for Riverside STW

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 Riverside STW are as follows:

Source – There is one main source that has been identified:

1. Sludge digestate

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

Pathway – There are two pathways that have been identified:

1. The process and site drains take any liquid to the head of the works which would negatively impact the process stability on site and would eventually impact on the receiving watercourse.
2. Sludge treatment centre is integrated with large sewage works; as a consequence,

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

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

1. The site is within 250m of a number of warehouses.
2. There are dwelling within 500m of the site
3. The site sits over a high vulnerability aquifer

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

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.