MOTT MACDONALD

CONTAINMENT ASSESSMENT FOR AFAN SLUDGE TREATMENT CENTRE

October 2023

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Mott MacDonald
4th Floor
Mountbatten House
Grosvenor Square
Southampton SO15 2JU
United Kingdom

T +44 (0)23 8062 8800
mottmac.com

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Issue and Revision Record

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Contents

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Abbreviation and Definition

WwTW - Wastewater Treatment Works

IED - Industrial Emission Directives

THP - Thermal Hydrolysis Plant

STC - Sludge Treatment Centre

ESCO - Enhanced Secondary Containment Options

Executive summary

Mott MacDonald has been appointed by Welsh Water to carry out a containment assessment of Afan Wastewater Treatment Works (WwTW), in particular the sludge treatment centre (STC) within the works. The purpose of this assessment is to determine the impact, risk, and high level options available to prevent a failure of primary containment within the STC from contaminating the surrounding environment.

This study is based on CIRIA C736 Containment Systems for the Prevention of Pollution (London, 2014), which provides guidance on identifying the hazards, assessing the risks, and mitigating the potential consequences of a failure of the primary sludge storage facility/source. The sources are referred from the 100123523_MSD_AFA Industrial Emission Directives (IED) Permit Application - Main Supporting Document (MSD) for Afan STC prepared earlier by Mott MacDonald in July 2022.

Existing secondary containment, including kerbs and speed humps, has been installed based on a prior CIRIA C736 risk-based approach to contain sludge from a credible failure scenario. At the request of Natural Resources Wales (NRW), this study considers the scenario of a complete failure from any primary containment within the IED permit boundary, and the suitability of potential options to provide secondary containment for such an event. The report sets out the approach taken to apply the CIRIA 736 principles within the accepted constraints of a retrofitted solution to an existing STC operation.

In this study, the site's condition, potential sources, modelling of surface water flows and sludge pathways to identify the spill containment requirement, and impact on receptors is outlined. For the event of a primary containment breach, the hazards presented for sources, pathways, and receptors are assessed as **high**. The effectiveness of the existing secondary containment reduces the likelihood of these hazards to **low**. This leads to a requirement for Class 2 tertiary containment to address the primary containment failure scenario.

The total volume of identified sources within the IED permit area is 10766m^3, stored across 14 tanks with individual volumes varying between 13m^3 to 4250m^3 (refer to section 2.1 for details of the individual tanks and volumes). The majority of volume is stored between the two Primary Digesters with a working volume of 4250m^3 each. The site is generally low lying and flat. In line with the CIRIA guidance, a worst-case scenario was chosen for modelling, which was the failure of one of the two Primary Digesters. The volume held by secondary containment for either of these failure scenarios would be sufficient to contain the failure from any other tank within the containment area.

The potential of flooding, fire, and jetting to affect this worst-case scenario was assessed as not credible. The site is outside flood zones, both digesters being built of non-combustible, reinforced concrete, and are more susceptible to seeping which would be identified through routine site walkovers by operators.

The worst-case scenario containment volume of 5215m^3 was calculated by taking the working volume plus 24hrs of rainfall from a 10% AEP storm event. The storage within the permit boundary was compared against the CIRIA C736 110% rule and 25% rules, and the 110% rule applies. The modelled spill volume was found to be greater than both the CIRIA C736 110% and 25% containment capacity requirements.

Five potential secondary containment options were proposed and assessed with DCWW asset managers and site operators to assess their feasibility. The high-level proposed option extends beyond the STC to capture all identified sources, and would require additional concrete walls and the use of flood gates across trafficable areas. It utilises the existing secondary containment of impermeable ground and kerbs/speed humps, which will help direct the flow to the existing drainage. In the event of a spill, drainage in the containment area will flow to the liquor returns chamber (already isolated from other drainage in the STC) and pumped to the head of the works. DCWW has provided updated emergency management procedures detailing how the response and recovery would be managed. The chamber can remove approximately 2000m^3 per day, which is sufficient to prevent any additional rainfall following the event from spilling out of the containment.

The suitability of this option is impacted by the requirement for regular vehicle flow through the STC. If flood gates are required to open and close too frequently, they could have prohibitive maintenance costs or fail to work in the worst-case scenario. Larger speed humps (greater than 100mm in height) are not suitable for the sludge tankers that use the site, which limits alternative options for the trafficable areas. The wall heights, as provided, do not include freeboard, these heights and their eventual location on site require further details and optimisations in subsequent design phases.

In line with the Best Available Techniques Reference Document for Waste Treatment (Bref), DCWW already employ a wide range of measures that reduce the likelihood and impact of overflows and provide controls for leak detection, as detailed in the supporting documentation for the Afan IED Permit Application. The applicability of providing buffer storage for this worst-case scenario must be considered against the space availability of the existing plant, the level of investment required, and the credibility of the scenario itself.

1 Introduction

1.1 Background

Dwr Cymru Welsh Water (DCWW) is required to provide containment of sludge spills at their Sludge Treatment Centres (STC) that process over 100t of sludge per day, to comply with the Industrial Emissions Directive. Natural Resources Wales (NRW) provides permits to demonstrate compliance with the Directive. Afan Wastewater Treatment Works (WwTW) contains one STC, with associated infrastructure, where sludge is treated through anaerobic digestion (AD).

Mott MacDonald has been appointed by DCWW to carry out a risk and containment options assessment of Afan STC. The purpose of this report is to assess the risks present at the Afan STC, the existing capacity available to contain accidental spills, and identify potential high-level secondary containment mitigation that could be implemented. The study is based on *CIRIA C736 Containment Systems for the Prevention of Pollution (London, 2014)*[1], which provides guidance on identifying the hazards, assessing the risks, and mitigating the potential consequences of a credible failure scenario from the primary storage facility, as well as the design of new containment systems, and the guidance provided in the Best Available Techniques (BAT) Reference Document for Waste Treatment. A summary of the approach to spill containment is described in Section 1.3.

1.2 Overview of Site and Activities

Afan STC is situated within Afan WwTW, which is located within Port Talbot. The site is manned 24/7 with one or more DCWW operators. The site is fully enclosed within the Tata Steel UK industrial works at Port Talbot, and surrounded to the north, east and south by steel manufacturing process plant. Access to the site is only through private roads by arrangement with Tata Steel. To the west, the final effluent from the treatment works is discharged into the Bristol Channel. The address for the site is Afan STC, Phoenix Wharf, Harbour Road, Port Talbot, SA13 1RA (NGR SS 76061 87329). A satellite overview of the location is presented in Figure 1.

[1] https://gptenvironmental.co.uk/CIRIA_report_C736_-_Containment_systems_for_the_prevention_of_pollution.pdf

Figure 1 - Satellite view of Afan WwTW and STC

The STC was constructed around 2001, with the STC being constructed around 2011. The STC is operated under the Urban Wastewater Treatment Regulations (UWwTR) and has a standalone Water Discharge Activity Environmental Permit. The waste activities at the site comprises of imports, physio-chemical and anaerobic digestion treatment, and the storage of waste, all for recovery purposes. The STC solely handles waste derived from the wastewater treatment process, either indigenously produced on-site or imported from satellite sites (pre-digestion). The site undertakes AD of this sewage sludge.

This document discusses the site's condition, potential pollution sources, modelling of surface water flows and sludge pathways to determine the spill containment requirement, and the effectiveness of the proposed containment in the event of catastrophic failure of assets or tanks within the STC.

1.3 Levels of Containment

Primary containment or storage is provided by the actual tank or vessel. It is the most important means of preventing major incidents involving the loss of sludge. It comprises the equipment used to store or transfer sludge such as storage tanks, intermediate bulk containers (IBCs), drums, pipework, valves, pumps and associated management and control systems. It also includes equipment that prevents the loss of primary containment under abnormal conditions, such as high-level alarms linked to shut-down systems.

Secondary containment is provided by a bund immediately surrounding the primary vessel or tank or as remote containment. It minimises the consequences of a failure of the primary storage. It comprises equipment that is external to and structurally independent of the primary storage, for example, localised concrete or earth bunds around storage tanks, or the walls of a warehouse storing drums. Secondary containment may also provide storage capacity for firefighting and cooling water.

Secondary containment minimises the consequences of a failure in the primary and secondary containment systems by providing an additional level of protection preventing the uncontrolled spread of the sludge. These include purpose-built structures, such as diversion tanks and lagoons, but can also use other measures such as containment kerbing to roadways and parking areas and impervious liners and/or flexible booms. Secondary containment will be used when there is an event that causes the escape of liquids from the secondary containment through failure or overflow (e.g. bund joint failure, or firewater overflowing from a bund or escaping from a building/warehouse during a prolonged fire).

With careful design and planning a system can be provided that is capable of providing the necessary degree of environmental protection. The overriding concern is the robustness and reliability of the system, which depends on a number of factors:

- 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, or wider environment, by closure of control valve(s).

1.3.1 BAT 19

The supporting documentation for the Afan STC permit includes a comparison of the Best Available Techniques (BAT) given in the BAT Reference Document for Waste Treatment (BREF). Of particular relevance to this risk and containment options assessment are sections 2.3.11, 2.3.13.2, and 6.1.5. Many of the techniques proposed are covered under DCWW's existing accident management procedures, best practice design and works operating manuals, which are provided as other supporting documentation to the Afan IED Permit Application. Further, the applicability of some techniques for containment are limited on existing sites. As Afan STC is part of an existing plant, the containment options were assessed in line with the BREF, where it can be reasonably applied on an existing site.

A summary of where the BAT are addressed across the permit application submission documents is included in the document B16399-123532-XX-XX-ME-WA-DH1010 Response to Containment Assessment Report Summary.

1.3.2 Existing Secondary Containment

In 2022, Mott MacDonald Bentley installed secondary containment measures in line with the CIRIA C736 risk assessments completed at each of the 5 zones within the Afan STC, as described in the permit supporting document B14411-123532-ZZ-XX-AS-ZA-CI1016 - Afan CIRIA 736 Risk Assessment - Summary. These measures are shown in drawing B14411-123532-XX-XX-DR-CA-CI9002, which is available in Appendix A. The operation and maintenance of this containment is also included as 100123523_MSD_O&MNewContain_AFA.

The existing secondary containment has been found to not contain all the credible scenarios, therefore, enhanced secondary containment needs to be considered.

1.3.3 Enhanced secondary containment

All the options considered are based around providing enhanced secondary, or secondary, containment measures for a worst-case scenario of primary containment failure within the IED permitted area. The objective of these options is to prevent a spill 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 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 to hold the spill on site.

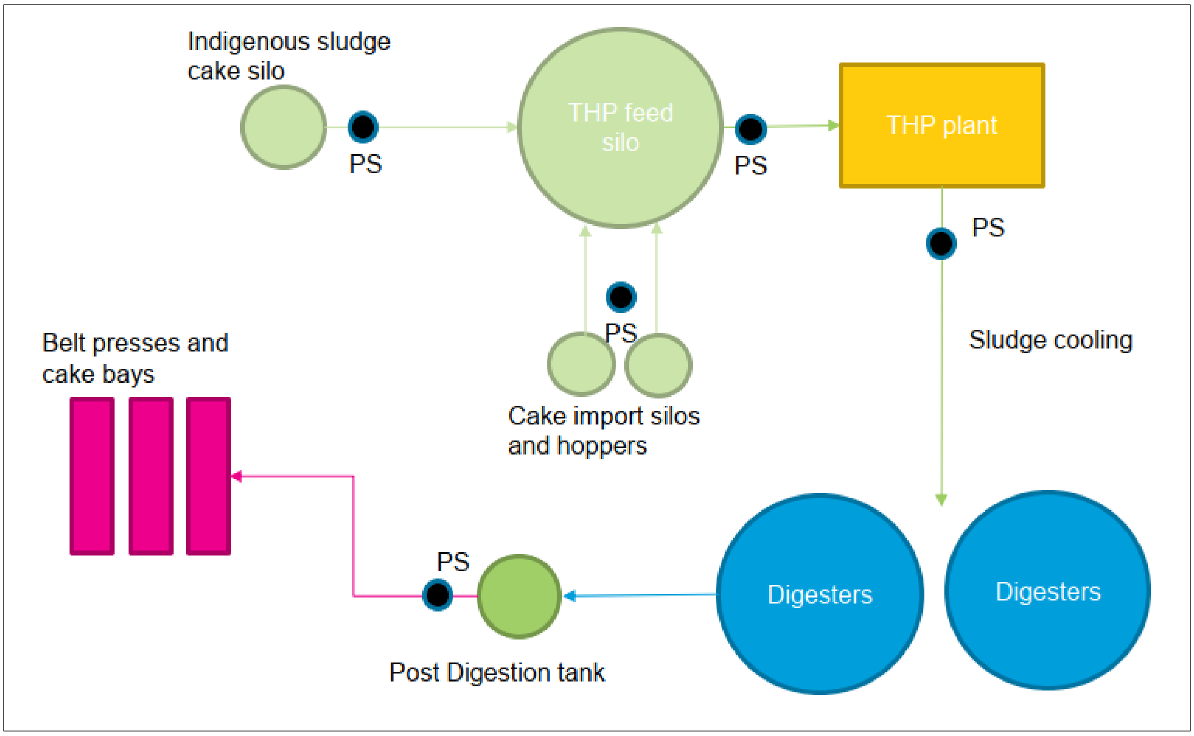
2 Site Details

2.1 Site operation and process

Afan STC is situated within Afan WwTW to treat urban wastewater indigenous sludge produced at the STC. The flow diagram of the process at the STC is shown in Figure 2, where the assets involved in the sludge treatment process and sludge flow direction are marked.

Indigenous secondary sludge is transferred from the SAS tank to centrifuges, where the first dose of polymer is added. The thickened sludge is then pumped into the indigenous cake silo, where it is pumped into Thermal Hydrolysis Plant (THP) feed silo. The THP feed silo also receives thickened sludge cake from imported cake silos/hoppers. From the THP feed silo, sludge is pumped into the THP process, which travels through pulper reactors, and a flash tank. The sludge is processed by using pressurised steam in the THP. Steam condensate and gases are either recaptured back into the THP process or captured in the foul gas drum and discharged into the digester. Treated sludge from the flash tank is pumped into digesters after cooling it to approximately 40ºC, where it is retained for a minimum of 13 days. The sludge is then transferred via gravity into the Post Digester Sludge Tank (PDST). From here it is pumped up to belt presses (sludge thickeners). Digested sludge is dewatered to 26 – 30% dry solids before being transferred to the cake barn (consisting of 3 bays) and left to mature for 4 days. After which it is taken away to be spread to land or quarantined off-site if it has not met the required pathogen limits.

Figure 2: Process Flow Diagram for STC



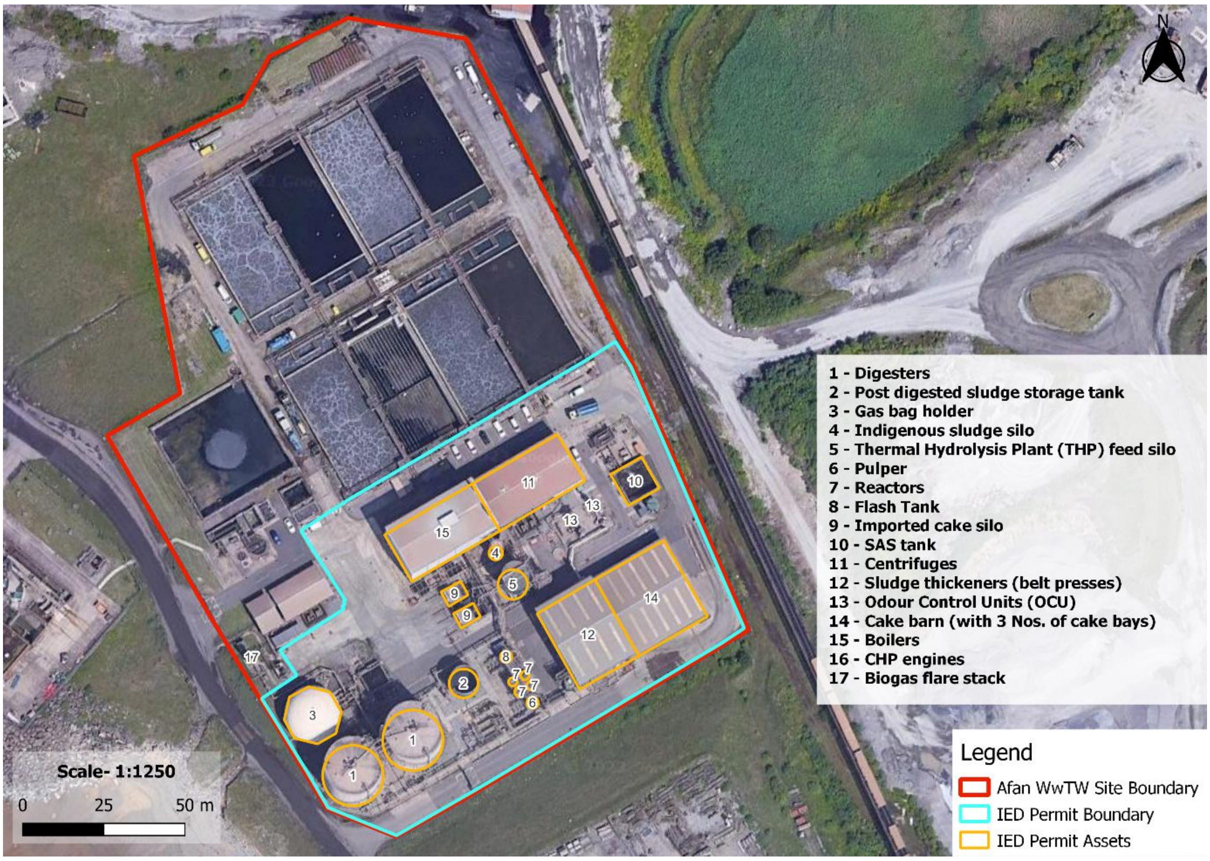
Source: IED Permit Application (Afan Main Supporting Document PDF) - 100123523_MSD_AFA, July 2022

The IED permit includes the assets which are tabulated in Table 2-1 and the location of these assets is marked in Figure 3. For clarity, in each case, the volume/capacity provided refer to the total tank capacity i.e. the maximum volume that a particular tank could potentially hold, with the exception of the digesters. Each digester feeds to a combined sludge overflow channel, which allows the upper headspace of the tank to generate biogas. The volume provided here is, therefore, the working volume of the tank (i.e. below the overflow outlets) as there are no operational or maintenance conditions where the sludge in either tank would be greater than 4250m^3.

Table 2-1: List of IED permit assets

Sr. No.	Asset Name	Description	Volume/ Capacity	Considered as "Source"	Justification
1	Digesters	2 Nos.	4250 m^3 each*	Yes	Digested sludge
2	Post digested sludge storage tank	1 No.	500 m^3	Yes	Digested sludge
3	Gas bag holder	1 No.	2000 m^3	No	Biogas
4	Indigenous sludge silo	1 No.	100 m^3	Yes	Thickened sludge
5	Thermal Hydrolysis Plant (THP) feed silo	1 No.	600 m^3	Yes	Thickened sludge
6	Pulper	1 No.	42 m^3	Yes	Thickened sludge
7	Reactors	4 Nos.	13 m^3 each	Yes	Thickened sludge
8	Flash Tank	1 No.	42 m^3	Yes	Treated sludge
9	Imported cake silo	2 Nos.	40 m^3 each	Yes	Thickened sludge
10	SAS tank	1 No.	400 m^3	Yes	Raw sludge
11	Centrifuges	2 Nos.	-	No	Thickened sludge
12	Sludge thickeners (belt presses)	3 Nos.	-	No	Digested sludge
13	Odour Control Units (OCU)	2 Nos.	-	No	Odorous air
14	Cake barn (with 3 Nos. of cake bays)	1 Nos.	450m^3	Yes	Matured sludge
15	Boilers	2 Nos.	3.9MWth each	No	Biogas/natural
16	CHP engines	2 Nos.	3.745MWth each	No	Biogas
17	Biogas flare stack	1 No.	1,500m^3/hr	No	Excess biogas

Figure 3: IED permit assets and satellite view



Loss of containment consists of loss of gaseous materials, failure of the liquid containment systems and material storages. In order to minimise the potential for accidental releases, various measures have been adopted at the site. All staff provided with responsibility for the handling or transfer of gaseous/liquid materials receive appropriate training for their role. All staff on site receive training for site emergency procedures and the actions to take in the event of discovering a gas leak/liquid spillage and the use of spill containment measures as part of their mandatory site induction training. Regular monitoring and inspection of storage vessels, pipework and gas levels/fluid levels shall be undertaken to ensure no fugitive emissions are being released and to ensure the structural integrity of the system remains uncompromised. All sludge treatment activities are undertaken in enclosed buildings or tanks.

2.2 Site condition

The Site Condition Report (SCR)[2] provides detailed information about land use, geology, hydrogeology and flooding, which can be found in the sections below.

2.2.1 Hydrology and flooding

The beach associated with the Bristol Channel is located adjacent to the south-western corner of the proposed permit boundary, with a tidal mark seen approximately 40m from the site boundary. The outline of a pond is also seen approximately 40m to the north-east of the wider STC site. Various flood risks are referred[3] and the details are provided in the following sub sections.

2.2.1.1 Risk of flooding from rivers

The current Natural Resources Wales flood map (Figure 4) shows the STC site, including the proposed permit boundary, is at very low risk (less than 0.1% chance of flooding each year) of flooding from rivers and local watercourses.

Figure 4: Flood risk from rivers

2.2.1.2 Risk of flooding from surface water and small watercourses

As per Figure 5, most of the site area is unlikely to experience surface water flooding. There is a very small area that is at low risk of flooding near the road along the southern boundary of the site.

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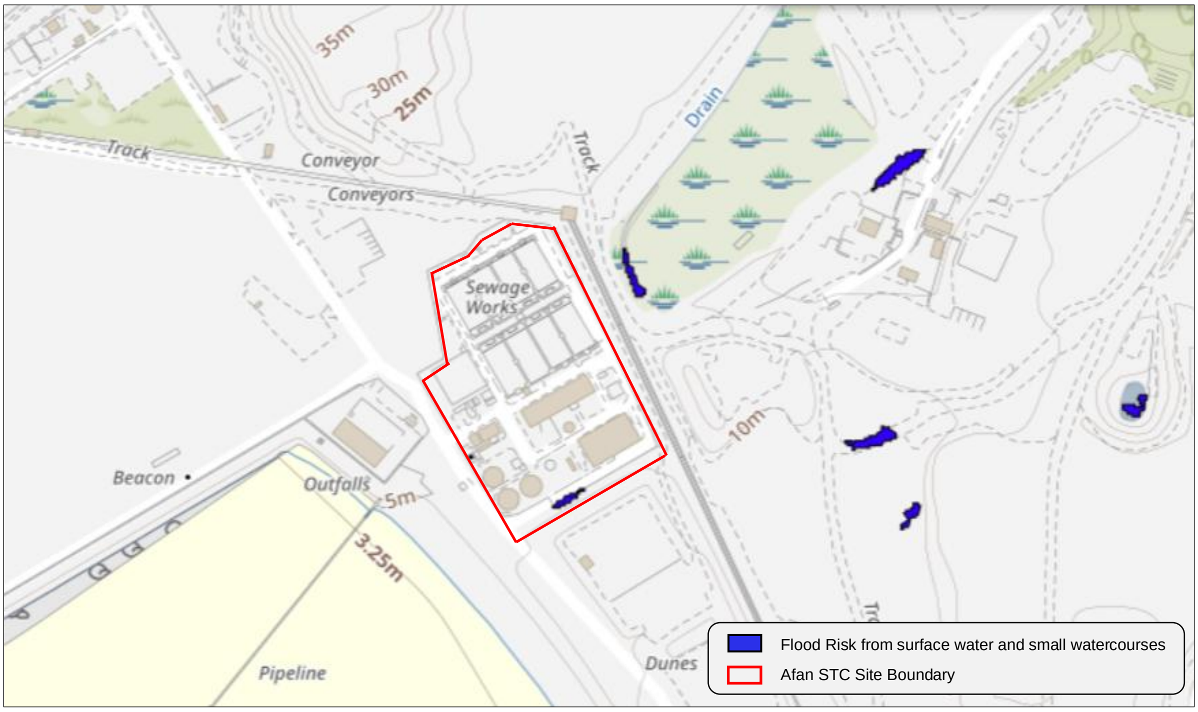
[2] IED Permit Application - 100123523_SCR_AFA (2022)

[3] https://check-your-flood-risk.naturalresources.wales

Figure 5: Flood risk from surface water and small watercourses



2.2.1.3 Risk of flooding from the sea

Figure 6 shows that, the location of the site is at very low risk from sea flooding.

Figure 6: Risk of flooding from the sea

In summary, the flood risk, due to various sources, is very low (less than 0.1% chance of flooding each year). Appendix B contains a copy of the flood risk report.

2.2.1.4 Risk of flooding from groundwater

The site is located in an area of 'Landscaped Ground', which refers to the area of reclaimed land. The site, lies upon an area of Blown Sand, comprising sands which are observed as superficial deposits. The Blown Sands superficial aquifer is designated as a Secondary A aquifer. Tidal Flat Deposits can be found adjacent to the site on the east side, and Marine Beach Deposits can be found adjacent to it on the west side. The Marine Beach Deposits are classified as a Secondary Undifferentiated aquifer. The site lies upon the South Wales Middle Coal Measures Formation and further underlain by the South Wales Lower Coal Measures Formation, which both comprise mudstone, siltstone and sandstone. The South Wales Middle Coal Measures formation is designated as a Secondary A aquifer.

The north of the wider STC site lies within an area of groundwater flooding capability with potential flooding at the surface. Directly north of the STC site there is potential for flooding of property situated below ground level. There are no areas of the proposed permit boundary indicated as being affected by groundwater flooding.

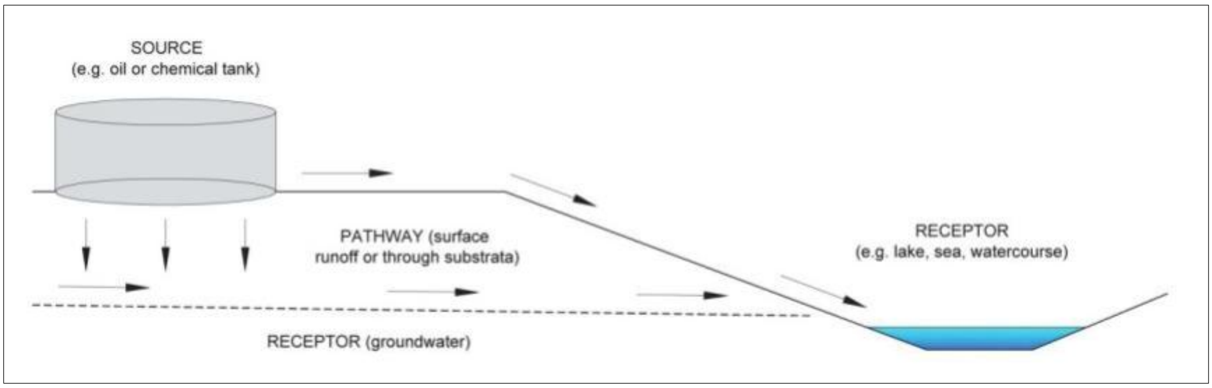
3 Source – Pathway – Receptor Analysis

3.1 Introduction

CIRIA C736 and ADBA Industry Guidance state how the hazard rating of the site risk and classification are to be calculated. This is detailed below and in B16399-123532-ZZ-XX-AS-ZA-CI1012 - Afan ADBA Assessment.

Source - Pathway - Receptor analysis is important for determining the Site Hazard Rating which helps to identify the level of containment requirement. Figure 7 shows the schematics diagram of the Source, Pathways and Receptors.

Figure 7: Schematic diagram of Source - Pathway - Receptor



The following sections discuss how the potential sources are identified, and how the sludge would travel/ spread along the pathways and reach the receptors.

3.2 Source

3.2.1 Tanks

To model the event of a credible and catastrophic tank failure which would result in loss of containment of sludge at Afan, the assets on site must be evaluated to identify the most significant failure events.

All potential sources are tabulated in Table 2-1 and in the attached ADBA Tool. The total volume of all sources containing sludge is 10,766m^3, with the two 4,250m^3 digesters making up the majority. The location of these tanks can be referred from Figure 3. These tanks are filled with either digested or thickened sludge. These tanks contain organic heavy elements including Nitrogen, Phosphorous, Ammonia, BOD, TSS, and COD, and the process can create algae blooms, methane and death of organisms, especially in the digestor tanks. All tanks are reinforced concrete tanks, apart from the THP tanks (pulper, reactor and flash tanks) and imported cake silo, which are all steel tanks. Their flammability and corrosivity is low.

As per CIRIA C736, the volume contained must be the larger of 110% of the capacity of the largest tank or 25% of the total storage capacity within the bunded area. The 110% and 25% rules were compared, and it was found that the 110% volume of one 4,250m^3 digestor tank (4,675m^3) was greater than the volume of 25% of all tanks within the IED permit (2,672m^3).

Therefore, for this containment assessment, the source to be contained is 4,675m^3 of sludge from the digestor.

3.2.2 Containment for all raw materials stored on site

As shown in Table 2-1, the volumes of each kind of raw material storage are significantly smaller than the volume of the digestors. The total volume of all non-digestor sources is only 2,266m3, compared to the minimum secondary storage volume of 4,675m^3 needed for the site. Therefore, any storage that contains these sources within the boundary and is sized using the CIRIA 110% rule will be capable of containing a spill from any of these other sources, even if all other sources were to spill at the same time. The primary digestors are not linked to any other identified source or each other, so containment of largest independent failure event is deemed sufficient for containing any other raw material without further consideration of the dependencies.

For this assessment, the location of each source (i.e. each raw material storage) is considered as a part of the containment options. When volume is discussed it will only refer to the primary digestors as the source being contained, however the same containment will act to contain all raw materials sources within the STC.

3.2.3 Firefighting water

In the event of a fire at the site, the volumes of firefighting water put onto the site to quell a fire are important to consider as a potential source of flooding. The capacity of the biogas holder located near to the digestors is 2,000m^3 in total (approximately 2.2 tonnes) and based on this quantity, the severity of a potential fire is categorised as medium by CIRIA C736 (see Table 3-1).

The volume of firefighting demand is around 4000m^3, however, as per CIRIA C736 this is specifically for chemical plants. The volume of water required would be less for an STC site compared to chemical plants. It is considered that the firefighting water demand would be less than 4000m^3 and less than the highest volume identified from the sources listed. The likelihood of a fire from the biogas holders resulting in the digestors failing and spilling during a 1 in 10 year rainfall event is highly unlikely, less than 1 in a million, hence, the firefighting water is not considered further as a potential source in this study.

Table 3-1: Firefighting water demand

Table 4.4 *Forecast of firefighting water needed to tackle major chemical plant fires (courtesy ICI)*

Plant hazard rating[1]	Firefighting water demand
High severity	Total demand 1620–3240 m^3/hr for four hours
Medium severity	Total demand 1080–1620 m^3/hr for four hours
Low severity	Total demand 540–1080 m^3/hr for four hours

Notes[1]

High severity includes plants with:

- over 500 tonnes of flammable liquid above its flashpoint
- over 50 tones LPG above its boiling point and over 50 bars
- over 100 tonnes combustible solid with ready flame propagation
- other factors what increase severity

Medium severity covers plants that fall between high and low severity ratings.

Low severity includes plants with:

- less than 5 tonnes flammable liquids above or below flashpoint
- less than 100 kg flammable gas under 1 bar or a flash liquid
- less than 5 tonnes readily combustible solid
- other factors that decrease severity

Source: CIRIA C736

3.2.4 Cake barn

The cake barn at the site is located inside the sludge dewatering building and is used to store treated cake after the dewatering of digested sludge to 26% - 30%. This cake barn is shielded by surrounding walls and a roof, but is open to the north and south to allow vehicle entry and exit. While it is a part of normal STC operations, the stored cake requires containment and is, therefore, included in this assessment.

3.2.5 Source Hazard Rating

From this assessment, the source hazard rating has been considered **medium**, due to the characteristics of the sludge contained within the tanks.

3.3 Pathway

Pathways are how a hazardous substance would reach a receptor. As per CIRIA C736, the area of search for potential receptors is governed by the potential pathways and these might include:

1. Simple overland flow following the local topography.
2. Existing pipes, sewers, drains or other underground features that could lead to a receptor such as a watercourse.
3. Permeable sub-soils and strata underlying a site that could provide a pathway to groundwater or a watercourse.

Multiple combinations of pathways may exist and should be considered. In considering the hazard rating of potential pathways the following should be considered[4].

1. The distance between the source and the various potential receptors.
2. Site layout (including topography), and the position and effectiveness of drains and other internal and external pathways.
3. Geographical, geological, and hydrogeological features that could either impede or facilitate the escape of inventory from the site. In addition, building foundations may impede or alter sub-surface drainage paths.
4. Climatic conditions and expected variability.

[4] https://gptenvironmental.co.uk/CIRIA_report_C736_-_Containment_systems_for_the_prevention_of_pollution.pdf

5. The direct effects of fire and the introduction of firefighting water, or foam.
6. The presence of treatment plants (on or off-site).
7. Modification of the inventory during passage through the pathway such as the cooling of a liquid.
8. Inventory that is not particularly mobile in ambient conditions may be soluble in water.
9. The scale of potential incidents (larger incidents and firewater generally have greater potential for mobilisation in the environment than smaller spills).

As per the ADBA tool, the guidance gives the following pathways are given the following hazard rating.

Pathway	**Environmental Hazard Rating**
Site is raised above a nearby receptor	M
Chalk	H
Fractured chalk	H
Principal aquifer	H
Groundwater protection zone 1	H
Annual rainfall < 1000 mm	L
Annual rainfall > 1000 mm	M
Site is in a flood plain	M
Site is at bottom of a hill	M
Site is connected to a sewage treatment works	M
Inflammable materials normally present on site in large quantities	M
Mitigation – secondary containment is present	L
If any of the site inventory has a runoff time of a few minutes	H
If any of the site inventory has a runoff time of a few hours.	M
If any of the site inventory has a runoff time of a few days	M
If any of the site inventory has a runoff time of a few weeks	L

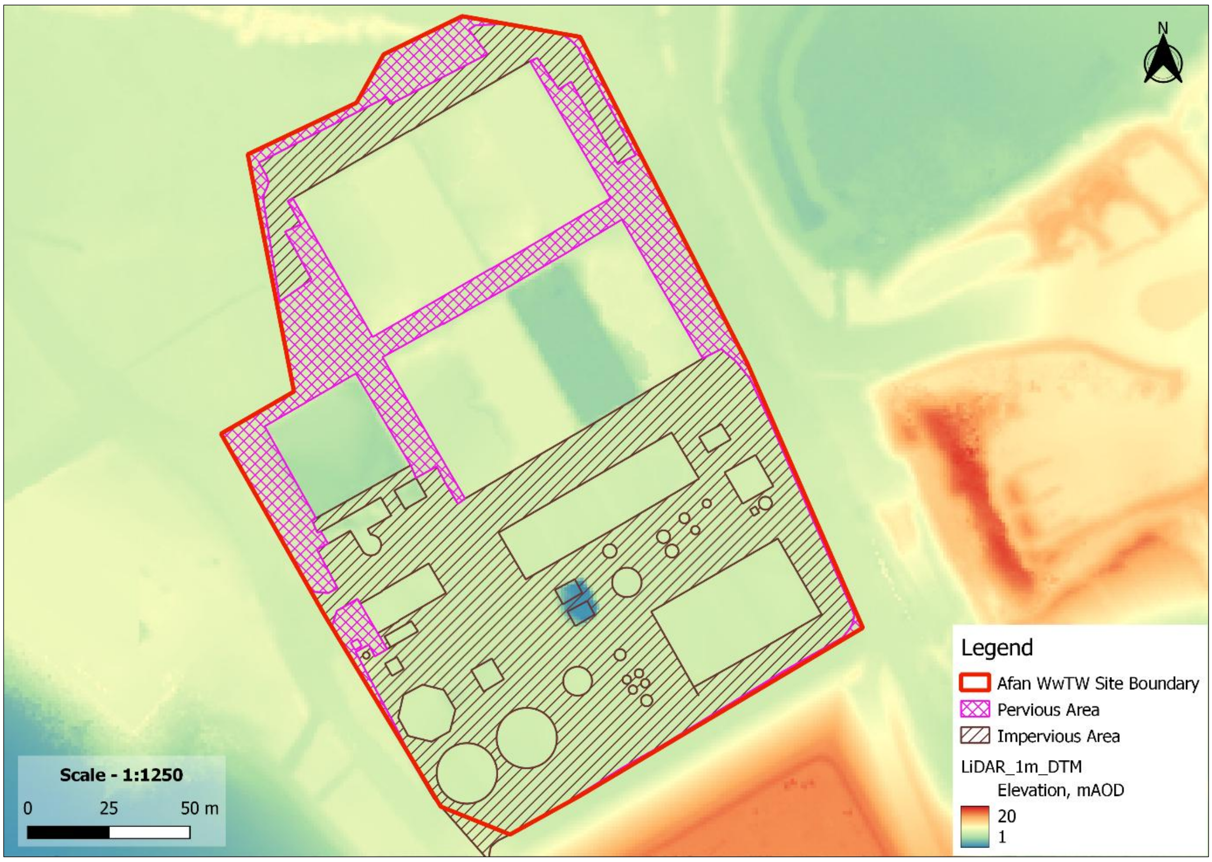
Two potential pathways are identified at Afan STC, these are overland flow and subsurface flow.

3.3.1 Overland flow pathway

Overland flow paths within the site are as per the existing topography. From the LiDAR data, it is observed that the elevation at the site varies from 7mAOD to 9.5mAOD. The rainfall-runoff water flows based on the topography and towards the area that has a relatively low elevation (Figure 8). This means that the topography of the site is such that in a loss of containment event, liquid sludge would flow under gravity and, therefore, the provision of additional containment measures is required to prevent flow into the water systems and surrounding environment. The majority of the site is covered by impervious layers (roads and concrete areas around the assets) (Figure 8). These will serve as a major pathway for sludge to reach the on-site receptors.

To understand the modelled flow pathways from digestor tank catastrophic failure refer to section 4 for more information. This run-off risk without containment has been classified as **medium** risk and is likely to reach the sea within hours.

Figure 8: Pathways at Afan STC



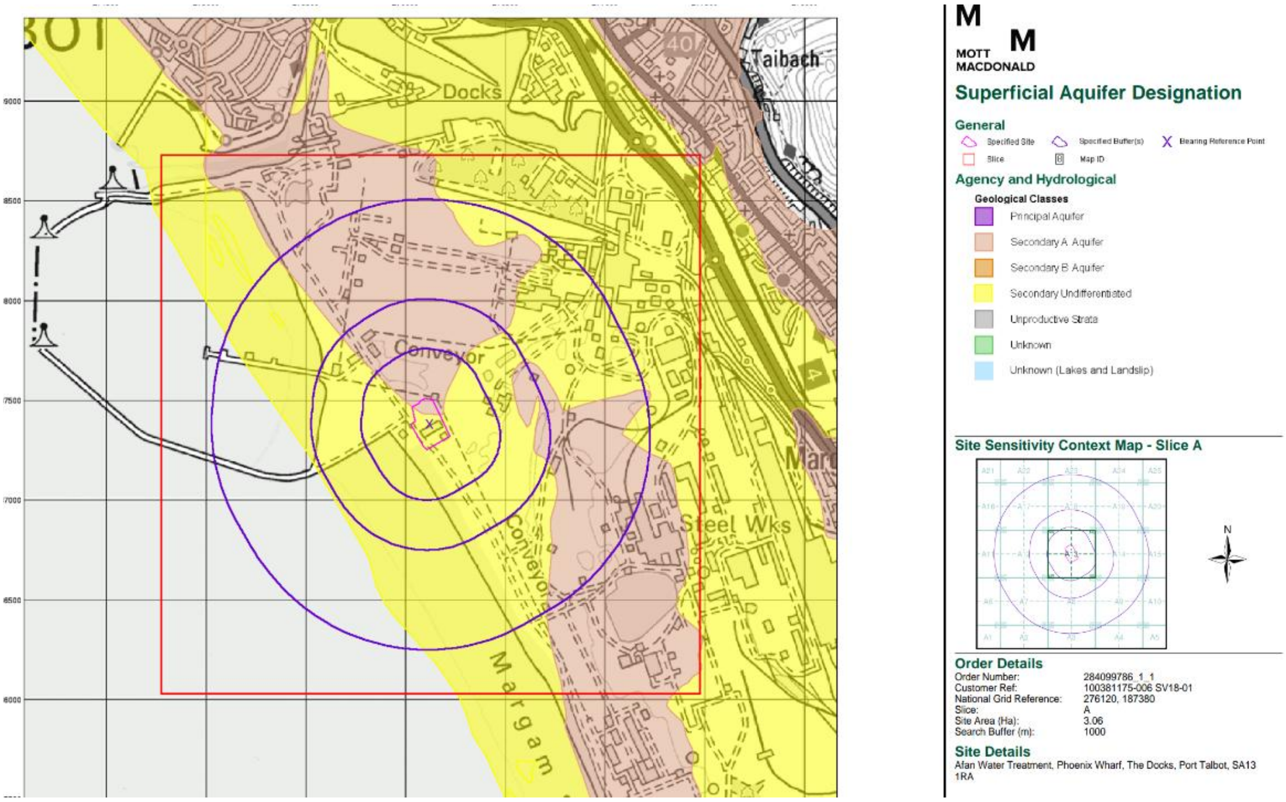
3.3.2 Groundwater/subsurface flow pathway

There are some grass and bushes (pervious area) within the site which could potentially serve as a pathway for sludge to enter the groundwater.

Afan, from the Cyfoeth Naturiol Cymru Interactive Map Viewer, is located in a Secondary A aquifer and Secondary Undifferentiated aquifer seen in Figure 9. These are defined as follows:

- Secondary A aquifer – comprising of *"permeable layers that can support local water supplies, and may form an important source of base flow to rivers".*
- Secondary Undifferentiated aquifer – comprising of *"where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type. These have only a minor value."*

Figure 9 - Groundwater Vulnerability Map



The simplified groundwater vulnerability from the Cyfoeth Naturiol Cymru Interactive Map Viewer shows this area is medium-high groundwater vulnerability risk, but is not in any groundwater safeguard zones or source protection zones. For this reason, it has been classed as a **medium** risk, and will be mitigated within the site boundary by replacing permeable areas with impermeable hardstanding to eliminate the pathway to the ground.

3.3.3 Pathway risk rating

Using the ADBA tool as guidance, the site has been given a pathway risk rating with no containment of **medium**. This is due to the presence of the Secondary aquifer in Afan, and the run-off time for the site inventory to reach the sea or surrounding grass areas, which would occur in hours.

3.4 Receptor

As per the ADBA tool, the guidance for environmental hazard rating for receptors are as follows and have been used to assess the receptor risk from spills:

Receptor	Within	Environmental Hazard Rating
Watercourse and bodies		
Rivers above potable water supplies	100m	H
Aquifers used for public supply	150m	H
High quality waters	1,000m	H
Agricultural abstraction points	50m	M
High value ecosystems	1,000m	M

Receptor	Within	Environmental Hazard Rating
Watercourse and bodies		
Recreational waters	50m	M
Small treatment works	50m	M
None of the above		L
Habitation		
Dwelling	250m	M
Workplace	250m	L
None of the above		L
Other		
SSSI/SPA/SAC	1,000m	L
RAMSAR Site	1,000m	L
None of the above		L

3.4.1 Off-site receptors

Afan STC is located adjacent to the Bristol Channel. The site does not fall with a nitrate vulnerable zone or within 500m of a Site of Special Scientific Interest (SSSI)[5].

3.4.1.1 Designated sites

There are several designated sites in the vicinity of Afan STC, and these are tabulated in Table 3-2.

Table 3-2: List of statutory designated habitats within 2km and 10km of the site

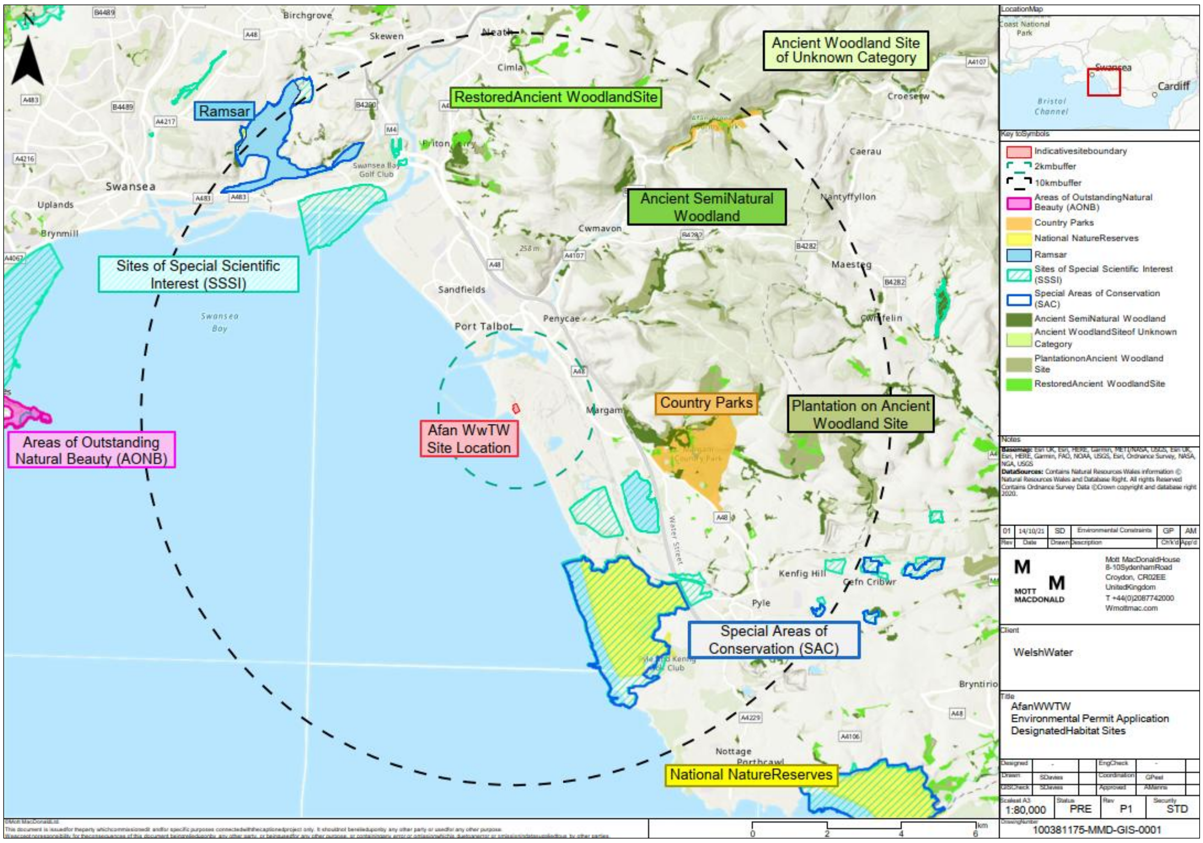
Sr. No.	Site Designation	Comments
1	Areas of Outstanding Natural Beauty (AONB)	Located west of the site
2	Country Parks	Located east & north-east of the site
3	National Nature Reserves	Located south-east of the site
4	Ramsar	Located north-west of the site
5	Sites of Special Scientific Interest (SSSI)	Located south-east & north-west of the site
6	Special Areas of Conservation (SAC)	Located south-east & north-west of the site
7	Ancient Semi Natural Woodland	Located from north to south-east of the site at various locations
8	Ancient Woodland Site of Unknown Category	Located north-east of the site
9	Plantation on Ancient Woodland Site	Located from north to south-east of the site at various locations
10	Restored Ancient Woodland Site	Located from north to south-east of the site at various locations

Source: IED Permit Application - 100123523_ConstraintsMaps_AFA

Sites listed in the above table (within 2km and 10km) are marked in Figure 10 below. There are no statutory designated habitats within 1km of the site, so the risk is deemed **low**.

[5] Source - IED Permit Application (Afan Main Supporting Document PDF) - 100123523_SCR_AFA.pdf
[7] Source - Protect groundwater and prevent groundwater pollution - GOV.UK (www.gov.uk)

Figure 10: Statutory designated habitat sites within 2km and 10km of the site



3.4.2 On-site receptors

There are assets on site which could potentially receive sludge from the failure of various sources (see Figure Figure 11). These receptors are listed in Table 3-3. The boundary of the STC aligns with the permit supporting document 100123523_LocationLayoutPlan_AFA, which is nominally the area to be covered under the IED permit.

Figure 11: Receptors within WwTW and STC

Table 3-3: List of receptors in WwTW and STC

Sr. No.	List of Receptors	Assets within IED Permit Area
1	Digesters	Yes
2	Post digested sludge storage tank (PDST)	
3	Gas bag holder	
4	Indigenous sludge silo	
5	Thermal Hydrolysis Plant (THP) feed silo	
6	Pulper	
7	Reactors	
8	Flash Tank	
9	Imported cake silo	
10	SAS tank	
11	Centrifuges (Inside Existing Dewatering Building)	
12	Sludge thickeners (belt presses) (Inside Sludge Dewatering Building)	
13	Odour Control Unit 1 & 2	
14	Boilers 2 nos. (Inside Existing Drier Building)	
15	CHPs 2 Nos. (Inside Existing Drier Building)	
16	Biogas flare stack	
17	Part of Odour Control Unit 1	
18	Return Liquor Chamber	
19	Strain Press Area	
20	Boiler Water Treatment Tank	

<table>
<tr><th>Sr. No.</th><th>List of Receptors</th><th>Assets within IED Permit Area</th></tr>
<tr><td>21</td><td>Boiler Water Treatment Booster Set</td><td rowspan="2"></td></tr>
<tr><td>22</td><td>Site Lab</td></tr>
<tr><td>23</td><td>Cake barn</td><td>Yes*</td></tr>
<tr><td>24</td><td>FE Outlet Chamber</td><td>No**</td></tr>
<tr><td>25</td><td>Admin Building</td><td>No</td></tr>
<tr><td>26</td><td>Industrial Water Pumping Station</td><td>Yes</td></tr>
<tr><td>27</td><td>Grit Trap with SBR Inlet PS & Storm Overflow Inlet Channel</td><td rowspan="5">No</td></tr>
<tr><td>28</td><td>SBR Outlet Pumping Station</td></tr>
<tr><td>29</td><td>Storm Tank</td></tr>
<tr><td>30</td><td>SBR Basins</td></tr>
<tr><td>31</td><td>Natural Gas Kiosk</td></tr>
</table>

*Cake barn is within the STC and is considered within the IED permit area, but not considered for secondary containment. See section 6.1 for more details.

**The FE outlet chamber is within the STC but requires protection from any loss of primary containment.

3.4.3 Sensitive human receptors

The closest sensitive human receptors are the staff in the office building (refer to Figure 11) which are within 10m of the critical sources. There are no residential dwellings within 250m of the site.

3.4.4 Receptor risk rating

Using the ADBA tool as guidance, the site has been given a receptor risk rating of **medium**. This is due to the presence of the Secondary aquifer in Afan and the beach being within 30m of the digestor.

3.5 Overall site classification

A hazard risk assessment for Afan STC, was also undertaken. Based on the use of the ADBA risk assessment, considering the source, pathway and receptor risk, Afan site hazard rating is deemed to be **moderate** and the likelihood of a spillage was classed as **medium**. Based on these risks, an overall site risk rating was determined to be **medium**, meaning that Class 2 containment is required.

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

4 Assessment of Failure Risk

4.1 Introduction

This section discusses the modelling of the site carried out to identify the potential impact due to the failure of possible sources identified in Section 3. Hydraulic modelling (spill modelling) has been carried out to understand the extent of a primary containment failure of sludge stored at Afan STC. As described in Section 1, secondary containment has already been installed across the STC, which is based on a credible failure scenario of foaming or pipe rupture. When determining the maximum extent of a failure of the tank without containment and potential options to mitigate this, a hypothetical scenario was developed consisting of a catastrophic failure of primary containment occurring after a 24-hour antecedent 10-year design storm. The following scenarios were used in the failure assessment of the STC.

a) Pre-failure - Rainfall is applied over the site to extract the initial water levels (IWL) at the end of a 24-hour simulation with provision of existing secondary containment options, which includes kerbs and speed humps.
b) Post-failure without containment options - Breaching of the critical source is applied with IWL defined and with provision of existing secondary containment options but no enhanced secondary containment options are included,
c) Post failure with containment options - Breaching of the critical source is applied with IWL defined along with the containment options i.e. both existing secondary and potential secondary containment options. Secondary containment options are discussed in Section 5.

4.2 Factors influencing sludge movement

When there is a sudden failure, the sludge from the critical sources would follow the local topography of the site as shown in Figure 12. The movement of sludge is influenced by various factors as below.

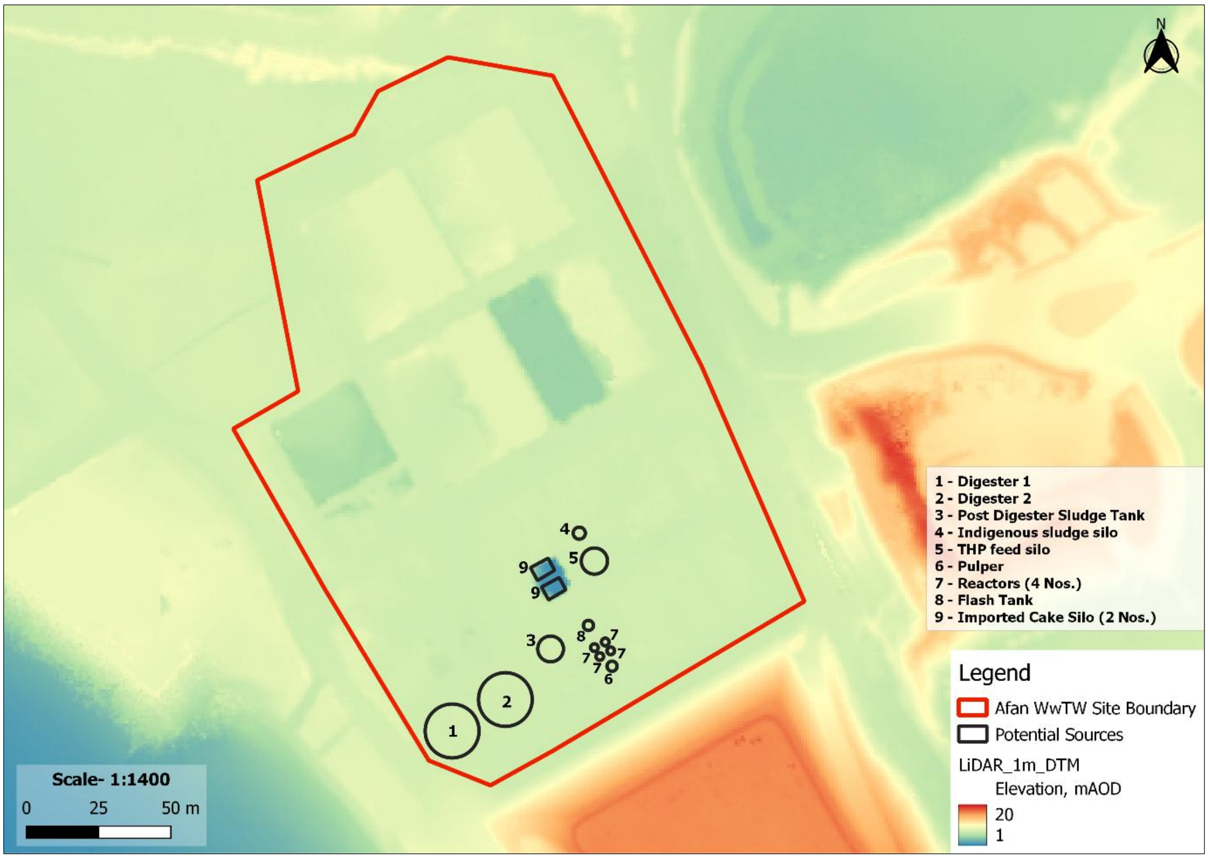
a) Topography
b) Surface roughness
c) Initial storage/ water levels

4.2.1 Topography

The ground elevations on the site generally varies between 7mAOD to 9.5mAOD. Both the digesters are installed in the south-west corner of the site. The PDST is located in the south of the site (at a height of approximately 10.5m) along with the pulper, reactors and flash tank, which are approximately 7.5m above the ground. Figure 12 shows the presence of a 6m deep well surrounding the imported cake silo[6]. The indigenous sludge silo and THP feed silo are located at the centre of the site, which are approximately 11m and 15m above the ground respectively.

[6] As confirmed with the site manager

Figure 12: Topography with potential sources



4.2.2 Surface roughness

Different surface types are represented within the model as shown in Figure 13 to replicate the on-site condition in the model. The roughness values are assigned based on the land use listed in Table 4-1.

Figure 13: Different surface types within STC

Table 4-1: Manning's n value adopted in the model

Materials ID	Manning's n	Description
1	0.100	Buildings
2	0.013	Roads - Concrete/ Asphalt
3	0.013	Hard standing area around the assets - Concrete finish
4	0.027	Earth with short grass & few weeds
5	0.030	Sand/Gravels
6	0.035	Pasture/ Short grass
7	0.060	Woodland - Trees with heavy growth of sprouts
8	0.100	All tanks - Raised above the ground

Source: Open Channel Hydraulics, Ven Te Chow

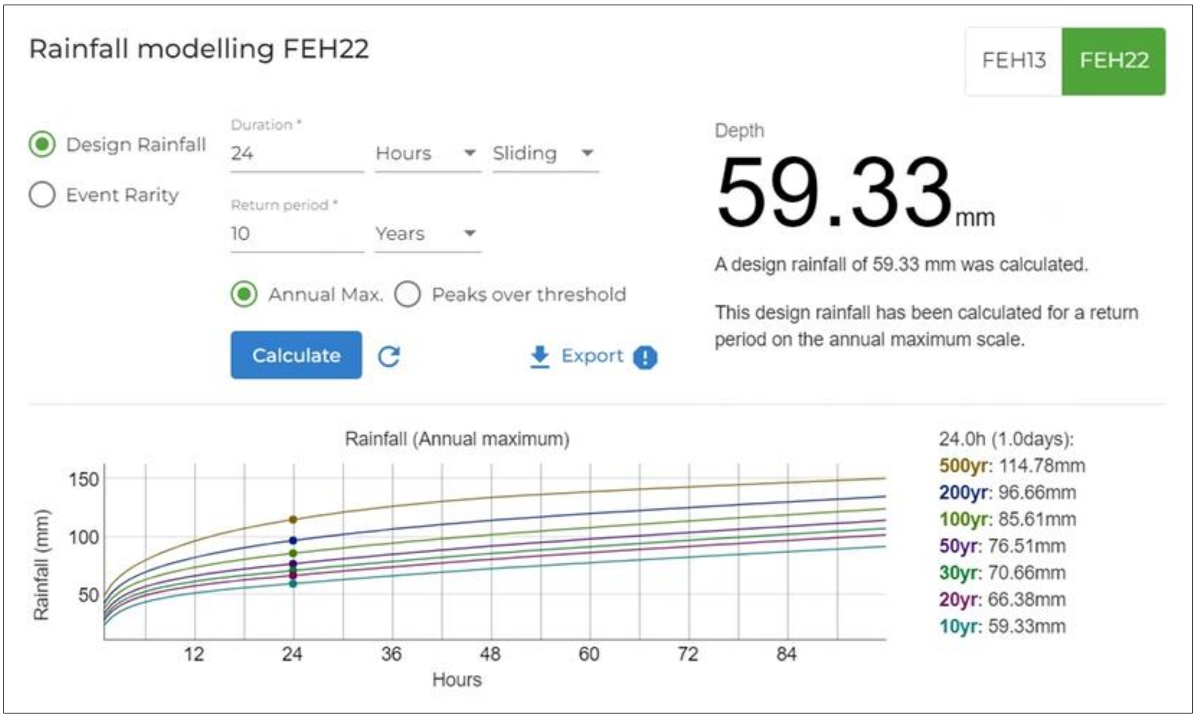
4.2.3 Initial conditions/initial water level

Sludge movement and storage depends on the available storage capacity on the site. As described in CIRIA C736, the containment should allow for accumulated rainfall within the bunded area 24 hours prior to a failure event. As Afan STC is a manned site and is visited 24/7, it is not practical to assume rainfall would remain within the containment for an extended period of time. Therefore, the 'pre-failure' scenario used was a 24hr duration, 1 in 10-year (10% AEP) rainfall event immediately prior to failure of primary containment. An initial model run was carried out which simulated the impact of this event to provide the initial conditions on the site where ponding had occurred in low-lying areas of the site. The details of the rainfall data used are described in Section 4.2.4.

4.2.4 Rainfall

Figure 14 shows the annual maximum rainfall depth of 59.33 mm for a 10-year return period of 24-hour duration. Two rainfall profiles (winter and summer) were derived from FEH22, UKCEH's latest rainfall frequency estimation model, and analysed for further assessment.

Figure 14: Rainfall data – Afan STC



The available storage on the site was assessed by the direct rainfall approach. In this approach, 1 in 10-year (10% AEP) design rainfall for summer and winter were applied over the entire site boundary (model extent) and the water levels were captured at the end of a 24-hour model simulation. The final water levels on the site are subsequently used in defining the storage capacity at the site after the design storm event. In this scenario, the initial condition is included in the model as initial water levels (IWL) from the 'pre-failure' case.

4.3 Pre-failure Scenario

In this scenario, the model is updated with the inputs discussed in Sections 4.2.1, 4.2.2 and 4.2.4 (viz. topography, surface roughness and the rainfall). Two scenarios of the model were run for a duration of 24-hour representing summer and winter rainfall. Based on the model results, the highest water level between these two events at the end of the 24-hour simulation is considered for further assessment.

4.4 Post failure assessment

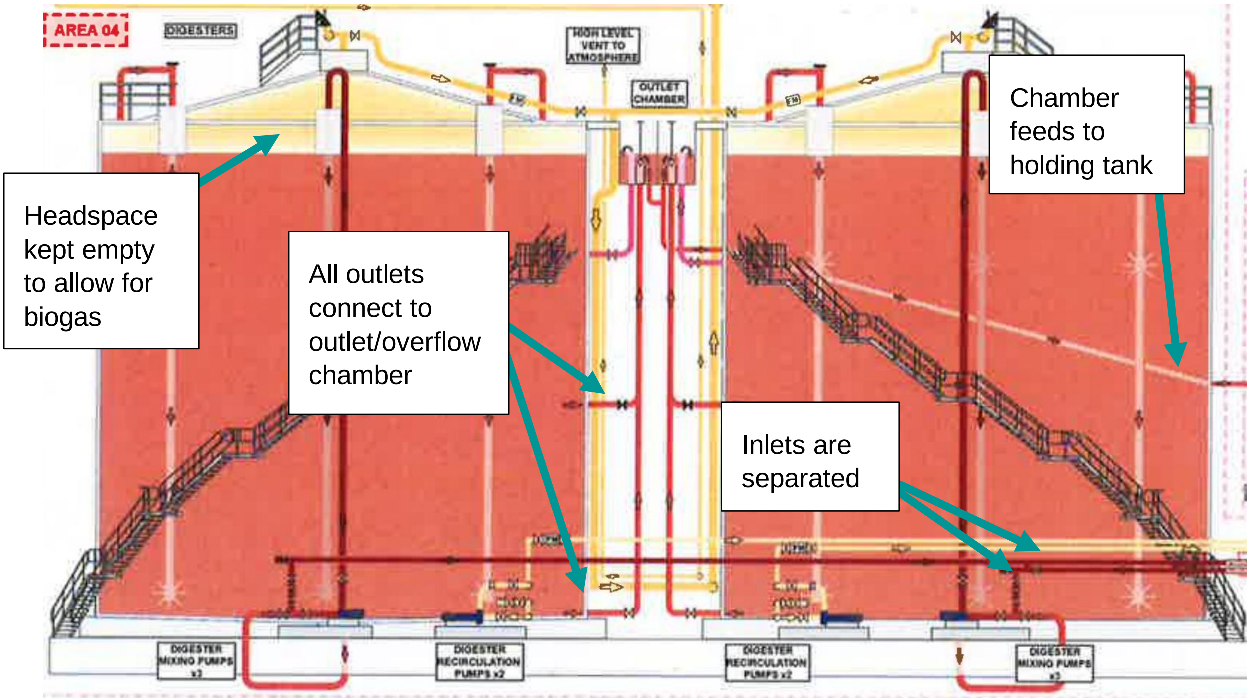
4.4.1 Breach inputs

CIRIA C736 states that when considering a loss of containment of sludge, the volume of substance should be based on the loss from a credible scenario, this need not necessarily involve the entire site inventory. The focus of this assessment is on the complete failure of any primary containment within the IED permit area.

None of the tanks are hydraulically linked, so rupture would affect only one digester or tank. Therefore, the volume from a credible failure scenario is the maximum capacity of the largest tank, which at Afan is the two primary digesters at 4,250m^3 each.

The volume of inventory to be used for modelling was assessed in line with section 4.3 of CIRIA C736. Of the sources listed in Table 2-1, the largest single tank are the Primary Digesters. These are made of reinforced concrete and have an overflow, which prevents sludge fully filling either tank past a volume of 4250m^3 as the headspace is used to generate biogas. This is demonstrated in Figure 15 below - an excerpt from the permit supporting document 100123523_MSD_ProcessFlow3_AFA.

Figure 15: Flow diagram demonstrating that the working capacity of both digesters is controlled by the outlet/overflow chamber and requirement to maintain free space for biogas generation.



As the structures are constructed of a class A1 non-combustible material[7], the risk of a prolonged fire or another scenario causing both tanks to rupture is not credible. Due to the volume of these tanks when compared with other sources, secondary containment for a catastrophic failure of either tank also provides full secondary containment for failure of any other sludge primary containment. The scenario used for modelling was a breach of primary containment of either digester, releasing 4250m^3 of sludge.

The breach was represented by applying a hydrograph (with a rectangular shape) discharging the volume of the asset being modelled over a one-minute duration[8]. This represents the sudden failure of

[7] Fire resistance (concretecentre.com)

[8] Source: CFRAM Guidance Note 24 – Breach Analysis, 2013

the source when a catastrophic failure occurs, and the entire contents of each source are released in one minute.

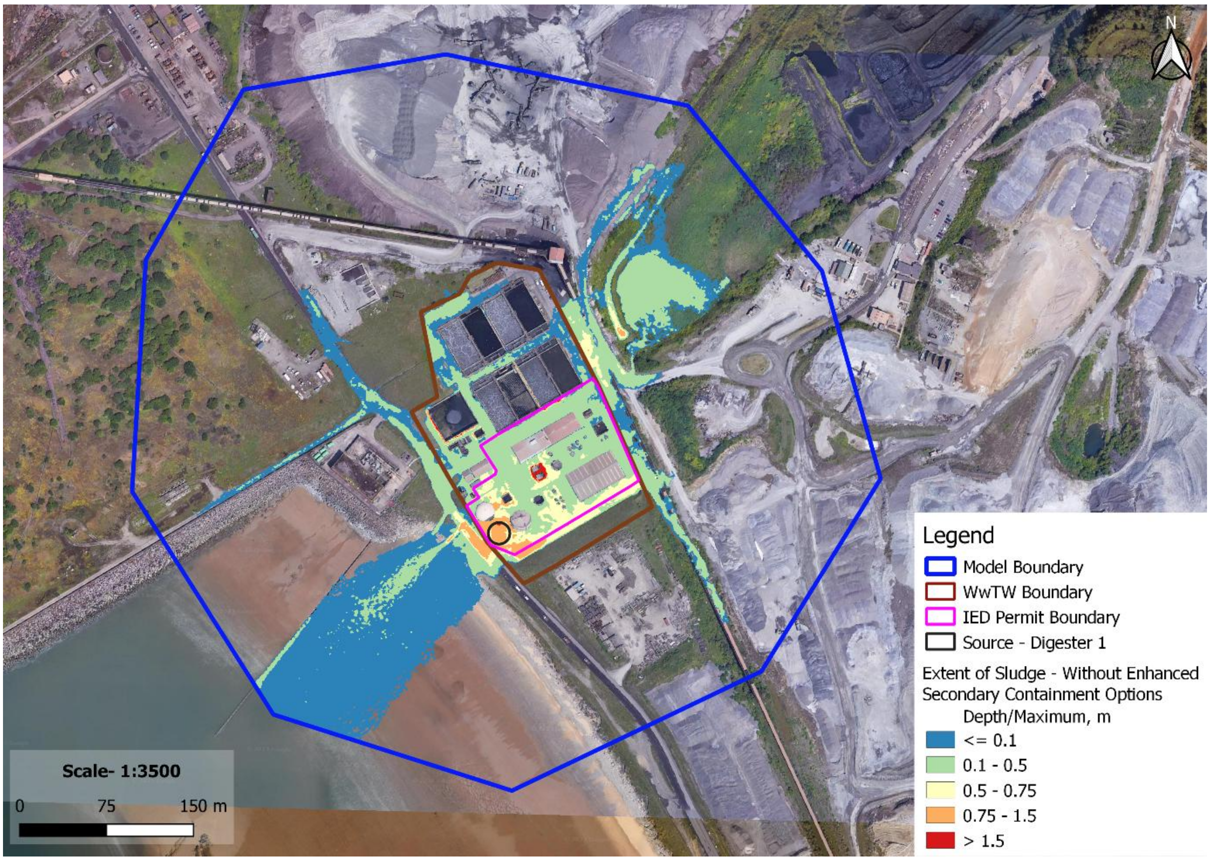
The peak of the hydrograph is derived from the total volume in cubic meters (e.g. Digester 1- 4250m^3) divided by the number of seconds in a minute (60 seconds) to obtain a constant inflow for one minute (4250 ÷ 60 = 70.83m^3/s).

4.4.2 Breach – Extent of uncontrolled failure

Sludge spill modelling was undertaken to assess the impact of an uncontained sludge spill on the Afan STC and STC and the surrounding environment. The results of the modelling showed that the spill is not self-contained within the site and, therefore, passive containment needs to be implemented to safeguard nearby receptors.

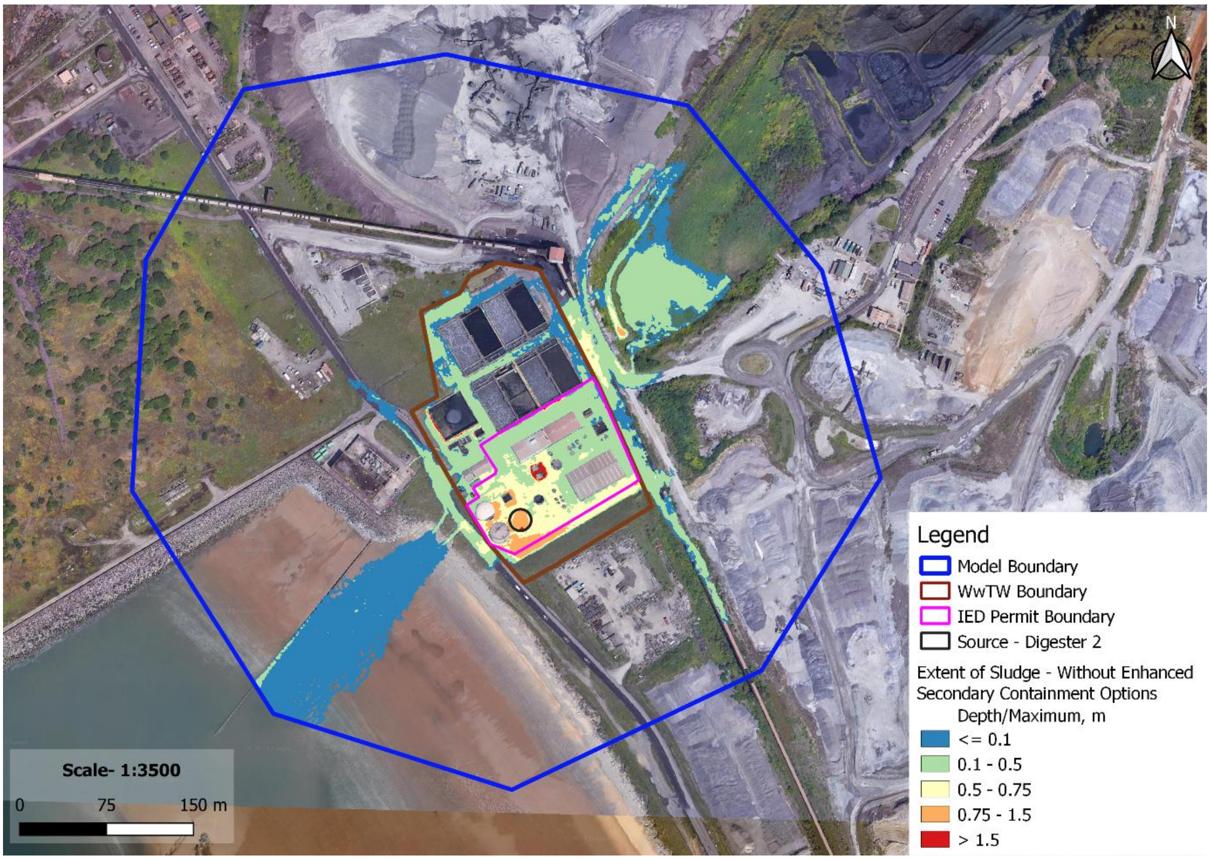
The breach of the source in the model without any rainfall data helps to understand the extent of pollutant spread. Failure of each source and its sludge extents is presented in the below model outputs (Figure 16 and Figure 17), which shows the extent of sludge spread 1hr after a failure event.

Figure 16: Extent of uncontrolled spill from Digester 1



RESTRICTED

Figure 17: Extent of uncontrolled spill from Digester 2

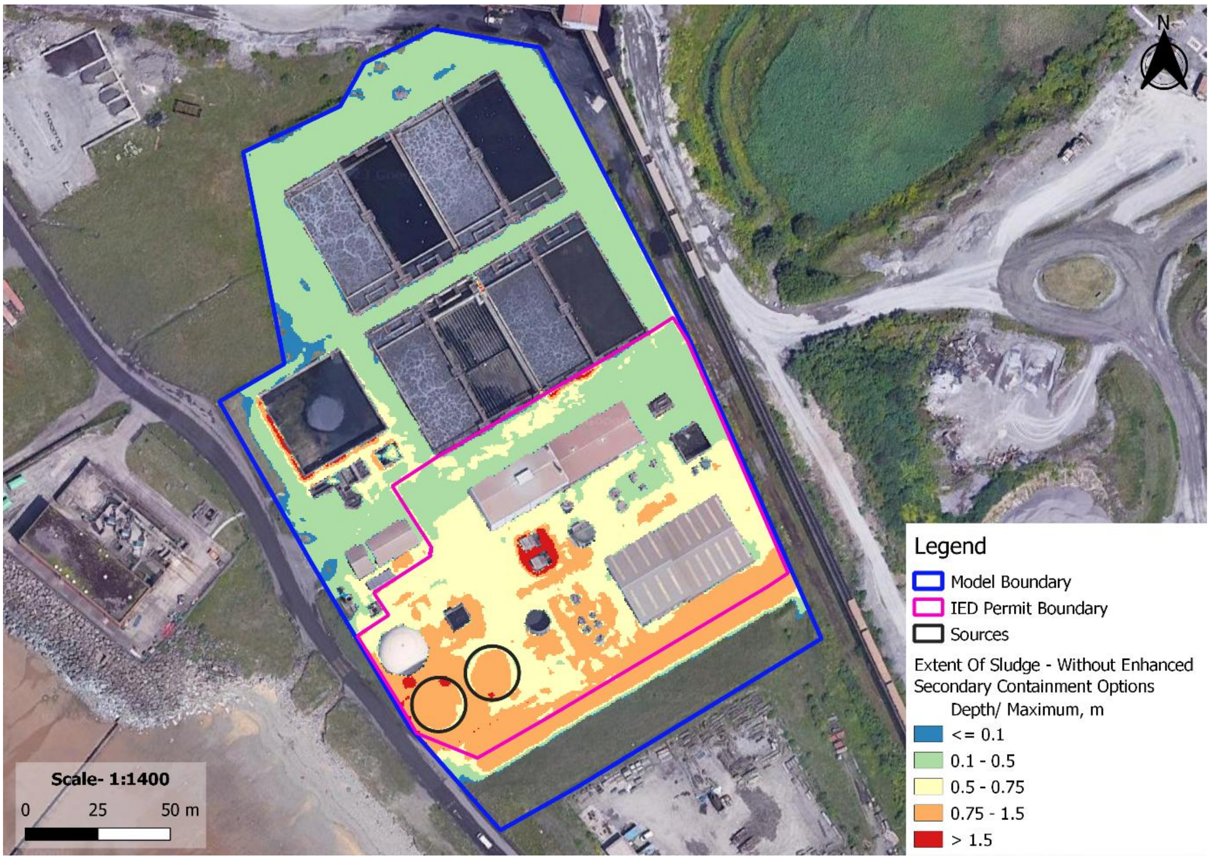


From the location of the digesters in the south-west corner of the site, sludge spreads towards the east, west and north and breaches the site perimeter, flowing into the Tata Steel site to the north east and onto the beach to the west at very shallow (<0.1m depth) levels. The extent of the sludge does not vary significantly depending on which of the two digesters fails.

4.4.3 Post failure including initial water levels

The post-failure scenario includes the initial water level (obtained from the pre-failure scenario model run) followed by breaching of the different sources (Digester 1 and Digester 2). To estimate a volume for containment, the volume from the failure of one tank with initial water levels is modelled as being entirely held within the entire site. The maximum depths of sludge generated from a failure of either digester (not both, as a combined failure is not credible) are shown in Figure 18. It is observed that the sludge spreads over almost the entire site area.

Figure 18: Combined extent of sludge from the post-failure of all sources - without Enhanced Secondary Containment



As per CIRIA C736, the volume contained must be the larger of 110% of the capacity of the largest tank or 25% of the total storage capacity within the bunded area. The 110% and 25% rules were compared with the volume considered in the model and it was found the volume of the post failure scenario exceeds both requirements (refer Table 4-2). The spill volume adopted for the containment options was this largest value.

Table 4-2: Containment system capacity comparison - '110%' and '25%' rules

110% of the capacity of the largest tank within bund (in m^3)	25% of the total capacity of all the tanks within the bund (in m^3)	Total volume including antecedent 24-hr rainfall (in m^3)
4675	2579	6622

4.5 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 (CIRIA 736) reviews current industry practice relating to source spill volume, section 4.2.8 (CIRIA 736) then summarises current industry practice relating to source spill volume in a tabular form.

Within section 4.2.1 (CIRIA 736), 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 736 recognises that this approach is not quantitative or based on a risk assessment and are arbitrary methods.

4.6 Total Spill Volumes

Table 4-3 below summarises the spill volumes used for this study:

Table 4-3: Total Spill Volumes

Tanks within containment area	No. of tanks	Effective volume per tank (m^3)	Total effective volume (m^3)
Digesters	2 Nos.	4,250	8500
Post digested sludge storage tank	1 No.	500	500
Indigenous sludge silo	1 No.	100	100
Thermal Hydrolysis Plant (THP) feed silo	1 No.	600	600
Pulper	1 No.	42	42
Reactors	4 Nos.	13	52
Flash Tank	1 No.	42	42
Imported cake silo	2 Nos.	40	80
SAS Tanks	1 No.	400	400
Total	**15**	**-**	**10,316**
Total Rainfall (mm)			59.33
110% of Largest Tank (m^3)			4,675
25% of all tanks			2,579m3
Design Spill Volume (m^3) - 110% Largest Tank			**4,675**

5 Assessment of Containment Options

5.1 Assessment overview

There were five options which were considered as part of the optioneering to deliver sufficient containment at the Afan STC. The five options put forwards for DCWW to consider are identified in section 5.4. However, the focus of this assessment report is not to provide detailed solutions for 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 Afan, existing features of the site, such as building structures and impermeable surfaces, are utilised, as much as practicable, to provide the enhanced secondary containment. The options considered, modifications and their functionality at Afan STC are listed below:

- Bund/walls to contain liquid. Due to the nature of an existing site, earth bunds have limited applicability within the available space on site and therefore containment is mainly based on a concrete or other impermeable wall. The heights provided in the options are based on the maximum sludge depth, with no freeboard allowance at this concept-level stage. The proposed concept option can be brought forward for design to determine appropriate wall geometry to account for surges and withstand hydraulic pressures from a spill (see section 6).
- Replacement of permeable areas (identified by visual discretion from satellite imagery) with impermeable surface.
- Raised kerbs on roadways to channel smaller spills to drainage.
- All buildings within the containment and transfer areas shall either have doors above the minimum sludge height or operational procedures implemented to keep equipment inside above the top water level.
- Containment ramps have been considered impractical after discussing with operations, as the often assumed 300mm ramp height is not traversable for a typical sludge tanker truck. As vehicle access is required through the site multiple times per day, adjustable flood barriers/gates have been considered for roadways.

5.2 Identified constraints

5.2.1 Operational constraints

The time to recovery and return site back to operation has been set at 3-4 days following direction by DCWW. As the site is always manned, the response to an event will be immediate. If the worst-case scenario has occurred, a response team will have been stepped up in accordance with DCWW's emergency management procedures to determine measures to respond and recover quickly from the event, which could include stopping the treatment works or tankering off waste. The containment volume, when not dictated by the 110% or 25% containment rules allows for one day of rain immediately preceding an event (post-event rainfall management is discussed in section 5.3).

5.2.2 Geotechnical and Environmental constraints

Ground conditions need to be considered during excavating, construction and backfilling activities.

Regarding the construction works, there are no significant environmental constraints as these will all be completed within a DCWW site.

5.3 Site drainage assessment

The volume of the drainage pipes has not been included in the storage capacity of the containment options. This means that in practice, the containment can hold more volume than the worst-case scenario estimate used for the assessment.

Site drainage and the flow of surface water is shown in the secondary containment as-built drawing in Appendix A. All drainage within the STC enters the liquor returns chamber, which is isolated from other site drainage, and can be pumped to the head of the works. The liquor returns pumps have been advised as capable of a 22.3l/s flow from Welsh Water and is a covered chamber. This equates to around 2000m^3/day that can be returned from the containment area. In the worst-case scenario, this would take around 2.5 days to empty. Comparing with the 24hr rainfall data used in the pre-failure modelling, these pumps will be sufficient to drain the bund and post-event rainfall faster than the bund can be filled even if rainfall continues at the same rate over this period.

5.4 Containment options

Two options were assessed in a workshop with DCWW and MMB, each option providing sufficient capacity to contain more than 110% of the working volume of one digester as per the CIRIA guidelines. The total contained volumes differ depending on the amount of rainfall captured within the bund prior to the failure event. Some options were ruled out due to their practicality to maintain site operations and other constraints, e.g space, access, safety and so on.

5.4.1 Option 1

Option 1 (Figure 19) was presented to, and discussed with, DCWW. Suitability of the option was discussed and is summarised below.

Figure 19: Option 1

This option surrounds the STC and extends in the southeast to cover the belt press and exclude the cake barn. This option excludes centrifuges and boilers in the north, providing secondary containment to all considered sources. The containment area is approximately 7,420m^2, but the actual available containment area will be less than this as areas utilised by tanks and buildings as not included in the storage volume. This option applies the 110% rule and contains more than the Design Spill Volume. The total contained volume comprises 6,622m^3. The maximum depth of sludge is around 2m, and requires walls and flood gates ranging from 1.2-2m around the permit boundary area.

The following observations were made about this option:

- It utilises existing kerbing and impermeable surfaces.
- The containment zone is in line with the existing containment previously constructed.
- A minor amendment to the permit boundary is needed
- It requires 2 flood gates which see frequent vehicle use – adjacent to the building with boilers (automatic flood gate) and cake barn (manual flood gate).

5.4.1.1 Suitability of option 1

This option has a minimum of additional infrastructure needed, as it utilises existing buildings and the existing secondary containment to hold the spill volume. All ground is already impermeable, and sludge is conveyed to the existing site drainage. This is beneficial as it lowers the capital costs.

5.4.2 Option 2

Option 2 (Figure 20) was presented to, and discussed with, DCWW. Suitability of the option was discussed and is summarised below.

Figure 20: Option 2

This option is similar to option 1 but relatively a lesser area for containment. The containment area is approximately 5,869m^2, but the actual available containment area will be less that this as areas utilised by tanks and buildings as not includes in the storage volume. This option applies the 110% rule. The total contained volume comprises 6,600m^3. The maximum depth of sludge is around 2.5m as the containment area is reduced compared to the option 1. Option 2 requires walls and flood gates ranging from 1.2m to 2.5m.

The following observations were made about this option:

- It requires two flood gates – one near the Digester and the other near the cake barn
- Surrounds the existing secondary containment.

- Walls of greater heights (greater than 2m) is required due to less containment area.

5.4.2.1 Suitability of option 2

The drainage within the STC will need to be reviewed to ensure it is contained on site. This option requires high walls for containment compared to option 1. As such it was deemed not a suitable containment option.

6 Proposed Mitigation

6.1 Proposed concept option

Following the options assessment, a proposed option was modelled and agreed by the assessment team as the most suitable high-level concept.

The option 1 is finalized based on the discussion with site managers based on its feasibility. The containment area is approximately 7,420m^2, but the actual available containment area will be less than this as areas utilised by tanks and buildings are not included in the storage volume. This option applies the 110% rule. The total contained volume comprises 6,622m^3. The maximum depth of sludge is around 2m and requires walls with heights ranging from 1.2m to 2m and 1.2m flood gates (both excluding freeboard).

The cake barn is excluded from the option as the treated sludge has a consistency of above 20% making it a thick solid cake like material with no flow capability, so any spill will not spread outside the barn. The cake barn itself is fully separated from the sludge dewatering building with walls. The proposed option will isolate the cake barn from any sludge/flow spill in case of failure inside the containment area.

Figure 21 shows the bunds and flood gates with the approximate height along with the location of critical sources.

Figure 21: Proposed Enhanced Secondary Containment option

The solution requires a new wall on top of the existing retaining wall surrounding the digesters, replacing the existing wall along the southern edge of the STC to the existing security gate, with an impermeable wall, and then surrounding the edge of the buildings that have boilers and centrifuges with similar impermeable walls. Flood gates are required at two access roads – one near to the building with boilers and other one near the cake barn.

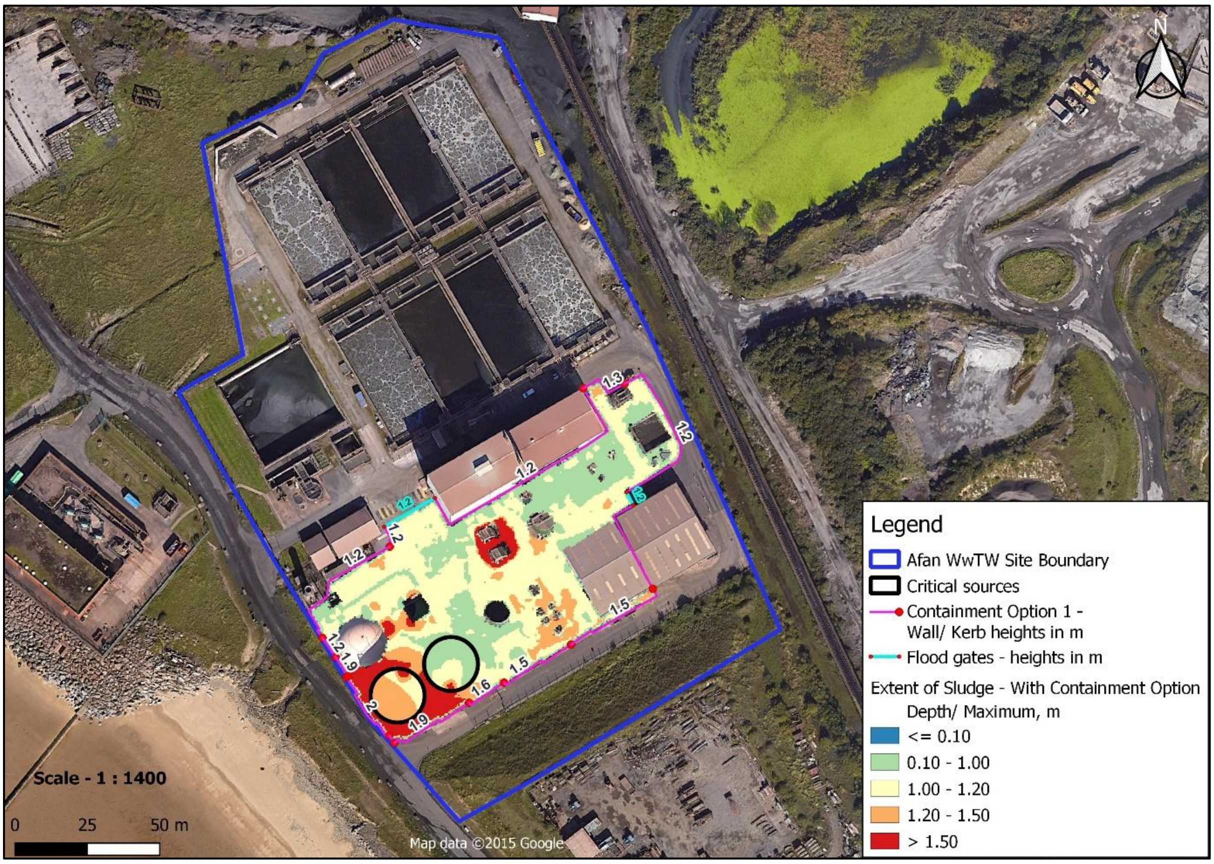
6.2 Suitability of proposed option

The proposed option incorporates the existing secondary containment and fully contains all the identified sources, while protecting key receptors like the transformer building. The area is similar to the original STC boundary, which is already covered with impervious ground, and the drainage in this area would need to be altered to flow to the liquor returns chamber to match the STC drainage. Using the 24-hr data for a 10% AEP storm at Afan, it can be projected that around 602m^3 of rainfall could be added each day after the failure event. This is less than the capacity of the pumps (average flow given as 22.3l/s), so continuous rainfall post-event would not overwhelm the containment.

The wall heights in option 2 is higher compared option 1 and this may pose as a constraint for the access – providing access in and out of the high walls using stairs without change in direction could be a challenge. With respect to procurement and operation, the height of the flood gate in option 2 stands difficult. Also, as there is a confined space around the digester and gas holder in option 2, this is less feasible compared to option 1.

The northern manual flood gate is on low-trafficked roads which would enable them to remain closed during routine operation. The automatic floodgates located adjacent to the dryer building will remain open during daytime operation and the control philosophy for the same shall be referred in B16399-123532-XX-AB-MA-ZA-OA0038 - Flood Gates Control Philosophy. However, this becomes a risk in option 2 as a flood gate is in close proximity to the digesters. The access gates already exceed the required height at each location, and if converted to a product suitable to withstand the sludge volume pressure and prevent leakage, inspection, and maintenance for them can be incorporated into the existing procedures for the access gates. This minimises the impact of the containment on the operation of the site. The maximum sludge depths from a failure of either digester is shown in Figure 22.

Figure 22: Combined extent of sludge from the post-failure of all sources - With Enhanced Secondary Containment Option

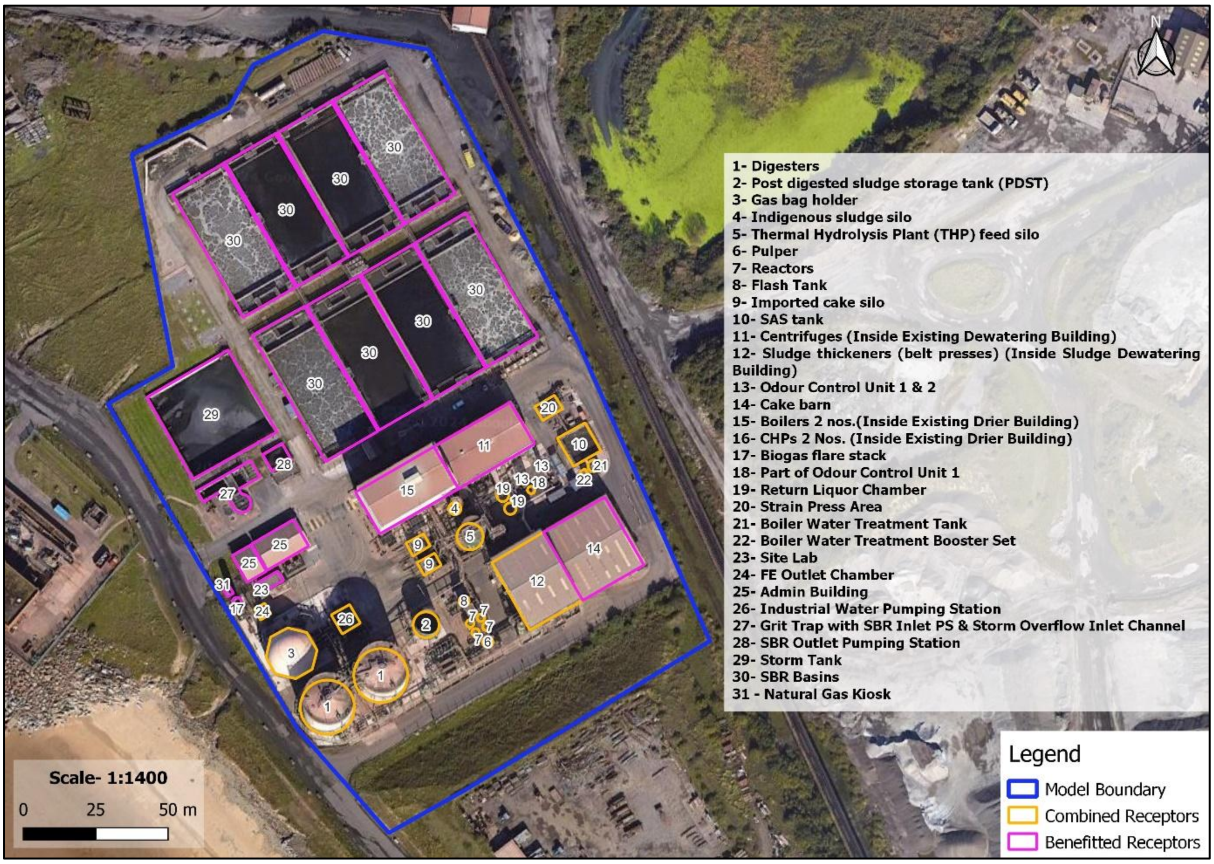


The height of the bund would vary based on the topography and hence detailed design of these secondary containment options should be carried out in the subsequent stages to optimise the height of the bunds. These heights do not account for the sub-surface drainage or the area of buildings within the containment area. The access points to these buildings are below the water level and would likely also be affected by any spill.

6.3 Impact of Enhanced Secondary Containment

Figure 22 shows the combined extent of sludge following the inclusion of containment measures within the STC. The modelling shows that there is no flow occurring off-site, into the critical assets and into the permeable areas within the wider STC. The receptors that are benefitted by the containment option are marked in Figure 23.

Figure 23: Benefitted receptors after inclusion of containment option



After the inclusion of the enhanced secondary containment, the list of receptors which remain at risk is tabulated in Table 6-1 together with the depth of sludge. The highest depth of sludge (2.8m) is found near Digester 1 due to its proximity to the bunds.

Table 6-1: Receptors with sludge depth – Post failure with containment options

Sr. No.	List of Receptors	Maximum depth of sludge, m (Without ESCO)	Maximum depth of sludge, m (With ESCO)
1	Digester - 2 nos.	2.7	2.8
2	Post digested sludge storage tank (PDST)	0.8	1.2
3	Gas bag holder	1.5	1.9
4	Indigenous sludge silo	0.7	1.1
5	Thermal Hydrolysis Plant (THP) feed silo	0.9	1.3
6	Pulper	1.0	1.5
7	Reactors - 4 nos.	1.1	1.6
8	Flash Tank	0.8	1.2
9	Imported cake silo	0.6	1.0
10	SAS tank	0.7	1.2
11	Centrifuges (Inside Existing Dewatering Building)	0.6	-
12	Sludge thickeners (belt presses) (Inside Sludge Dewatering Building)	0.8	1.4
13	Odour Control Unit 1 & 2	0.5	0.9

Sr. No.	**List of Receptors**	**Maximum depth of sludge, m (Without ESCO)**	**Maximum depth of sludge, m (With ESCO)**
14	Cake barn	0.9	-
15	Boilers 2 nos. (Inside Existing Drier Building)	0.7	-
16	CHPs 2 Nos. (Inside Existing Drier Building)	0.7	-
17	Biogas flare stack	0.3	-
18	Part of Odour Control Unit 1	0.5	0.9
19	Return Liquor Chamber - 2 nos.	0.6	1.0
20	Strain Press Area	0.6	1.3
21	Boiler Water Treatment Tank	0.8	1.1
22	Boiler Water Treatment Booster Set	0.7	1.0
23	Site Lab	1.2	-
24	FE Outlet Chamber	0.7	1.2
25	Admin Building	0.9	-
26	Industrial Water Pumping Station	1.2	1.7
27	Grit Trap with SBR Inlet PS & Storm Overflow Inlet Channel	1.1	-
28	SBR Outlet Pumping Station	1.4	-
29	Storm Tank	2.3	-
30	SBR Basins – 8 nos.	2.6	-
31	Natural Gas Kiosk	0.4	-

From the table above, it can be seen that the depth of sludge increases (by up to 0.5m) around a number of the receptors due to the presence of the proposed containment option. The assets which are protected by enhanced secondary containment options have no sludge around them (Admin building, Site lab, Cake barn, Existing Drier building and Existing Dewatering building). The depth of sludge around the FE outlet chamber is 1.2m however, this requires protection around it to prevent any sludge entering it.

6.4 Jetting and Surge Flows

Due to the location and material of the tanks and their distance from the boundary of the containment area, the risk of contamination through jetting is not considered a credible scenario.

There is a low risk of jetting occurring from the Primary Digesters due to their materials of construction, for which catastrophic failure is deemed to be less of an issue. Failure is more likely to begin with major seeping from the tanks which would be spotted during routine and regular site walkovers as a part of daily operations. For other failure sources, the containment is sufficiently remote (horizontal distance from the containment wall exceeding height of tank) that jetting could not result in a breach of containment.

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, though wall heights would need to include freeboard depending on the proximity to the digesters to allow for surge effects.

6.5 Risks of proposed containment option

The proposed enhanced secondary containment option would need to be constructed on, and around, an existing site. The walls have heights varying from 1.2 m to 2m. The sludge depths mean that containment of the worst-case scenario without using flood gates is unlikely hence two flood gates are proposed having height of 1.2m with additional freeboard. However, the site has vehicles arriving and leaving 24/7, which would require frequent opening and closing of these gates, especially the automatic one next to the drier building, hence its planned to be kept open during operating hours, operation philosophy of which should be referred in B16399-123532-XX-AB-MA-ZA-OA0038 - Flood Gates Control Philosophy. The wall and gates would need to withstand the hydraulic pressures of the contained spill, which can be achieved by following the appropriate construction standards. The exact heights will need to account for the final position of the walls and allow for any surge effects which can be determined in the later detailed design stage. Pedestrian and emergency egress would also be needed at certain intervals, which would be stairs over the containment walls.

6.6 Construction Standards

The containment bund wall constructed at Afan STC shall be built to British Standards BS EN 15258-2008, CIRIA 124 - Barriers for containment and control of land contamination, and using best practices as outlined in CIRIA C736 – Containment Systems for prevention of pollution – Chapters 6 and 7, CIRIA C608 - Use of sewage sludge in construction and HSE document ‘Principles, design and operation of Containment Level 4 facilities’.

6.7 Emergency procedures for spill containment

Details of the emergency management procedures used by DCWW to respond to and recover from a failure of primary containment in the Afan STC are included in the Accident Management Plan (100123523_AMP_AFA).

6.7.1 Liquor Returns

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

6.7.2 Automatic Isolation Valves/Level Signals

For the catastrophic loss of containment scenarios for the digester area discussed, such a loss could be automatically detected by the pressure transducers which act as the level monitoring devices. These devices will be used to detect a rapid change in digester level. A catastrophic failure would be identified by the rate of change in tank level being larger than expected at normal operation. The signal from the sensors would be used to automatically prevent any adverse impact on sewage treatment. Any of the following options could be considered during detailed design based on feedback from client and operations, though at least one must be chosen to mitgate the spill risk.

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

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

C. The option of the level sensor signal from an abnormal rate of change triggering an alarm system for an operator has been considered.

Additionally, DCWW will install an additional laser level device within the containment area to monitor levels outside the digester. These additional sensors will providing triple validation of any digester failure but also detecting any other sludge asset failures.

Once the spillage has been stopped and contained, any sludge in the drainage system, will either be tankered away to other sites or pumped back to the head of the work in a controlled manner therefore, not creating adverse effects at the inlet.

7 Conclusion

Based on the use of the ADBA risk assessment, considering the source, pathway and receptor risk, Afan site hazard rating is deemed to be **moderate** and the likelihood of a spillage was classed as **medium**. Based on these risks, an overall site risk rating was determined to be **medium**, meaning that Class 2 containment is required.

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

For this assessment, as per CIRIA C736, the volume contained must be the larger of 110% of the capacity of the largest tank or 25% of the total storage capacity within the bunded area. The assessment shows that 110% of the digester tank (4,675m^3) is the minimum volume to be contained.

The current containment on the Afan site does not protect the wider environment and a mitigation option is required. Various options were explored and the proposed option is a combination of walls and flood gates on the STC boundary contains sludge within the site boundary and to prevent it from leaving site, entering into the critical assets or affecting other sensitive receptors. The hydraulic modelling shows that the proposed mitigation option has a containment volume of 5215m^3, greater than the minimum volume and is successful in retaining sludge on the site from a complete failure of one primary digestor including in the event of a 1 in 10 year return period rainfall event falling 24 hours before. Using the pumps on site as well as tankers, any spill could be cleared up within 3 to 4 days and the treatment works resumes its normal operation.

8 Assumptions

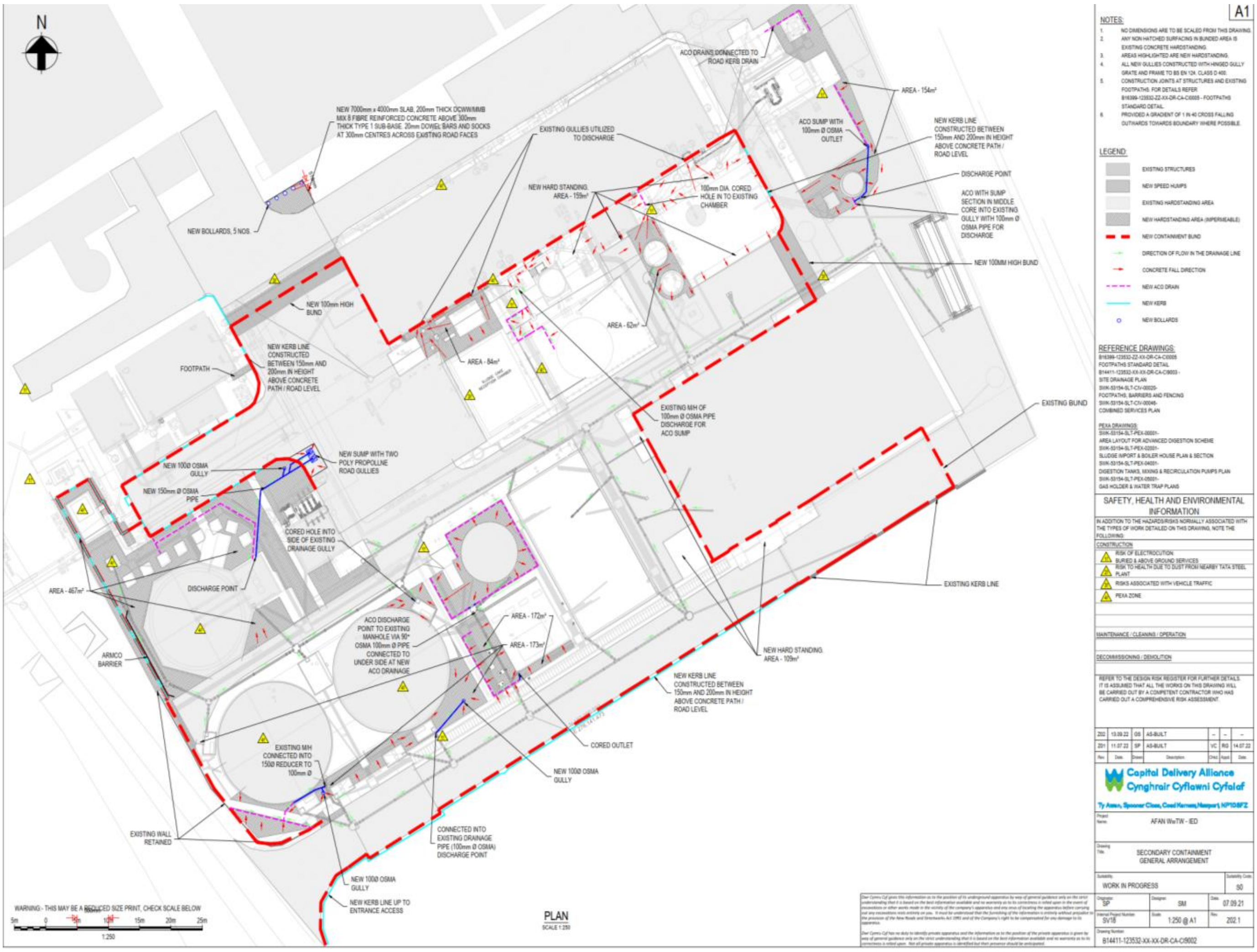
The model is built and assessed with various assumptions as listed below. The complex drainage and spill containment requirements are identified by developing a 2D model using TUFLOW software. The model helps to visualize the performance of any proposed containment design.

1) The sludge spillage was modelled as a typical water flow in terms of viscosity.
2) ADBA classification tool was updated with the available limited information received from the client.
3) The extent of the model is adopted based on the property boundary of STC and bit extended along the ridges, wherever necessary.
4) Buildings, tanks, and other assets within STC which are elevated above the ground are raised in the model (post-failure scenario) based on information received from the client and a high roughness value is assigned. However, at a few locations (where information from the client) is missing, the height of the buildings/ assets is assumed from 3D buildings in Google Earth.
5) In the pre-failure scenario, the buildings/ assets are raised by only 0.3m as there are instabilities caused where rainfall is added to the areas of the assets and then immediately flows off the elevated area and falls to ground level.
6) As per the discussion with client, any kind of survey data which includes topography/ grid elevation points (covering the entire STC boundary) was not available. Hence, the latest LiDAR data of 1m resolution downloaded from https://datamap.gov.wales/ has been used in the assessment which provides sufficient details to prepare terrain surface for the study.
7) Land use is represented by downloading the OS Vector Map. Additionally, buildings and roads were digitized and included in the model based on Google Satellite Aerial Imagery.
8) FEH22 design rainfall is generated using the catchment descriptors of the site location downloaded from https://fehweb.ceh.ac.uk/GB/map. Rainfall is extracted for a 10-year return period 24-hour duration using the InfoWorks ICM tool.
9) The breach/failure analysis was undertaken by applying the point inflow in the model. The location of the point inflow is the same as that of the storage facility. The breach was represented by a rectangular hydrograph with the volume of the asset discharged over a one-minute duration[9] representing the sudden failure of the source.
10) In the breach analysis, the tanks are raised by 0.5m only in their respective failure scenario to avoid the instabilities and represent the real-time situation at the time of failure.
11) The density of biogas from the biogas holder is assumed to be 1.1 kg/m^3 for calculating the volume of firefighting water required at the site.
12) The enhanced secondary containment options were included in the pre-failure scenario with the provision for cross drainage (openings in the bund) to simulate the initial water levels for the post failure scenarios and the cross drainage must be assessed in the detailed design stage to minimise any loss of flood storage.

[9] Source: CFRAM Guidance Note 24 – Breach Analysis, 2013

13) The existing buildings/structures have potential structural strength, and they are fit enough to constrain and retain the sludge around them.

A. Existing Secondary Containment As-built Drawing



B. Flood Risk Report at Afan STC

Flood risk report for the area within 10 metres of:

AFAN WATER TREATMENT, PHOENIX WHARF, THE DOCKS, PORT TALBOT, SA13 1RA

Very low risk

Flooding from rivers

Risk less than 0.1% chance each year

Very low risk

Flooding from the sea

Risk less than 0.1% chance each year

Very low risk

Flooding from surface water and small watercourses

Risk less than 0.1% chance each year

The risk levels are: High, Medium, Low and Very low.

This area:

- Does not benefit from flood defences
- Has no recorded flooding

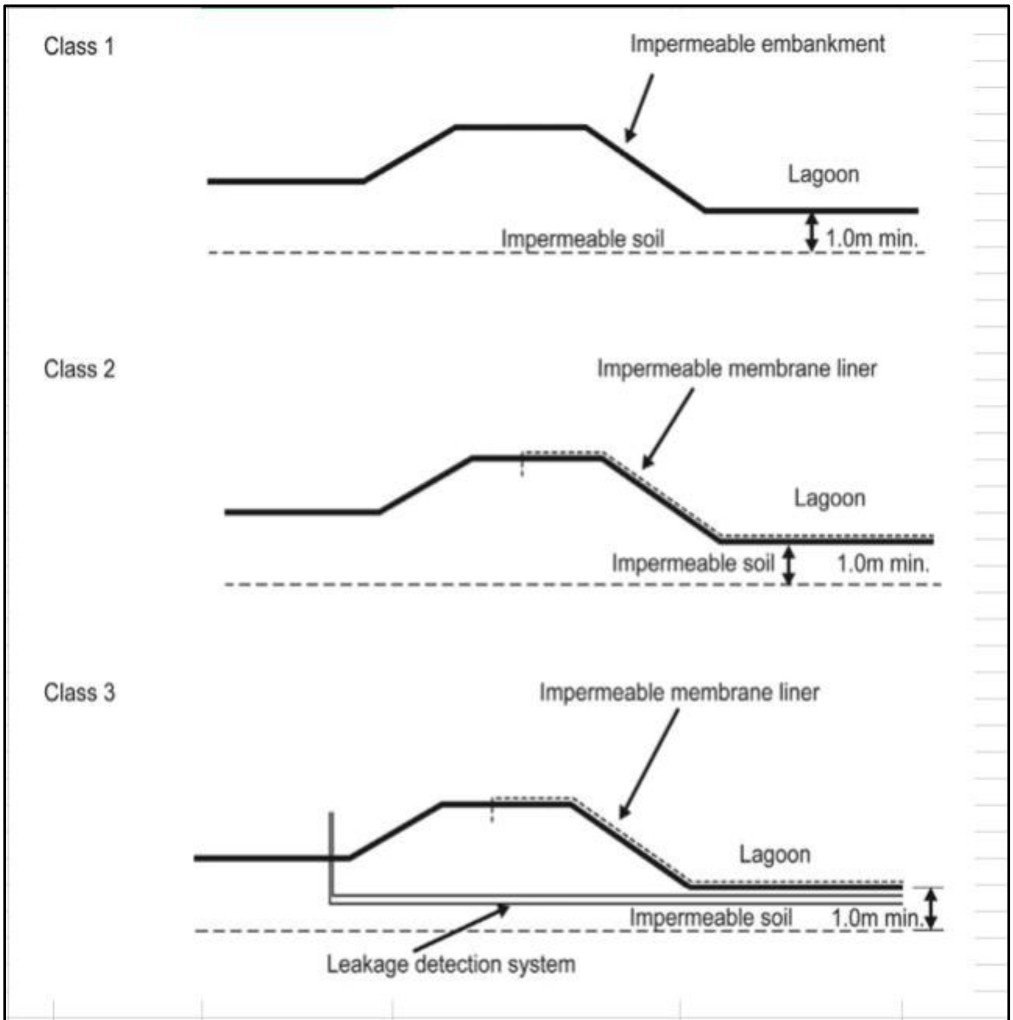
This risk level takes into account the effect of any flood defences that may be in this area. Flood defences reduce, but do not completely stop the chance of flooding as they can be overtopped or fail.

Please note

We cannot give the flood risk for individual buildings because this depends on building features and other local factors like drainage conditions.

Source: https://check-your-flood-risk.naturalresources.wales

B.1 Standard containment designs



It should be stressed that in all cases the ground and soil conditions should comply with the impermeability, stability and durability criteria set out previously. Where impermeable linings and leakage detection systems are required these are as an **additional** level of protection and **not** to compensate for inadequate ground and soil conditions.