Figure 4 Location of Sensitive Receptors (Education / Leisure)

Table 1 Esholt Receptor sensitivities

Receptor Name	Receptor Map Reference	Distance from Site (m)	Receptor Type	Receptor Sensitivity
Residential properties to north	R1	640	Residential	High
Residential properties to east	R2	430	Residential	High
Residential properties to south	R3	760	Residential	High
Residential properties to west	R4	1140	Residential	High
Commercial businesses to north	C1	70	Commercial	Medium
Commercial businesses to east	C2	1370	Commercial	Medium
Commercial businesses to south	C3	390	Commercial	Medium
Commercial businesses to west	C4	1570	Commercial	Medium
Industry to north	I1	800	Industrial	Low
Industry to east	I2	540	Industrial	Low
Industry to south	I3	435	Industrial	Low
Industry to west	I4	930	Industrial	Low
Schools to the north	E1	1565	Education	High

Receptor Name	Receptor Map Reference	Distance from Site (m)	Receptor Type	Receptor Sensitivity
Schools to the east	E2	615	Education	High
Schools to the south	E3	805	Education	High
Schools to the west	E4	2110	Education	High
Leisure/recreation to the north	L1	785	Leisure/recreation	Medium
Leisure/recreation to the east	L2	1060	Leisure/recreation	Medium
Leisure/recreation to the south	L3	685	Leisure/recreation	Medium
Leisure/recreation to the west	L4	830	Leisure/recreation	Medium

2.3 Meteorological Conditions

In the UK, the prevailing wind directions are commonly from the west and south-west. The wind direction and speed will impact the dispersion of odour emissions from site. There is currently no wind station on site to measure meteorological conditions.

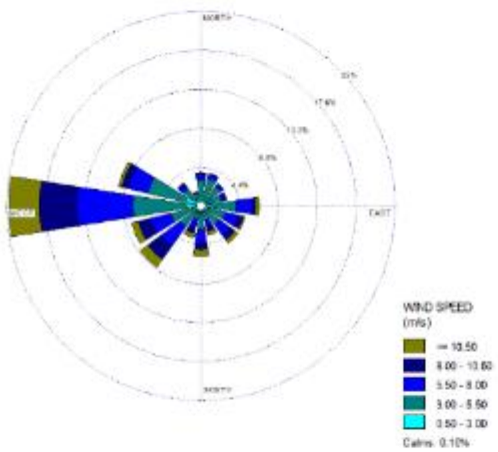
Leeds Bradford airport meteorological station is 4km north-east of the site. There is also a meteorological station in Sheffield city centre, closer to the works. The meteorological data included below consist of 1-hourly average data suitable for use in atmosphere dispersion modelling software.

The meteorological data from Leeds Bradford airport meteorological station has been incorporated into the site's odour risk assessment whereby wind direction and frequency are used to determine the "pathway effectiveness" from source to receptor. Data for 2017 has been adopted for the odour risk assessment as there would be no variability in pathway risk scoring when using a different year. It is more critical for the risk assessment to determine a representative meteorological station location that met. year. The met. year should be updated within every 5 years to ensure the prevailing wind direction and wind speeds are still representative.

Wind direction and speed is also included as part of the on-site sniff testing however, this is based on short-term variations and recorded at the time of assessment (see Section 5.1 Sniff Testing).

The wind rose plot for Leeds Bradford airport is included in Figure 5.

Figure 5 Leeds Bradford Airport Windrose Plot (2017)



2.4 Process Description

Liquid sludge and sludge cake treated within the STF originates from several sources:

- Indigenous sewage sludges, including indigenous primary sludge and indigenous surplus activated sludge (SAS) arising from sewage treatment processes operated within the wider Esholt WwTW are piped directly to the STF.
- Liquid sludges generated by other, smaller YW sewage works (with lower capacity or capability for treating sludges on-site) are imported to Esholt STF for additional treatment. These sludges may be received in the form of liquid sludge or sludge cake.

Imported liquid sludge and indigenous primary sludge

Imported liquid sludge is delivered to site by tanker. The tanker unloads at the dedicated sludge import area and sludge is pumped (using vehicle mounted pumps) into the sludge screen feed tank (655 m^3 concrete tank) where it is mixed with indigenous primary sludge pumped directly via underground pipework from Esholt WwTW. Headspace air from this tank is routed to a local Odour Control Unit (referred to as OCU 1). This is currently operated as a dispersion only stack. The sludge is screened using two Huber enclosed rotating screens. Screenings drop into a skip and are disposed of off-site.

After screening, sludge is pumped via a sub-surface pipework, to Consolidation Tank 5 (2,500 m^3 uncovered concrete tank) (referred to on site as 'Consol 5') where sludge is blended and mixed using air injection.

Indigenous SAS

Liquid surplus activated sludge (SAS) is pumped directly from the co-located Esholt WwTW to two SAS storage tanks (2 x 2000 m^3 uncovered concrete tanks). These tanks are air mixed and operate on a fill/draw basis over a 24 hour period.

Sludge from the SAS tanks is transferred to the drum thickener building, via above and below ground pipework. There are four individual drum thickeners (with separate pipes feeding them) located within the building, these are operated manually as and when the process requires. Polymer solution is injected into the sludge stream within the flocculation tank to encourage separation of water from the sludge as the sludge is rotated in the drum. The thickener liquors are returned via the liquor return supernatant pumping station (uncovered below ground sump) to Esholt WwTW for full treatment.

Air is extracted from the drum thickeners and treated in a carbon filter OCU (referred to as OCU 4) prior to dispersal via twin dispersal stacks, approximately 7 m high and located to the north end of the SAS thickener building. Ambient air from the building is passively dispersed via louvre vents; ambient building air is not odorous under normal operating conditions due to the direct drum extraction.

The thickened sludge is then transferred to the SAS transfer tanks (2 x 400 m^3 uncovered concrete tanks). Thickened sludge tanks is mixed via pumps.

From the SAS transfer tanks the thickened SAS is then pumped to the mixed sludge tanks where it is mixed with indigenous primary and imported liquid sludges which are pumped from Consol tank 5. There are two covered concrete mixed sludge tanks with a capacity of 1,200 and 1,130 m^3 respectively. The mixed sludge tanks have an air mixing system to prevent settlement and septicity. Air from these tanks is extracted and routed to a local OCU (OCU 2). This is currently operated as a dispersion only stack.

Sludge dewatering

From the mixed sludge tanks, sludge is transferred to three dewatering centrifuges. A polymer solution is introduced to the sludge stream to encourage separation of water and sludge within the centrifuges. This polymer is stored as a dry powder within a silo (15 tonne storage capacity) and is mixed with towns (potable) water within the polymer mixing tank (25 m^3 capacity) located adjacent to the centrifuges. The liquid centrate is transferred via the liquor pumping station and returned for full treatment within Esholt WwTW.

Imported sludge cake

Imported sludge cake is tipped from an enclosed wagon to the dedicated sludge cake reception unit which is enclosed when tipping operations are not taking place. Sludge is moved from the sludge cake hopper and is rewetted with final treated effluent (to target ~21% dry solids) and pumped to the Thermal Hydrolysis Process (THP) feed silos. The sludge cake is rewetted to provide feedstock consistency and mobility. Transfer lines are trace heated and insulated to reduce the risk of freezing and pipe rupture.

Dewatered sludge is passed forward to the THP feed silos (2 no. 210 m^3 steel tanks) where it is combined with re-wetted imported sludge cake. Feedstock from THP feed silos is then transferred to the THP feed hopper (16.2 m^3 steel tank). Headspace air from the THP feed silos and feed hopper is extracted and routed to a local OCU (OCU 3). This is currently operated as a dispersion only stack.

Thermal Hydrolysis Plant (THP)

At Esholt STF, thermal hydrolysis technology is used prior to anaerobic digestion to enhance sludge treatment; the process acts to make the sludge more biodegradable, increasing biogas production within the digesters and assisting with pathogen kill in the final product. The THP at Esholt comprises 6 no. 22.7 m^3 reactor vessels, which operate in pairs. Each pair of reactors operates a batch process as follows: a reactor pair is filled with dewatered sludge and heated to around 165 °C using steam generated by boilers. The reactors are held at this temperature for 30 mins and act like a pressure cooker to break down organic matter in the sludge making it more digestible for the microbes in the anaerobic digester. After 30 minutes the steam is flashed out to the next pair of reactors (as a pre-heat stage) and the reactor tanks are emptied. Activity within each pair of reactors is staggered with one pair being filled, one pair undergoing active reaction and the final pair being emptied at any one time. Steam is transferred from one pair of reactors to the next to supplement boiler steam supply and maximise operational efficiencies. The plant is equipped with safety features including pressure relief vents to allow emergency venting of steam and prevent damage to equipment.

The THP achieves 96% pathogen kill, in combination with the normal anaerobic digestion process, this eliminates the need for post-digester liming or cake storage and maturation prior to landspreading.

There is a facility to extract sludge, at approximately 21% dry solids, from process pipework prior to the THP. This is undertaken as a contingency in the event that there are operational problems within the THP that limits its processing capacity. Due to constant generation of sewage sludge by the WwTW, if needed dewatered sludge can be removed from pipework prior to the THP and stored temporarily on the conditioning pad (description of this area is provided below). The dewatered sludge is then fed back into the process when processing capacity is restored.

Sludge digestion

Following THP, sludge is transferred to a steel buffer tank (39.5 m^3) and from there is passed forward via digester feed lines to the digesters. Heat exchangers are located within the digester feed lines to reduce sludge temperature to the optimal temperature range for mesophilic anaerobic digestion activity (37-43 °C). Cooling water is discharged to the WwTW for treatment. There are 4 no. aluminium-clad and insulated concrete digester tanks located on site, each with a capacity of 3,533 m^3. The anaerobic digesters operate as a continuous process with sludge being continually fed into the base of the digester and treated sludge being displaced from the top. Digester retention time is determined by the feed rate (which is dependent on other site operations such as the THP and sludge import activities) but is typically 10-11 days. The digesters are mixed by gas mixing systems, which utilise biogas from the headspace of each digester; the gas is compressed and then reintroduced using an array of mixing nozzles on the floor of the digester. The digesters do not require any supplementary heating due to the temperature of the sludge being passed forward from the THP.

An automatic anti-foam dosing system is in place to control digester foaming. This system uses a radar level probe in the digester headspace and compares this to the pressure level sensor at the bottom of the digester to determine the depth of foam. Upon detection of foam, final treated effluent is sprayed into the digester head space through nozzles in the digester roof. If this is not effective in breaking up the foam, a chemical anti-foam is mixed with final treated effluent and dosed into the headspace of the digester via the same spray nozzles. This system includes operator-adjustable dosing setpoints and failsafe systems; if the foam level continues to increase mixing systems are inhibited and if this continues the digester feed will be inhibited. Antifoam is stored in an 1m^3 IBC located on a bunded spill pallet.

Sludge extracted from the digesters is fed to the degassing tanks (2 no. 685 m^3 GRP coated concrete tanks) prior to onward processing. These tanks are equipped with air mixing to introduce oxygen and prevent the anaerobic generation of methane. The tanks are covered and headspace air is extracted and discharged via a stack, approximately 5 m high.

Biogas storage and use

Biogas generated by the digester is piped to one of two double membrane biogas holders on site, one of these has a capacity of 2,380m^3 and the other a capacity of 1,040m^3. The biogas holders provide gas buffering capability in order to allow for fluctuations in gas production. Each gasholder has an ultrasonic level detector to monitor the level of the inner membrane and hence the volume of gas stored. The level detectors are used to control the start and stop of the CHP, composite boilers and waste gas burner. There is a methane gas detector fitted between the two membranes to detect any leaks in the system and alert the plant operators.

Pressure relief valves (PRVs) are located on the inlet biogas pipeline serving each biogas holder as well as outer membrane vent valves on each holder. PRVs are also located at the digesters (2 no. at each digester). These valves are an essential safety mechanism and will release gas to atmosphere in the event of a build of pressure preventing damage to equipment. The digester valves are also an ‘anti-vacuum’ design to prevent tank damage from negative pressures. Additional gas release valves are installed at various points, for instance between the degassing tanks and centrifuge feed tanks. The primary purpose of these is to prevent air-locking within pipework and subsequent loss of pumping.

Excess liquids within the biogas system are removed via condensate traps. These are located at various points in the system including on pipework between the digesters and biogas holders, prior to the waste gas burner, and prior to the CHPs and boilers. These collected liquids are transferred to the WwTW for treatment.

Biogas, via a gas booster, is currently used as the sole fuel source for the CHP units operating at Esholt STF; no natural gas or other alternative fuel is available. The CHP facility comprises four reciprocating engine generator sets. Two of these engines (referred to as CHP 1 and 2) have a thermal input of 1.53MW and two (referred to as CHP 3 and 4) have a thermal input of 3.63MW each. The CHPs generate electricity which is used to power essential site processes. Heat from the combustion process is used in waste heat recovery boiler stages, with any excess being discharged using air cooled radiators.

There are two 6.2MW Cochran Low NO_x composite steam raising boilers on site which generate steam for the THP as well as hot water which feeds the low temperature hot water (LTHW) ring main. These composite boilers combine direct firing of gas oil and the capability to receive waste heat from the exhaust gases fed from CHPs 3 and 4. The combined heat input is used for steam raising. The primary fuel for the boiler direct firing stage is currently low sulphur gas oil, with biogas as a backup fuel source. When operating at full capacity the digesters are able to generate sufficient biogas to fuel all four CHPs. The boilers may be fired by biogas in the event that one or more the CHPs is unavailable.

Gas oil for the boilers is stored in a 108 m^3 steel tank. This tank includes an integral bund providing secondary containment for the main tank and its fill point. Tertiary containment is provided around the tank filling area in the form of a low roll over bund with drain gully inside. The arrangement is compliant with the Oil Storage Regulations (2001). In addition to the two composite boilers a waste heat recovery (WHR) boiler operates on site. This has no direct firing capacity but recovers heat from CHP 1 and 2 exhaust gases to generate steam for the THP as well as hot water which also feeds the LTHW ring main.

The LTHW ring main receives recovered heat from the engine systems via heat exchangers. This is exported to provide space heating for the adjacent Esholt Hall conference centre owned and operated by YW as well as pre-heating biogas feed to the CHPs. Each engine is fitted with an air-cooled radiator to allow excess heat not required by the LTHW system. This allows the engines to run at full load independently of the demand of the LTHW system and steam generating plant, if necessary.

CHP engine and boiler combustion products are discharged via a 15 m high stack located adjacent to the boilerhouse. Contained within a single windshield are 6 exhaust stacks. These are: CHPs 1 and 2 (via waste heat boiler), CHP 3 and 4 (via or bypassing boiler 1 and 2 economisers) and exhaust stacks for boilers 1 and 2.

In periods where biogas generation exceeds CHP engine and boiler capacity (e.g. in the event of multiple plant shutdown/failures) biogas is directed to the waste gas burner. Since there are four CHP engines and two steam boilers with biogas firing capability, flaring rarely occurs. The flare facility comprises a 3,400m³/hr enclosed thermal combustor with 7.5m high exhaust stack and is located at a safe distance from the digesters and other biogas handling and treatment activities. Flare stack operation is automated based on gas level. If the gas level is high then the flare will operate, however utilisation of the gas is preferred over flaring. The flare provides 0.3 second retention time at 1,000 °C.

The areas around the digesters and gas storage and use are classified as a potentially explosive atmosphere, with strict provisions on the control of potential ignition sources in line with requirements of the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR).

Digested sludge treatment, handling and disposal

Digested sludge is pumped from the degassing tanks located adjacent to the anaerobic digesters to the digested sludge dewatering facility via a combination of above and below ground pipes, including a short section crossing the River Aire. The pipe crosses the river alongside the STF access roadway and is located at road level, on the far side and downstream of the road bridge barrier. The height above the river and roadside barrier provides protection for the pipe in the event of serious flooding which may bring large debris down river.

There are two separate sets of facilities for digested sludge dewatering. The first of these, which is used preferentially, is known as the sludge export facility. Sludge is transferred from the degassing tanks to two export dewatering feed tanks, each of which is of steel construction and 1,604 m^3 capacity. These tanks are not covered and have air mixing systems to prevent settlement and inhibit generation of methane. Polymer solution is injected into the sludge stream and taken to one of two export centrifuges where the sludge coagulates and supernatant liquor is removed by centrifugal forces. Dewatered liquor drops from the centrifuges into the export centrate sump and is pumped back to the WwTW for treatment.

The final digested and dewatered sludge cake is transferred via conveyers from the centrifuges up over a push-wall and into the covered sludge cake export barn. The whole area under the conveyer and sludge cake barn is an engineered impermeable surface, with water runoff draining to the WwTW for treatment.

In addition to the export dewatering facility there is a second dewatering area, which provides additional capacity for digested sludge treatment and handling. This takes place in what is known as the conditioning area. When the THP/digestion plant are running at full capacity, sludge would typically be diverted to this second dewatering facility for approximately 5-10 minutes in each hour. During these periods, sludge is transferred from the degassing tanks to two conditioning feed tanks, each of which is of concrete construction and have a capacity of 1,200 and 1,130 m^3. These tanks are not covered and have air mixing both to prevent settlement and inhibit generation of methane.

Polymer solution is injected into the sludge stream and taken to one of three centrifuges where the sludge coagulates and supernatant liquor is removed by centrifugal forces. Dewatered liquor drops from the centrifuges into the centrate sump and is pumped back to WwTW for treatment.

The final digested and dewatered sludge cake is transferred via conveyers on to the cake pad. The area under the conveyer and cake pad is an engineered impermeable surface, with water runoff draining the head of the works for treatment.

The digested sludge cake produced by this facility does not require liming or storage to ensure adequate pathogen kill and is suitable for immediate despatch from site to be landspread for agricultural benefit. The THP stage increases destruction of volatile sludge components within the digester, meaning that the final sludge cake has reduced odour generation potential.

The conditioning cake pad also serves certain contingency functions, both for operations at Esholt and for the wider strategic regional sludge treatment infrastructure operated by YW. The cake pad may on a temporary basis be used for interim storage of digested sludge cake produced at other YW sites, in circumstances such as the failure of assets or non-availability of normal disposal routes. It may also be used for interim storage of raw undigested sludge cake from Esholt or from other YW sites before being treated at Esholt STF, treated at another YW STF or sent off site to an alternative treatment/disposal route (subject to all applicable regulatory constraints).

A diagram of the Esholt STF process is shown in Figure 6 below. The location of odour sources is provided in Figures 7 and 8 below.

Figure 6 Esholt STF Process Flow Diagram

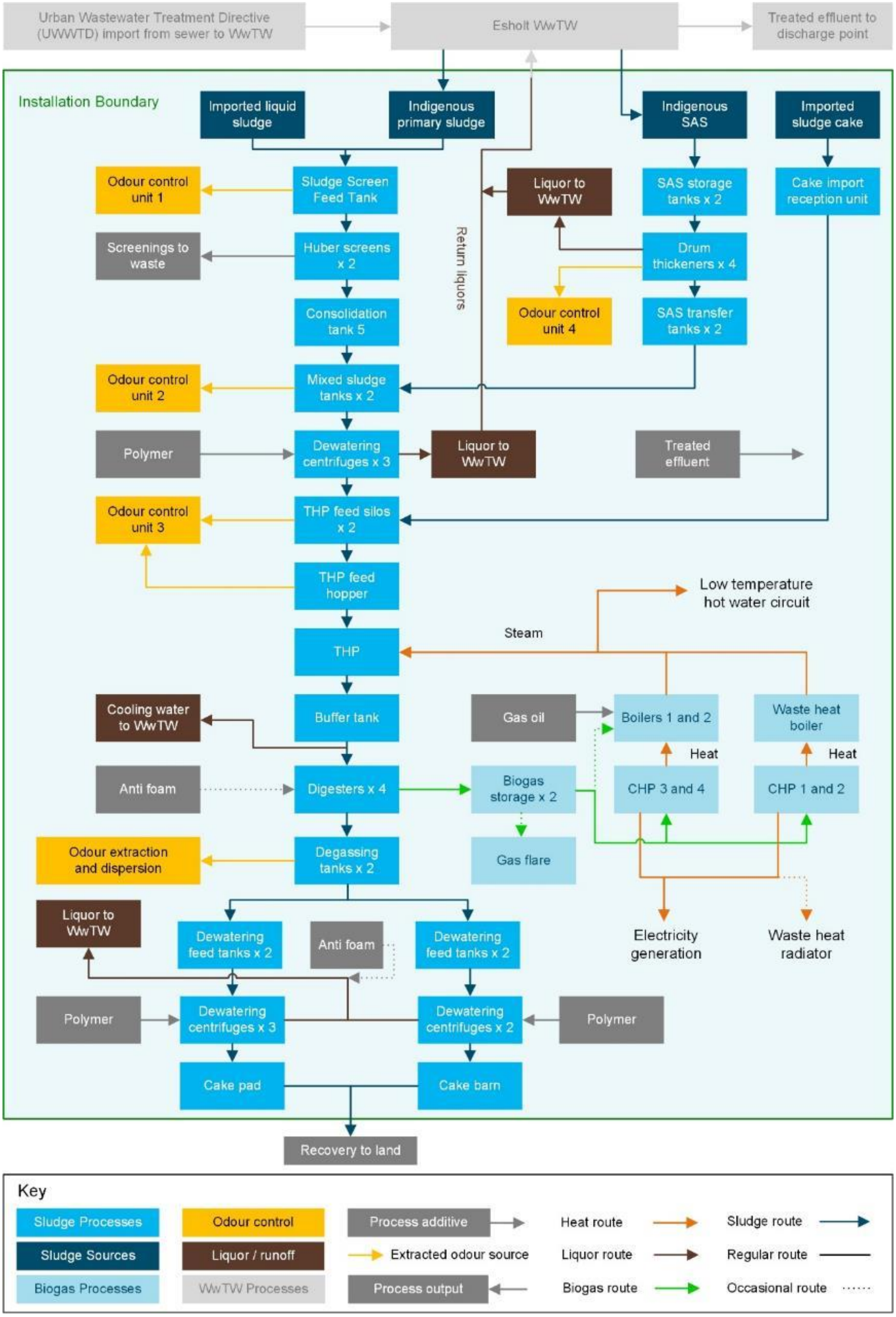
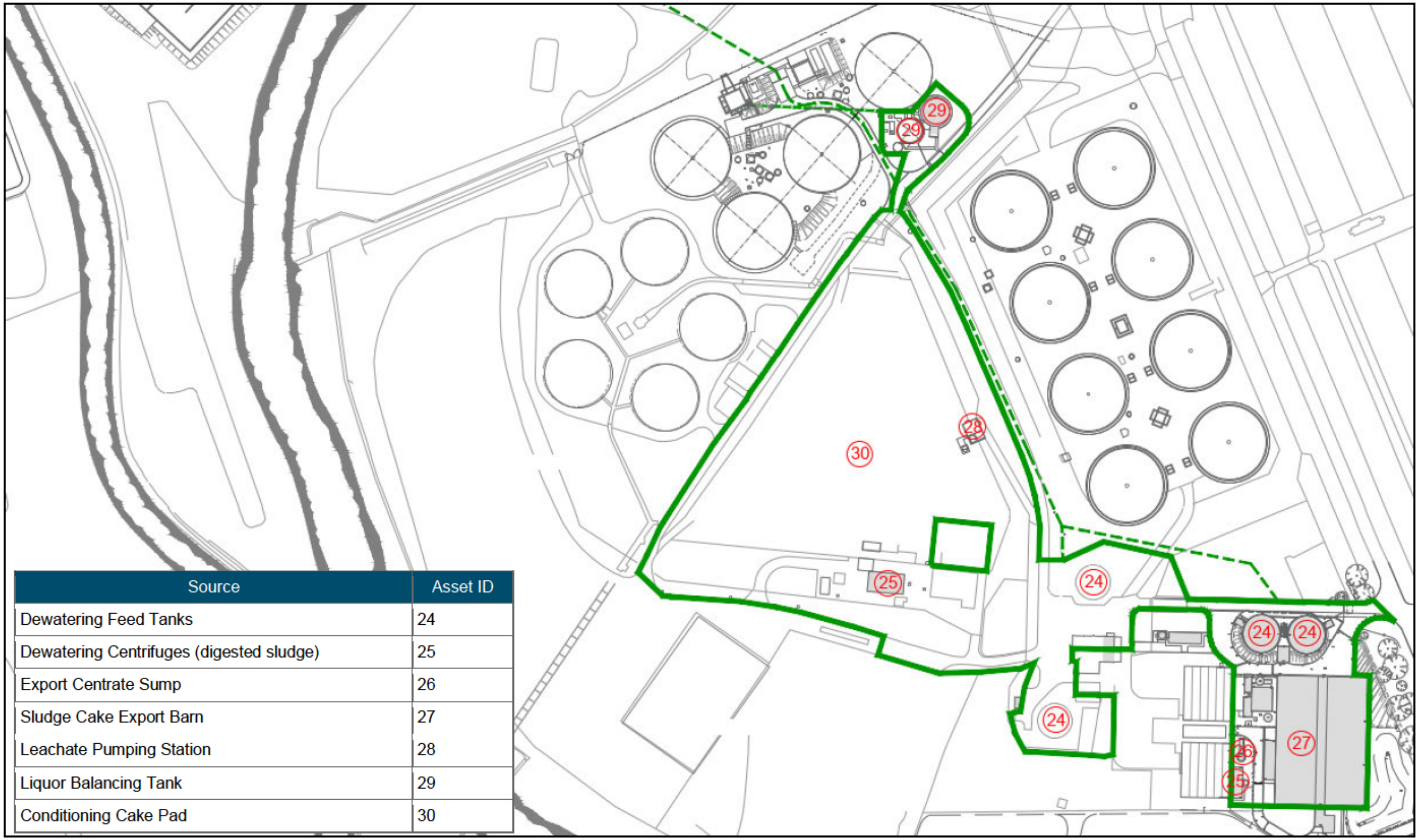


Figure 7 Esholt STF Source Locations (1 of 2)

Source	Asset ID
Sludge Screen Feed Tank	1
OCU 1 (imports)	2
Huber Screens	3
Screening Skips	4
Consolidation Tank 5	5
Mixed Sludge Tanks	6
OCU 2 (mixed sludge tanks)	7
SAS Storage Tank	8
Drum Thickeners	9
OCU 4	10
SAS Transfer Tank	11
Thickener Liquor Sump	12
Sludge Cake Reception Unit	13
THP Feed Silos	14
THP Feed Hopper	15
OCU 3 (THP feed)	16
THP Reactor Vessel	17
THP Buffer tank	18
Dewatering Centrifuges (raw sludge)	19
Centrate Pumping Station	20
Digesters	21
Degassing Tanks	22
Degassing Tank ventilation Stack	23
Biogas Relief Valves	31
THP Relief Valves	32
Biogas Holder	33
Flare	34

Figure 8 Esholt STF Source Locations (2 of 2)



Source	Asset ID
Dewatering Feed Tanks	24
Dewatering Centrifuges (digested sludge)	25
Export Centrate Sump	26
Sludge Cake Export Barn	27
Leachate Pumping Station	28
Liquor Balancing Tank	29
Conditioning Cake Pad	30

Type of waste accepted at Esholt STF, and their odour characteristics are summarised in Tables 2 and 3 below.

Table 2 Types of Waste Accepted and Restrictions - Imported and Indigenous wastes to the sludge AD process (digesters)

Waste Code	Description of the waste
19	Wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use
19 02	Wastes from physico/chemical treatments of waste (including dechromatation, decyanidation, neutralisation)
19 02 06	Sludges from physico/chemical treatment other than those mentioned in 19 02 05, specifically sewage sludge
19 06	Wastes from anaerobic treatment of waste
19 06 06	Digestate from anaerobic treatment of animal and vegetable waste
19 08	Wastes from waste water treatment plants not otherwise specified
19 08 05	Sludges from treatment of urban waste water

Table 3 Types of Waste Accepted and Restrictions – for dewatering / storage only

Waste Code	Description of the waste
19	Wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use
19 02	Wastes from physico/chemical treatments of waste (including dechromatation, decyanidation, neutralisation)
19 02 06	Sludges from physico/chemical treatment other than those mentioned in 19 02 05, specifically sewage sludge.
19 02 06	Sludges from physico/chemical treatment other than those mentioned in 19 02 05, specifically sewage sludge conditioned with sanitised green waste.
19 02 06	Sludges from physico/chemical treatment other than those mentioned in 19 02 05, specifically sewage sludge conditioned with wood waste.
19 02 06	Sludges from physico/chemical treatment other than those mentioned in 19 02 05, specifically sludge phyto conditioned.
19 06	Wastes from anaerobic treatment of waste
19 06 06	Digestate from anaerobic treatment of animal and vegetable waste
19 08	Wastes from waste water treatment plants not otherwise specified
19 08 05	Sludges from treatment of urban waste water

2.5 Process Odour Sources

The odour potential of a source can be broken down into three key considerations:

- How inherently odorous the compounds present are.
- The unpleasantness of the odour.
- The magnitude of the odour release.

When trying to determine the offensiveness of an odour source, site-specific odour sampling should be considered in the first instance. In the absence of source odour emission data, the assessment criteria will consider the Environment Agency's Horizontal Guidance Note (H4). H4 looks to categorise how offensive odours are with sources/processes/activities that are considered 'most offensive' odours include septic effluent or sludge and biological landfill odours. All raw sludge treatment processes would be considered to have a high odour offensiveness unless source-specific odour sampling is undertaken demonstrating a low level of odorous compounds. Processes containing the below material are considered to represent a high odour offensiveness:

- Indigenous sludge
- Sludge imports (liquid and solid)
- Sludge liquors

Processes containing the below material are considered to represent a medium odour offensiveness:

- Rags and screenings
- Digested sludge
- Digested sludge liquors
- Digested sludge cake (stored)

No processes on an STF are considered to store material that represents a low odour offensiveness unless supported by source-specific odour sampling.

The unpleasantness of an odour can be used in defining the source odour offensiveness. This is typically achieved through source material hedonic tone assessments, however; these types of assessments are not typically available for a site without source-specific sampling.

The risk source odour potential critical risk scoring for odour offensiveness and mitigation / control adopted is summarised in Table 4.

Table 4 Source Odour Potential Risk Scoring

Source	Risk Rating		
	High	Medium	Low
Odour Offensiveness	Very odorous compounds (H_2S, Mercaptans) with low odour threshold. Unpleasant odour - "Most Offensive". Unpleasant hedonic	Compounds involved are moderately odorous. Unpleasantness - process classed in H4 as "Moderately Offensive" or where	Compounds involved are only mildly offensive. Unpleasantness - process classed in H4 as "Less Offensive".

Source	Risk Rating		
	High	Medium	Low
	tone. Large, permitted process / Surface Area.	odours have neutral or slightly unpleasant hedonic tone. Smaller permitted process / Surface Area.	Neutral to positive hedonic tone.
Mitigation / Control	Open air operation with no containment. Reliance solely on good management techniques and best practice.	Some mitigation measures in place but significant residual odour remains.	Effective mitigation measures in place (e.g. BAT, BPM) leading to little or no residual odour.

Table 5 displays the site sludge odour sources, with an inventory of material, quality, and storage capacity, and goes on to explore the odour offensiveness and emission risk. The location of each odour source (asset ID) is shown on Figures 7 and 8 above.

Table 5 Esholt STF Sludge Inventory of odorous materials

Source	Asset ID	Source Type	Storage capacity (m^3)	Average retention time	Frequency of Operation	Odour Description	Hedonic Tone	Odour Offensiveness	Mitigation Measures	Emission Release Type	Emission Risk
Sludge Screen Feed Tank	1	Liquid Imports	655	~15 minutes	Continuous	Septic sludge, sulphide	Unpleasant	High	Covered and extracted process	Abnormal – fugitive only as off-gases ducted to OCU in normal operation	Low
OCU 1 (imports)	2	Treated gases	N/A	N/A	Continuous	Treated off gases	Acceptable	Low	Enclosed system with odour treatment	Point	Low
Huber Screens	3	Indigenous, Liquid Imports	N/A	N/A	Continuous	Septic sludge, sulphide	Unpleasant	High	Covered without extraction process	Fugitive	Medium
Screening Skips	4	Screenings	N/A	N/A	Continuous	Screenings	Unpleasant	Medium	Open to atmosphere	Diffuse	medium
Consolidation Tank 5	5	Indigenous, Liquid Imports	2,500	~4 days	Continuous	Septic sludge, sulphide	Unpleasant	High	Open to atmosphere	Diffuse	High
Mixed Sludge Tanks	6	Indigenous, Liquid Imports	1,200 and 1,130	~24 hours	Continuous	Septic sludge, sulphide	Unpleasant	High	Covered and extracted process	Abnormal – fugitive only as off-gases ducted to OCU in normal operation	Low
OCU 2 (mixed sludge tanks)	7	Treated gases	N/A	N/A	Continuous	Treated off gases	Acceptable	Low	Enclosed system with odour treatment	Point	Low
SAS Storage Tank	8	SAS sludge	2 x 2000	~1.5 days	Continuous	Treated sewage / Earthy	Mildly Unpleasant	Medium	Open to atmosphere	Diffuse	
Drum Thickeners	9	SAS sludge	N/A	N/A	Intermittent daily	Treated sewage / Earthy	Mildly Unpleasant	Medium	Covered, within a building and extracted process	Abnormal - fugitive only as off-gases ducted to	Low

Source	Asset ID	Source Type	Storage capacity (m^3)	Average retention time	Frequency of Operation	Odour Description	Hedonic Tone	Odour Offensiveness	Mitigation Measures	Emission Release Type	Emission Risk
										OCU in normal operation	
OCU 4	10	SAS sludge	700 m^3/hr	N/A	Continuous	Treated off gases	Acceptable	Low	Enclosed system with odour treatment	Point	Low
SAS Transfer Tank	11	SAS sludge	2 x 400	~1.25 days	Continuous	Treated sewage / Earthy	Mildly Unpleasant	Medium	Open to atmosphere	Diffuse	
Thickener Liquor Sump	12	SAS sludge liquors	N/A	N/A	Continuous	Treated sewage / Earthy	Mildly Unpleasant	Medium	Open to atmosphere	Diffuse	
Sludge Cake Reception Unit	13	Imported Sludge Cake	2 x 60	~2 days	Intermittent daily	Septic sludge, sulphide	Unpleasant	High	Covered with vent to atmosphere	Point	
THP Feed Silos	14	Indigenous, Liquid Imports, Imported Sludge Cake	2 x 210	~24 hours	Continuous	Septic sludge, sulphide	Unpleasant	High	Covered and extracted process	Abnormal – fugitive only as off-gases ducted to OCU in normal operation	Low
THP Feed Hopper	15	Indigenous, Liquid Imports, Imported Sludge Cake	16	~30 minutes	Continuous	Septic sludge, sulphide	Unpleasant	High	Covered and extracted process	Abnormal – fugitive only as off-gases ducted to OCU in normal operation	Low
OCU 3 (THP feed)	16	Treated gases	N/A	N/A	Continuous	Treated off gases	Acceptable	Low	Enclosed system with odour treatment	Point	Low
THP Reactor Vessel	17	Indigenous, Liquid Imports, Imported	22.7	30 mins	Continuous	Septic sludge, sulphide	Unpleasant	High	Fully contained process	Abnormal – fugitive only as process is fully contained	Low

Source	Asset ID	Source Type	Storage capacity (m^3)	Average retention time	Frequency of Operation	Odour Description	Hedonic Tone	Odour Offensiveness	Mitigation Measures	Emission Release Type	Emission Risk
		Sludge Cake									
THP Buffer tank	18	Indigenous, Liquid Imports, Imported Sludge Cake	40	~15 minutes	Continuous	Septic sludge, sulphide	Unpleasant	High	Fully contained process	Abnormal – fugitive only as process is fully contained	Low
Dewatering Centrifuges (raw sludge)	19	Indigenous, Liquid Imports, Imported Sludge Cake	N/A	N/A	Intermittent daily	Septic sludge, sulphide	Unpleasant	High	Covered and within a building	Diffuse	Medium
Centrate Pumping Station	20	Undigested Sludge Liquors	N/A	N/A	Continuous	Digested sludge / Earthy	Acceptable	Medium	Open to atmosphere	Diffuse	Medium
Digesters	21	Indigenous, Liquid Imports, Imported Sludge Cake	4 x 3,544	~9-12 days	Continuous	Biogas, Methane/ sulphide	Unpleasant	High	Covered and extracted to biogas storage Full containment of biogas is a critical safety consideration	Abnormal - fugitive only as biogas is collected for use on site.	Low
Degassing Tanks	22	Digested Sludge	2 x 685	~24 hours	Continuous	Digested sludge / Earthy	Acceptable	Medium	Covered and extracted process	Abnormal – fugitive only as off-gases ducted to ventilation stack in normal operation	Low
Degassing Tank ventilation Stack	23	Digested Sludge	N/A	~24 hours	Continuous	Digested sludge / Earthy	Acceptable	Medium	Extraction and ventilation to atmosphere	Point	Medium

Source	Asset ID	Source Type	Storage capacity (m^3)	Average retention time	Frequency of Operation	Odour Description	Hedonic Tone	Odour Offensiveness	Mitigation Measures	Emission Release Type	Emission Risk
Dewatering Feed Tanks	24	Digested Sludge	2 x 1,604, 1,200 and 1,130	~1-2 days	Continuous	Digested sludge / Earthy	Acceptable	Medium	Open to atmosphere	Diffuse	Medium
Dewatering Centrifuges (digested sludge)	25	Digested Sludge Cake	N/A	N/A	Intermittent daily	Digested sludge / Earthy	Acceptable	Medium	Covered and within a building	Diffuse	Medium
Export Centrate Sump	26	Digested Sludge Liquors	25	~30 minutes	Continuous	Digested sludge / Earthy	Acceptable	Medium	Open to atmosphere	Diffuse	Medium
Sludge Cake Export Barn	27	Digested Sludge Cake	~1,500	Storage as a contingency measure – storage period varies	Continuous	Digested sludge / Earthy	Acceptable	Medium	Partially contained enclosure	Diffuse	Medium
Leachate Pumping Station	28	Leachate	25	~30 minutes	Continuous	Digested sludge / Earthy	Acceptable	Medium	Open to atmosphere	Diffuse	Medium
Liquor Balancing Tank	29	Sludge Liquors	400, 660	~24 hours	Continuous	Digested sludge / Earthy	Acceptable	Medium	Open to atmosphere	Diffuse	Medium
Conditioning Cake Pad	30	Digested Sludge Cake	~4,000	Storage as a contingency measure – storage period varies	Continuous	Digested sludge / Earthy	Acceptable	Medium	Open to atmosphere	Diffuse	Medium
Biogas Relief Valves	31	Digested Sludge	N/A	N/A	Emergency operation	Biogas, Methane/ sulphide	Unpleasant	High	Critical process safety requirement. Operates only as required under abnormal process conditions	Point	Low

Source	Asset ID	Source Type	Storage capacity (m^3)	Average retention time	Frequency of Operation	Odour Description	Hedonic Tone	Odour Offensiveness	Mitigation Measures	Emission Release Type	Emission Risk
THP Relief Valves	32	Indigenous, Liquid Imports, Imported Sludge Cake	N/A	N/A	Emergency operation	Biogas, Methane/ sulphide	Unpleasant	High	Critical process safety requirement. Operates only as required under abnormal process conditions	Point	Low
Biogas Holder	33	Biogas	2,380m^3 and 1,040m^3	N/A	Continuous	Biogas	Unpleasant	High	Enclosed vessel. Full containment of biogas is a critical safety consideration	Abnormal - fugitive only as biogas is collected for use on site.	Low
Flare	34	Combusted biogas	N/A	N/A	Emergency Operation	Combustion	Acceptable	Low	Biogas is combusted	Point	Low
Raw materials (odour potential of raw materials stored and used on site)											
Polymer (liquid)		Raw material	IBCs ~ 5 m^3	Continuous	N/A	Aliphatic	Neutral	Low	Material is contained during storage and use	Fugitive	Very low
Polymer (powder)		Raw material	~ 55 m^3	Continuous	N/A	None	N/A	Low	Material is contained during storage and use	Fugitive	Very low
Antifoam		Raw material	IBCs ~ 5 m^3	Continuous	N/A	Characteristic	Neutral	Low	Material is contained during storage and use	Fugitive	Very low
Water treatment chemicals		Raw material	~ 760 litres	Continuous	N/A	Characteristic	Neutral	Low	Material is contained during storage and use	Fugitive	Very low
Glycol		Raw material	2 m^3	Continuous	N/A	None	Neutral	Low	Material is contained during storage and use	Fugitive	Very low
Lubrication oil		Raw material	1 m^3	Continuous	N/A	Characteristic	Unpleasant	High	Material is contained during storage and use	Fugitive	Very low
Propane		Raw material	1,410 kgs	Continuous	N/A	Characteristic	Unpleasant	High	Material is contained during storage and use	Fugitive	Very low

Source	Asset ID	Source Type	Storage capacity (m^3)	Average retention time	Frequency of Operation	Odour Description	Hedonic Tone	Odour Offensiveness	Mitigation Measures	Emission Release Type	Emission Risk
Gas oil		Raw material	108,000 litres	Continuous	N/A	Characteristic / Aromatic / Sulphur	Unpleasant	High	Material is contained during storage and use	Fugitive	Very low
Diesel		Raw material	2,500 litres	Continuous	N/A	Characteristic / Aromatic / Sulphur	Unpleasant	High	Material is contained during storage and use	Fugitive	Very low

2.6 Odour Control Units

There are four odour control systems on site that treat odorous emissions from the sludge treatment facility. The four odour control systems are summarised as:

- OCU 1 – Single stage activated carbon unit extracting and treating odorous air from the sludge import tank
- OCU 2 – Single stage activated carbon unit extracting and treating odorous air from the sludge mixing tanks
- OCU 3 – Single stage activated carbon unit extracting and treating odorous air from the THP feed silos
- OCU 4 – Single stage activated carbon unit extracting and treating odorous air from the drum thickeners

OCUs 1, 2 and 3 are currently being operated as extraction and stack dispersion units. YW is committed to undertake works necessary to refurbish these OCUs to ensure they operate to effectively treat odours. This work will be completed no later than December 2024. The key process performance parameters for each OCU are highlighted below:

Table 6 Esholt STF OCU 1 Performance Parameters

Parameter	Carbon Filter		
Media Type	Activated Carbon Upper Layer (EE-ZE KMn04) Middle Layer (OxySorb) Lower Layer: (EE-ZE KMn04)		
Media Volume (m^3)	2		
Media Life (Yrs)	2 years average		
Pressure Drop Across Bed (Pa)	No information available		
Inlet Parameters			
Parameter	**Min**	**Average**	**Max**
Airflow (m^3/hr)	595	700	805
Hydrogen Sulphide (ppm)	1.0*	3.6*	8.6*
Di-methyl Sulphide (ppm)	0.1*	0.55*	1.5*
Mercaptans (ppm)	0.1*	1.0*	3.0*
VOCs (ppm)	0.7*	6.4*	12.2*
Ammonia (ppm)	0.0*	0.25*	1.0*
Humidity (RH%)	NA	< 100%	100%
Gas Temperature (°C)	NA	15 (Ambient)	NA
Stack Outlet Performance			
Odour Concentration (ou_E/m^3)	1,000		
Hydrogen Sulphide (ppm)	< 0.5		

*Measured as part of June 2021 odour survey

Table 7 Esholt STF OCU 2 Performance Parameters

Parameter	Carbon Filter		
Media Type	Activated Carbon Upper Layer (EE-ZE KMn04) Middle Layer (OxySorb) Lower Layer: (EE-ZE KMn04)		
Media Volume (m^3)	8.5		
Media Life (Yrs)	2 years average		
Pressure Drop Across Bed (Pa)	No information available		
Inlet Parameters			
Parameter	**Min**	**Average**	**Max**
Airflow (m^3/hr)		2,493	
Hydrogen Sulphide (ppm)	1.1*	2.8*	5.1*
Di-methyl Sulphide (ppm)	0.1*	0.3*	0.5*
Mercaptans (ppm)	1.5*	2.3*	3.0*
VOCs (ppm)	3.0*	4.5*	5.9*
Ammonia (ppm)	0*	ND**	ND**
Humidity (RH%)	NA	< 100%	100%
Gas Temperature (°C)	NA	15 (Ambient)	NA

Parameter	Carbon Filter
Stack Outlet Performance	
Odour Concentration (ou_E/m^3)	1,000
Hydrogen Sulphide (ppm)	< 0.5

*Measured as part of June 2021 odour survey
**Non detected as part of June 2021 odour survey

Table 8 Esholt STF OCU 3 Performance Parameters

Parameter	Carbon Filter		
Media Type	Activated Carbon Upper Layer (EE-ZE KMn04) Middle Layer (OxySorb) Lower Layer: (EE-ZE KMn04)		
Media Volume (m^3)	6		
Media Life (Yrs)	2 years average		
Pressure Drop Across Bed (Pa)	No information available		
Inlet Parameters			
Parameter	**Min**	**Average**	**Max**
Airflow (m^3/hr)	948	1,115	1,282
Hydrogen Sulphide (ppm)	0.320*	0.598*	0.910*
Di-methyl Sulphide (ppm)	0*	ND**	ND**
Mercaptans (ppm)	0.1*	0.3*	0.4*
VOCs (ppm)	1.5*	1.8*	2.1*
Ammonia (ppm)	0*	ND**	ND**
Humidity (RH%)	NA	< 100%	100%
Gas Temperature (°C)	NA	15 (Ambient)	NA
Stack Outlet Performance			
Odour Concentration (ou_E/m^3)	1,000		
Hydrogen Sulphide (ppm)	< 0.5		

*Measured as part of June 2021 odour survey
**Non detected as part of June 2021 odour survey

Table 9 Esholt STF OCU 4 Performance Parameters

Parameter	Carbon Filter		
Media Type	Activated Carbon		
Media Volume (m^3)	TBC		
Media Life (Yrs)	2 years average		
Pressure Drop Across Bed (Pa)	No information available		
Inlet Parameters			
Parameter	**Min**	**Average**	**Max**
Airflow (m^3/hr)	948	700	1,282
Hydrogen Sulphide (ppm)	TBC	TBC	TBC

Di-methyl Sulphide (ppm)	TBC	TBC	TBC
Mercaptans (ppm)	TBC	TBC	TBC
VOCs (ppm)	TBC	TBC	TBC
Ammonia (ppm)	TBC	TBC	TBC
Humidity (RH%)	NA	< 100%	100%
Gas Temperature (°C)	NA	15 (Ambient)	NA
Stack Outlet Performance			
Odour Concentration (ou_E/m^3)	1,000		
Hydrogen Sulphide (ppm)	< 0.5		

3 Odour Critical Plant Operation

3.1 Odour Critical Sources

Given the control measures that are in place during operation of the facility, these contributions (if any) are unlikely to increase the odour impact on the receptors outside of the site boundary.

Management of releases includes reducing turbulence, containment and abatement. Where odorous gasses are finally released, controlling the height of release through a stack or the timing of releases through management of activities can influence dispersion before there is an impact on people. Potential on site odour releases associated with Esholt STF are given in Table 9 below.

Table 10 Esholt STF Odour Critical Sources (operational controls)

Asset	Asset ID	Potential Odour Source	Odour Control Measures	Odour Risk	Mitigation Trigger	Mitigation Measures	Timescale	Responsible Person
Sludge Screen Feed Tank	1	Liquid Imports	Tank covered and odour controlled. Inspection hatches kept closed. Sludge is mixed and regular throughput is maintained	Unlikely given control measures in place	Failure of OCU extraction fans & increase in complaint frequency / odour sniff test identifies sludge odours off-site.	Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer
OCU 1 (imports)	2	Treated gases	Duty / Standby extraction fan to be available. Prevent increase of fugitive emissions risk from covered processes.	Unlikely given control measures in place	Standby Fan Failure	Standby extraction fan to be in service. Investigate cause of limited extraction.	Support from OCU supplier to be arranged next availability	Product and Process Engineer
Huber Screens	3	Indigenous, Liquid Imports	Sludge screen is contained asset	Unlikely given control measures in place	Screens missing cover sections / odour sniff test identifies sludge odours off-site.	Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer
Screening Skips	4	Sludge Screenings	Regular throughput maintained, replacement of full skips, no excess storage of screenings.	Unlikely given control measures in place	Screenings spill local to skip. Increase in complaint frequency / odour sniff test identifies sludge screenings off-site.	Early removal / replacement of skip	Within 5 working days of incident	Product and Process Engineer
Consolidation Tank 5	5	Indigenous, Liquid Imports	Regular throughput maintained. Risk assessment and odour plan in place before cleaning of any tank.	Potential odour risk if odours are elevated.	Increase in complaint frequency / odour sniff test identifies indigenous sludge odours off-site.	Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer

Asset	Asset ID	Potential Odour Source	Odour Control Measures	Odour Risk	Mitigation Trigger	Mitigation Measures	Timescale	Responsible Person
Mixed Sludge Tanks	6	Indigenous, Liquid Imports	Tank covered and odour controlled. Inspection hatches kept closed. Sludge is mixed and regular throughput is maintained	Unlikely given control measures in place	Failure of OCU extraction fans & increase in complaint frequency / odour sniff test identifies sludge odours off-site.	Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer
OCU 2 (mixed sludge tanks)	7	Treated gases	Duty / Standby extraction fan to be available. Prevent increase of fugitive emissions risk from covered processes.	Unlikely given control measures in place	Standby Fan Failure	Standby extraction fan to be in service. Investigate cause of limited extraction.	Support from OCU supplier to be arranged next availability	Product and Process Engineer
SAS Storage Tank	8	SAS Sludge	Risk assessment and odour plan in place before cleaning of any tank.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies digested sludge liquor odours off-site.	Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer
Drum Thickeners	9	SAS Sludge	Thickeners are contained asset	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies indigenous sludge odours off-site.	Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer
OCU 4 (drum thickeners)	10	Treated gases	Duty / Standby extraction fan to be available. Prevent increase of fugitive emissions risk from covered processes.	Unlikely given control measures in place	Standby Fan Failure	Standby extraction fan to be in service. Investigate cause of limited extraction.	Support from OCU supplier to be arranged next availability	Product and Process Engineer
SAS Transfer Tank	11	SAS Sludge	Risk assessment and odour plan in place before cleaning of any tank.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies digested	Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer

Asset	Asset ID	Potential Odour Source	Odour Control Measures	Odour Risk	Mitigation Trigger	Mitigation Measures	Timescale	Responsible Person
					sludge liquor odours off-site.			
Thickener Liquor Sump	12	SAS Sludge Liquors	Risk assessment and odour plan in place before cleaning of any tank.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies digested sludge liquor odours off-site.	Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer
Sludge cake reception unit	13	Imported Sludge Cake	Complete process as rapidly as possible. Shut hatch doors as soon as tipping is complete.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies sludge cake import odours off-site.	Dose with odour control chemical	Within 5 working days of incident	Product and Process Engineer
THP Feed Silos	14	Indigenous, Liquid Imports, Imported Sludge Cake	Tank covered and odour controlled. Inspection hatches kept closed. Sludge is mixed and regular throughput is maintained	Unlikely given control measures in place	Failure of OCU extraction fans & increase in complaint frequency / odour sniff test identifies sludge odours off-site.	Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer
THP Feed Hopper	15	Indigenous, Liquid Imports, Imported Sludge Cake	Tank covered and odour controlled. Inspection hatches kept closed. Sludge is mixed and regular throughput is maintained	Unlikely given control measures in place	Failure of OCU extraction fans & increase in complaint frequency / odour sniff test identifies sludge odours off-site.	Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer
OCU 3 (THP feed)	16	Treated gases	Duty / Standby extraction fan to be available. Prevent increase of fugitive emissions risk from covered processes.	Unlikely given control measures in place	Standby Fan Failure	Standby extraction fan to be in service. Investigate cause of limited extraction.	Support from OCU supplier to be arranged next availability	Product and Process Engineer

Asset	Asset ID	Potential Odour Source	Odour Control Measures	Odour Risk	Mitigation Trigger	Mitigation Measures	Timescale	Responsible Person
THP Reactor Vessel	17	Indigenous, Liquid Imports, Imported Sludge Cake	Vessel fully sealed. (refer also asset ID 32) Risk assessment and odour plan in place before cleaning of any tank.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies indigenous sludge odours off-site.	Investigate reactor performance and schedule reactive maintenance.	Same day as incident	Product and Process Engineer
THP Buffer tank	18	Indigenous, Liquid Imports, Imported Sludge Cake	Vessel fully sealed. (refer also asset ID 32)Risk assessment and odour plan in place before cleaning of any tank.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies indigenous sludge odours off-site.	Investigate reactor performance and schedule reactive maintenance.	Within 5 working days of incident	Product and Process Engineer
Dewatering Centrifuges (raw sludge)	19	Indigenous, Liquid Imports, Imported Sludge Cake	Centrifuges are contained asset	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies indigenous sludge odours off-site.	Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer
Centrate Pumping Station	20	Sludge liquors	Risk assessment and odour plan in place before cleaning of any tank.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies digested sludge liquor odours off-site.	Investigate thickener / centrifuge performance and schedule reactive maintenance	Same day as incident	Product and Process Engineer
Digesters	21	Indigenous, Liquid Imports, Imported Sludge Cake	Tank is covered and biogas extracted. Risk assessment and odour plan in place before cleaning of any tank.	Unlikely given control measures in place	Loss of digester performance (see table 11 for monitor parameters)	Investigate digester performance and schedule reactive maintenance.	Same day as incident	Product and Process Engineer
Degassing Tanks	22	Digested Sludge	Risk assessment and odour plan in place before cleaning of any tank.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies digested	Review the digester performance	Immediately	Product and Process Manager / Process Engineer

Asset	Asset ID	Potential Odour Source	Odour Control Measures	Odour Risk	Mitigation Trigger	Mitigation Measures	Timescale	Responsible Person
					sludge odours off-site.			
Degassing tank ventilation stack	23	Treated gases	Duty / Standby extraction fan to be available.	Unlikely given control measures in place	Standby Fan Failure	Standby extraction fan to be in service. Investigate cause of limited extraction.	Within 5 working days of incident	Product and Process Engineer
Dewatering Feed Tanks	24	Digested Sludge	Risk assessment and odour plan in place before cleaning of any tank.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies digested sludge odours off-site.	Review the digester performance	Immediately	Product and Process Manager / Process Engineer
Dewatering Centrifuges (digested sludge)	25	Digested Sludge Cake	Centrifuges are contained asset	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies sludge cake storage odours off-site.	Check digester performance.	Same week as incident	Product and Process Engineer
Export Centrate Pumping Station	26	Digested sludge liquors	Risk assessment and odour plan in place before cleaning of any tank.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies digested sludge liquor odours off-site.	Investigate thickener / centrifuge performance and schedule reactive maintenance	Same day as incident	Product and Process Engineer
						Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer
Sludge Cake Export Barn	27	Digested Sludge Cake	Cake to be handled by the loader only twice (once to move from conveyor to pad, and once to load into the export wagon) to minimise disturbance and odour release.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies sludge cake storage odours off-site.	Restrict process and reduce storage volumes.	Same week as incident	Centrifuge unit operator

Asset	Asset ID	Potential Odour Source	Odour Control Measures	Odour Risk	Mitigation Trigger	Mitigation Measures	Timescale	Responsible Person
Leachate Pumping Station	28	Leachate	Risk assessment and odour plan in place before cleaning of any tank.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies digested sludge liquor odours off-site.	Dose sludge with odour control chemical	Within 5 working days of incident	Product and Process Engineer
Liquor Balancing Tank	29	Sludge Liquors	Risk assessment and odour plan in place before cleaning of any tank.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies digested sludge liquor odours off-site.	Investigate thickener / centrifuge performance and schedule reactive maintenance	Same day as incident	Product and Process Engineer
Conditioning Cake Pad	30	Digested Sludge Cake	Cake to be handled by the loader only twice (once to move from conveyor to pad, and once to load into the export wagon) to minimise disturbance and odour release.	Unlikely given control measures in place	Increase in complaint frequency / odour sniff test identifies sludge cake storage odours off-site.	Restrict process and reduce storage volumes.	Same week as incident	Centrifuge unit operator
Biogas Relief Valves	31	Biogas	Planned maintenance on equipment. Monitoring of digester pressures. Flare available to burn excess gas.	Unlikely given the control measures in place. Critical safety system.	Prolonged / frequent use of safety valve.	Failures are investigated and reactive maintenance undertaken.	Same day as incident	Product and Process Engineer
THP Relief Valves	32	Indigenous, Liquid Imports, Imported Sludge Cake	Planned maintenance on equipment. Monitoring of vessel pressures.	Unlikely given the control measures in place. Critical safety system.	Prolonged / frequent use of safety valve.	Failures are investigated and reactive maintenance undertaken.	Same day as incident	Product and Process Engineer
Biogas Holder	33	Biogas	Planned maintenance on equipment. Monitoring of digester pressures.	Unlikely given the control measures in place.	Prolonged / frequent use of safety valves.	Failures are investigated and reactive maintenance undertaken.	Same day as incident	Product and Process Engineer

Asset	Asset ID	Potential Odour Source	Odour Control Measures	Odour Risk	Mitigation Trigger	Mitigation Measures	Timescale	Responsible Person
			Flare available to burn excess gas.	Critical safety system.				
Flare	34	Combusted biogas	Planned maintenance on equipment.	Unlikely given the control measures in place. Critical safety system.	Prolonged / frequent use of flare.	Failures are investigated and reactive	Same day as incident	Product and Process Engineer
OCU / odour extraction stacks (Performance)	2, 7, 10 16	Treated gases	OCU performance is monitored.	Unlikely given control measures in place emissions from OCU outlet	Airflow rate +/- 15% design value	Standby extraction fan to be in service. Check OCU media for fouling / blockages. Check OCU for airflow bypassing	Site investigation by operations same day as incident Support from OCU supplier to be arranged immediately if issue not resolved by site operations	Product and Process Engineer
					Pressure drop +/- 15% design value across media beds	Check OCU media for fouling / blockages. Check OCU media for bed collapse / bypassing	Site investigation by operations same day as incident Support from OCU supplier to be arranged immediately if issue not resolved by site operations	Product and Process Engineer
					0.5 ppm Hydrogen Sulphide at outlet	Check OCU for airflow bypassing	Site investigation by	Product and Process Engineer

Asset	Asset ID	Potential Odour Source	Odour Control Measures	Odour Risk	Mitigation Trigger	Mitigation Measures	Timescale	Responsible Person
						Check removal rates across OCU Investigate replacement of carbon media	operations same day as incident Support from OCU supplier to be arranged immediately if issue not resolved by site operations	
					OCU stack odour concentration > 1,000 ou_E/m^3	Check OCU for airflow bypassing Check removal rates across OCU Investigate replacement of carbon media	Site investigation by operations same day as incident Support from OCU supplier to be arranged immediately if issue not resolved by site operations	Product and Process Engineer

3.2 OCU Performance Investigation

The OCU shall be monitored and maintained by site operations. Whereby there is an issue with an OCU's operability or treatability that cannot be resolved by site operations, a 3rd party specialist shall be engaged immediately to arrange for support. In the event that the 3rd party specialist cannot directly mobilise to site, the product and process engineer shall manage the OCU's operation to reduce the risk of compromised performance.

The 3rd party specialist shall be commissioned to undertake an asset condition and performance assessment. The assessment shall include as a minimum the tasks outlined in Appendix 3 but shall extend to any additional tasks to include the highlighted issues by operations.

As part of the assessment, the 3rd party specialist with support from YW operational staff shall work to resolve any issues to ensure the OCU is returned to normal operating conditions. Any issues that cannot be resolved on the day or requires additional parts shall be raised as an action to be managed by operational staff.

At the end of the asset condition and performance assessment the 3rd party specialist shall provide a summary report that documents findings and associated actions / recommendations to return the OCU to normal operating conditions.

3.3 Protocol for Dosing Odour Control Chemical

In the event that there is failure of process mitigation measures that could lead to increased risk of elevated odours, chemical can be dosed directly into the sludge to mitigate this risk.

4 Odour Impact

4.1 Odour Dispersion Model

An odour dispersion model has not been developed for Esholt STF as part of this OMP.

Odour dispersion modelling including site specific olfactometric surveys shall be undertaken in the event of increased frequency of odour complaints or operational changes with a perceived increase in odour impact risk.

4.2 Odour Survey Results

An odour survey has been undertaken on selected STF processes as part of the qualitative odour risk assessment. The odour survey was undertaken during June 2021 to assess the odour emissions from the uncovered and treated emission source. Table 10 includes a summary of the survey results.

Table 11 Esholt STF Odour Survey Results

Source	Odour Concentration	Odour Emission Rate	Hydrogen Sulphide	Ammonia
	(ou_E/m^3)	($ou_E/m^2/s$)	(ppm)	(ppm)
Digested Cake – Disturbed	476	4.9	0.018	24.5
Digested Cake – Static	263	2.7	0.010	1.8
Raw Cake – Disturbed	501	5.2	0.030	ND*
Raw Cake - Static	961	10.0	0.077	ND*

*None detected

4.3 Qualitative Odour Risk Assessment

A qualitative odour risk assessment of Esholt STF has been undertaken by Stantec to determine the odour impact risk at sensitive receptors local to the works. The assessment relies on subjective professional judgement but uses the generic guidance methodologies provided and referenced in documents such as the Institute of Air Quality Managements (IAQM) Guidance on the Assessment of Odour for Planning, the Scottish Environmental Protection Agency (SEPA) Odour Guidance 2010, the Environment Agency's Horizontal Guidance Note H1 Environmental Risk Assessments for Permits, and Annex A of H1 – Amenity & accident risk from installations and waste activities.

These guidelines use the Source-Pathway-Receptor concept in which it evaluates the relationship between source(s) of odour, the pathway or transmission route by which exposure may occur at a given receptor(s) who may be affected/impacted.

How well a qualitative odour risk assessment predicts the odour impact for a scenario is dependent on how well the Source-Pathway-Receptor approach can be assessed and scored. This type of assessment is based on subjective judgement and therefore, robust assessment criteria are required. Where subjective judgement for a criterion could be considered broad, sub-criteria have been determined to provide a more detailed judgement.

The odour offensiveness of the sludge assets have adopted the risk ratings included in Table 3. The pathway from source to receptor considers the distance, local terrain and meteorological conditions, as highlighted in Section 2.3.

The sensitive receptors considered in the assessment are documented in Figure 9 and Table 11.

Figure 9 Esholt STF Odour Risk Assessment Sensitive Receptor Locations

Table 12 Esholt STF Odour Risk Assessment Sensitive Receptors

Receptor ID	Receptor Type	Distance from Site (m)	Receptor Sensitivity
Esholt Hall	D01	115	High
Home Farm Industrial Park (Home Farm House and Home Farm Cottage)	D02	283	High
Low Ash Farm	D03	636	High
St. Paul's Church	D04	673	High
Church Lane	D05	685	High
Bottom Farm	D06	455	Low

Receptor ID	Receptor Type	Distance from Site (m)	Receptor Sensitivity
Apperley Bridge Railway Station	D07	431	Medium
Nunwood House	D08	444	High
Crow Tree House	D09	860	High
JCT600 Head Office	D10	591	Medium

4.4 Results

The results of the qualitative odour risk assessment are summarised in Table 12.

Table 13 Esholt STF Odour Risk Assessment Results

Receptor ID	Receptor Type	Source Odour Potential	Pathway Effectiveness	Odour Exposure	Receptor Sensitivity	Likely Odour Effect
Esholt Hall	Residential	High	Moderately Effective Pathway	Medium Risk	High	Moderate Adverse Effect
Home Farm Industrial Park (Home Farmhouse and Home Farm Cottage)	Residential	High	Moderately Effective Pathway	Medium Risk	High	Moderate Adverse Effect
Low Ash Farm	Residential	High	Ineffective Pathway	Low Risk	High	Slight Adverse Effect
St Paul's Church	Cultural	High	Ineffective Pathway	Low Risk	High	Slight Adverse Effect
Church Lane	Residential	High	Ineffective Pathway	Low Risk	High	Slight Adverse Effect
Bottom Farm	Farm	Medium	Moderately Effective Pathway	Low Risk	Low	Negligible Effect

Receptor ID	Receptor Type	Source Odour Potential	Pathway Effectiveness	Odour Exposure	Receptor Sensitivity	Likely Odour Effect
Apperley Bridge Railway Station	Commercial	Medium	Ineffective Pathway	Negligible Risk	Medium	Negligible Effect
Nunwood House	Residential	Medium	Moderately Effective Pathway	Low Risk	High	Slight Adverse Effect
Crow Tree House	Residential	Medium	Ineffective Pathway	Negligible Risk	High	Negligible Effect
JCT600 Head Office	Commercial	Medium	Ineffective Pathway	Negligible Risk	Medium	Negligible Effect

A qualitative odour risk assessment has been undertaken for Esholt STF considering twenty-five process activities across two separate areas on site and potential odour effect on ten receptors. The assessment has been based on a Source-Pathway-Receptor approach and is primarily based upon professional judgement.

The qualitative odour risk assessment for Esholt STF has indicated that two considered sensitive receptors are exposed to a moderate adverse odour effect with the remaining eight receptors exposed to either a slight adverse or negligible adverse odour effect. The two receptors exposed to a moderate adverse odour effect are Esholt Hall and Home Farm Industrial Park, located to the north-east of the site with both receptors representing residential receptors. YW has not received any odour complaint from these locations and therefore, there could be the potential that this assessment is overly conservative when considering odour effects at these locations.

All sensitive receptors to the south of the STF are considered to have a negligible odour effect, attributed to the receptor distance from the site and subsequent ineffective odour pathway. This assessment supports Yorkshire Water's view that complaints received from Apperley Bridge area close to the river and Greengates traffic junction are most likely to be associated with other odour sources and not the STF.

The site-specific odour survey has highlighted that whilst the digested sludge cake is stored in a partially covered barn or outside, it represents a low odour potential source due to the low odour emission rate. However, the cake storage pad has been considered a medium risk odour offensiveness due to the surface area occupied by the cake. The digested sludge cake emissions are typical of those observed on other sites which do not generate odour risk or complaints and as long as the process is healthy and sludge cake stockpiling is managed effectively, would not be considered a future risk of odour at surrounding receptors.

For the overall site, it is considered that Esholt STF does not have an adverse odour effect on its surrounding receptors. However, appropriate levels of monitoring of the STF should be undertaken to ensure a healthy process is maintained and that there is no deterioration in odour emissions from the site, notably the odour control units operating as dispersion stacks and cake stockpiling on the cake pad. If increased odour complaints were to be received and attributed to STF operation, mitigation measures should be implemented to reduce off-site odour effects.

4.5 BAT Conclusions

BAT Conclusion 14 describes specific measures which may be appropriate for the prevention or reduction of diffuse emissions to air. BAT Section 14d is associated with the "containment, collection and treatment of diffuse emissions" and includes techniques such as:

- Storing, treating, and handling waste and materials that may generate diffuse emissions in enclosed buildings and/or enclosed equipment (e.g., conveyor belts);
- Maintaining the enclosed equipment or buildings under adequate negative pressure;
- Collecting and directing emissions to an appropriate abatement system via an air extraction system and/or air suction systems close to the emission sources.

In terms of the applicability of this technique it is noted that: "The use of enclosed equipment or buildings may be restricted by safety considerations such as the risk of explosion or oxygen depletion. The use of enclosed equipment or buildings may also be constrained by the volume of waste."

An assessment of STF processes carried out at Esholt has been undertaken against BAT 14d. Table 13 provides a summary of compliance for diffuse and untreated odour sources. Abnormal / fugitive only release (associated with failure of the OCU or off gas collection system) have not been considered here.

Table 14 BAT Compliance / Alternative Techniques

Source	Source ID	BAT Compliance Review	Alternative Techniques	Compliance Restrictions
Sludge screen feed tank	1	Tank is covered and extracted via OCU (see below for comments in relation to the OCU)	N/A	N/A
OCU 1	2	OCU is no longer operational and is currently acting as a dispersion stack.	None – see Table 15 Odour Improvement Plan	None
Huber Screens	3	Screens, although of a proprietary enclosed design, do not facilitate creating a negative pressure environment.	Source is enclosed. Area subject to regular inspection and management, source not considered to contribute to off-site odour nuisance potential. No sensitive receptors in close proximity. Adequate measures considered to be in operation.	None
Screenings Skips	4	Skips open to atmosphere with no containment or treatment of emissions.	Area subject to regular inspection and management, source not considered to contribute to off-site odour nuisance potential. Adequate measures considered to be in operation.	None
Consolidation Tank 5	5	Tank is open to atmosphere with no containment or treatment of emissions.	Odour management techniques in use rather than specific BAT containment measures – see Table 15 Odour Improvement Plan	None
Mixed sludge tanks	6	Tank is covered and extracted via OCU (see below for comments in relation to the OCU)	N/A	N/A
OCU 2	7	OCU is no longer operational and is currently acting as a dispersion stack.	None – see Table 15 Odour Improvement Plan	None
SAS Storage Tank	8	Tank is open to atmosphere with no containment or treatment of emissions	Odour management techniques in use rather than specific BAT containment measures SAS has inherently lower emissions generation potential. See Table 15 Odour Improvement Plan	None
Drum Thickeners	9	Thickeners are extracted via OCU (see below for comments in relation to the OCU).	N/A	N/A
OCU 4	10	OCU in operation.	N/A	N/A
SAS Transfer Tank	11	Tank is open to atmosphere with no	Odour management techniques in use rather than	None

Source	Source ID	BAT Compliance Review	Alternative Techniques	Compliance Restrictions
		containment or treatment of emissions.	specific BAT containment measures SAS has inherently lower emissions generation potential. See Table 15 Odour Improvement Plan	
Thickener Liquor Sump	12	Sump is open to atmosphere with no containment or treatment of emissions.	Odour management techniques in use rather than specific BAT containment measures. See Table 15 Odour Improvement Plan	None
Sludge cake reception unit	13	Cake reception containers are covered and passively vented to air	None – see Table 15 Odour Improvement Plan	None
THP feed silos	14	Tank is covered and extracted via OCU – see below for comments in relation to the OCU.	N/A	N/A
THP hopper	15	Tank is covered and extracted via OCU – see below for comments in relation to the OCU.	N/A	N/A
OCU 3	16	OCU is no longer operational and is currently acting as a dispersion stack.	None – see Table 15 Odour Improvement Plan	None
Dewatering Centrifuges (raw sludge)	19	Centrifuges, although of a proprietary enclosed design, do not facilitate creating a negative pressure environment.	Source is enclosed. Area subject to regular inspection and management, source not considered to contribute to off-site odour nuisance potential. No sensitive receptors in close proximity. Adequate measures considered to be in operation.	None
Centrate pumping station	20	Sump is not covered	None – see Table 15 Odour Improvement Plan	None
Degassing tanks	22	Tank is covered, extracted and dispersed – see below for comments in relation to the dispersal stack.	N/A	N/A
Dispersion stack for degassing tanks	23	No OCU or other air treatment / abatement in place.	None – see Table 15 Odour Improvement Plan	None
Dewatering Feed Tanks	24	Tank open to atmosphere with no containment or treatment of emissions.	Tank contains digested sludge only which is inherently less odorous. No sensitive receptors in close proximity. See Table 15 Odour Improvement Plan	None

Source	Source ID	BAT Compliance Review	Alternative Techniques	Compliance Restrictions
Dewatering Centrifuges (digested sludge)	25	Centrifuges, although of a proprietary enclosed design, do not facilitate creating a negative pressure environment.	Source is enclosed. Area subject to regular inspection and management, source not considered to contribute to off-site odour nuisance potential. No sensitive receptors in close proximity. Adequate measures considered to be in operation.	None
Export Centrate sump	26	Chamber open to atmosphere with no containment or treatment of emissions.	Liquors arise from digested sludge only which is inherently less odorous. No sensitive receptors in close proximity. See Table 15 Odour Improvement Plan	None
Sludge Cake Export Barn	27	Cake Pad located within an export barn without extraction or treatment of emissions.	Odour management techniques in use rather than specific BAT containment measures. Digested sludge only, which is inherently less odorous, during normal operating conditions. Adequate measures considered to be in operation, as supported by odour measurements and impact assessment.	N/A
Leachate Pumping Station	28	Chamber open to atmosphere with no containment or treatment of emissions.	Liquors arise from digested sludge only which is inherently less odorous. No sensitive receptors in close proximity. See Table 15 Odour Improvement Plan	N/A
Liquor Balancing Tank	29	Tank open to atmosphere with no containment or treatment of emissions.	Liquors arise from digested sludge only which is inherently less odorous. No sensitive receptors in close proximity. See Table 15 Odour Improvement Plan	N/A
Conditioning Cake Pad	30	Cake Pad open to atmosphere with no containment or treatment of emissions.	Odour management techniques in use rather than specific BAT containment measures. Digested sludge only, which is inherently less odorous, during normal operating conditions. Adequate measures considered to be in operation, as supported by odour measurements and impact assessment.	The use of enclosed equipment or buildings is constrained by the volume of cake stored.

4.6 Odour Improvement Plan

The identified odour improvements for the site are detailed in Table 14.

Table 15 Esholt STF Odour Improvement Plan

Action No.	Source	Asset ID	Improvement Plan	Timescale
1	Uncovered tank (undigested primary and imported sludge): Consol tank 5	5	Install fixed cover and extract and treat in new OCU	Dec 2024
2	Uncontained odour sources (undigested sludge sources): thickener liquor sump, centrate pumping station	12, 20	Install fixed covers and extract and treat in existing OCU	Dec 2024
3	Uncovered tanks (low emission sources): SAS storage tanks, SAS transfer tanks, dewatering feed tanks, liquor balancing tanks	8, 11, 24, 29	Install floating ball covers	Dec 2024
4	Uncovered sumps (low emission sources): export centrate sump, leachate pumping station	26, 28	Install fixed covers	Dec 2024
5	Odour dispersion stacks 1, 2 and 3	2, 7, 16	Refurbish and reinstate OCUs	Dec 2024
6	Covered but untreated odour source: sludge cake reception vessels	13	Extract and treat in existing OCU	Dec 2024
7	Degassing tank ventilation stack	22, 23	Existing tank air extraction to be routed to biogas system	Dec 2024

5 Monitoring and Control of Odours

All monitoring should clearly relate to the assessment of odour control and complete records must be kept in an auditable format. The only way to determine whether the processes on site are under control, and to keep them under control, is to do appropriate monitoring.

As far as possible, Esholt STF is operated to minimise odour generation and release. As long as the treatment process satisfies the normal design criteria, odour should be minimal. To minimise odour nuisance, it is important to ensure that Esholt STF is operating at its optimum. Covers and hatches should always be replaced to maintain the integrity of enclosures provided to collect odorous air.

5.1 Sniff Testing

Sniff testing is recognised by Yorkshire Water as a useful technique to build up a picture of the impact the odour has on the surrounding environment over time. Sniff testing shall be used to support profiling site odour impact, investigate odour complaints and to introduce temporary odour mitigation measures.

Sniff testing shall be undertaken on site on a weekly basis by site operational staff. It is accepted that operational staff may not be ideal for sniff testing of site odours as they have adapted to odours from the site. However, this will provide a baseline for routine observations. The weekly operator sniff tests shall assess the site boundary and focus on the detection of any odours that could potentially be leaving site.

Monthly sniff tests shall be carried out by non-site-based staff (Technically Competent Manager) who are not adapted to site odours. The monthly sniff test shall be carried out at additional test locations local to source to profile the location of any fugitive emission sources.

In the event of increased odour complaints being received (and being potentially attributed to the STF operations), site operators shall undertake a sniff test including off-site sniff testing local to the complaint location(s). In the occurrence of a significant odour event or repeated complaints, a third-party shall be engaged for an additional odour investigation including on and off-site sniff testing.

A third-party odour sniff test is scheduled to be undertaken twice a year for comparison with Yorkshire Water (operator and monthly tester) observations. The third-party sniff test shall include both on and off-site locations based on surrounding sensitive receptors and complaint locations. The off-site locations shall be reviewed prior to any third-party testing to ensure any recent changes to sensitive receptors are considered.

The location of weekly and monthly on-site sniff testing locations has been included in Figures 10 and 11, respectively.

Figure 10 Esholt STF Weekly On-Site Sniff Testing Locations

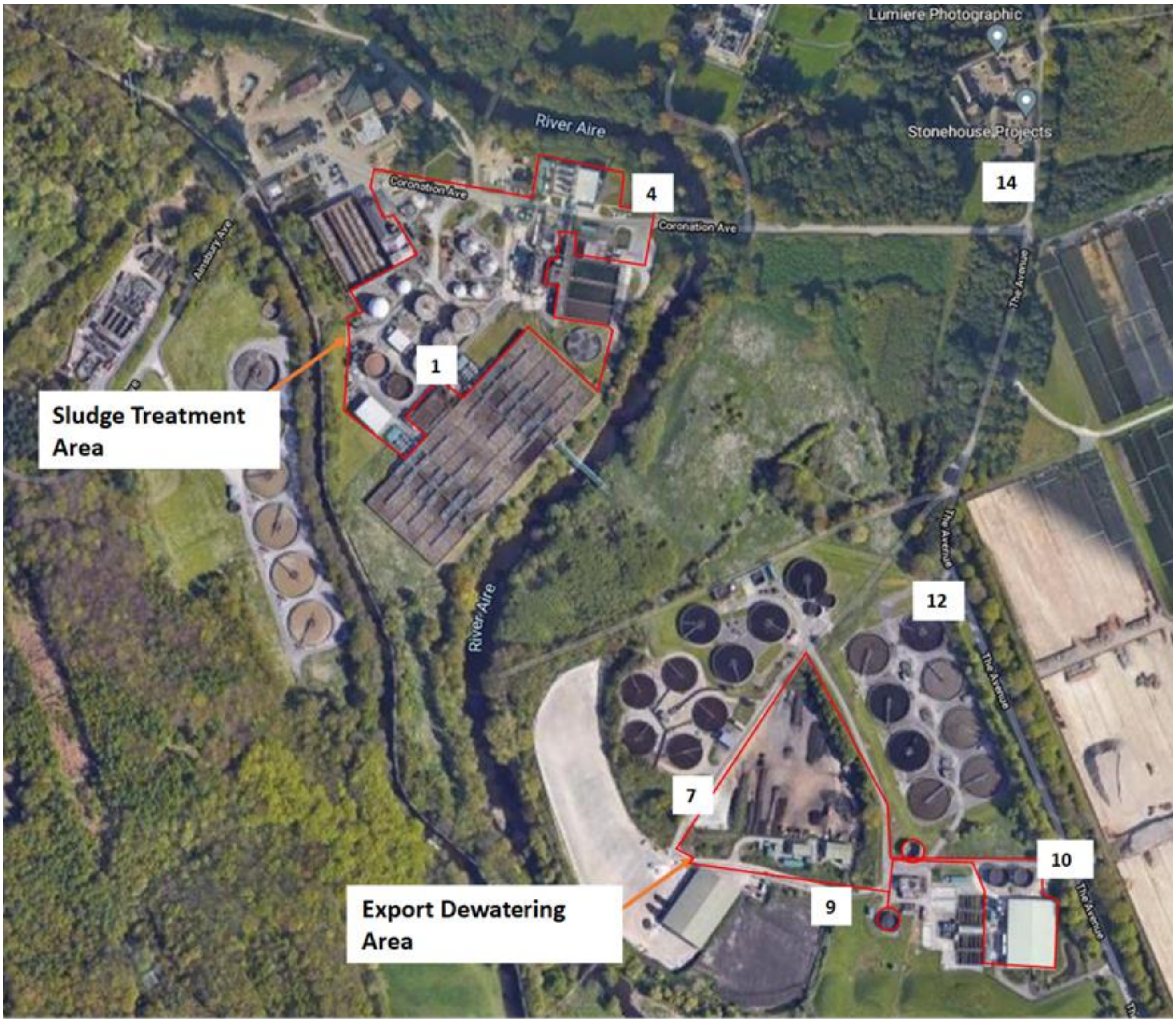
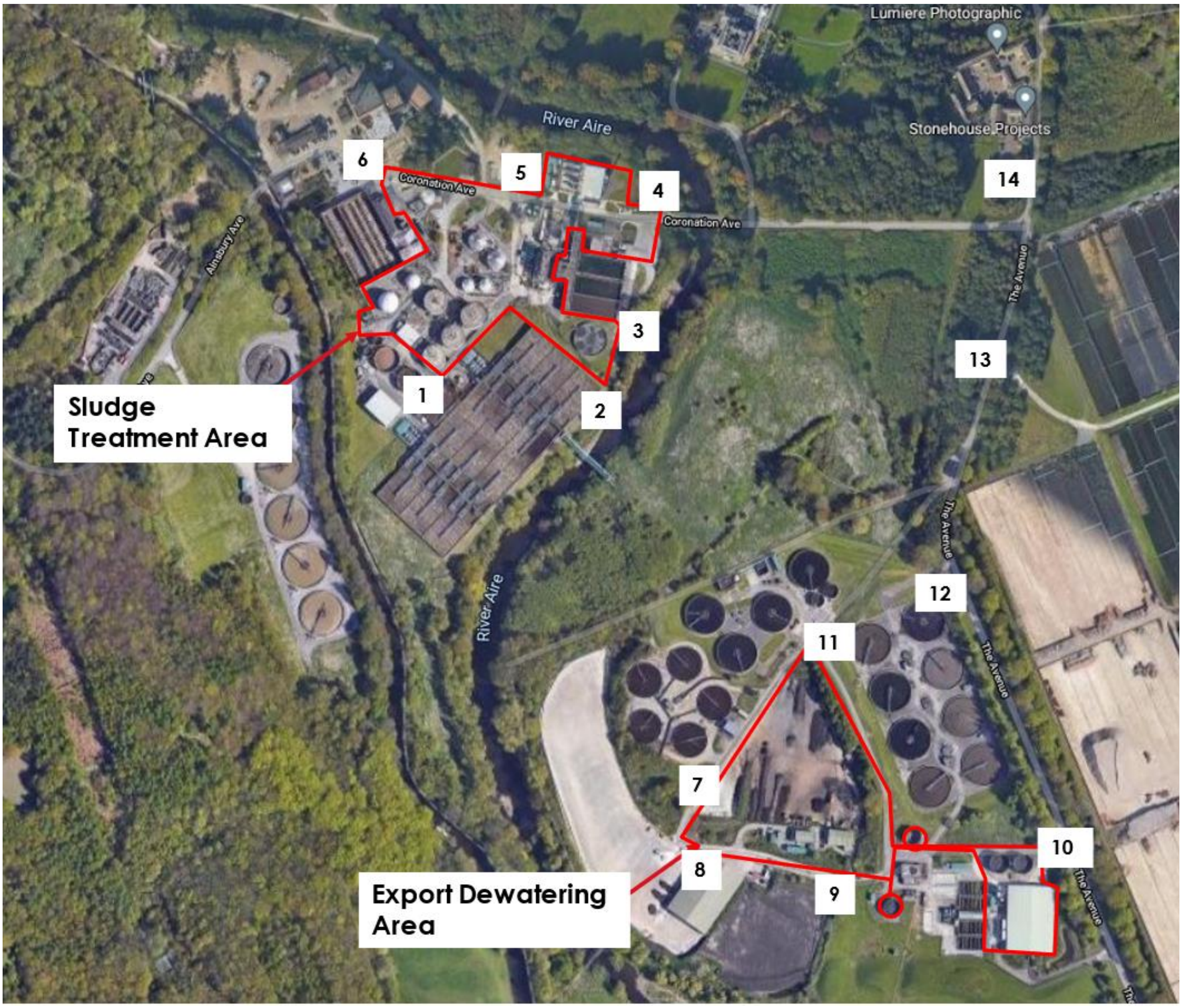


Figure 11 Esholt STF Monthly On-Site Sniff Testing Locations



5.2 Channelled Emissions

Ammonia is not anticipated to be present in the OCU inlet and therefore, no continuous monitoring is proposed.

The OCU stack outlet shall be subject to third party sampling every 6 months to sample for odour, hydrogen sulphide and ammonia.

The full monitoring and sampling for the OCU is included in Appendix 3.

Third party specialist support shall be sought if operations cannot determine the root cause of OCU failure.

5.3 Imports/Exports

The Site Operating Procedures include instructions on how sludge must be imported. The YW Safe Loading & Discharging of Sludge Road Tankers is available in Appendix 6. Tankers shall be filled and emptied in a way that minimises odour discharge.

5.4 Sludge Treatment and Disposal

Raw or co-settled sludges always smell objectionable, but the odour becomes stronger during storage, as anaerobic decomposition occurs, leading to high concentrations of malodorous compounds in sludges and sludge liquors. Digested sludges are less odorous, particularly after they have cooled. To minimise the generation of odours, where possible, fresh sludge shall be processed and sent to digestion as quickly as possible before further treatment and removal from site. Raw sludges stored upstream of digestion would never be stored for more than 2 days in normal plant operation.

5.5 Sludge Thickening and Storage

Accumulation of sludge in the system can cause increased odour release in storage tanks, as well as from sludges and liquors when thickening takes place. To minimise odours from the Esholt STF, the works should be operated as follows:

- Minimise retention prior to thickening, dewatering or digestion;
- Prevention of sludge accumulation in off-line tanks; and
- Proactive identification of potential problems and tankering of sludges to other sites with odour abatement.

5.6 Anaerobic Digestion

The digestion process breaks down a wide range of odorous compounds, which may be released if care is not taken to avoid turbulence of the sludge after digestion. Odour problems may be caused by:

- Saline intrusion (or industrial wastes) leading to elevated sulphate concentrations of raw sludge, giving a greater sulphide potential;
- Emissions of biogas resulting in significant odour problems; and
- Incomplete digestion leading to odour release from secondary digestion tanks.

Suggested remedial measures include:

- Check seals and valves to prevent the release of biogas;
- Ensure gas handling system is balanced and that pressure relief valves do not operate prematurely;
- Ensure all excess gas is flared and that flare stack ignition is immediate and reliable;
- Addition of iron salts or other chemicals to precipitate or inhibit the formation of sulphide.

There are odour checklists for both YW Operators and Team Leaders in Appendix 2.

5.7 Site Operation and Management Procedures

- All operating practices should be compliant with the site O&M manuals. The Integrated Management System (IMS) developed by YW to cover Environmental, Health & Safety and Quality elements of all aspects of YW activities will also apply.
- The IMS identifies the environmental aspects and impacts of all YW plants, including the facility at Esholt. The facility will operate under the IMS which shall include:
  - Quality management procedures for operational aspects, for example: preventative electrical and mechanical maintenance, safe working procedures, accident / incident response and emergencies;
  - Specialist contractors shall be employed by YW to undertake any non-routine or specialised maintenance tasks;
  - Use of only YW approved contractors. YW maintain an approved contractors list which is used for appointment of all YW contractors. This requires contractors to achieve a high level of environmental competence / performance. YWS Framework Contractors are required to operate an EMS in accordance with ISO 14001;
  - Preparation/issue of risk assessments and method statements by all contractors before starting work. These risk assessments and method statements will include consideration of odour and measures in place to control odour releases. These are prepared as part of the 'hand - over' and 'hand – back' certificate or 'permit to work'; and
  - Regular environmental and quality audits to be carried out. These shall include a review of potential odour and identify any additional control measures which may be required.

5.7.1 Procedures for Operation Plant

All operating practices should be compliant with the site O&M manuals, YW company practice and the OMP.

5.7.2 Routine Inspection and Recording

Visual inspection of facility processes will be carried out on regular basis as part of staff duties. In addition, regular checks of the OCU performance as described in Appendix 3 shall be carried out. If abnormal odour is witnessed, YW staff shall record details in the Odour Log Spreadsheet of the observation and immediately investigate. During any such recording carried out as part of this OMP, it is important to document any potential contribution from other off-site sources of potential odour nuisance located outside of the facility boundary. An odour monitoring record sheet to be used in the event of site odours is included in Appendix 4.

5.7.3 Maintenance by Engineering Reliability Staff

Engineering Reliability staff (Mechanical Fitters, Electricians and ICA Technicians) carry out routine maintenance of plant and equipment. There is also proactive maintenance of the OCU. This includes odour abatement equipment.

Routine maintenance requirements are included within YW's Work Management System (WMS) task lists for the site and are forwarded to members of this team via their Toughbook. Feedback on planned maintenance carried out is recorded in WMS by the Engineering Reliability staff member via their Toughbook and transferred to SAP for storage.

5.7.4 Reporting Faults and Identifying Maintenance Needs

For faults requiring immediate attention, the Product and Process Engineer raises a SAP notification and calls it through to the Scheduling & Planning Team. If it meets a high priority according to the Risk Assessment Matrix (RAM), it will be attended as a scheduling buster for the relevant YW Engineer to attend site.

For less urgent faults the Product and Process Engineer raises a SAP notification. It will be converted into a SAP job and picked up by the Scheduling & Planning Team and progressed accordingly. If at any time the situation changes, and the job becomes more urgent, the Product and Process Engineer (PPE) would re-prioritise the SAP job in line with the RAM and call through to the Scheduling & Planning Team.

Routine maintenance requirements are fed to YW's maintenance team via SAP.

5.7.5 Replenishing Chemicals / Consumables

The OCU performs an important function for the overall control of odour across the site. When consumables in the OCU need to be replenished they are ordered via YW's ordering system. An order is set up for each chemical and stocks are replenished via a one-off Order. Delivery notes must be kept in a folder on site.

5.7.6 Initiating OCU Media Replacement

Before 12 months of operation carbon samples from the OCUs are manually taken on a given schedule in the Operator's task list and sent for laboratory analysis to determine the lifespan of the media. Once at around 70% spent an order is raised for replacement of the media.

5.8 Changing Dispersion Conditions

Site activities that could lead to increased site emissions will be avoided when there are poor dispersion conditions or during sensitive periods (hot days, when people are more around). If not possible to be avoided, additional monitoring in the form of sniff testing and monitoring of site performance shall be undertaken. In the event that site activities are resulting in increased off-site odours or customer complaints, the activity shall be rescheduled / undertaken during low-risk times / weather conditions.

Table 16 Esholt STF Changing Dispersion Risk

Asset	Changing Dispersion Condition	Mitigation Trigger	Mitigation Action	Time scale	Responsible Person
Screening skip	Hot Days, School Holidays (summer)	Temperature - >26°C and significant odour complaints	Increase frequency of skip export from site	Forecast in advance – 5-day weather forecast	Product and Process Engineer
Sludge cake import	Hot Days, School Holidays (summer)	Temperature - >26°C and significant odour complaints	Cake import facility in operation between 8am to 6pm	Forecast in advance – 5-day weather forecast	Product and Process Engineer
Sludge cake export	Hot Days, School Holidays (summer)	Temperature - >26°C and significant odour complaints	Cake export between 8am to 6pm only	Forecast in advance – 5-day weather forecast	Product and Process Engineer

6 Emergency and Incident Response

This section addresses the issue of appropriate response to odour incidents caused by process failure or equipment breakdown. These emergency procedures include the:

- Foreseeable situation that may compromise the ability to prevent and minimise odorous releases from the process;
- Actions to be taken to minimise the impact; and
- Person responsible for initiating the action.

Where abnormally high odour levels are observed – indicating odour pollution a PPE will be required to take appropriate contingency measures. These measures should include:

- Investigating the odour incident and its cause(s);
- Bringing the process back under control; and
- Minimising exposure or annoyance effects.

Table 16 below summarises incident / emergency control measures in place. The YW odour emergency contact details for Esholt STF are available in Appendix 1.

Table 17 Esholt STF Incident/Emergency Control Measures

Failure/Abnormal Situation	Potential Odour Source	Potential Impact	Mitigation Measures	Actions to be Taken	Timescale for Rectification	Responsible Person
Failure of the odour control unit	Untreated air	High – OCUs provide treatment for odorous air from the Permitted site. Failure of OCU would result in release of abnormal operational fugitive odours direct to atmosphere	Routine maintenance. Regular monitoring of equipment performance. Duty standby functionality. Standby capacity in the media beds.	For plant failure - investigate and repair.	Site operator to investigate on same working day. Support from OCU supplier to be arranged for next availability	Site Operator
Liquid sludge import spillage	Liquid sludge	Medium – low volume spillage likely to go directly to drain which returns to the WwTW for treatment.	Pipework and tanks undergo regular inspections. Planned maintenance on equipment	Stop source of spill and immediately wash down area.	Immediate	Tanker Driver
				Arrange repair.	Job to be raised and promoted on same working day or next	Site Operator
				Record spillage and actions taken in site diary.	Same day as incident	Site Operator
Sludge cake spillage	Sludge Cake	Medium to High depending on volume of spill	Regular inspection and planned maintenance	Stop source of spill and immediately wash down area.	Immediate	Tanker Driver
				Arrange repair.	Job to be raised and promoted on same working day or next	Site Operator
				Record spillage and actions taken in site diary.	Same day as incident	Site Operator
				If there is likely to be any offsite impact inform manager and technically competent manager immediately.	Same day as incident	Site Operator
Contingency storage of	Raw/Indigenous sludge cake	High	Regular inspection and planned maintenance	Arrange repair	Job to be raised and promoted on same	Site Operator

Failure/Abnormal Situation	Potential Odour Source	Potential Impact	Mitigation Measures	Actions to be Taken	Timescale for Rectification	Responsible Person
raw/indigenous sludge on cake pad					working day or next. Work to be prioritised. Raw sludge cake to be processed through the digester as priority.	
High pressure conditions in digesters	Release from Pressure Relief Valve	Medium - Biogas would be vented at high pressure to aid dispersion	Gas pressure is regulated and monitored	Diversion of biogas to Waste Gas Burner	Immediate	Site Operator
				Investigate likely sources of high pressure in the digester and resolve (e.g. blocked outlet)	Immediate	Site Operator
Loss of Biogas containment	Leaks from gas holder membrane	Medium	Double gas holder membrane system with gas pressure between the membranes regulated and monitored. Methane detectors operated with alarms to alert operators of any leakage between membranes.	Diversion of biogas to CHP plant or Waste Gas Burner. Inspection maintenance and repairs of gas holder as appropriate	Immediate	Site Operator
				Record details and Actions taken in site diary	Immediate	Site Operator
Staff unavailability	Risk of increase to site odours due to limited operational resources	Low	Staff replacement	Operator replacement from another site Remote monitoring from Control Room / off-site / another site	Same day / For next working day	Product and Process Engineer / Site Manager
Asset Fire	Risk of increase to site odours due to limited	Medium	Regular inspection and planned maintenance	Remote monitoring from Control Room / off-site / another site	Immediate	Product and Process Engineer

Failure/Abnormal Situation	Potential Odour Source	Potential Impact	Mitigation Measures	Actions to be Taken	Timescale for Rectification	Responsible Person
	access and inability to operate assets					
Very high rainfall	Flooding	Low	Increased monitoring of media and sludge storage	Check the performance of the Odour Control Unit when water levels drop and replace media as required (if media has been flooded it may need replacing)	Site operator to investigate on same working day. Support from OCU supplier to be arranged for next availability	Product and Process Engineer

7 Inspection/Monitoring/Maintenance Schedules and Records

7.1 Inspection/Monitoring/Maintenance Schedules for Odour Abatement Equipment

A list of routine monitoring and maintenance tasks for the odour control units is included in Appendix 2. Reference should also be made to the OCU O&M manuals as applicable.

Proactive maintenance tasks are included within SAP task lists for each site and are forwarded to the PPE via their Toughbook for completion.

Monitoring results from the inlet and outlet of the odour control units will be recorded as appropriate. Refer to Appendix 3 monitoring schedule.

Feedback on maintenance of odour abatement equipment and pipework is recorded in SAP by the PPE via their Toughbook. YW maintenance staff also provide feedback on work carried out by them.

A review of the OCU plant effectiveness, including measurement of inlet and outlet process and emissions parameters. Any improvements required will be identified and timescales for implementation proposed. This odour management plan will be updated with details of this planned improvement work.

7.2 Key Process Monitoring

Records of site deliveries for the odour control system are stored on site.

The site is operated under a full PLC SCADA control with data logging and interrogation of key parameters to maintain safe, efficient, and low emissions operation. Table 13 includes the key process monitoring provisions for processes associated with emissions to air.

Table 18 Key Process Monitoring Provisions

Emission point / description	Parameter	Monitoring approach	Monitoring frequency
Sludge intake	Intake volume	SCADA	Continuous during unloading operations
	% dry solids	SCADA	Continuous during unloading operations
CHP (A1, A3, A5, A6)	Operating hours	SCADA	Continuous data logging
	Electricity generated	SCADA	Continuous data logging
	Load required / actual (%)	SCADA	Continuous data logging
	Biogas flow / pressure to CHP	SCADA	Continuous data logging
	Heat circuit temperatures (deg. C)	SCADA	Continuous data logging
Boilers (A2, A4)	Load required / actual (%)	SCADA	Continuous data logging
	Biogas / natural gas flow / pressure to boiler	SCADA	Continuous data logging
	Heat circuit temperatures (deg. C)	SCADA	Continuous data logging
	Heat circuit flow	SCADA	Continuous data logging
Flare compound (A7)	Biogas to flare (m^3)	SCADA	Continuous data logging
	Run hours	SCADA	Continuous data logging
Dispersion stacks (A10, A11, A12, A14)	Operational status	SCADA	Indication

Emission point / description	Parameter	Monitoring approach	Monitoring frequency
OCU 4 (A13)	Operational status	SCADA	Indication
Biogas storage (A8, A9)	Gas level (%)	SCADA	Continuous data logging
	Gas pressure (mb)	SCADA	Continuous data logging
	Methane %	SCADA	Continuous data logging
THP	Temperature (deg. C)	SCADA	Continuous data logging
	Pressure	SCADA	Continuous data logging
Digesters	Volume	SCADA	Continuous data logging
	Volatile Fatty Acids (VFAs)	Manual	Periodic
	Alkalinity	Manual	Periodic
	Process temperature	SCADA	Continuous data logging
	% solids (intake)	SCADA	Continuous data logging
	Retention (hours)	SCADA	Continuous data logging
	Temperature	SCADA	Continuous data logging
	H_2S (ppm)	SCADA	Continuous data logging
Centrifuges	Dry solids (%)	SCADA	Continuous data logging
	Flow	SCADA	Continuous data logging

8 Customer Communications

8.1 External Complaints

External odour complaints are received by Loop, which is the external company YW uses for all customer contacts. The call handler will work with the caller to understand the source of the issue. They will explore where the caller experienced the odour, whether it is a repeat or a singular issue, when and where it's most noticeable, what site the odour may be coming from, a description of the smell and if it's the first time it's been noticed. Loop record all complaints on the ICE system and contact the appropriate site owner, via the YW Control Room, to manage the complaint. The complaint will be passed to the Site Manager within 30 minutes or next working day if out of hours. The issue will be dealt with as a matter of priority. ICE is a computer program used to record and manage customer contact. The complainant may or may not request feedback of the cause and resolution of the issue. The odour contact form is included in Appendix 8.

When a complaint has been received, Site will undertake an investigation using the Site Checklist and record details of the investigation in the Odour Investigation Form (Appendix 9).

Odour complaints will be investigated at this site on the same working day (where practicable) and ideally within 2 working days of being aware of the issue. The investigation must not be carried out any later than 5 working days after being aware of the issue.

The Technical Optimiser should then put a note in the site diary and odour diary to record the complaint and inform the TCM and Site Manager of their findings.

Any actions will be resolved as a matter of priority. If immediate resolution of the odour issue can't be carried out, and where reasonably practicable, mitigation measures will be undertaken. Actions will be recorded on the investigation form. Feedback of the issue and the actions undertaken will be sent to the Customer Case Manager to communicate to the Complainant (if requested).

In the event of multiple complaints, and / or the potential for multiple complaints to occur, the Duty Manager will be informed and an incident response will be instigated.

8.2 Internal Complaints

If the PPE or any YW staff identify an abnormal odour release, the PPE will undertake an investigation using the Operator Site Checklist and complete any actions the investigation suggests. The PPE should then put a note in the site diary and the odour site dairy and inform the Technical Optimiser and Site Manager of their findings.

The odour complaint process is included in Appendix 7.

8.3 Community Engagement

Customers are at the heart of what we do at Yorkshire Water. In the event of an odour issue affecting multiple customers within the community, Yorkshire Water's communication team will decide the level of response that is required. This could include, but not be restricted to, stakeholder liaison (communication through local councillors, MPs and affected businesses), local media liaison and/or community meetings to discuss the issues and actions that will be undertaken to rectify the issue. Customer engagement events would be held if the odour severity dictated this level of response. Customers may be encouraged to keep an odour diary to record when odour is perceived to be a greater issue.

9 Training

9.1 Training Requirement

9.1.1 Sludge Treatment Facility

All staff receive training to cover operation of the site, assessment of odour and monitoring and maintenance of the OCU on the site. The training requirements for key staff at Esholt STF are displayed in Table 18 below.

Table 19 Esholt STF Training Requirements

Post	Training Requirement
Product and Process Site Manager	• Awareness of the responsibilities for avoiding odour nuisance. • Monitoring / maintenance of odour abatement equipment. • Odour control procedures during start-up / shut down. • Procedures for abnormal conditions. • Requirements of the OMP and Environmental Permit.
Product and Process Engineer	• Awareness of the responsibilities for avoiding odour nuisance. • Monitoring / maintenance of odour abatement equipment. • Odour control procedures during start-up / shut down. • Procedures for abnormal conditions. • Requirements of the OMP and Environmental Permit.

9.2 Training Received

Records for training received by all employees are held electronically.

Records of environmental training are kept with YW's company IMS.

Appendix 1 Emergency Contacts

Table 20 Esholt STF Contacts

Area	Contact
Bradford Council Environmental Health	01274 432111
Environment Agency	03708 506 506
Odour Abatement Systems Suppliers	Greenacre Environmental Services Ltd
OCU Maintenance Provider	Greenacre Environmental Services Ltd
Esholt STF Odour related Yorkshire Water Contacts	Site Manager: Gavin Stowell Site Optimiser: Scott Jones

Appendix 2 Odour Checklist

CHECKLIST FOR SITE ODOUR INVESTIGATION

AREA OF WORKS	POTENTIAL PROBLEM		FOLLOW UP ACTION REQUIRED
ODOUR MANAGEMENT PLAN (OMP)	Does the site have an OMP?	YES / NO	
	Is the site operated according to the OMP?	YES / NO	Inform Treatment Team Leader
SITE - GENERAL	Are all covers in place?	YES / NO	Replace covers and close hatches as required
	Are all access hatches closed?	YES / NO	
INLET WORKS	Is the crude sewage black and / or smelly?	YES / NO	Inform Treatment Team Leader
Screening	Are there any spilled screenings?	YES / NO	Clean up spills
	Are the compacted screenings clean?	YES / NO	Inform Treatment Team Leader if screenings are not clean
Grit Removal	Is there any spilled grit?	YES / NO	Clean up spills
	Is the grit clean?	YES / NO	Inform Treatment Team Leader if grit is not clean
Screening and Grit Skips	Do the screenings skips smell?	YES / NO	Inform Treatment Team Leader
	Do the grit skips smell?	YES / NO	Inform Treatment Team Leader
	Are the screenings skips too full?	YES / NO	Empty skips as needed
	Are the grit skips too full?	YES / NO	Empty skips as needed
Storm Tanks	Have the storm tanks been left full following a storm?	YES / NO	Empty and clean out tanks as needed
	Is there any sludge left in the bottom of the tanks?	YES / NO	
PRIMARY TANKS	Are the tanks black and / or smelly?	YES / NO	Inform Treatment Team Leader
	Are the tanks gassing?	YES / NO	
	Is there excess scum on the surface?	YES / NO	
BIOLOGICAL FILTRATION	Are the aeration vents blocked?	YES / NO	Inform Treatment Team Leader
	Is there any ponding?	YES / NO	
ACTIVATED SLUDGE	Do the dissolved oxygen levels in the aeration lanes match the setpoint(s)?	YES / NO	Adjust dissolved oxygen levels as required
	Do the MLSS fall within the tramlines for the site?	YES / NO	Increase / decrease RAS rate as needed
FINAL TANKS	Are the tanks black and / or smelly?	YES / NO	Inform Treatment Team Leader
	Are the tanks gassing?	YES / NO	
	Is there excess scum on the surface	YES / NO	
TERTIARY TREATMENT	Any there any site specific issues?	YES / NO	Inform Treatment Team Leader
SLUDGE TREATMENT	Are there any sludge spills?	YES / NO	Clean up spills
Imports and Exports	Does the tanker filling and emptying process cause significant release of odour?	YES / NO	Inform Treatment Team Leader
Sludge Thickening and Storage	Are all covers are in place?	YES / NO	Replace covers and close hatches as required
	Are all access hatches closed?	YES / NO	
	Are the doors to sludge treatment buildings / sludge cake stores kept closed?	YES / NO	Close doors as required
Anaerobic Digestion	Is all excess gas flared?	YES / NO	Inform Treatment Team Leader
	Is flare stack ignition immediate and reliable?	YES / NO	
	Are the whesso valves / PRVs operating prematurely?	YES / NO	
	Are the seals on the condensate traps intact?	YES / NO	
ODOUR ABATEMENT	Is there any detectable odour downwind of the stack?	YES / NO	Inform Treatment Team Leader
	Is the fan(s) working?	YES / NO	Arrange for fan to be repaired
GENERAL	Are there any outstanding actions from a previous investigation?	YES / NO	Complete actions

NAME: ____________________ DATE: ____________________

CHECKLIST FOR SITE ODOUR INVESTIGATION
PRODUCT + PROCESS OPTIMISER / TREATMENT TEAM LEADER

AREA OF WORKS	POTENTIAL PROBLEM		FOLLOW UP ACTION REQUIRED
ODOUR MANAGEMENT PLAN (OMP)	- Does the site have an OMP?	YES / NO	
	- If the site is not operated according to the OMP	YES / NO	Make changes to site operation to minimise odour production and release
SITE - GENERAL	- Are all covers in place? - Are all access hatches closed?	YES / NO YES / NO	Replace covers and close hatches as required
INLET WORKS	- If the crude sewage black and / or smelly	YES / NO	Check incoming sewage for septicity (in conjunction with Operations Support team) Contact Industrial Waste to check for potential septic discharges
Screening	- Are there any spilled screenings?	YES / NO	Clean up spills
	- If the compacted screenings are not clean	YES / NO	Optimise operation of screenings handling equipment
Grit Removal	- Is there any spilled grit?	YES / NO	Clean up spills
	- If the grit is not clean	YES / NO	Optimise operation of grit handling equipment
Screening and Grit Skips	- If the screenings skips smell	YES / NO	Check that screenings are clean and free from organic material; optimise screenings handling equipment if needed Empty skip(s)
	- If the grit skips smell	YES / NO	Check that grit is clean and free from organic material; optimise grit cleaning system if needed Empty skip(s)
	- Are the screenings skips too full? - Are the grit skips too full?	YES / NO YES / NO	Empty skips as needed Empty skips as needed
Storm Tanks	- Have the storm tanks been left full following a storm? - Is there any sludge left in the bottom of the tanks?	YES / NO YES / NO	Empty and clean out tanks as needed
PRIMARY TANKS	- If the tanks are black and / or smelly	YES / NO	Check inlet for septicity. Check levels of sludge in the tank and increase desludge rate if needed
	- OR If the tanks are gassing	YES / NO	
	- If there is excess scum on the surface	YES / NO	Remove excess scum
BIOLOGICAL FILTRATION	- If the aeration vents are blocked	YES / NO	Unblock aeration vents
	- If there is ponding	YES / NO	Consider increasing flushing rate and / or forking media
ACTIVATED SLUDGE	- Do the dissolved oxygen levels in the aeration lanes match the setpoint(s)?	YES / NO	Adjust dissolved oxygen levels as required
	- Do the MLSS fall within the tramlines for the site?	YES / NO	Increase / decrease RAS rate as needed
FINAL TANKS	- If the tanks are black and / or smelly	YES / NO	Check inlet of tanks for septicity. Check levels of sludge in the tank and increase desludge rate if needed
	- OR If the tanks are gassing	YES / NO	
	- If there is excess scum on the surface	YES / NO	Remove excess scum
TERTIARY TREATMENT	- If there are any site specific issues	YES / NO	Investigate and rectify
SLUDGE TREATMENT	- Are there any sludge spills?	YES / NO	Clean up spills
Imports and Exports	- If the tanker filing and emptying process causes significant release of odour	YES / NO	Investigate whether the process can be modified to reduce odour emissions Consider changing timing of tanker operations to reduce nuisance potential
Sludge Thickening and Storage	- Are all covers are in place? - Are all access hatches closed?	YES / NO YES / NO	Replace covers and close hatches as required
	- Are the doors to sludge treatment buildings / sludge cake stores kept closed?	YES / NO	Close doors as required
Anaerobic Digestion	- If all excess gas is not flared	YES / NO	Contact ER to investigate
	- If flare stack ignition is not immediate and reliable	YES / NO	Contact ER to investigate
	- If the whesso valves / PRVs operate prematurely	YES / NO	Contact ER to investigate
	- If the seals on the condensate traps leak or are damaged	YES / NO	Contact ER to investigate
ODOUR ABATEMENT	- If there is any detectable odour downwind of the stack	YES / NO	Check OCU using additional checklist
	- Is the fan(s) working?	YES / NO	Arrange for fan to be repaired
GENERAL	- If there are any outstanding actions from a previous investigation	YES / NO	Complete actions

NAME: ______________________________ DATE: ____________________

Appendix 3 OCU Performance Check List

Task	Frequency	Performance Indicators	Method	Actions to be Taken	Responsible Person
Odour Abatement Plant – Biofilter					
Gas flow rate	Continuous	+/- 15% design value (21,260 m^3/hr)	Gas flow meter / EN 16911-1 and MID for EN 16911-1	Odour abatement plant shall be regularly checked and maintained to ensure appropriate performance. Odour abatement plant shall be managed in accordance with manufacturer's guidance.	Operations
Temperature (inlet)	Daily	For information only	Temperature probe /Traceable to national standards		Operations
Thatching / compacting	Weekly	As per O&M	Back pressure		Operations
					Operations
pH (biofilter drainage effluent)	Continuous	pH 6 – 8	pH metre		Operations
Differential pressure	Continuous	+/- 15% design value (-224 Pa)	Recognised industry method		Operations
Check irrigation rates of biological OCU	As per O&M	As per O&M	Monitor flow on the unit.	Adjust wetting rate as required.	Operations
Check and clean the irrigation nozzles on the biological OCU	As per O&M	As per O&M	As per O&M	Clean as required	Operations
Efficiency assessment	Every 6 months	Hydrogen Sulphide – 98% removal rate Ammonia – 90% removal rate Mercaptans – 95% removal rate Dimethyl Sulphide – 20% removal rate VOCs – 50% removal rate	Media health, air-flow distribution and emission removal efficiency (BS EN 13725 for odour removal)	Third party survey to assess performance of the OCU including contaminant removal rates, media health, channelling of media.	3rd Party Specialist
Odour Abatement Plant – Carbon Filters					
Moisture / humidity	Daily	For information only	Moisture meter	Odour abatement plant shall be regularly checked and maintained to ensure appropriate performance. Odour abatement plant shall be managed in accordance with manufacturer's guidance.	Operations
Differential pressure	Continuous	+/- 15% design value (-1,278 Pa)	Recognised industry method		Operations
Efficiency assessment	Annual	99% removal of contaminants	Emission removal efficiency (BS EN 13725 for odour removal)		3rd Party Specialist

Task	Frequency	Performance Indicators	Method	Actions to be Taken	Responsible Person
Odour Abatement Plant – Outlet Stack					
Temperature	Continuous	For information only	Temperature probe /Traceable to national standards	N/A	Operations
Hydrogen sulphide	Every 6 months or as agreed in writing by the Environment Agency.	As per BAT 8 / BAT 34	CEN TS 13649 for sampling NIOSH 6013 for analysis	Investigate OCU performance. Arrange third party specialist support. Replace OCU media	3rd Party Specialist
Ammonia	Every 6 months or as agreed in writing by the Environment Agency.	As per BAT 8 / BAT 34 (0.3 – 20 mg/Nm^3)	EN ISO 21877	Investigate OCU performance. Arrange third party specialist support. Replace OCU media	3rd Party Specialist
Containment and Extraction System					
Extraction fan visual inspection	Monthly	No damage / leakage/ signs of corrosion	Visual inspection	If fans are damaged raise a job with ER	Operations
Extraction fan noise	Monthly	Increase noise or vibration from the fan motor	Listen	If fan is in fault or running noisy raise a job with ER	Operations
Check fan drive belt condition and tension	Annually	As per O&M	As per O&M	Check / Repair. Raise a job with ER	Operations
Check fan motors	Annually	As per O&M	As per O&M	Check / Repair. Raise a job with ER	Operations
Check physical integrity of ducting	Monthly	No signs of degradation or other damage and no holes	Visual Inspection	Raise a job with ER	Operations
Check duct supports	Monthly	No damage or corrosion	Visual Inspection	Raise a job with ER	Operations
Process covers visual inspection	Monthly	Good cover integrity. No damage / gaps allowing for fugitive emission leakage.	Visual inspection	If process covers are damaged raise a job with ER	Operations

Appendix 4 Odour Monitoring Record Sheet

Odour Monitoring Record Sheet

																	Sheet No:	
				METEROLOGICAL CONDITIONS							ODOUR[1]		SOURCE		SITE STATUS		CORRECTIVE ACTION	
Date	Location	Time	Staff Name	Weather Temp	General air quality	General air stability	Wind Strength	Wind Direction	Bar Pressure	cloud cover	Intensity 0-6	Offensiveness / Nature	Source within facility	External source	Facility Activities		Action required	Action implemented

[1] *Intensity: 0 No odour, 1 Very faint odour, 2 Faint odour, 3 Distinct odour, 4 Strong odour 5, Very strong odour, 6 Extremely strong odour

Appendix 5 Sniff Testing Record Sheet

Test by		Start Time	
Date		End Time	
Weather Condition		Temperature	
Wind Strength		Wind Direction	

Location No. / Name	Nearest Receptor Sensitivity	Intensity	What does it smell like?	Frequency of odour?	Is the source evident?	Other comments / observations
1. Dewatering Liquors Balance Tank	Low / Medium / High	0 No odour 1 Very faint 2 Faint odour 3 Distinct odour 4 Strong odour 5 Very strong odour 6 Extremely strong odour.		Constant / Intermittent	Yes / No Source area / name to be provide. Might be that maintenance work if occurring and you can detect increased odours due to that activity, or call smell cake import wagon etc	Are there odours detected from other sources? Farm / Landfill / other industry etc
2. Sludge Thickening Building						
3. Boiler House						
4. Flare Compound						

5. Cake Import Facility						
6. Screen Feed Tank						
7. Thickener Feed Tank						
8. Cake Pad North						
9. Cake Pad North-East						
10. Cake Pad South-East						
11. Digested Sludge Storage						
12. Final Settlement Tanks						
13. Primary Settlement Tanks						
14. Storm Tanks						

Appendix 6 Safe Loading and Discharge of Sludge Road Tankers

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Safe Loading & Discharging of Sludge Road Tankers

Occupational Health & Safety Management System

Safe Working Procedure SWP 007

Safe Loading & Discharging of Sludge Road Tankers

Document Control Ref:	SWP 007
Document Location:	OH&S Database / Safe Working Procedures
Document Custodian:	OH&S Department
Review Period:	5 Years

Revision History

Issue	Date	Reviewed By	Amendment Details
1	31/12/2013	D. Ross	New document
2	13/02/2015	D. Ross	Clauses 2.10, 2.21, 2.25, 3.3, 3.4, 3.5, 3.15
3	12/10/2016	S. Ross, C. Birkenshaw, M. Blanchard, J. Pell	Updated to reflect current practice
4	30/10/2018	J. Pell, M Blanchard	Updated gas monitor requirements & reviewed document

Doc. No. SWP 007 Page 1 of 7 Issue 4: 30/10/2018

Uncontrolled if Printed

Document Classification - Private

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The following notes are for your guidance. For further information, or if in doubt, contact your line manager / Safety Advisor who will give further help or advice.

Minimum Number of Persons Required:	**Major Hazards:**
1	• Hydrogen sulphide • Slips, trips and falls • Manual Handling • Stored energy • Pressure systems • Noise • Falls from height
Essential Safety Equipment Required: • Personal gas monitor • Safety footwear • Hand protection • Hi-Vis jacket/vest • Eye protection • Head protection (hard hat) • Hearing protection • First aid kit (Include. Eyewash) • Task lighting	
Training and/or Documentation required: • Please see Section 6 – Further Guidance.	

1. Introduction

1.1 Sludge tanker 'barrels' are classed as pressure vessels and are subject to annual examination by a competent person. Only fully trained YW personnel, or authorised persons who understand how all the controls pressure relief valves etc. function, may operate this equipment.

Note: Do not use pressure vessels that you are not familiar with or have not been trained on and seek advice and support.

1.2 Pressurised vessels are potentially hazardous under working conditions, and daily checks should be made of the satisfactory operation of safety critical devices such as the Pressure Relief Valve. Follow the detailed supplier's instructions regarding operator's daily checks.

1.3 Sewage and sewage sludge are substances that are potentially hazardous to health. Avoid skin contact, ingestion and inhalation of aerosols. Always wear your personal protective equipment and follow good hygiene practices.

1.4 Experience has shown that during the operation of a vacuum tanker, hydrogen sulphide can be vented from the tanker barrel. The use of suitable portable gas monitors is therefore a mandatory requirement at all times whilst on-site.

1.5 Avoid leaving pressure vessels containing sludge parked overnight. (Where this cannot be avoided ensure that the vessels are adequately vented by the means of leaving the vent valve open).

1.6 Follow designated traffic routes, one way systems etc. and comply with site speed restrictions.

Task

2. Loading the Tanker (Vacuum Transfer)

2.1 On arrival on site, check that your personal gas monitor is turned on – has been calibrated (in a clean air environment) - and is worn on your person at all times whilst on-site (near your breathing zone).

2.2 Complete a 360° check of the tanker/loading area. Consider the environment around you – hazard identification, wind direction, vehicle movements, people in close proximity to the vehicle e.g. operators/contractors etc. Ensure all inlet and outlet valves are closed and then open the vent breaker valve before removing the end-cap.

2.3 Where practicable attach sufficient 'vent bagging' to the compressor exhaust extension pipe to vent any hydrogen sulphide away from the work area to ensure a safe working area is provided. Also consider the positioning or repositioning of your vehicle to reduce the potential of H_2S in the working zone.

Note: Ensure that any gases being vented away from the tanker are not creating additional hazards to other people or processes and are not likely to enter a confined space.

2.4 If loading from a hose already connected to sludge holding tank, check hose for weight kick and gently lift (hose may possibly still have liquid left in it). Never assume any hose is sound - check for splits and excessive wear. Also check that couplings are in good condition and the correct sealing ring is in place before using the tanker hose. If the tanker hose is found to have faults, the tanker hose must never be used and be disposed of correctly.

2.5 Connect the hose between the tanker inlet valve and the loading point. Check that all connections are correctly fitted and all air taps are closed.

Note: The use of gloves in couplings is an unacceptable practice – do not use to create a seal in the bauer coupling.

2.6 Ensure that the changeover valves are in the vacuum/suck position.

2.7 Open the travel valve (if not automatic where fitted).

2.8 Once connections to vehicle and sludge tanks are made and vehicle power take off (PTO) is engaged if applicable, the driver should carefully monitor the loading operation. This may be achieved by standing in a safe location outside of the vehicle, observing the loading procedure.

Note: Keep clear of the exhaust area when loading and venting the barrel.

2.9 Yorkshire Water vehicles predominantly use a hydraulic pack. If using a donkey engine, do not engage the PTO as this will damage the hydraulic pack.

2.10 Start the vacuum pump and check that vacuum starts to develop.

2.11 Monitor the dial gauge to ensure the vacuum develops.

2.12 Open inlet valve on tanker.

2.13 If loading from sludge tank open outlet valve on loading point slowly.

2.14 Look and listen for air or product leaks.

2.15 On tankers fitted with sight glass, check isolation valves are open.

2.16 Feel the hose for sludge going through it and check the sight glass when loading for sludge rising in the barrel.

2.17 You may not always get a full load on the first attempt.

2.18 If this happens, vent the barrel and ensure the dump tank is empty and then re-start vacuum pump and check that vacuum starts to develop.

2.19 Monitor the dial gauge to ensure the vacuum develops.

2.20 When tanker is nearly full (sight glass and dial gauge) close the valve on sludge tank and then open the air release valve to enable the tanker hose to be emptied safely on completion of loading.
Note: Sight glasses should be clearly marked to the correct level for vehicle weight.

2.21 Close inlet valve on tanker.

2.22 Turn off vacuum pump and vent tank.

2.23 Disconnect tanker hose and put away in a safe place ensuring site is left in a clean and safe state.

2.24 Connect end cap and ensure relevant valves, such as vent valves, are closed before moving vehicle.

2.25 In addition to the vacuum loading of tankers, barrels may also be loaded by external pumping. Please refer to the pump loading safe working procedure.

2.26 Complete a 360° walk-around check of the vehicle, equipment and immediate work area.

Note: At sites where there are no fixed tanker points, sludge (or sewage), may have to be drawn directly from an asset which is not a sludge holding tank. Ensure that steps are taken to minimise risk by using the correct tools, considerations are made for working at height, avoid confined spaces and other hazards. If in any doubt about the safety of the operation, consult your line manager.

3 Discharging the Tanker (Pressure)

3.1 Yorkshire Water vehicles predominantly use a hydraulic pack. If using a donkey engine, do not engage the PTO as this will damage the hydraulic pack.

3.2 On arrival on site, check that your personal gas monitor is turned on – has been calibrated (in a clean air environment) - and is worn on your person at all times whilst on-site (near your breathing zone).

3.3 Complete a 360° check of the tanker/loading area. Consider the environment around you – hazard identification, wind direction, vehicle movements, people in close proximity to the vehicle e.g. operators/contractors etc. Ensure all inlet and outlet valves are closed and then open the vent breaker valve before removing the end-cap.

3.4 Open air tap on barrel before removing end cap.

3.5 If discharging from a tanker hose already connected to sludge holding tank, check hose for weight, kick and gently lift (it is possible that the hose may still have liquid left in it). Never assume any tanker hose is sound - check for splits and excessive wear. Also check that couplings are in good condition and the correct sealing ring is in place before using the hose.

3.6 Connect hose between the tanker outlet valve and the off-loading point. Check that all connections are correctly fitted and all air taps are closed.

Note 1: Ensure that tanker hoses are securely connected before operating the V5, rotork valves or manual valves at the off-loading point.

Note 2: The use of gloves in couplings is an unacceptable practice – do not use to create a seal in the bauer coupling.

3.7 Ensure that the discharge point rotork or manual operating valve is fully open before opening the tanker rear outlet valve.

3.8 Open the outlet valve on tanker.

3.9 Ensure that the changeover valves are in the pressure/blow position.

3.10 Open travel valve (if fitted and not automatic).

3.11 Start pump.

3.12 Monitor the Dial Gauge for pressure.

3.13 Feel the hose for sludge going through and where possible visually check the V5 machine or sight glass to make certain liquid is discharging (no blockages).

3.14 Where ever possible it's always better to turn the pump off before the last of the sludge is discharged as this helps to reduce odour, prevent the bagging from bouncing and H2S.

3.15 Be aware that when discharging under pressure the load can be "discharged" with significant force and sludge can spray over a wide area, especially in windy conditions.

3.16 If discharging to a level below the barrel outlet, the preferred method is by gravity as it is a safer but possibly slower operation. Ensure that you have left the pipe work clear of the product.

3.17 Close tanker outlet valve (and ensure any manual/rotork valves at the discharge point are left closed).

3.18 Turn off pump and vent tank in a suitable location to prevent H2S exposure to all parties.

3.19 Open air tap and release remaining air pressure within the tanker hose slowly.

3.20 Disconnect tanker hose and replace end cap.

3.21 Store the tanker hose in a safe place.

3.22 Clean out dump tank and clean up any spillages.

3.23 Ensure all valves are in the correct position. Connect end cap and ensure relevant valves, such as vent valves, are closed before moving vehicle.

3.24 Complete a 360° walk-around check of the vehicle, equipment and immediate work area.

4 Action in the Event of a Gas Monitor Alarm

4.1 The gas monitor is designed to alarm at any reading above 10 parts per million of hydrogen sulphide with a pre warning at 5ppm.

4.2 If an alarm is activated, the driver must immediately shut down the load/discharge operation and walk away from the vehicle. This will remove you from the immediate gas hazard as detected by the monitor.

4.4 Advise any person in the local area that there is hydrogen sulphide present and ask them to leave the area until you give the all clear.

4.5 Check your gas monitor – the reading will start to decrease as you move out of the gaseous atmosphere.

4.6 Periodically check the reading of the monitor, when the reading has dropped to a safe level and press the reset button on the monitor. Walk back towards the working area, checking gas levels.

4.7 If the alarm sounds again, repeat the above process.

4.8 Once the alarm indicates it is safe at the vehicle controls – re-start the load/unload process.

4.9 All gas monitor alarms over 10ppm must be reported as 'Near Misses'.

4.10 The alarm will indicate the presence of hydrogen sulphide and you must follow the SWP if the alarm sounds.

4.11 Multiple alarm activations may occur at a site during a load/unload. If this occurs for a prolonged period stop work at this site and seek immediate advice from your line manager.

4.12 Time Weighted Average alarm means that you should inform your line manager and stop working with sludge for the day when using a gas monitor.

5 Incident and Hazard Reporting

5.1 Report all Accidents to your line manager immediately and complete an accident report on Safeguard.

5.2 Report all Near Misses using the YW incident reporting system on Safeguard.

5.3 Report all Hazards using the YW Hazard Reporting System on Safeguard.

5.4 Report any vehicle defects promptly in accordance with the YW Fleet defect reporting procedures.

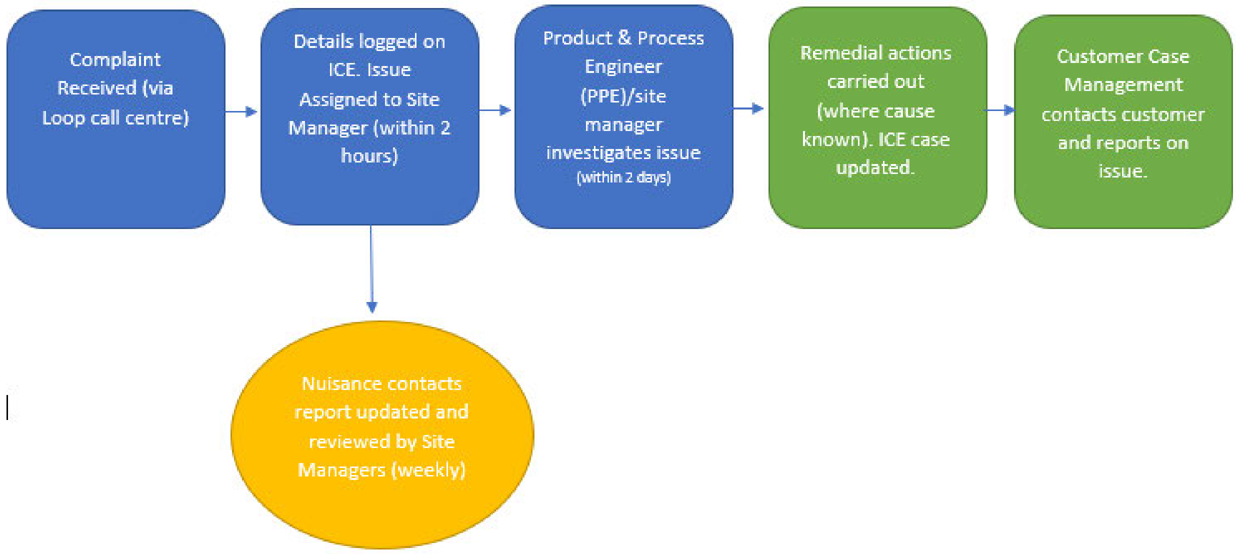
6 Further Guidance

Management Procedures / Safe Working Procedures / Technical Specifications (held on Safeguard) that are also relevant include:

- SWP 053 – Personal Safety & Security
- SWP 078 – Safe Use of Mobile Phones
- MP 05 – Lone Work
- MP 34 – Manual Handling

REMEMBER: IF IN DOUBT - ASK YOUR LINE MANAGER / SAFETY ADVISOR

Appendix 7 Odour Complaint Process



Appendix 8 STF Odour Complaint Form

Loop handle customer complaints being reported to Yorkshire Water. The call Handler will work with the complainant to try and locate the odour. Loop uses a software system called ICE to record the issue. If the issue is believed to be arising from a sewage works, the call handler will work through the following forms to pinpoint the issue.

Customer's details (name and address, if provided)	
When did the odour occur	
Time when the odour occurred	
Where was the location of the odour	
Is the odour happening now or was it in the past	
Does the customer know what is causing the smell	
What is a description of the odour (sewage / drains / eggy / sweet composting)	
Is this the first time the odour has been noticed	
Where is the odour at its worst (inside/outside house/boundary)	
Any other comment	

Appendix 9 Odour Investigation Form

The following investigation form will be used by Operational staff in the event of an odour complaint being received.

Date of odour complaint	
Time of odour (if known)	
Name of YW colleague investigating issue	
Postcode where the issue was identified (if known)	
Weather at the time of odour complaint (including temperature)	
Wind Direction (from onsite wind monitor) and strength (no wind, light, gusty, heavy)	
Description of smell from Complainant (if known)	
Is this linked with other complaints	
Do you know what asset is causing the issue	
Can the asset be identified through sniff testing (follow sniff testing monitoring programme in the odour management plan)	
Can the issue be resolved immediately	
If no, what actions are needed to resolve the issue	
If the issue is going to take >2 days to resolve, can the issue be mitigated to reduce the odour effect	
Does the odour management plan need updating to discuss the cause/action/mitigation	
Date when resolved	

Appendix 11 Secondary Containment Risk Assessment

Esholt Secondary Containment Assessment

January 2023

Sign-Off Sheet

Project details	
Project number	41527729 0301
Project name	Environmental permitting for IED sites
Date	January 2023
Client details	
Client name	Yorkshire Water Service Ltd
Client address	Western House Halifax Road Bradford West Yorkshire BD6 2SZ
Document details	
Document title	January 2023
Document version	V3
Report author	Kiran Parmar
Report reviewed by	
Report approved by	
Report by	Stantec <<Add address>>

Disclaimer

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Contents

List of Figures

List of Tables

1 Introduction

As part of the Industrial Emissions Directive (IED) permit application for Esholt Sludge Treatment Facility (STF), Yorkshire Water (YW) has undertaken an assessment of the significance and potential environmental risks associated with a loss of containment of process vessels. YW has also reviewed existing provisions and potential improvement options against Best Available Techniques (BAT) principles, in alignment with CIRIA 736[1].

Esholt STF falls under the IED as a Part A(1) installation by virtue of exceeding the 100t/d capacity limit for anaerobic digestion (AD). The permit will cover sludge import, sludge screening, sludge dewatering, the thermal hydrolysis plant (THP), sludge digestion, biogas processing and utilisation, liquor balancing, and cake management. This document focuses on the secondary containment aspects of the permit requirements, in particular the application of BAT, and should be viewed in parallel with the main permit application document, in particular Section II: Technical Description, Section III: Accident Risk Assessment and Section V: Site Condition Report.

1.1 Site details

Figure 1 shows an aerial view of Esholt STF. Esholt is a large STF and is situated to the northeast of Bradford, England. The site treats indigenous sludge from the co-located wastewater treatment works which serves a population equivalent of 427,210 from Bradford and surrounding Leeds area, it also receives imports of sludge from other YW sites. Figure 2 indicates the key activities at Esholt STF via a process flow diagram. The key activities are the sludge reception and screening, sludge dewatering plant, THP, anaerobic digestion, biogas handling and combustion, dewatering, and associated routes of gaseous, liquid, and solid materials and energy. These processes are further discussed in Section 3.2.1.

Figure 1. Esholt STF aerial view. Permit boundary in green. © Google, 2021

[1] CIRIA (2014) Containment systems for the prevention of pollution: Secondary, tertiary, and other measures for industrial and commercial premises (C736; 2014)

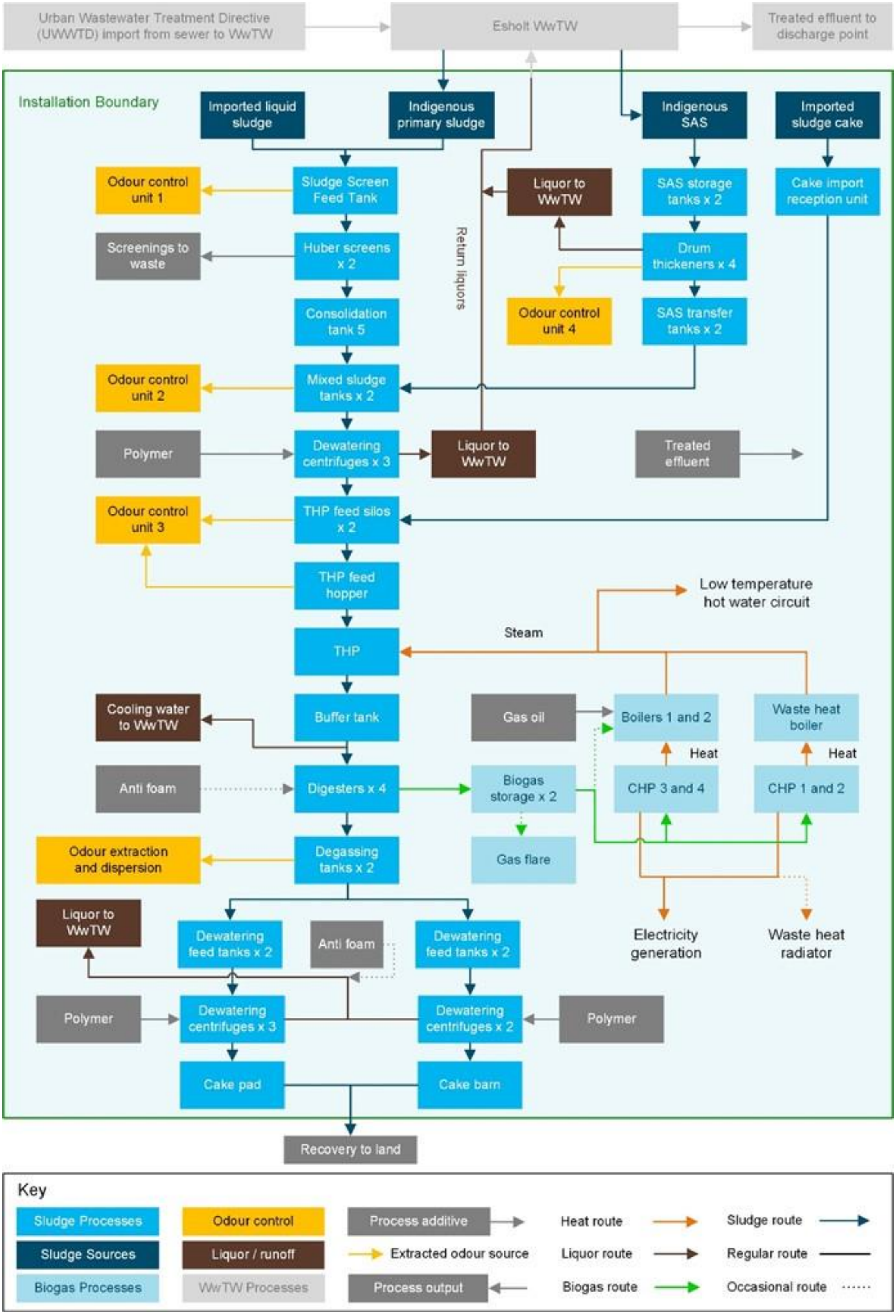

Figure 2. Process flow diagram Esholt STF.

1.2 Overview

YW commissioned Stantec to assess existing provisions and, where necessary, improvement options for secondary containment at the site. Stantec have provided risk-based supporting evidence to accompany the permit application, which demonstrates the most appropriate solution(s) for IED BAT compliance using CIRIA 736 standards. To fully understand the requirement for secondary containment and to provide environmental protection at Esholt, two different industry standard tools have been used, these are shown within the flow chart in Figure 3.

Firstly, the Anaerobic Digestion and Biogas Association (ADBA) secondary containment risk assessment tool has been applied to assets at Esholt. The ADBA assessment tool provides a methodology for determining the specific design of secondary containment systems at a site, based on an assessment of sources, pathways and receptors which are at highest risk, and the types of control options which would provide protection. However, as an existing installation in continuous operation, retrospectively applying a standard secondary containment bund to all sludge tanks and containers presents significant technical, operational, safety and logistical challenges. It is also noted that the location of Esholt STF within a wider wastewater treatment works (WwTW) presents opportunities in terms of utilising other existing YW assets as part of the pollution containment and prevention solution, and the ADBA tool does not have the flexibility to reflect this in the solutions it recommends.

Having regard to this limitation, a bespoke source, pathway, receptor approach has been developed by Stantec and applied to identify and risk assess bunding solutions favoured by the ADBA approach, as well as additional site-specific options for secondary containment.

Whilst these tools are discrete pieces of work, they come together to provide a detailed evidence base for intervention at Esholt.

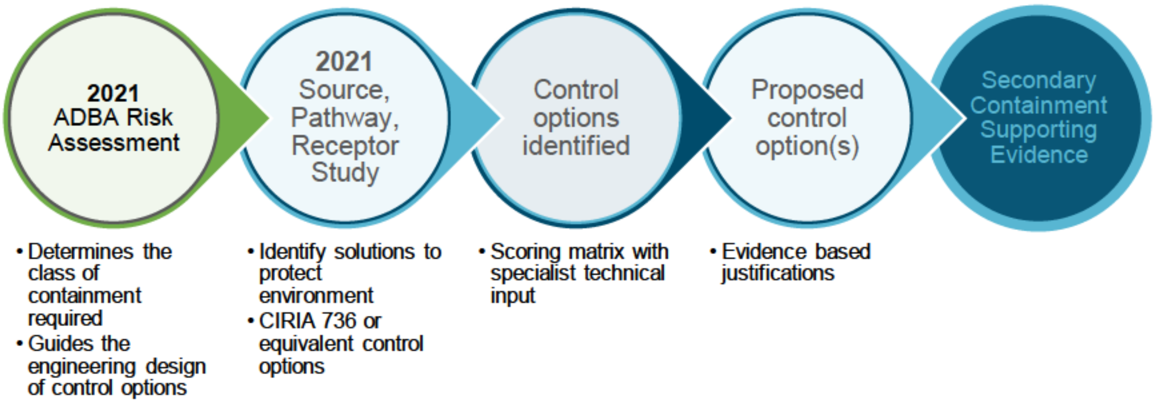

Figure 3. Flow chart showing the approach taken to provide secondary containment supporting evidence.

2 ADBA risk assessment tool findings

The ADBA Risk Assessment Tool is based on CIRIA 736 requirements for the prevention of pollution: including secondary and tertiary containment, and other measures for industrial and commercial premises. An assessment is presented in Appendix 1 and the findings are summarised in this chapter.

2.1 Class of required secondary containment for Esholt

To identify the class of containment deemed to provide sufficient environmental protection in the ADBA Risk Assessment, the tool uses a source, pathway, receptor model. This identifies hazards posed to the environment and assigns a class of containment based on the site hazard rating and likelihood of loss of primary containment. The approach is summarised in Figure 4 below.

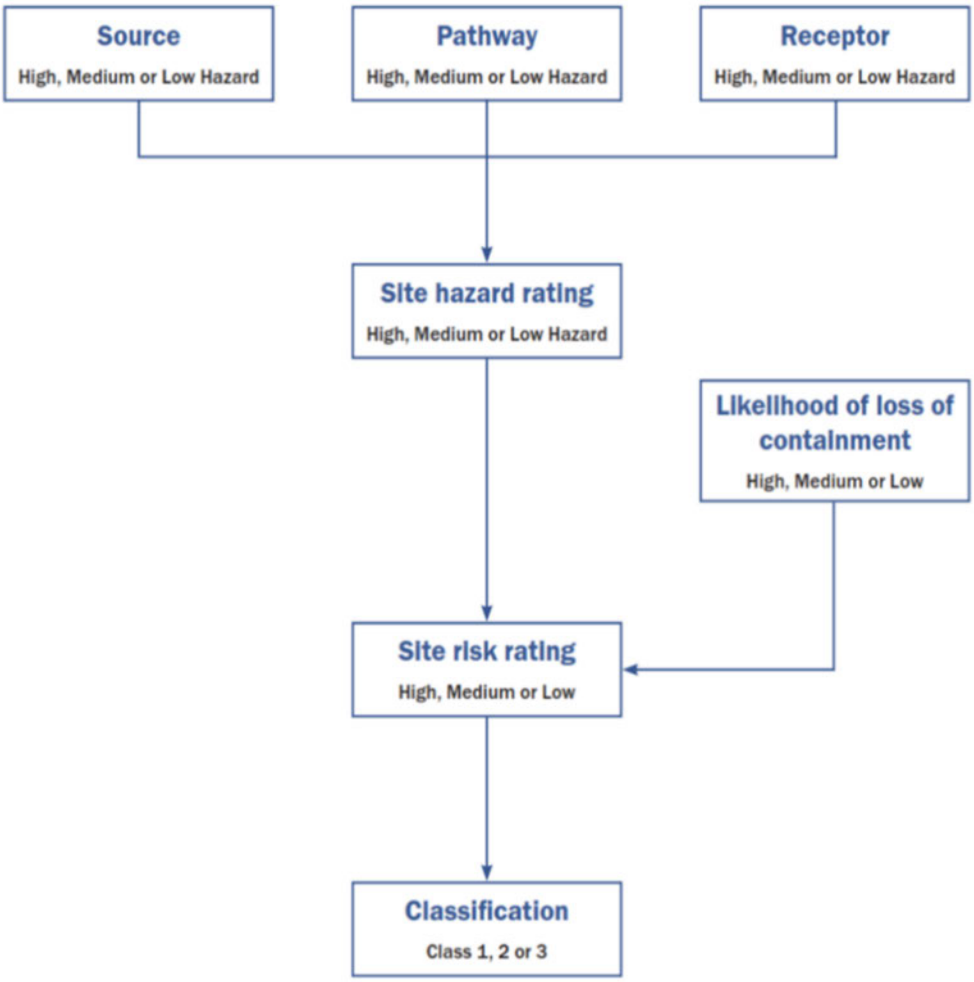

Figure 4. ADBA risk assessment classification flowchart.

The ADBA Risk Assessment Tool scored the source element as ‘High risk’, pathway elements as ‘High risk’ and the receptor element as ‘High risk’ at Esholt owing to the significant volumes of sewage sludge stored onsite and due to the surface runoff and site drainage pathways to the sensitive receptor, the River Aire. Leeds Liverpool canal is not considered as a high-risk receptor as although it is close to the STF, it is significantly uphill of all process tanks and will not be affected by potential sludge spills. In summary, this assessment approach indicates that Esholt STF has an overall site hazard rating of ‘High Risk’. The likelihood of failure was ‘Low Risk’ due to the type of infrastructure involved and the mitigations at the site e.g., regular tank inspections and level sensors.

According to Table 4 within the ADBA tool (box 2.2 CIRIA 736), reproduced in Figure 5 below, the combination of a high site hazard rating and a low likelihood rating, gives the overall site risk as medium. The indicated class of secondary containment for **Esholt STF was therefore deemed as being Class 2.**

Table 4: Overall site risk rating as defined by combining ratings of site hazard and probability of containment failure *(Box 2.2 CIRIA 736)*

Possible combination	Overall Risk Rating	Indicated class of secondary containment
HH, HM, OR MH	HIGH	Class 3
MM, HL, OR LH	MEDIUM	Class 2
LL, ML, OR LM	LOW	Class 1

Figure 5. ADBA classification matrix.

The ‘Esholt STF ADBA Secondary Containment Risk Assessment’ outlines the information and data utilised in greater detail, as well as the assumptions applied to undertake a secondary containment risk assessment. The requirement for ‘Class 2’ type secondary containment within Esholt STF has been used to inform the next stage of the risk assessment, spill modelling and the site-specific options appraisal carried out by Stantec in 2021 to support the permit application process (See Chapter 3).

3 Solution appraisal

3.1 Objectives

The purpose of this stage of the assessment is to determine the significance and potential environmental risks associated with a loss of containment from sludge vessels within the Esholt STF, and to review existing provisions and a potential improvement solution against BAT principles, including CIRIA C736. As described previously, this stage of the process is informed by the outputs of the ADBA tool, but also considers options which are outside the scope of the ADBA scoring system utilising a bespoke methodology which adopts source-pathway-receptor principles in a qualitative risk-based framework.

3.2 Sources in the anaerobic digestion and dewatering areas

The sources of risk which have been identified at Esholt are shown in Figure 6 below. These assets occupy two areas of the site, which are considered separately within this report:

- the anaerobic digestion facility – 'AD Area'.
- the dewatering area (east of the River Aire) – referred to as 'DW Area'.

A third permitted area located to the north-west, the SPC area, is used for storage of legacy conditioned materials. This area contains no storage vessels and is not in active use for any current STF operations. This area is therefore outside the scope of this report.

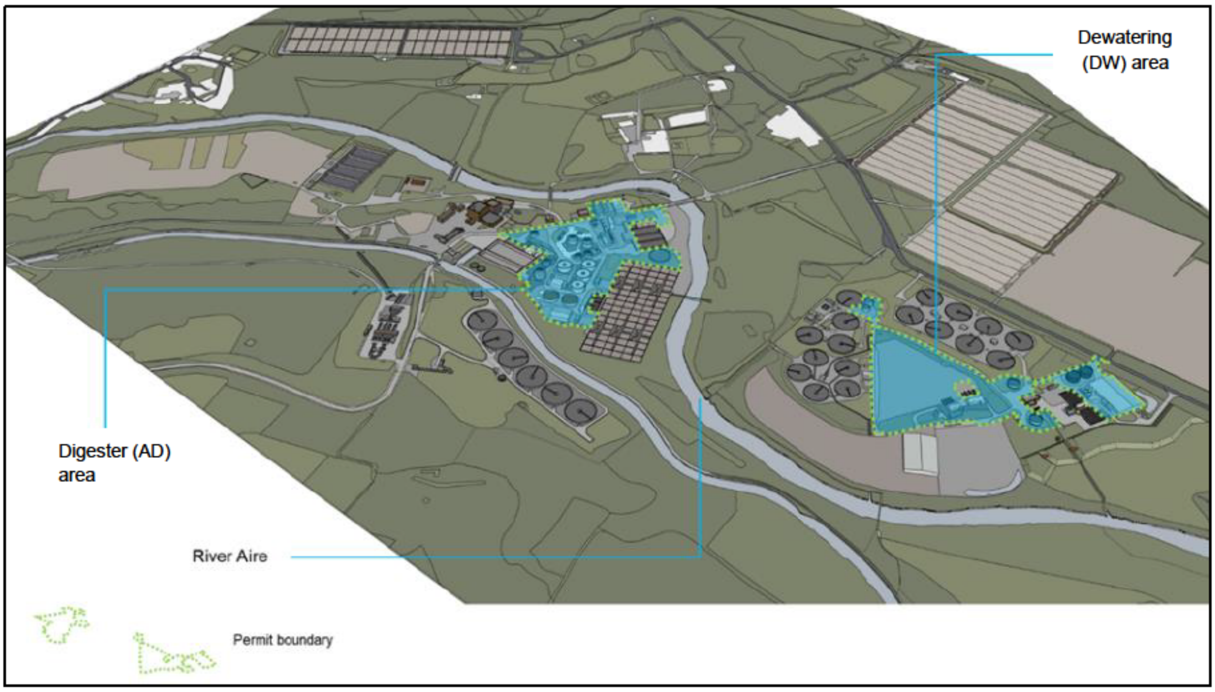

Figure 6. Esholt sources of risk and site areas.

3.2.1 Bulk storage vessels (anaerobic digestion area)

Tanks within the AD area are labelled within Figure 7 and a detailed discussion of risk sources and existing control and mitigation measures associated with the AD Area is provided below.

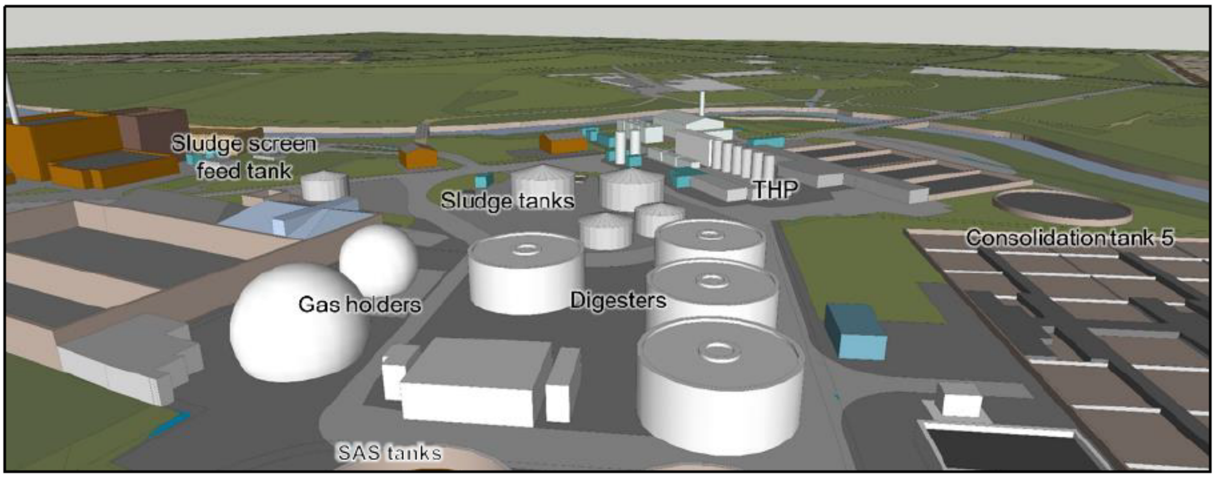

Figure 7. Tanks within the AD area.

3.2.1.1 Sludge reception, treatment and handling

Sewage sludges and sludge cake treated within the STF originates from several sources:

- Indigenous sewage sludges, including indigenous primary sludge and indigenous surplus activated sludge (SAS) arising from sewage treatment processes operated within the wider Esholt WwTW are piped directly to the STF.
- Sewage sludges generated by smaller YW sewage works (with lower capacity or capability for treating sludges on-site) are imported to Esholt STF for additional treatment. This may be received in the form of either liquid sludge or sludge cake.

Liquid sludge and sludge cake are delivered to the site by tanker / covered tipper lorry, the maximum load typically being 28 tonnes with unloading routinely taking up to 30 minutes. Only appropriately authorised vehicles can discharge at the site as shown in Figure 8. This is controlled using 'WaSP' loggers, valves on the discharge pipework will only open when a driver presents appropriate authentication to the system. The WaSP loggers record the source of the sludge, the time and date of delivery, the total volume discharged and average percentage dry solids of the load.

Figure 8. Sludge unloading area via WaSP loggers.

3.2.1.2 Sludge screen feed tank (1 no.)

Imported liquid sludge is delivered to site by tanker. The tanker unloads at the dedicated sludge import area and sludge is pumped (using vehicle mounted pumps) into the sludge screen feed tank (Figure 9, 655 m^3 concrete tank) where it is mixed with indigenous primary sludge pumped directly via underground pipework from Esholt WwTW. Headspace air from this tank is routed to a local Odour Control Unit (referred to as OCU 1). This is currently operated as a dispersion only stack. The sludge is screened using two Huber enclosed rotating screens.

Figure 9. Sludge screen feed tank.

3.2.1.3 Consolidation tank 5 (1 no.)

After screening, sludge is pumped via a sub-surface pipework, to consolidation Tank 5 (Figure 10, 2,500 m^3 uncovered concrete tank) (referred to on site as 'console tank 5') where sludge is blended and mixed using air injection.

Figure 10. Consolidation tank 5.

3.2.1.4 Indigenous SAS storage tanks (2 no.), thickening polymer tanks (3 no.) and SAS transfer tanks (2 no.).

Liquid surplus activated sludge (SAS) is pumped directly from the co-located Esholt WwTW to two SAS storage tanks (Figure 11, 2 x 2000 m^3 uncovered concrete tanks). These tanks are air mixed and operate on a fill/draw basis over a 24-hour period.

Figure 11. SAS storage tanks.

Sludge from the SAS tanks is transferred to the drum thickener building, via above and below ground pipework. There are four individual drum thickeners (with separate pipes feeding them) located within the building, these are operated manually as and when the process requires.

Liquid polymer is delivered to site either by tanker (bulk delivery) or is delivered in 1 m^3 IBCs. The bulk tanker delivery point is located on the eastern side of the building. Bulk polymer deliveries are transferred into a 10 m^3 bunded GRP bulk storage tank located within the thickener building and from there are transferred to the 3 m^3 bunded GRP polymer prep tank. IBC deliveries directly feed the liquid polymer prep tank. Liquid polymer is diluted with potable water within the 3 m^3 bunded GRP polymer prep tank before being transferred to the adjacent 3 m^3 bunded GRP polymer make up tank. Both the make-up and prep tanks are located within a common bund. A spillage within any of the three polymer tanks would be manually removed from the bunds and disposed off outside of the installation site. From the make-up tank the polymer solution is injected into the sludge stream within the flocculation tank (one flocculation tank per pair of drum thickeners) with final treated effluent added as a 'carrier' before being transferred to thickener drums. The polymer encourages separation of water from the sludge as the sludge is rotated in the drum to remove excess liquid. The thickener liquors are returned via the liquor return supernatant pumping station (uncovered below ground sump) to Esholt WwTW for full treatment. The thickened sludge is passed forward to the SAS transfer tanks (see below for further detail).

The drum thickeners are equipped with automatic spray bars which provide continual self-cleaning. The automatic spray bars operate using treated final effluent. A manual jet wash is available for additional cleaning requirements; this system utilises potable water. A full drum cloth clean is also carried out periodically (approximately every 1-2 months, as required).

The thickened sludge is then transferred to the SAS transfer tanks (Figure 12, 2 x 400 m^3 uncovered concrete tanks). The thickened sludge tanks are mixed via pumps.

Figure 12. SAS transfer tanks (side by side images).

3.2.1.5 Mixed sludge tanks (2. No).

From the SAS transfer tanks the thickened SAS is then pumped to the mixed sludge tanks where it is mixed with indigenous primary and imported liquid sludges which are pumped from consolidation tank 5. There are two covered concrete mixed sludge tanks with a capacity of 1,200 and 1,130 m^3 respectively (Figure 13).

Figure 13. Mixed sludge tanks.

3.2.1.6 Sludge dewatering: (polymer tanks 2 no.)

From the mixed sludge tanks, sludge is transferred to three dewatering centrifuges. A polymer solution is introduced to the sludge stream to encourage separation of water and sludge within the centrifuges. This polymer is stored as a dry powder within a silo (15 tonne storage capacity) and is mixed with towns (potable) water within the polymer mixing tank (25 m^3 capacity) located adjacent to the centrifuges. The liquid centrate is transferred via the liquor pumping station and returned for full treatment within Esholt WwTW.

3.2.1.7 Wetted imported sludge cake: (THP feed silos 2no. and THP feed hopper 1 no.)

Imported sludge cake is tipped from an enclosed wagon to the dedicated sludge cake reception unit which is enclosed when tipping operations are not taking place. Sludge is moved from the sludge cake hopper and is rewetted with final treated effluent (to target ~21% dry solids) and pumped to the Thermal Hydrolysis Process (THP) feed silos (refer to description below for further detail of these process tanks and the THP itself). The sludge cake is rewetted to provide feedstock consistency and mobility. Transfer lines are trace heated and insulated to reduce the risk of freezing and pipe rupture.

Dewatered sludge is passed forward to the THP feed silos (2 no. 210 m^3 steel tanks, refer to Section 3.2.1.8 for further detail of this process) where it is combined with re-wetted imported sludge cake. It is rewetted to provide feedstock consistency and mobility. Feedstock from THP feed silos is then transferred to the THP feed hopper (16.2 m^3 steel tank).

3.2.1.8 Thermal hydrolysis plant (THP)

At Esholt STF, thermal hydrolysis technology is used prior to anaerobic digestion to enhance sludge treatment; the process acts to make the sludge more biodegradable, increasing biogas production within the digesters and assisting with pathogen kill in the final product. The THP at Esholt, as shown in Figure 14 and Figure 15, comprises 6 no. 22.7 m^3 reactor vessels, which operate in pairs. Each pair of reactors operates a batch process as follows: a reactor pair is filled with dewatered sludge and heated to around 165°C using steam generated by boilers. The reactors are held at this temperature for 30 mins and act like a pressure cooker to break down organic matter in the sludge making it more digestible for the microbes in the anaerobic digester. After 30 minutes the steam is flashed out to the next pair of reactors (as a pre-heat stage) and the reactor tanks are emptied. Activity within each pair of reactors is staggered with one pair being filled, one pair undergoing active reaction and the final pair being emptied at any one time.

Figure 14. Thermal hydrolysis plant (THP).

Steam is transferred from one pair of reactors to the next to supplement boiler steam supply and maximise operational efficiencies. The plant is equipped with safety features including pressure relief vents to allow emergency venting of steam and prevent damage to equipment.

The THP achieves 96% pathogen kill, in combination with the normal anaerobic digestion process, this eliminates the need for post-digester liming or cake storage and maturation prior to land spreading.

3.2.1.9 Sludge digestion: buffer tank (1 no.) and digesters (4 no.)

Following THP, sludge is transferred to a steel buffer tank (Figure 15, 39.5 m^3) and from there is passed forward via digester feed lines to the digesters. Heat exchangers are located within the digester feed lines to reduce sludge temperature to the optimal temperature range for mesophilic anaerobic digestion activity (37-43 °C). Cooling water is discharged to the WwTW for treatment.

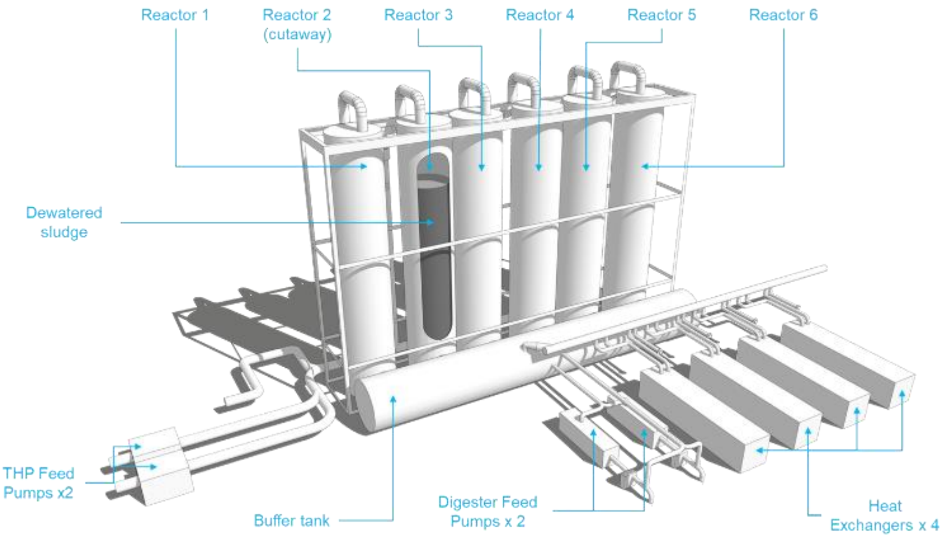

Figure 15. Digester steel buffer tank within the THP.

There are 4 no. aluminium-clad and insulated concrete digester tanks located on site, each with a capacity of 3,533 m^3 (Figure 16) The anaerobic digesters operate as a continuous process with sludge being continually fed into the base of the digester and treated sludge being displaced from the top. The digesters operate independently of each other and have a maximum feed rate of around 127.5 tonnes / day dry solids (at 10% dry solids) or 1,272 m^3 /day across the four digesters. Digester retention time is determined by the feed rate (which is dependent on other site operations such as the THP and sludge import activities) but is typically 10-11 days. The digesters are mixed by gas mixing systems, which utilise biogas from the headspace of each digester; the gas is compressed and then reintroduced using an array of mixing nozzles on the floor of the digester. The digesters do not require any supplementary heating due to the temperature of the sludge being passed forward from the THP.

Grit build up within digesters is a normal feature of operation, the digesters are cleaned out (including accumulated grit) every 10 years as part of the planned periodic inspection which also includes an internal and external inspection of tank integrity and replacement of instrumentation and gas mixing equipment as required. The planned hydrocyclone (to be added between the sludge import screens and Consolidation Tank 5) will help to reduce future grit build up, although internal cleaning will still be required.

An automatic anti-foam dosing system is in place to control digester foaming. This system uses a radar level probe in the digester headspace and compares this to the pressure level sensor at the bottom of the digester to determine the depth of foam. Upon detection of foam, final treated effluent is sprayed into the digester head space through nozzles in the digester roof. If this is not effective in breaking up the foam, a chemical anti-foam is mixed with final treated effluent and dosed into the headspace of the digester via the same spray nozzles. This system includes operator-adjustable dosing setpoints and failsafe systems; if the foam level continues to increase mixing systems are inhibited and if this continues the digester feed will be inhibited. Antifoam is stored in an 1m^3 IBC located on a bunded spill pallet.

Figure 16. Four digesters.

3.2.1.10 Degassing tanks (2 no.)

Sludge extracted from the digesters is fed to the degassing tanks (2 no. 685 m^3 GRP coated concrete tanks) prior to onward processing. These tanks are equipped with air mixing to introduce oxygen and prevent the anaerobic generation of methane. The tanks are covered, and headspace air is extracted and discharged via an odour dispersal unit with a stack approximately 5 m high.

Figure 17. Degassing tanks.

3.2.2 Bulk storage vessels (dewatering area)

A detailed discussion of risk sources and existing control and mitigation measures associated with the dewatering area (DW area) is provided below.

3.2.2.1 Digested sludge treatment, handling and disposal:

Digested sludge is pumped from the degassing tanks located adjacent to the anaerobic digesters to the digested sludge dewatering facility via a combination of above and below ground pipes, including a short section crossing the River Aire. The pipe crosses the river alongside the STF access roadway and is located at road level, on the far side and downstream of the road bridge barrier. The height above the river and roadside barrier provides protection for the pipe in the event of serious flooding which may bring large debris down river.

3.2.2.2 Export dewatering feed tanks (2 no.) and cake export barn

There are two separate sets of facilities for digested sludge dewatering. The first of these, which is used preferentially, is known as the sludge export facility. Sludge is transferred from the degassing tanks to two export dewatering feed tanks (Figure 18), each of which is of steel construction and 1,604 m^3 capacity. These tanks are not covered and have air mixing systems to prevent settlement and inhibit generation of methane. Powdered polymer stored within a 25 m^3 storage silo, or liquid polymer stored in IBCs located within a GRP kiosk, is mixed with potable water within a polymer mixing tank. The polymer solution is injected into the sludge stream and taken to one of two export centrifuges where the sludge coagulates and supernatant liquor is removed by centrifugal forces. Dewatered liquor drops from the centrifuges into the export centrate sump and is pumped back to the WwTW for treatment.

The final digested and dewatered sludge cake is transferred via conveyers from the centrifuges up over a push-wall and into the covered sludge cake export barn (Figure 19). The whole area under the conveyer and sludge cake barn is an engineered impermeable surface, with water runoff draining to the WwTW for treatment.

Figure 18. Export dewatering feed tanks.

Figure 19. Export cake barn.

3.2.2.3 Conditioning feed tanks (2 no.)

In addition to the export dewatering facility there is a second dewatering area, which provides additional capacity for digested sludge treatment and handling. This takes place in what is known as the conditioning area. When the THP/digestion plant are running at full capacity, sludge would typically be diverted to this second dewatering facility for approximately 5-10 minutes in each hour. During these periods, sludge is transferred from the degassing tanks to two conditioning feed tanks, each of which is of concrete construction and have a capacity of 1,200 and 1,130 m^3 (Figure 20). These tanks are not covered and have air mixing both to prevent settlement and inhibit generation of methane. Powdered polymer stored in 750kg bags are suspended over a hopper dosing system which feeds a make-up tank where the powdered polymer is mixed with potable water and transferred to an ageing tank and finally a storage tank. The polymer solution is injected into the sludge stream and taken to one of three centrifuges where the sludge coagulates, and supernatant liquor is removed by centrifugal forces.

Figure 20. Conditioning feed tanks.

3.2.2.4 Centrate balance tanks (2 no.) and cake pad.

Dewatered liquor drops from the centrifuges into the centrate sump and is pumped back to WwTW, via centrate balance tanks, for treatment (Figure 21, capacity of 400 and 600 m^3).

Figure 21. Centrate balance tanks.

The final digested and dewatered sludge cake is transferred via conveyers on to the cake pad (Figure 22). The area under the conveyer and cake pad is an engineered impermeable surface, with water runoff draining the head of the works for treatment. The digested sludge cake produced by this facility does not require liming or storage to ensure adequate pathogen kill and is suitable for immediate despatch from site to be land spread for agricultural benefit. The THP stage increases destruction of volatile sludge components within the digester, meaning that the final sludge cake has reduced odour generation potential.

The conditioning cake pad also serves certain contingency functions, both for operations at Esholt and for the wider strategic regional sludge treatment infrastructure operated by YW. The cake pad may on a temporary basis be used for interim storage of digested sludge cake produced at other YW sites, in circumstances such as the failure of assets or non-availability of normal disposal routes. It may also be used for interim storage of raw undigested sludge cake from Esholt or from other YW sites before being treated at Esholt STF, treated at another YW STF or sent off site to an alternative treatment/disposal route (subject to all applicable regulatory constraints).

Figure 22. Conditioning cake pad.

3.2.3 Tank volumes

Tank volumes are summarised in Table 1 below.

Table 1. STF tanks at Esholt STF and associated capacities and construction.

Tank	Area	Size m^3 (each tank)	Constructed	Construction
1 no. sludge screen feed tank	AD	655	2013	Concrete
1 no. consolidation tank 5	AD	2,500 ([a]1,250)	2007	Concrete (partially subsurface)
2 no. mixed sludge tanks	AD	1,200 / 1,130	2013	GRP coated steel

Tank	Area	Size m³ (each tank)	Constructed	Construction
2 no. SAS storage tanks	AD	400	2007	Concrete
1 no. thickening polymer storage tank	AD	10	2007	GRP
1 no. thickening polymer make up tank	AD	3	2007	GRP
1 no. thickening polymer prep tank	AD	3	2007	GRP
2 no. SAS transfer tanks	AD	2,000	2007	Concrete
1 no. pre-THP centrifuges polymer make up tank	AD	25	2013	GRP
2 no. post-THP centrifuges polymer make-up tank (a and b)	AD	16 / 1	2013	GRP
2 no. THP feed silos	AD	210	2013	Steel
1 no. THP feed hopper	AD	16	2013	Steel
6 no. THP reactor vessels	AD	23	2013	Stainless steel
1 no. digestate buffer tank	AD	40	2013	Steel
4 no. digesters	AD	3,533	2008-2013	Concrete with aluminium cladding and insulation
2 no. degassing tanks	AD	685	2007	Concrete
2 no. export dewatering tanks	DW	1,604	2013	GRP coated steel
2 no. conditioning feed tanks	DW	1,200 / 1,130	1998-2006	Concrete
2 no. centrate balance tanks	DW	400 / 600	2014	Concrete/GRP steel

[a] volume of sludge stored above ground for subsurface installations.

3.2.4 Engineering and maintenance standards

YW maintain in-house standards which define the types of assets that meet the requirements of their business, how they should be built and then maintained. In relation to Esholt this covers:

- Design and construction of all assets, including selection of appropriately qualified design and build contractors.
- Procedures for inspection and testing of storage vessels, including internal and external inspections, thickness assessment and non-destructive testing.
- Regular inspections of above ground assets and associated pipework at defined intervals.
- Documented log of any actions arising as a result of these inspections.

YW's asset standards have been developed over many years and where relevant require compliance with Civil Engineering Specification for the Water Industry (CESWI) Seventh Edition March 2011 and the Water Industry Mechanical and Electrical Specifications (WIMES 9.02).

Contractors involved in the design/build of the Esholt scheme were YW framework contractors, appointed following a rigorous EU tender process; this process involved an assessment of past experience, technical competency, design capability and quality procedures.

The combination of all these measures significantly reduces the risk of a catastrophic tank failure, thus reducing the likelihood of secondary containment being required. Nonetheless, it is recognised that the risk of a catastrophic tank failure cannot be eliminated, and external factors could always arise leading to very low likelihood, high consequence events (such as missile generation arising from other plant failure, domino effects or *force majeure*, for example an aircraft impact or terrorist attack).

3.3 Existing site surfaces

Most of the active process areas within the installation are covered by buildings and hardstanding, with some peripheral areas of soft landscaping (grass and gravel cover). Surfacing was generally observed to be in good condition across the site with no significant evidence of cracks or erosion. Site surfacing for the AD and DW area is illustrated in Figure 23 and Figure 24 respectively.

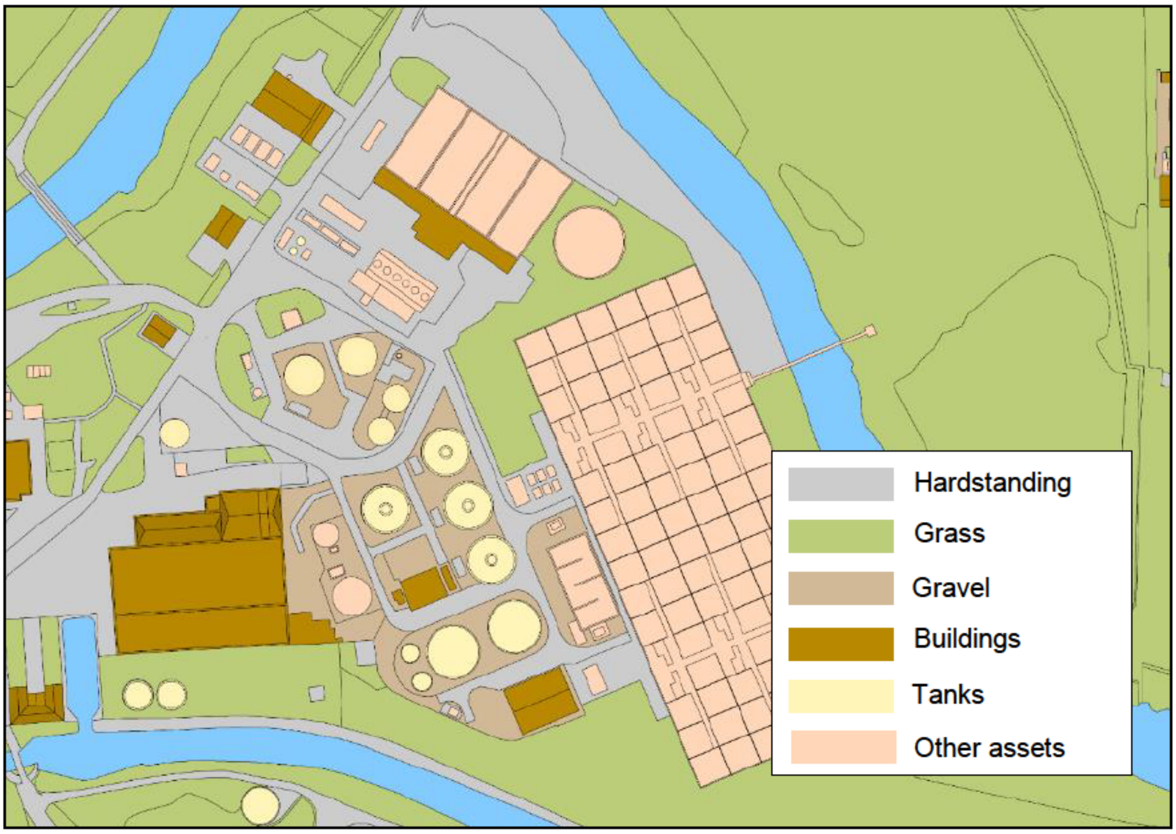

Figure 23. Esholt AD area site surfaces.

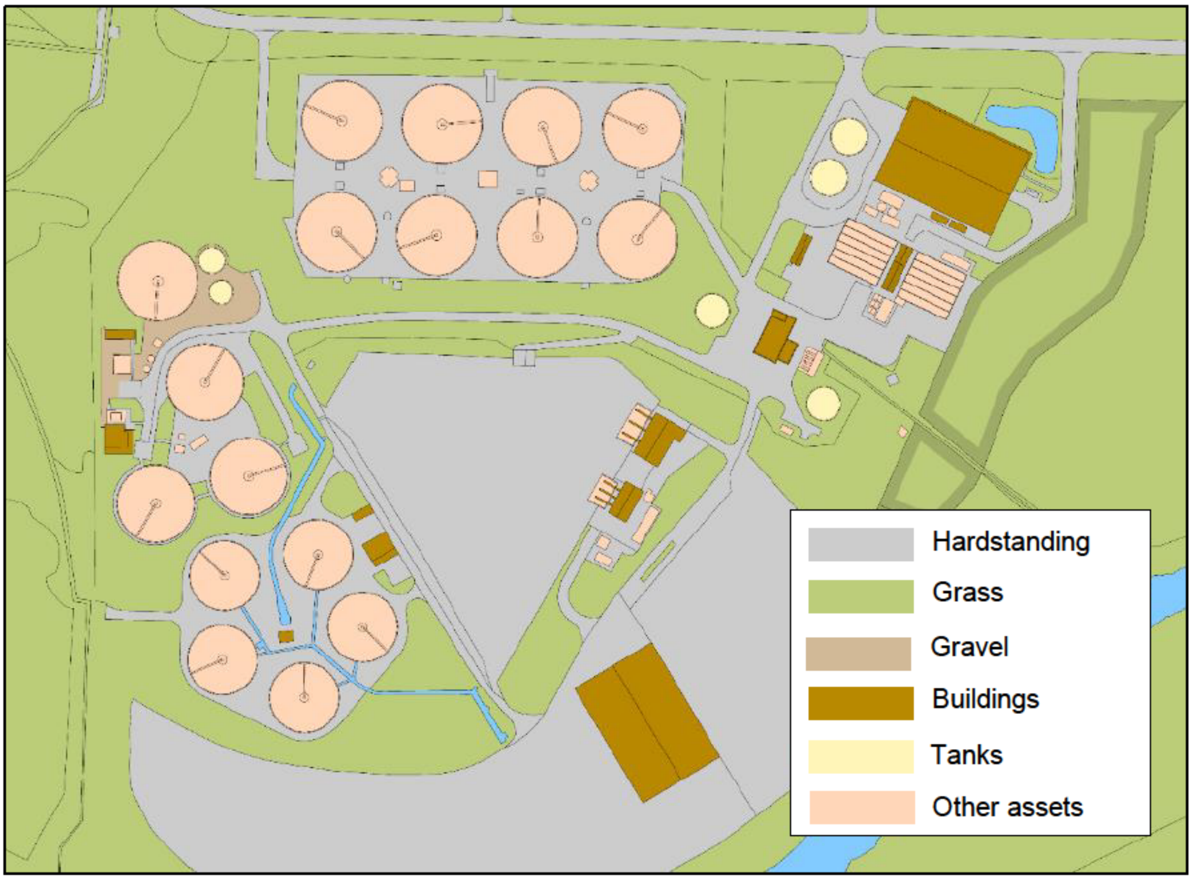

Figure 24. Esholt DW area site surfaces.

3.4 Pathways

Pathways are the routes by which pollutants could potentially travel from a source to the point where they could cause damage, the receptor. The potential pathways in this assessment were determined using computation flow modelling using defined source spillage volumes. The modelling approach, limitations and spill volumes are outlined in the following sections, allowing the principal pathways to be identified.

3.4.1 Spill modelling

To model the potential impact of spills to the environment from the various sludge treatment assets at Esholt STF and defined credible pathways, YW has used PondSIM, a computational overland flow modelling tool. PondSIM can represent the flow of a liquid spill across an area of ground, taking account of local topography and flow restrictions (such as barriers). Applying this to the Esholt site has allowed visualisation of the likely effects of a spill occurring within each of the key areas of the permitted installation.

3.4.1.1 Modelling limitations and uncertainties

As with any computational modelling tool, there are a number of assumptions required and associated modelling limitations and uncertainties:

- PondSIM is designed to model the overland flow of water; as such it is not able to account for the typically higher viscosities associated with sludge, which results in a larger modelled inundation extent than would be expected in reality.

- The model cannot allow for flow to drains and other subsurface features.
- Surge is not accounted for within the model. Instead, this will be allowed for by ensuring final designs consider CIRIA C736 recommendations, while recognising the loss of kinetic energy as viscous sludge travels over flat ground.
- The model assumes that no mitigation measures are put in place following an incident to curtail flow.
- The model assumes that the full modelled volume spills from a single point.
- Assets are treated as simple flow barriers in the model, which may result in deflections being observed where in reality flow would spread out.

Therefore, the modelled outputs are considered to be a worst-case inundation scenario resulting from sludge spills at Esholt. Notwithstanding these limitations, the use of PondSIM is considered appropriate for the purpose intended in this study and allows for the rapid screening and assessment of asset risks to support prioritisation of risk mitigation.

To counter these limitations, several worst-case assumptions were selected relating to the potential failure events, including spill volumes.

3.4.2 Spill volumes

YW has followed CIRIA C736 guidance on spill volumes to be modelled i.e., values equivalent to the containment provided by bunded tanks have been used. For a single tank the volume should be calculated on the basis of 110 per cent of the capacity of that tank. For multi-tank installations, the containment volume should be calculated on the basis of 25 per cent of the total capacity of all the tanks in a common area (which is based on the assumption that it is unlikely that more than 25 per cent of tanks will fail simultaneously), or 110 per cent of the largest tank, whichever is greatest.

The Esholt sludge treatment processes are installed over a large geographical area. The topography of this area means site spills need to be considered using a number of scenarios and catchment locations, listed in Table 2 and described below:

- AD Area
  - The AD area would require containment sufficient to hold 25 per cent of the total stored volume to achieve equivalent protection to a transitional multi-tank installation. Consolidation tank 5 has been included in this scenario due to its continuous use within the treatment process, additionally a large proportion is contained underground, therefore only the above ground volume of this tank has been modelled.
- DW area - will be modelled using multi-spill containment catchment areas as per Figure 25.
  - DW area 1 – the south conditioning feed tank containment will need to hold 110 percent of tank volume.
  - DW area 2 – the export dewatering tanks are hydraulically linked and containment will need to hold 110 percent of combined volume.
  - DW area 3 – the centrate balance tanks are hydraulically linked and containment will need to hold 110 percent of combined volume.
  - DW area 4 – the north conditioning tank containment will need to hold 110 percent of tank volume.

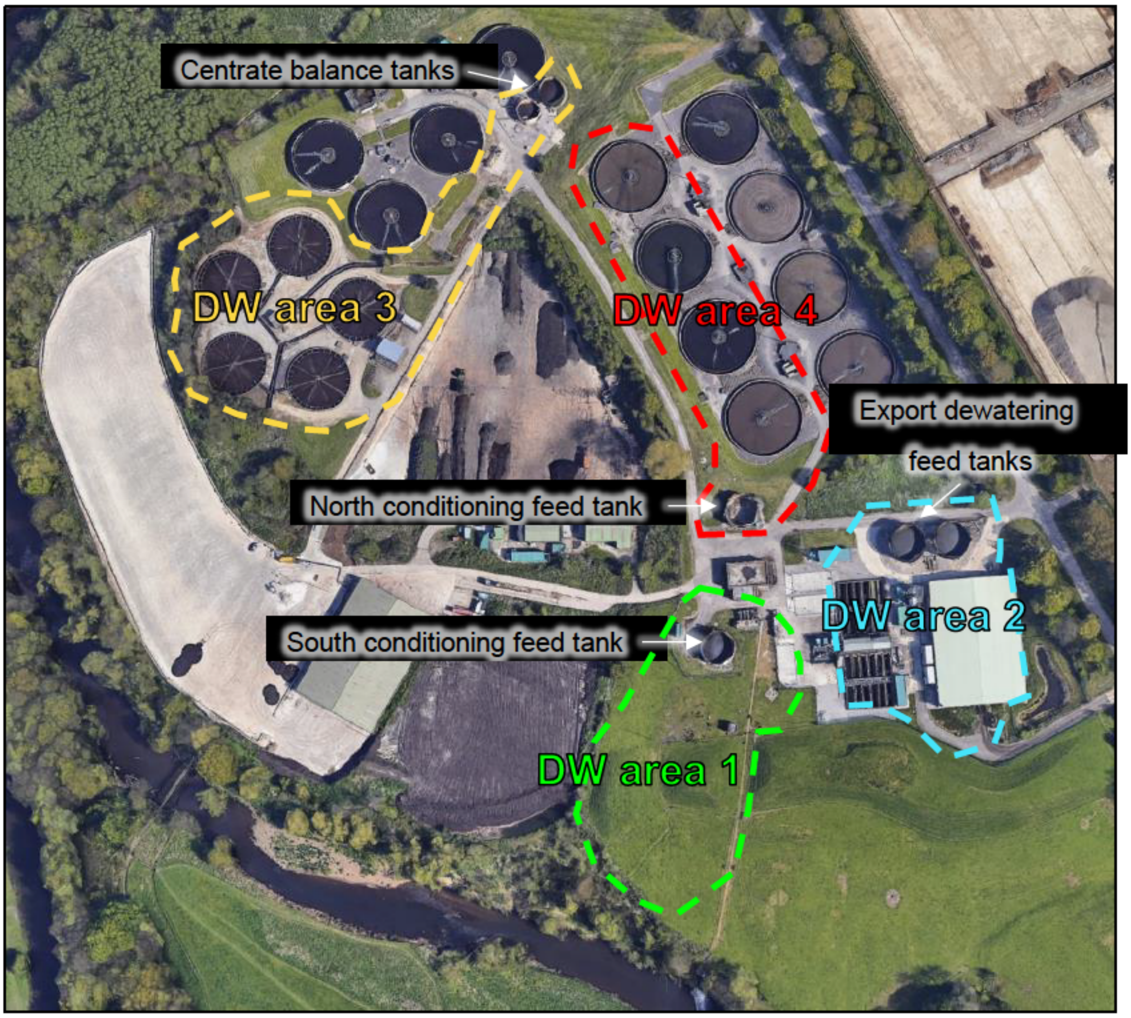

Figure 25. DW area 1, 2, 3 and 4 spill containment catchments used in the spill model.

Table 2. Volume of material used in spill modelling scenarios.

Scenario	Capacity calculation	Material containment volume (m^3)	Modelling reference
AD area	25% total capacity of tanks in 'AD area'.	6,195	Figure 26
DW area	110% total capacity of south conditioning feed tank in 'DW area 1'	1,243	Figure 27
	110% total capacity of export dewatering feed tanks in 'DW area 2'	3,529	
	110% total capacity of centrate balance tanks in 'DW area 3'	1,100	
	110% total capacity of north conditioning tank in 'DW area 4'	1,320	

3.5 PondSIM modelling of unmitigated pathways

This section presents the modelling outlining the potential unmitigated flow routes from the identified source, via surface pathways as calculated by PondSIM to the identified receptors.

This first stage of the modelling assessment considered the effect of a simultaneous loss of containment at both AD and DW areas.

It is important to note that owing to the limitations described in 3.4.1.1, and the specific topography of the site, it is not felt that PondSIM outputs at Esholt are representative of the likely impact of a tank collapse. The detail of this is discussed in following sections, but common themes are:

- PondSIM models fluids as having very low viscosity. This leads to fluids travelling significant distances. In practice, pooling is likely to occur i.e., large spread in a small area, rather than long 'streams' covering significant distances.
- The aerial survey used to support the modelling is imperfect. At Esholt there are several small surface features which would be likely to retain sludge, that were not captured in the aerial survey. See photos in the following section for additional detail.
- PondSIM cannot model capture of liquid within site drainage system. In practice, the modelled flows travel over some areas of ground that has contained drainage which will capture a proportion of spilt material.

Figure 26. AD area: model showing unmitigated result of spills from existing tanks.