SRN36 Bioresources Strategy
Technical Annex

2nd October 2023

Version 1.0

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1. Executive Summary

Our plan is to make use of markets to deliver our Bioresources Long-term Strategy developed through risk assessment, options appraisal and solutions selection detailed in this document have highlighted where opportunities and limitations may arise. We will look to utilise sludge trading, market delivery options and third-party funding options to support the development of our strategy.

We have developed our strategy by understanding the external and internal factors that are impacting our operation. These factors have been key inputs in our modelling to understand the interventions that we need to make to ensure we implement an adaptive, future-proof and sustainable sludge treatment and disposal strategy.

Our strategy is completely aligned with our overall Long-term Delivery Strategy (LTDS) and we are proposing to deliver the AMP8 scope through a combination of:

- SRN19 BOTEX Technical Annex
- Cost Adjustment Claim to implement our conversion to more advanced processes in Kent (Ashford and Ham Hill Advanced Anaerobic Digestion – SRN21 Advanced Digestion Cost Adjustment Claim)
- WINEP Enhancement to provide cake storage resilience across our area (SRN43 WINEP – Bioresources Cake Storage Enhancement Business Case)
- An additional Enhancement case to cover unfunded Industrial Emissions Directives (IED) compliance costs (SRN37 Industrial Emissions Directive (IED) Enhancement Business Case)
- 2 notified items to account for uncertainty related to IED and impact of Farming Rules for Water and landbank availability (SRN58 – Uncertainty Mechanisms Technical Annex)

Scope and purpose

Sewage sludge is the semi-solid by-product of wastewater treatment processing. Our overall bioresources services involve the transport, treatment, recycling, and disposal of sewage sludges. These activities fall within our regulated activities as a sewage undertaker.

Our Bioresources strategy is a key component of our long-term strategic aims of ‘Protecting and Improving the Environment’ and ‘Understanding and supporting our customers and communities’ identified in our Long-Term Priorities.

Our proposed Vision for the Future for Bioresources is “*to create a resilient & sustainable Bioresources Operation that maximises value for the environment and our customers through the use of efficient and adaptive solutions*”.

To meet this ambition, we have developed a Bioresources Management Strategy that sets out the objectives for the management of sludge produced at our wastewater treatment plants focused on:

1. Treat sludge efficiently and cost-effectively to produce materials that benefit downstream supply chains,
2. Achieve 100% compliance with Bioresources Assurance Scheme (BAS) whilst eliminating our reliance on secondary treatment,
3. Create sustainable outlets for biosolids or any other materials,
4. Maximise the energy recovery from sludge,
5. Restore operational resilience and mitigate future threats,

6. Contribute significantly to the company's ambition to reduce its operational zero carbon by 2030 and contribute to the UK Net Zero target of 2050.

A number of issues are impacting the primary outlet for biosolids (currently agricultural recycling), and these have, in part, driven the need to review and revise the company-wide sludge strategy. The most notable constraints which affect potential outlets, are considered more fully in **Section 3** of the strategy document but include:

1. Availability of agricultural outlets, driven by tightening regulations,
2. Current and predicted sludge quantities and quality,
3. Resilience to climate change,
4. The condition of the existing asset base to meet regulations.

Market review

In addition, to a number of engagement activities/initiatives to stimulate interest from third parties who could provide us with bioresources services, following Ofwat guidance, we have considered six key market opportunities as part of our Strategy. This is discussed in **Section 6** of the strategy document but can be summarised as follows:

Headroom trades

Sludge treatment capacity is traditionally designed with initial spare capacity to allow for population growth in the area and for routine maintenance. This results in companies having some ‘excess’ headroom which is not put to operational use until later in the assets life (except for short-term use to facilitate maintenance at nearby sites). It was proposed that the use of this for trades could allow more efficient routing of sludge across company borders to closer or more efficient sites.

A small proportion of our sludge has been traded to other companies and similarly we have received a small proportion of sludge from others. As confirmed by the work undertaken with Business Modelling Applications (BMA) and several other WaSCs, we consider headroom trades as an opportunity – especially at critical times – to mitigate costs on a very ad-hoc basis. However, an agreement in principle for mutual trading remains in place with Wessex Water for short-term emergency trading.

We have also been regular attendees at cross-industry sessions where capacity issues have been discussed. These have been beneficial in understanding the current situation across the industry.

Joint capacity

Historically companies build capacity for their own use. Shared capacity may yield greater efficiency through rationalising sites at the regional level, rather than the company level.

BMA work highlighted that building joint capacity in the current operating context offers little benefit. However, when adding limitations and stress factors to the model such as landbank availability challenge (as discussed in **Section 3**), the impact on avoided CapEx can be significant when capacity is jointly shared with other companies.

Cotreatment (including co-digestion)

Cotreatment (including codigestion) is the mixing of waste streams or feedstocks and treating of them in the same assets.

We have identified limited opportunities for co-treatment with other organic wastes which can be hindered by the differing regulatory regimes and further restrictions related to applying treated biosolids to agricultural land as a result. We continue to engage with the Environment Agency in developing their Sustainable Sludge Strategy which may address some of these barriers. Going forward, we will continue to investigate further any options with other organic waste specialists in or near our operational area.

Co-location with other waste processing

Co-location of other waste processing with sludge treatment centres can allow waste streams to be kept separate while allowing some site assets and staff costs to be shared where skills are cross functional.

Similarly, to the above, some of the opportunities identified previously have not been progressed because of the potential impact our product would have on a 3rd party operator' End of Waste status for their end product which would be revoked as a result. Additionally, we understand the energy potential from our sludge is limited compared to the type of waste usually processed which makes our sludge less attractive.

Project finance & Outsourcing

One option would be to fund some aspects of the strategy through non-regulated investment, through either our shareholders or a third-party. Non-regulated invested is likely to be more flexible both in terms of the level and pace of investment/benefits required.

We are currently carrying out a Market Engagement exercise on the provision of treatment and disposal of sewage sludges through a third party. Whilst the type of treatment, type of contract and location of the work is left open on purpose, our preference would be to convert our operation to more advanced type of treatments (Advanced Digestion and/or Advanced Thermal Conversion), starting in our Kent region, as developed in our Cost Adjustment Claim for Ashford and Ham Hill Advanced Anaerobic Digestion (AAD). The request for information also invites potential suppliers to contribute to the exercise to better understand market capability and appetite and shape a subsequent tender.

Methodology

The methodology for our strategy development for bioresources comprised the following key activities:

1. Data gathering and validation, including analysis of existing and future sludge production, treatment technologies, landbank assessments and evaluation of alternative outlets,
2. Internal workshops to assess selected options,
3. Collaborative water industry work,
4. Evaluation of the results of the assessment and solutions for each area,
5. Modelling and sensitivity analysis to stress-test the selected solutions and ensure they are adaptive.

The methodology and results from the options assessment are detailed in **Section 4**. Further development of the solutions and overall long-term strategy are described further in **Section 5**.

Summary of findings/strategic recommendations

We produce c111,000 tonnes dry solids per annum of sludge treated at our 16 sludge treatment centres (STCs). Population growth in our region and changes to wastewater treatment process (to meet permits) are forecast to increase the quantity of sludge by 9% by 2030, and because of the current available capacity and age of our asset base, carrying on operating sustainably will be a challenge. We have no choice but to look at how we manage our asset base to continue to provide our bioresources services.

Our proposed solution involves consolidation of sludge treatment centres (to fewer but larger sites) and upgrading to Advanced Anaerobic Digestion (AAD) as the primary means of sludge treatment. AAD will strengthen our operation and mitigate immediate threats as it reduces the amount of biosolids recycled to agriculture, opens up additional farmland for spreading and is a more stable product less likely to cause public nuisance.

In our Asset Management Plan for the period 2025-2030 (AMP8) we are proposing to focus on our sites in Kent by consolidating the STCs there into 2 large AAD facilities at Ashford and Ham Hill. Our plans in Kent are further detailed in our SRN21 Advanced Digestion Cost Adjustment Claim.

We are also proposing in AMP8 to provide additional biosolids storage across all regions to ensure we have adequate storage capacity that is resilient to seasonal fluctuations in demand and weather that is not favourable to land stockpiling/spreading activities. This additional storage described in detail in our SRN43 WINEP-Bioresources Cake Storage Enhancement Business Case will also help minimise operational impact in the eventuality that our ability to recycle to land will be significantly hindered.

In AMP9/10 (2030-2040), our focus will shift to Sussex & Hampshire where we will further consolidate sites and convert them to AAD whilst also implementing thermal treatment technologies to fully mitigate land recycling risks. Thermal conversion will allow us to diversify away from agricultural recycling, providing resilience to this uncertain outlet. If given enough time, the preference would be to develop Advanced Thermal Conversion (ATC) type of technologies as they seem to provide the greatest benefit from a resource recovery (energy and nutrients) and carbon perspective. However, ATC technologies (e.g., Pyrolysis, Gasification) are still emerging technologies and as such will need time to develop. Our plan is to start testing the concept at scale in AMP8 but if pressures on the landbank materialise sooner than expected, our alternative option to ATC would be incineration, a much less environmentally friendly solution. In AMP10 and beyond we will also look at other emerging opportunities around resource recovery in order to maximise the benefits extracted from sludge.

This strategy will be reviewed in line with the Price Review process or when significant changes in regulatory policy, market conditions or when new technology becomes commercially available.

1. Introduction

1.1. Overview

Southern Water Services Ltd (SWS) provide essential services to 2.6 million water customers and 4.7 million wastewater customers across Sussex, Kent, Hampshire and the Isle of Wight. We are responsible for the transfer of sewage to wastewater treatment plants, its treatment and the subsequent discharge of the treated effluent back into the water environment. We are also responsible for the treatment and management of the sewage sludge (Bioresources) that is generated from our wastewater treatment plants. This results in around 111,000 tonnes dry solids (TDS) of raw sludge being produced every year and treated at our 16 Sludge Treatment Centres (STCs) to produce over 280,000 tonnes of compliant Biosolids and generate c. 60GWh a year of renewable electricity which is reused on our sites or exported to the national grid.

Bioresources from wastewater treatment plants are primarily the organic by-product of the physical and biological treatment of wastewater and is comprised of the solids removed during the treatment processes. Bioresources are a valuable resource rich in nutrients and organic matter that promote crop growth, and energy. Our purpose in the provision of our Bioresources services is: “We safely and efficiently process bioresources in the interests of our customers, society and the environment”.

This strategy document describes our current Bioresources operation whilst highlighting the shortfalls and emerging risks affecting its continuing operation. It assesses the various technical solutions which have been looked at alongside opportunities created by opening the market to other potential entities. It provides a framework for our specific investment proposals, particularly in the period 2025-2030 for the periodic review of our charges.

We aim to improve our sludge management practices by developing and utilising new and additional sludge treatment / management technologies and creating suitably robust contingency measures to manage the impacts of climate change and periods of supply chain disruption. This will deliver better value to our customers and guarantee the continuous production of biosolids that are highly valued by farmers in our region as part of their long-term nutrients management plans. In the longer-term we may need to reduce our reliance on agriculture as the primary outlet and ensure that we have a robust solution that will allow us to diversify and adapt to external influences.

As early as 1995, we committed to recycling all sludge as treated biosolids; this is common practice (87% of UK’s treated sewage sludge (biosolids) is recycled as an agricultural fertiliser and soil improver1). Currently we employ a number of treatment technologies to produce a biosolids that can go to agriculture. Over the past 5-years, on average 99.7% of the sludge we produced has been recycled to agriculture with the remaining 0.3% going to land restoration. Agricultural land is currently the only strategic outlet for our biosolids, with other outlets only available to mitigate short-term tactical issues. We are fully committed to ensure our bioresources service comply with all relevant Regulations and Codes of Practice and as such are fully compliant with the Biosolids Assurance Scheme (BAS), the industry quality assurance scheme which is 3rd party accredited/audited.

1.2. Strategic objectives and scope

This document has been prepared to set out the long-term strategy for the management of the Bioresources produced at wastewater treatment plants under our control. Our proposed Vision for the Future is “*to create a resilient & sustainable Bioresources Operation that maximises value for the environment and our* *customers through the use of efficient and adaptive solutions."* We believe that it is necessary to improve our current level of resilience whilst upgrading our asset base to best available technologies, in order to reduce our exposure to future threats and enable us to efficiently capitalise on opportunities.

The management of bioresources includes sludge production, treatment, transport, reuse or disposal, monitoring and reporting. In developing and implementing the strategy, our objectives for our bioresources activities include:

1. Treat sludge efficiently and cost-effectively to produce materials that benefit downstream supply chains,
1. Achieve 100% compliance with Bioresources Assurance Scheme (BAS)[2] whilst eliminating our reliance on secondary treatment,
2. Create sustainable outlets for biosolids or any other materials,
3. Maximise the energy recovery from sludge,
4. Restore operational resilience and mitigate future threats,
5. Contribute significantly to the company's ambition to reduce its operational zero carbon by 2030 and contribute to the UK Net Zero target of 2050.

In building our strategy for Bioresources, we have considered our existing operation and asset base, current and upcoming legislations, guidance documents and internal policies. We have also assessed future risks (e.g. tightening of regulation, climate change and customers' expectations) and opportunities and have benchmarked technological solutions against these. As a result, we have set out investment requirements and highlighted opportunities for future works. As circumstances may change in future this strategy needs to stay adaptive and to this effect will be reviewed in line with the Price Review process or when significant changes in regulatory policy, market conditions or when a relevant new technology becomes commercially available to ensure it is relevant.

2. Current Strategy and Operation

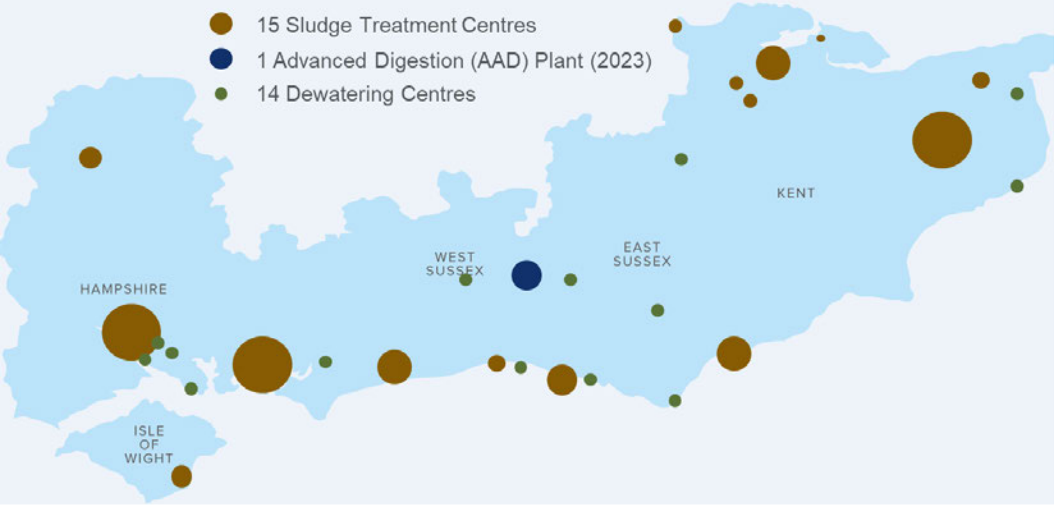
Sludge produced at our wastewater treatment plants contains large volumes of water which is removed through thickening or dewatering processes either at the local treatment works, at one of our 14 dewatering centres, or at one of the STCs, depending on which is most practical. We generally use road tankers and trucks to transport the sludge either as liquid or dewatered cake. In 2022/2023, our fleet of tankers drove more than 861,800 kms to move our liquid sludge between sites whilst our trucks moved our dewatered cake across just under 183,300km.

The sludge treatment and disposal processes that we use depend on the type, quantity and location of the raw sludge produced. Our operation includes a diverse range of assets that are used to:

- Thicken the sludge to reduce transport costs and to help further processing,
- Transport the raw sludge by road or pipelines,
- Remove unwanted detritus (e.g., paper, rag and plastics) from the raw sludge using screens,
- Treat the raw sludge using a variety of biological (primary digestion only), and/or chemical processes,
- Produce and clean biogas which is used to generate heat and electricity in combined heat & power (CHP) engines,
- Provide enhanced treatment to achieve higher environmental standards for beneficial recycling to land,
- Store sludge to provide resilience across our operation whilst optimising treatment and disposal of treated product,
- Transport and recycle biosolids to land, for use as a soil enhancer and fertiliser.

The location of our current sludge treatment and dewatering centres in each area are described in **Figure 1** below, historically these were not strategically located but rather developed around the largest WWTWs.

Figure 1: Southern Water's Current Sludge Treatment Locations



From a strategic perspective, multiple options are available to us to ensure appropriate treatment, storage, transport and disposal of sludge. Unlike a sewage treatment works which usually operates in isolation within a specific catchment, we believe it is best to approach the operation of our STCs and dewatering centres as an interconnected system. Whilst this makes the development of our strategy more complex (the impact of a specific adjustment at one location needs to be understood and assessed across the whole operation) it also improves overall efficiency, resilience and maximises opportunities.

Our current operations rely on lime stabilisation and maturation of our treated sludge cake to achieve continued compliance with recycling to land requirements (i.e., E. Coli reduction), while we assessed the most favourable long-term options. Our current operation enables us treat 100% of our sludge in accordance with all relevant regulations and Codes of Practice, which are consolidated within the Biosolids Assurance Scheme (BAS)2. Over the past 5-years, on average 99.7% of the sludge produced has been recycled to agriculture with the remaining 0.3% going to land restoration.

Our evaluation – developed further in **section 4** below and in our for SRN21 Advanced Digestion Cost Adjustment Claim at Ashford & Ham Hill - has shown that lime treatment is no longer sustainable due to the significant carbon footprint associated with the process, the cost of materials and chemicals, and lack of reliability of the operation, the nuisance it creates to our neighbours (odour), the H&S risk it poses on our operatives and the wider environmental dis-benefit in producing the lime.

Historically – and partly driven by Ofwat - our focus has been to ensure we kept our customers' bills low, therefore we endeavoured to efficiently maximise the use of our existing assets and chose a lower CapEx strategy.

As a result of the increased length of time key assets have been in operation for, their performance is now deteriorating, which will hinder our ability to mitigate some of the risks and threats presented in **Section 3**. However, this also means we now have a real opportunity to propose and implement an ambitious long-term strategy that will reduce risks whilst meeting the rapidly evolving regulations governing bioresources management.

We aim to improve our sludge management practices by developing and utilising new and additional sludge treatment / management technologies and the creation of suitably robust contingency measures to manage impacts of climate change and periods of supply chain disruption. This will better serve our customers and ensure the continuous production of biosolids that are beneficially supplied to farmers. In the longer-term we need to reduce our reliance on this single outlet and ensure that we have a robust solution that will allow us to diversify and stay adaptive to changes.

2.1. Long term ambition

Given our current total reliance on agricultural land for recycling of the final biosolids output, our bioresources operation is at risk to any restriction of this outlet. In the longer-term we may need to reduce our reliance on this one outlet and ensure that we have a robust solution that will allow us to diversify and stay adaptive to changes by:

- **Ensuring compliance with legislation** – including compliance with Environmental Permitting requirements associated with the Industrial Emissions Directive to reduce the risk of environmental pollution and adherence to the Reduction and Prevention of Agricultural Diffuse Pollution Regulations, commonly known as the Farming Rules for Water (FRfW) to reduce the risk of diffuse pollution on farms (as outlined in **Section 3**).

- **Maximising benefit of biosolids** – by continuing to improve our sludge management practices and developing and utilising new and additional sludge treatment / management technologies to improve the versatility of our outputs.

- **Deliver value for customers -** Better serve our customers by providing a less odorous product and less fugitive emissions from our processes, by moving away from lime stabilisation. This includes providing a better product for the farmers who receive the continuous production of biosolids that are currently beneficially supplied to our farmers for spreading onto their agricultural land. Ensuring we create suitably robust contingency measures to manage impacts of climate change and periods of supply chain disruption.

- **Maximising renewables generation** – through the treatment of sludge to produce biogas or hydrogen that can be utilised through Gas to Grid injection and electricity and heat generation in Combined Heat and Power (CHP) plants or gas to vehicle fuel.

Our customers consider that preventing pollution from our operation to the environment should be a Priority level 1 and top area to improve on (as per SRN14 Customer Insight Technical Annex **section 4.2**). Making these improvements to our sludge treatment centres we will contribute to achieving a higher level of environmental protection. In addition, our suggested interventions will improve the reliability of our overall wastewater infrastructure - now and in future – which is also considered as a Priority level 1 by our customers (as per SRN14 Customer Insight Technical Annex **section 4.2**). This strategy also aligns with our long-term delivery strategy (SRN12 Long-term Delivery Strategy Technical Annex) which aims at delivering sustainable and cost-effective solutions.

3. Overview of Risks and the Drivers for Change

It is fundamental that as part of our strategy development process, we consider external and internal drivers that may impact our bioresources service. We need to assess how these future drivers will affect our processes and the performance of our assets, as well as understanding what this means for expenditure. The key external challenges are summarised in **Table 1** below:

Table 1: External influencing factors

Analysis	Key Challenges
Political	Regulatory and market reform
Economic	Commodity prices Financeability
Social	Population growth Customers requirements Public Perception
Technological	Opportunities to innovate
Legal	Quality and environmental legislative changes
Environmental	Climate change Landbank availability

3.1. Political

Ofwat have concluded that bioresources can offer significant customer benefit through opening a competitive market, without which there will continue to only be small incremental benefits each AMP[3]. This could allow new entities to enter the sludge treatment and disposal market. This will open some of our sludge business to competition, it will also offer opportunities for us to offer our services to other companies or make use of other companies' assets and avoid us having to invest in new capacity.

3.2. Economic

Commodity prices

Energy costs have been rising and are forecast to remain well above the pre-2021 average for the foreseeable future[4]. Where it is economic for us to invest in new equipment to increase the generation and recovery of energy we will continue to do so. Our aspiration is to recover as much energy as technically possible from our bioresources operation and – where possible - go beyond energy neutrality for our bioresources services (i.e., we will produce more energy from sludge than we need) and export the excess to the rest of our business (in most cases Wastewater Network+) or to the grid.

Electricity or heat aren't the only types of energy that we have to consider. We move untreated sludge between operational sites as well as treated biosolids to final outlets. This uses significant amounts of diesel (approximately 5.8m litres in 22/23) which can be price volatile due to a complex range of factors. Potential` volatility can put added pressure on maintaining our current operational costs. As such we are always looking at ways to reduce the volumes of sludge transported between sites (by removing more water before it is tankered away) and reducing the amount of biosolids we recycle (through improvements in the treatment process – including dewatering – and alternative disposal options). Additionally, the consumption of this diesel released almost 15,000 tonnes of CO_2e in 2022/2023 (based on emission factors for diesel biofuel blends).

We are considering ways to reduce this through adopting green fuels, such as biomethane which could be used to run a fleet of vehicles, where electric vehicles are not viable.

Inorganic fertilisers prices have also increased significantly over the recent years sometimes resulting in farmers having to scale back their operation[5]. Producing a compliant and attractive biosolids (less odorous, easier to handle) will make a more attractive and affordable alternative to farmers, as some of them have mentioned in our survey (**Appendix 1**).

Financeability

The bioresources regulatory pricing landscape is evolving with a separate price control for bioresources introduced at PR19 in order to influence the development of a competitive market for bioresources (sewage and wider organic waste market). Several investment models are available to us each having their benefits and constraints. Accordingly, there are several funding options available in the case that new capital is required to implement a new strategy. This is discussed further in **Section 6** Review of Market Opportunities.

One option is to fund some aspects of the strategy through non-regulated investment, through either our shareholders or a third-party. Non-regulated investment is likely to be more flexible both in terms of the level and pace of investment/benefits required. Further work is being carried out to explore the non-regulated capital investment options.

Funding options also include the potential for us to lease some (or all) of our STCs to a third-party which would invest, build, and operate all bioresources assets in return for a gate fee over an agreed term. Whilst this option would shift the challenging task of designing and implementing a sustainable strategy for bioresources in the South-East to another entity, we would need to understand how much control we would retain over the level of investment but also on ensuring compliance, ODIs and legislations/regulations are adequately dealt with on our sites.

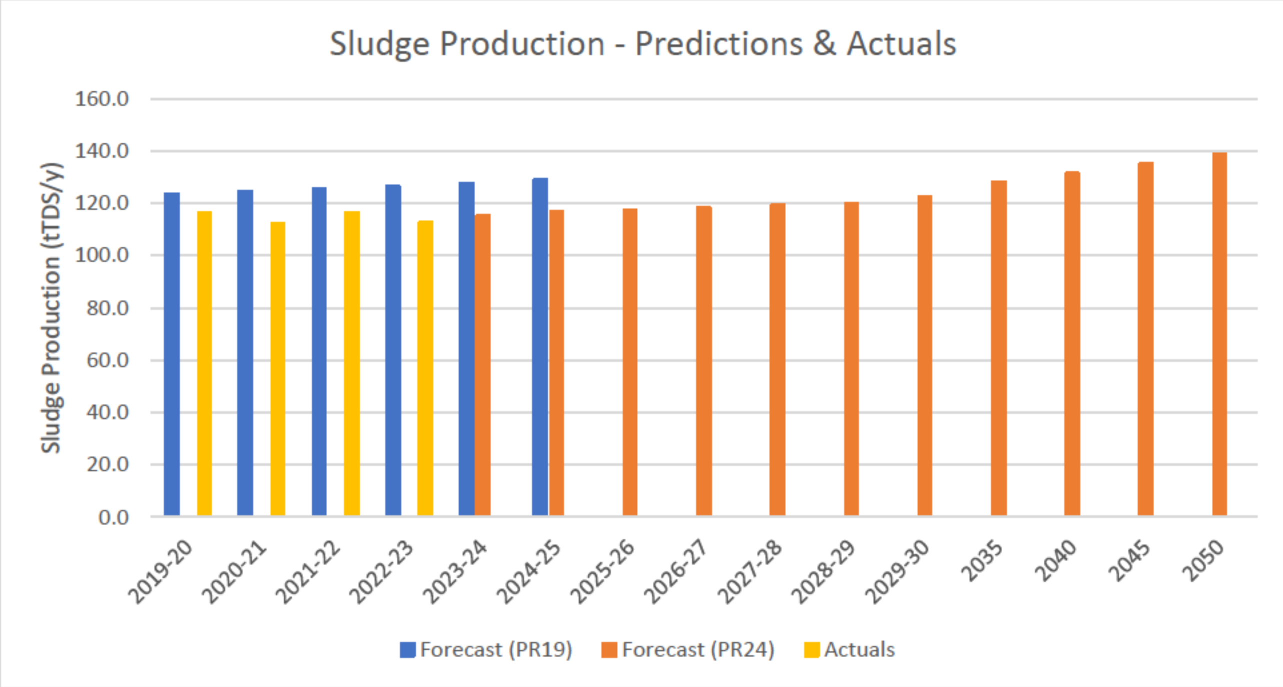
3.3. Social

Growth pressures

Population growth forecasts point to a 33% increase within our operational area by 2100 according to our [redacted] forecast. This, combined with changing wastewater treatment standards as part of the WINEP will lead to higher volumes of sludge to be treated and disposed of and ultimately will increase pressure on the performance of our operation.

Figure 2 below shows the projected sludge production up to 2050 (including impact of WINEP schemes on sludge production in AMP8). It also shows the challenge to accurately predict figures as historical data shows a slight over estimation (of about 8.5% average) of our PR19 sludge production forecast compared to actuals. Our Enhancement Case on WW Growth (SRN44) partly explains this gap as population growth forecast used at PR19 is estimated to be around 2% higher than actual population figures due to the forecast tool used at the time (Experian). The case also explains that the new tool used at PR24 ([redacted]) aligns better with the linear projection from actual population growth 2014/2015 to 2021/2022 giving us more confidence in our updated forecast figures. The remaining gap could be explained by inaccuracies related to the way actuals are calculated. Sludge production at each STC is currently calculated daily based on the measured volume of sludge pumped to our digesters and daily spot samples and analysis of solids content within this sludge. We are mitigating this issue by finalising the installation of on-line solids content analysers on which will give us a more accurate – and continuous throughout the day - value of the proportion of solids within our sludge.

Figure 2: Predicted increase in sludge production due to population growth



From an asset resilience perspective, growth is a significant risk to consider going forward as the condition and capacity of our current bioresource asset base – especially digestion facilities – is already under stress and will not be able to meet our predicted medium-term growth (e.g. AMP8/9) in certain areas – especially Kent - as shown on **Table 2**.

- "Design Headroom" assumes 100% capacity under standard operation and no other constraints, with Kent being our most stressed area.
- "Base" is what is what is considered as achievable accepting constraints on peripheral assets (e.g. capacity of dewatering, thickening, CHP engines).
- "Current" is what is achieved at present.

Table 2: Digestion Headroom

Region	Standard Demand		Stressed System (+20% demand)	
	Design Headroom vs Base (%)	Current % Headroom vs Base (%)	Design Headroom vs Base (%)	Current % Headroom vs Base (%)
All	24.9	6.3	10.0	-12.3
IoW	31.6	31.6	17.9	17.9
Hants	19.6	7.5	3.5	-11.0
Sussex	34.2	7.3	21.0	-11.3
Kent	19.9	0.7	3.9	-19.1

Customer requirements

One of the most important areas for our customers is to see improvement in minimising pollution and the need to reduce our carbon footprint and greenhouse gas emissions (as per SRN14 Customer Insight Technical Annex **section 4.2**). Our work towards achieving this includes compliance with the permits for our sites pertaining to the Industrial Emissions Directive (IED)[6] as well as considering the impact of our use of fossil fuels and exploring potential alternative sources.

Feedback from the farmers receiving our treated biosolids (See **Appendix 1**) also suggest they are concerned about the quality of the product we provide them with, and potential future risks posed by pollutants such as microplastics. This, in addition to the wider landbank risk highlighted below re-enforces the need to improve resilience of our sludge treatment in the shorter-term whilst enabling us to transition to more advanced types of treatment (e.g. Advanced Thermal Conversion described further in **Section 4** below) which are expected to fully mitigate the risks associated with such emerging contaminants.

Public perception & expectation

The way the public perceives our activities, especially the recycling of our biosolids to agriculture, could have a significant impact on our existing operation. The increased scrutiny and expectation from the public is likely to amplify and accelerate the risks mentioned in the Legal (e.g. tightening of regulations) and Environmental (emerging pollutants) **sections** below. A backlash akin to what we are experiencing with combined sewer overflows (CSO) could for example force retailers to rethink how they source some of their products, in turn impacting farmers operation.

3.4. Technological

Our asset base is predominately conventional anaerobic digestion (CAD) with additional lime treatment or maturation to ensure a reliably sufficient level of E. Coli reduction across the process is maintained. Given the growth drivers and the changes in regulation around IED compliance and emerging risks we will need to address shortfalls in capacity treatment and achieve higher treatment standards. As Table 2 shows, we currently have limited headroom capacity in our digestion assets at peak demand, which puts pressure on being able to maintain compliance with our treated biosolids.

The past few years has seen a significant development in the technology employed in sludge treatment. Thermal hydrolysis is the norm now for advanced digestion processes, but other options (discussed further in **Section 4**) are adaptable to flex to the changing technology readiness. Advanced thermal conversion is likely to be the next significant process change and even though the technology still needs to be proven at significant scale in our industry, a few commercial scale units have started to emerge and should be tested in AMP8 with a potential implementation over the subsequent AMPs (9 and 10).

Due to the methods employed in sewage treatment, potentially valuable nutrients are transferred to the sludge as it is recovered, and they become concentrated further down the treatment process. Nutrient recovery from sludge liquors is a well understood and viable concept[7,8] which could be further developed as new technologies such as thermal conversion become commercially available. The most useful of which would be phosphate as this is deemed a finite natural resource[9] and could be marketed as a fertiliser replacement. Other useful resources of interest in our sludge are ammonia, bio-polymers, enzymes and metals, etc.

3.5. Legal

We have a range of legal obligations to adhere to with respect to the management of sludge and how we contract for services connected with sludge. The production, treatment, re-use or disposal of sludge is controlled by a substantial amount of regulation and we control and monitor our handling, treatment and management of sludge to make sure that we comply with these regulatory and industry standards.

Many of the regulatory requirements have recently been introduced and we have been improving our procedures, equipment and technology to meet these required interventions. In addition to legislation there are several non-statutory guidance documents in relation to sludge management that we also need to be conversant with. Given the industrial nature of our processes, we also have to comply with a wide range of Health and Safety rules to protect our workforce and wider stakeholders.

Summary of key legislation and guidance

- Sludge (Use in) Agriculture Regulations 1989
- Environmental Permitting Regulations (England & Wales) Regulations 2010
- Industrial Emissions Directive (IED) transposed by the Environmental Permitting (England and Wales) (Amendment) Regulations (EPR) 2013
- Waste Framework Directive
- Reduction and Prevention of Agricultural Diffuse Pollution (England) Regulations 2018 – commonly known as the Farming Rules for Water (FRfW)
- Health and Safety at Work etc. Act 1974
- The Control of Major Accident Hazards Regulations 2015
- The Dangerous substances and explosive atmospheres regulations 2002

Supplementing these are many guidance notes and associated codes of conduct including:

- Biosolids Assurance Scheme
- Safe Sludge Matrix
- Biological waste treatment: appropriate measures for permitted facilities
- Containment systems for the prevention of pollution – CIRIA C737

In addition, we need to adhere to Licence Condition E1 when we procure services connected with sludge to ensure we don’t show undue preference to internal business. This links closely with our desire to ensure we effectively utilise the market to procure these services.

A comprehensive list of current legislation is included in **Appendix 2** – this is reflective of regulation as of August 2023.

Forthcoming policy developments and uncertainties

The legislative arena is continually evolving, and we need to be aware of how this impacts our operation and service. Our strategy might be affected by new Government policy, strategy and associated objectives and/or targets and subsequent new regulations but it could also contribute to the achievement of future environmental protection and sustainability objectives, some anticipated future policy developments are highlighted in **Table 3**. We need to be flexible in our approach to ensure we can adapt to these with minimal impact on our operation.

Table 3: Anticipated future policy developments relevant to sewage sludge management

Legislation and guidance	Overview
Defra Chemicals Strategy[10]	Long-anticipated chemicals strategy to tackle chemicals of concer which may significantly impact the future strategic direction(s) there are chemical standards for sewage sludge and / or biosolic and whether it remains appropriate for current uses.
Environment Agency's Sustainable sludge strategy[11]	Planned transition for the regulation of biosolids application t agricultural land to move from the Sludge (Use in agricultur Regulations (SUiAR) to the Environmental Permitting Regulatior (EPR) – there is some uncertainty to permit conditions and whethe this will impact operational flexibility of the current pathway.

In addition, continued uncertainty (highlighted in **Table 4**) as identified in the Water UK 'Developing a long-term strategy for bioresources in England'[12], is putting increased pressure on the amount of available land we can utilise. We need to increase our resilience to these uncertainties around the potential reduction and restriction of landbank availability for recycling biosolids and we need to be flexible in our approach to ensure we can adapt to these with minimal impact on our operation and protect customers from increasing costs.

Table 4: Uncertainties relevant to sewage sludge management

Uncertainty	Overview
Biosolids spreading windows, application rates and storage requirements	The Farming Rules for Water focus on nutrient controls and the uncertainty over the regulators' (EA/DEFRA) interpretation of 'Rule 1', could impose restrictions on the timing of organic manure applications and would affect the spreading windows - this is covered further in the 'Landbank' section. In addition, the impact of the proposed move to Environmental Permitting Regulations (EPR) for biosolids recycling leads to uncertainty over permit conditions and may impact operational flexibility of the current pathway.
Industrial Emissions Directive (IED) implementation at AD sites	The transposition of the IED under EPR and the late issuing of guidance from the EA has led to uncertainty over permit requirements to ensure compliance for example, specification of secondary containment, return liquor sampling and final biosolids cake storage.
Emerging contaminants	Potential limits on emerging contaminants remain unknown e.g., risks posed PFAS type chemicals, microplastics and anti-microbial resistance - this is covered further in the 'Landbank' section. This may impact on the chemical standards for biosolids and again whether it remains appropriate for current uses.

3.6. Environmental

Climate change mitigation

Wetter winters and more summer storms will change the nature of the loads and flows into our treatment sites, requiring adaptive approaches to mitigate risk, these can seriously impact the volumes of sludge arisings being captured as well as the quality of this sludge. Climate change events (particularly greater flooding) will also impact our ability to access farmland for our biosolids to be recycled.

As part of our environmental ambition, we're aiming to reach net zero carbon emissions and we've been involved in developing the sector's roadmap to commit to zero emissions ahead of the UK government's national zero carbon goal.

The Ofwat Net Zero principles position paper[13] expectation is that reducing emissions should be the focus before offsets are considered. Many of the process emissions associated with sludge treatment facilities will continue to be addressed by the IED permitting with related Emission Limit Values (ELVs), but there is a need to ensure further solutions that have a positive carbon impact on the environment are considered across our business. Bioresources can play a significant role in either reducing process emissions or increasing the biogas produced and utilising it into technologies with better carbon footprints (e.g., Combined Heat and Power or Biomethane upgrade/Gas to Grid).

Landbank

Our aim is to continue to recycle our treated sewage sludge to agricultural land as it is a cost-effective solution from our perspective – compared to other alternatives such as incineration or landfill - but also for the farmers we work with as it provides them with useful nutrients (Nitrogen, Phosphorous, Sulphur and micronutrients), a source of organic matter and reduces their reliance on expensive and less sustainable inorganic fertilisers (Appendix 1). However, this agricultural land is not owned or controlled by us, and we are dependent on farmers choosing to use our product. We expect to see more pressure/restrictions on agricultural land recycling (i.e., less land available for our biosolids) which would lead us needing to seek alternative disposal outlets in the future. The main drivers are:

- **Competition:** Sludge is not the only organic based fertiliser that is available to farmers. Markets already exist in composted green waste and from commercial AD plants that receive food or commercial wastes. We expect to see significant capacity growth in these products between now and 2035. To mitigate this currently, we operate under the Biosolids Assurance Scheme, a UK wide standard, to give the farming community confidence that our biosolids are produced with a minimum standard in compliance with all the relevant legislation. We have remained 100% compliant with this scheme.

- **Change in regulation:** We, along with the wider industry, are fully supportive of the objectives of the Reduction and Prevention of Agricultural Diffuse Pollution (England) Regulations, more commonly referred to as Farming Rules for Water (FRfW)[14], which were introduced in April 2018, and which manage diffuse pollution from agriculture including nutrient management and planning. To this effect, since Autumn 2020, there has been a greater focus on restricting applications of biosolids in the autumn (aiming to reduce nitrogen losses) and the frequency of further applications (aiming to reduce phosphorus losses).

  National targets have also been set to reduce Phosphorous and Nitrogen contributions from agriculture to the water environment and in addition, tighter discharge consents as per the Water Industry National Environment Programme (WINEP) will lead to greater sludge production and increase the P content of the biosolids.

  In addition, the uncertainty over the regulators' (EA/DEFRA) interpretation of Rule 1 (highlighted in Table 4), which imposes restrictions on the timing of organic manure applications and would affect the spreading windows and application rates of biosolids to land by effectively banning most biosolids applications in late summer/autumn, which contributes to approximately 75% of our application.

  As an industry, we have been working closely with the EA throughout AMP7 to mitigate some of the risks associated with the autumn spreading ban through the development of the BAS Standard Package of Measures to Benefit the Environment, also known as '20 measures', to meet the outcome focussed objectives and written requirements of the FRfW. The water industry committed to recycle biosolids to land in England in compliance with these measures from 1st July 2022.

Due to a statutory guidance note issued by DEFRA in June 2022, the EA are not currently enforcing Rule 1 of the FRfW but this may change as a review is planned for 2025 and would result in further restrictions to agricultural recycling from AMP8 onwards. Because of the perceived significance of the above risk on access to landbank for our Biosolids, the industry decided to collectively assess the impact of Farming Rules for Water at national level through a National Landbank Assessment.

More information about the parameters of the scenarios tested and detailed results from this National Landbank Assessment are discussed in our SRN43 WINEP Bioresources Cake Storage Enhancement Case as well as our SRN21 Advanced Digestion Cost Adjustment Claim for Ashford & Ham Hill. The assessment confirms that under the current application of FRfW, there is enough landbank available for the industry's biosolids production. However, as highlighted by the national landbank modelling assessment, if Rule 1 were to be applied, there is likely to be insufficient available agricultural land for all biosolids produced in the UK, forcing the industry to seek alternative outlets such as landfill or thermal destruction technologies (e.g., incineration in the shorter-term)

- **Emerging Contaminants:** There is a need to understand where emerging contaminants (e.g., 'forever chemicals' such as PFAS, microplastics etc) are coming from, their fate during and after treatment and how to reduce them at source. Under the Environment Agency's Sustainable Sludge Strategy, understanding the risks attributed to novel contaminants (including persistent organic pollutants, antimicrobial resistance and microplastics) potentially present within biosolids is also highlighted. The chemical complexity of our current biosolids production and the potential environmental impact from new hazards is undergoing further evaluation by the Environment Agency which may also constrain our ability to rely on the agricultural landbank in the future. The outcomes of the Chemicals Investigation Programme Phase 3 (CIP3) and subsequent programme of investigations (CIP4) will have implications on bioresources management and use in the future, as will the forthcoming, to be confirmed Chemicals Strategy as highlighted in **Table 3.**

- **Impact of infectious diseases and pests**: Whilst the multiple barrier approach (e.g., controls on sewage sludge treatment and biosolids use) in the Safe Sludge Matrix and more recently the BAS, provides robust protection against pathogenic microorganisms, the impact of any adjacent disease outbreaks (e.g., foot and mouth outbreak) could impact on the timing and availability of the land outlet for recycling.

3.7. Internal drivers

Affordable Services

We need to provide all of our services to our customers for a price that is affordable to them. This means we must ensure that we can run stable, efficient and sustainable services going forward. As a business we have conflicting pulls on our funding, and therefore we have to make decisions as to where we spend the money to make the best investments for all our stakeholders; this often means we have to phase the implementation of the selected solutions and sometimes cannot deliver all the improvements we would like to do.

Skills & Capability of Staff

Sludge treatment technology is moving away from simpler processes, such as lime stabilisation, that are easily managed to those that are more aligned to other process industries i.e. thermal hydrolysis. A change in the skills and capability of staff is needed to manage these processes effectively, especially in the future when technologies such as Advanced Thermal Conversion (e.g. pyrolysis or gasification) become more widespread.

Limited options

We currently have two solutions for the disposal/recycling of sludge – land recycling or 3rd Party trading. This provides the business with a significant risk and a more balanced portfolio of options is required to manage this risk. Opportunities such as dried sludge as a fuel, thermal disposal and resource recovery, will help to address this issue but adequate time and capital to develop and implement will be required.

4. Options assessment methodology

This section summarises the options assessment methodology and sets out the screening process/decision making framework that was used to come up with a list of feasible options. The options assessment was carried out in parallel with the development of the long-term strategy with a focus on AMP8 in preparation for PR24. The WINEP related solutions have been selected following the EA's specific guidance set out in the WINEP Options development guidance. Some aspects of the work – especially Stage 2 of the WINEP (Identification of Risks and Issues) - were carried out in collaboration with the rest of the industry.

4.1. Technology appraisal

A number of technologies could be employed to treat sewage sludge and achieve our wider bioresources strategy objectives.

Early on at the beginning of AMP7, a high-level qualitative assessment was carried out to start better understanding the opportunities and limitations of several key technologies. These are summarised in **Figure 3** below:

Figure 3: Early qualitative assessment of sludge treatment options

Sludge Treatment Options	Security of final outlets	Ease of promotion	Social & Environmental Impacts	Adaptive Pathway	CapEx
Conventional Digestion (Current) Lime stabilisation AD Sludge Cake (Biosolids)	• Risks of non-compliance for agriculture use mitigated by expensive & non-sustainable methods • 85% volume reduction	Well understood and widespread concept	• Odour • Vehicle movements		
Advanced Digestion (AAD)	• Enhanced product, compliant for agriculture use • 90% volume reduction	Well understood and widespread concept	• Contained odour • Reduced vehicle movements • Higher C footprint (vs. Conv. Dig)		
Advanced Thermal Conversion (ATC) Biochar	• High potential product (Biochar) • 99% volume reduction • End of Waste classification for output(s) to be obtained	Not yet well understood and regulated concept Interest from EA	• Significant reduction in vehicle movements • Potential for C sequestration	Synergistic with Advanced Digestion	TBU
Incineration Ash	• Inert material (ash) with some potential • 99% volume reduction • No landbank required	Challenging/lengthy permitting & planning processes	• Significant reduction in vehicle movements • NIMBY • Significant C footprint		

In order to develop this piece of work further. We undertook a thorough technology appraisal exercise, with the help from 3rd party consultant, [redacted]. The first step included an online questionnaire to canvas opinions from a range of stakeholders within the business as well as other independent bioresources practitioners, from across the end-to-end value chain. The multidisciplinary specialities of the panel engaged ensured a meaningful range of views and priorities could be captured.

The questionnaire requested stakeholders to rate each technology below (further details in **Appendix 3**, including additional technologies considered but not retained in the survey) against a set of criteria.

- Mesophilic Anaerobic Digestion (MAD) also known as Conventional Anaerobic Digestion (CAD)
- Advanced Anaerobic Digestion (AAD)
- Lime Stabilisation
- Thermal Treatment - incineration
- Thermal Treatment - advanced thermal conversion (ATC)
- Drying

- Drying and pelletizing
- Composting

The criteria considered as critical success factors which were used to rate the technologies short-listed included:

- Alignment with our corporate strategic objectives
- Associated Carbon impact
- Reference Facilities Available
- Confidence in producing a compliant biosolids
- Innovation
- Cost (CapEx, OpEx and whole life cost)
- Complexity of operation
- Deliverability within programme
- Constructability (permitting, planning, land take)
- Ability to adapt to load fluctuations (Modular build)
- Environmental and Customer Impact (emissions, noise, odour, vehicle movements)
- Operability and Maintainability (availability of consumables, spares, chemicals)
- System Availability (shut downs etc.)
- Energy generation potential
- Resource recovery potential

The results of the questionnaire (Raw Score in **Table 5** below) showed Advanced Digestion technology as the technology rated with the highest score against the agreed set of criteria and incineration rating the lowest. In order to stress-test the rating of the technology suite, a multi-criteria assessment workshop was planned, facilitated by the consultant, [redacted], and attended by all relevant stakeholders from across the business. The criteria were weighted by all participants independently to add more granularity and confidence in the ranking of the technologies. The criteria given the most weight were the associated carbon impact of the technology and its ability to produce a compliant biosolids. When the weightings were applied to the raw scores, no significant changes in the overall process selection were observed (see Weighted Score in Table 5), with AAD remaining the preferred solution and incineration the least preferred.

The weightings were further reviewed collectively to understand how they aligned with our corporate strategy. The consensus was to increase the weighing for 'Environmental and Customers impacts' so that it would be at least comparable with 'Biosolids Quality'. Once again, the moderated scores (see Moderated Score in Table 5) showed no significant changes in the overall process selection, with AAD still being the preferred solution (however thermal hydrolysis process (THP) was now the preferred option) again with incineration the least preferred. The heating, pasteurisation and hydrolysis process (HpH)[15] and THP AAD systems scored very closely throughout the process.

Table 5: Technologies ranking based on different types of scoring

	Raw Score	Weighted Score	Moderated Score
Advanced Anaerobic Digestion (AAD) - thermal hydrolysis (THP)	2	2	1
Advanced Anaerobic Digestion (AAD) - HpH system	1	1	2
Mesophilic Anaerobic Digestion (MAD)	3	3	3

Advanced Anaerobic Digestion (AAD) - pasteurisation (PAS)	4	4	4
Composting	6	7	5
Drying and pelletizing	5	6	6
Thermal Treatment - advanced thermal conversion (ATC)	7	5	7
Lime Stabilisation	8	9	8
Drying	9	8	9
Thermal Treatment - incineration	10	10	10

In summary, the conclusions of the technology appraisal were:

1. Overall AAD is the technology with the highest ranking across the various scores
2. Whilst requiring low capital investment, our current lime operation is not sustainable, has known limitations (e.g., odour complaints) and does not enable us to extract the maximum possible value from our sludge
3. AAD and drying are understood to be the best technologies to ensure biosolids is consistently produced to highest bacteriological standards, which will reduce the impact of the landbank challenge. However, we are reluctant to reinvest in dryer technology based on our own previous experience (i.e. high energy consumption) and risks related to their operation[16]
4. Incineration & ATC are the only technologies capable of fully mitigating the landbank risk by converting the sludge to an inert material
5. ATC did not score highly in the technology appraisal, due to uncertainty of the technology readiness level, however it did score significantly higher than incineration and therefore was deemed a more preferrable thermal disposal option. As such ATC was evaluated further as it offers an alternative outlet to land recycling and has the potential to fully mitigate the risks associated with this outlet.
6. Local planning for incineration is known to be a challenge[17] and our customers feel this would be a step back for SWS (**Appendix 4.b**). It is a well understood process but it is also known to be expensive, partly due to the low resource recovery potential

4.2. Cooperative work with Water Industry

We have worked collaboratively with other WaSCs, the Environment Agency, Ofwat and other stakeholders to identify the common issues, and potential solutions, that are being faced by all companies. These have included various WaterUK groups (e.g.,Biosolids Network, IED Task and Finish Group) and numerous projects and working groups including the Water UK Bioresources Strategy for England, PR24 Bioresources WINEP Issues, Ofwat econometric model develop group, Market development group, Business In the Community (BITC) – Optimising Bioresources[18] etc.

In doing so we have identified common environmental risks and issues that need to be addressed, along with potential options to solve them. This has included identifying where action is required to deliver compliance with statutory and statutory plus obligations and has also identified where the activities are not meeting stakeholder expectations and so where non-statutory actions may be proposed the output of these collaborations has been taken account of in considering the appropriate solutions and steps for the development and implementation of our long-term strategy.

4.3. Customers

To successfully implement a long term bioresources strategy it is important to ensure the confidence of stakeholders impacted by the strategy. Farmers for example, the end users of our treated biosolids, are critical in ensuring our strategy aligns with their operation, expectations and future demand. There is also a need to ensure wider stakeholder confidence in the biosolids to land route and with that, continued accreditation to the industry Biosolids Assurance Scheme.

We undertook qualitative and quantitative approaches to our farmer engagement including in-depth interviews and surveys of the farming community operating in our region to gain feedback on the products delivered to them, the benefits and barriers to using biosolids, the positives and negatives associated with the delivery of biosolids, and their needs in order to inform our strategy. We also approached our wholesale water and wastewater customers and asked for their views on this topic as well as on our proposal to invest in more advanced technologies such as Advanced Thermal Conversion.

The feedback received (**Appendix 1.a & 4.a**) from our customers is generally supportive of recycling treated biosolids to agriculture as this avoids extensive use of manufactured fertilisers that can harm the environment; is a good source of organic matter and nutrients. However, our customers are mindful that this product should not be damaging to the environment / soil when compared to traditional inorganic fertilisers. It is primarily external factors that would prevent the future use of biosolids by farmers – this includes regulatory constraints, phosphorus levels in the soil or restrictions on certain soil types. These stakeholder concerns therefore have the potential to impact the longevity of the agricultural outlet without further investment to improve the product quality to make it more consistent, less odorous, and drier (to make application to land easier) which makes it more desirable and better received by our farmers.

We outlined the potential implications of regulatory developments on our current operation and especially the impact of the Farming Rules for Water on the availability of the landbank to recycle our biosolids. Our customers broadly felt that changes in regulations are a positive step in order to protect the environment. However, if a significant proportion of our biosolids cannot be recycled to agriculture, the fall-back solution in the medium-term for the industry is the development and implementation of incineration plants. . Understandably, our customers expressed concerns that this feels like a significant backwards step especially in an era of climate changes, requiring the need for more sustainable solutions (**Appendix 4.b**).

5. Solutions

To help shape our long-term strategy further, we use our Decision Support Tool (DST) provided by [redacted]. The model called Decisio is a digital simulation of our Bioresources operation and can provides connected AI-optimised decision recommendations by analysing a vast array of potential scenarios. Critically, these decision recommendations are not made in isolation but are connected, ensuring coordination across planning and execution time horizons. The impact of internal and external operational events is also considered to ensure both the short- and long-term implications are considered, and optimal adjustments recommended.

From our operation perspective, the model includes:

- Movement of raw liquid and cake sludge from wastewater treatment plants to STCs
- Treatment of the sludge (including – but not limited to - biogas production and usage, incentives, cost of commodities cost of maintenance)
- Recycling of our biosolids to agriculture (or further treatment)

It also contains capital expenditures (cost curves) for existing key assets such as dewatering, thickening, digestion facilities but also technologies which are new to us such as AAD or incineration. Other key assets data such as availability, efficiency and age have been integrated into it. Carbon data is also available within the model as it uses the latest version of the Carbon Accounting Workbook[19] (CAW) to estimate carbon emissions (Scope 1 and 2). With this extensive amount of information, when operated, the model is left to decide what investment the operator should make over a 25-year period whilst targeting the lowest TotEx.

It is worth noting the model does not understand limitations such as space constraints on site, difficulty of access to sites or availability of fleet to move sludge around.

The model was first calibrated using latest Annual Performance Report (APR).

The first unconstrained version of our model suggested that our current operation (Conventional Digestion followed by liming or maturation) was the most cost-effective option under current conditions. This not surprising as, although the cost of chemicals is significant, the capital costs involved with lime plants is minimal. However, as described in **Section 4**, we do not consider liming as being a sustainable form of treating our sludge and believe it needs to be replaced with more advanced types of treatment.

5.1. AMP8 Solutions – AAD in Kent

We concentrated part our plans for AMP8 on our Kent region as we consider our operation in this area as being the most challenging with:

- Minimum headroom available, especially in winter periods where decommissioning digesters for routine maintenance is not always possible
- Older key assets in operation compared to other regions, resulting in poor performance
  - CHP engines with an average age of 13yo vs 10yo for other areas
  - Dewatering facilities with an average age of 21.1yo vs 18.6yo for other areas and containing the 2 oldest assets at 29yo
  - Digestion facilities with 2 digesters likely to need to be fully refurbished within the next 5 years

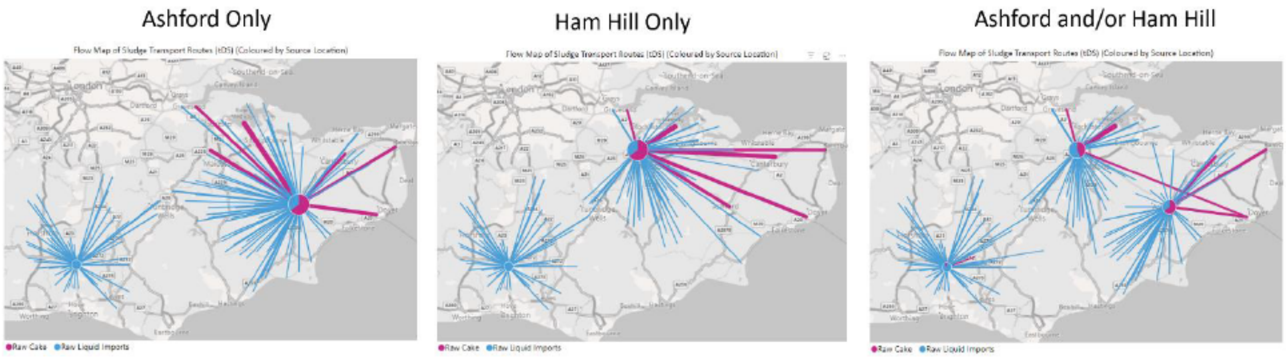
- Greater potential for consolidation of sites as 7 STCs are currently in operation, some of them less than 10 miles apart

As it was decided that liming or maturation were no longer sustainable option for the treatment of our sludge, a new baseline was created which included the implementation of secondary digestion as a mean to ensure the biosolid produced was compliant to relevant standards. Physical constraints were also introduced as some sites lack space or are located on Sites of Special Scientific Interest where significant changes would be challenging to implement. The baseline was compared against AAD with two specific locations selected after various iterations of the model:

- Ashford (South-Kent) is our largest site in Kent with adequate space for additional plants with the view to consolidate Canterbury
- Ham Hill (North-Kent) has significant space available on site to become a much large hub with excellent vehicle access with the view to consolidate Aylesford, Gravesend, Motney Hill & Queenborough

Table 6 summarises the results obtained when testing the Kent model in the Best Likely conditions, where landbank availability has been slightly reduced to account for recent tightening of regulations (Scenario 3 of **Appendix 5**). Sensitivity analysis was carried out to understand the impact of carbon (either without or at its current valuation) as well as how different AAD configuration would influence the decision (either Ashford AAD only, Ham Hill AAD only or both sites as AAD – a snapshot of the resulting sludge movement available from the Decisio model is shown on **Figure 4**).

Figure 4: Sludge movement for different AAD configurations (Decisio)



In this scenario, no significant difference was observed between the baseline and the AAD single site options when price of carbon is not taken into consideration. However, all AAD options becomes more attractive when price of carbon is integrated into the calculation. In this case, there is also no significant difference (£320k pa) between the 2 sites AAD option and the Ashford only option, which is essentially the cost for better resilience.

Table 6: Best Likely case

Over 25y	TOTEX (£m)	TOTEX (incl. Carbon) (£m)
Baseline (Secondary Digestion)	1,765	2,093
Ashford AAD Only	1,792	1,881
Ham Hill AAD Only	1,798	1,891
Ham Hill & Ashford AAD	1,801	1,889

Table 7 summarises the results obtained when testing the Kent model in the Most Likely conditions, where landbank availability has been dramatically reduced to account for impact of the full implementation of Farming Rules for Water (Scenario 4 of **Appendix 5**). The value carbon prices used for the sensitivity analysis in this instance is the projected value for 2030[20].

Table 7: Most Likely case

Over 25y	TOTEX (£m)	TOTEX (incl. Carbon) (£m)
Baseline (Secondary Digestion)	2,069	2,413
Ashford AAD Only	1,764	2,038
Ham Hill AAD Only	1,774	2,058
Ham Hill & Ashford AAD	1,799	2,073

In this scenario, regardless of the carbon prices or the site configuration, the AAD option is the most favourable option. Whilst the Ashford AAD option only comes systematically as the most favourable option, the TotEx impact of having 2 AAD sites in operation in Kent is minimal (£1.4m pa) compared to the added Operational resilience it would provide.

Based on the above, the preferred solution is to consolidate our 7x AD sites in Kent into two large AAD facilities in AMP8 (Ashford and Ham Hill), as developed further in our Cost Adjustment Claim for Advanced Digestion (SRN21) for Ashford and Ham Hill. This will restore resilience in the area, ensure biosolids compliance is achieved through a sustainable operation, increase energy production and enable economies of scale in delivery and operations.

Whilst AAD process still produces a cake which will need to be sent to agriculture, the quality of the cake is better compared to conventional processes (drier, easier to manage and store). It can also be applied on a wider range of crops which would help mitigate the increase pressure on the landbank in the short to medium-term.

As described in more detail in our SRN37 IED Enhancement Business Case, the consolidation of a number of our sites would also avoid expensive upgrades to comply with IED requirements, at sites where AD would cease (please see further details in Industrial Emissions Directive section below).

5.2. AMP8 Solutions – Cake storage & asset base resilience

In parallel of the conversion of our Kent region to AAD additional cake storage will be provided across all regions to ensure we have adequate storage capacity that is resilient to seasonal fluctuations in demand and weather that is not favourable to land stockpiling/spreading activities. This additional storage described in detail in our SRN43 WINEP Bioresources Cake Storage Enhancement Business Case will also help minimise operational impact in the eventuality that our ability to recycle to land will be significantly hindered (Scenario 4 as described in **Appendix 5**).

In addition to the enhancement schemes discussed above, we believe a significant improvement of our asset is required. As discussed in **Sections 2 (Current Operation) & 3 (Risks)**, our operation lacks resilience and whilst our strategy is implemented over the next AMPs, we need to ensure our assets can reliably operate until more significant changes can take effect. As part of our BOTEX (SRN19 Botex Technical Annex), we will take a very targeted and system-wide approach to ensure our asset replacement programme is fully integrated with our Strategic changes.

5.3. Industrial Emissions Directive

The Industrial Emissions Directive (IED) takes an integrated approach to controlling pollution to air, water and land, and aims to prevent and reduce harmful emissions by ensuring industries operate under Best Available Techniques (BAT). We fully support the intentions of the IED. However, due to changes in guidance and the approach being taken in assessing permit applications, the scope and scale of the improvements required to comply with permit conditions has increased beyond what was previously communicated and hence significant investment is now required. To this effect we have included an SRN37 IED Enhancement Business Case as part of our PR24 submission. This will enable us to:

- deliver associated improvements necessary to achieve compliance and provide protection to the environment and human health
- address the risk of industrial emissions due to the biological treatment of sewage sludge at 16 sites to successfully achieve permit determinations to continue to operate these facilities
- reduce the risk posed due to fugitive emissions to atmosphere and from the risk of spillages to land and water due to loss of structural containment and spillages.

The scope is very divers and includes containment solutions (incl. containment walls & impermeability of soils), covering of tanks, improvement of odour control units, improvement of inspections & monitoring (incl. leak detection).

5.4. Future AMPs solutions

Following the work planned for AMP8, the core pathway of our long-term strategy will be focused on continuing our transition to AAD and further consolidation of our sites, where relevant. Building upon the learnings from AMP8, we expect this to be fully completed within AMP9/10. Whilst further modelling is required to fully confirm the location of these sites, some early work has already highlighted some potential locations, as presented on Figure 5.

In terms of biogas use in AMP8, the current regulatory landscape is steering us away from Biomethane upgrade and injection to the grid (see **Appendix 6**). We conducted a cost benefit assessment of Biomethane Upgrade vs CHP following OFWAT's publication of the PCs for Green House Gases for Ham Hill. Whilst the study showed that choosing Biomethane injection over CHP will delivers 100kTCO_2 reduction over the 20y M&E asset life of the Ham Hill example, this would also result in an additional £1.4m annual cost compared to CHP. This is because under the current set-up for new Biomethane plants, whilst we would be allowed to forgo the value of biomethane RGGOs (Renewable Gas Guarantees of Origin) for exported biomethane and claim GHG PC incentives, we'd also have to lose the subsidy. For this reason, our strategy for AMP8 will carry on with implementation of Combined Heat & Power engines for our biogas use We will continue to monitor any changes and opportunity that may arise.

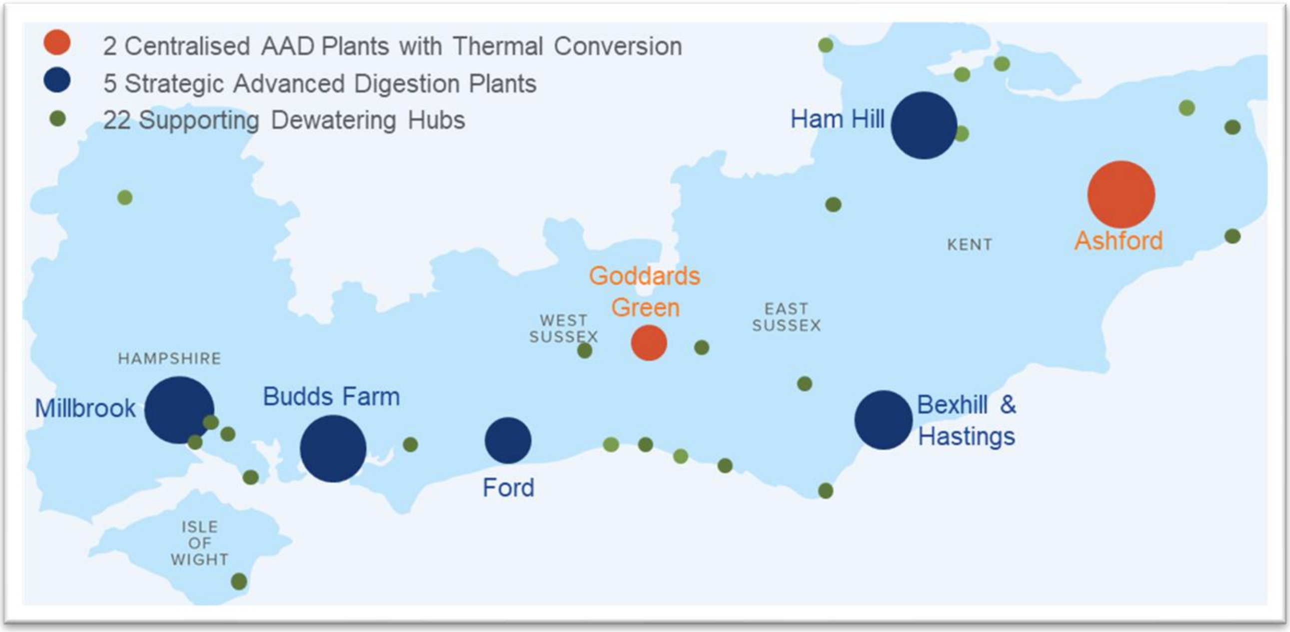
Whilst transitioning to AAD will put us in a much stronger position from a landbank challenge perspective, the process will still produce a biosolids which will need to be managed. Our core pathway assumes that – even though we'll have to travel further to find suitable land – we will still be able to recycle our product to agriculture at least until 2040-2050. Following this, alternative routes would need to be used. As described in **Section 4**, the only technologies which would enable us to achieve this are Thermal Destruction processes – either incineration or ATC (e.g. Pyrolysis or Gasification for example). Our preferred option in this scenario would be to develop and implement ATC as - although it is not as proven as incineration in our industry - it has the potential to offer more attractive benefits[7]:

- Resources with potential phosphorous recovery from the ash-like product called biochar
- Additional energy generation (including fuels – hydrogen)
- Reduced operational carbon with long-term pyrogenic carbon sequestration in biochar

Our experience and industry research[21] suggest that ATC type of technology would also fit well if installed at the back of AAD process with a well-integrated mass & energy balance as a result of the flowsheet.

Our plan is to build upon the various studies, horizon scans and technology appraisals available and look into assessing the benefits, opportunities and limitation of this concept at smaller scale in AMP8, with the view to start implementing at full scale at one (or more – see **Figure 5**) of our sites in AMP9/10. We know other WaSCs are also interested in understanding this concept further, we believe a joint effort - at industry level - would enable us to test a wider range of technologies and conditions to make a more informed decision moving forward. There is an opportunity to engage in that space through the investigation work undertaken under the WINEP driver for microplastics. The current submission includes an allowance for testing of ATC type of technologies in AMP8 in collaboration with the rest of the industry. It is worth noting that the choices presented above are only indicative and subject to more detailed site level analysis.

Figure 5: Potential future Bioresources system



5.5. Adaptive planning

As per **Sections 3 & 4** (as well as the Bioresources section of our SRN12 Long-Term Delivery Strategy Technical Annex), should the restrictions in landbank happen quickly or in the very short-term (for example within the next 5 to 10 years), the only current option to us in the very short term would be landfilling. This option is not sustainable as it does not generate any value from our biosolids. It is also likely that landfill sites will be unable to accept significant volumes of sludge generated by all WaSCs in England, which is likely to increase costs of disposal dramatically. It is also incompatible with DEFRAs objective for “near elimination of biodegradable waste disposal in landfill from 2028” which has been supported by the landfill tax (levied on materials containing organic matter) since 1996[22].

We modelled the potential impact of the above using our DST and it suggested an alternative pathway, as more than 2/3 of our sludge would need to be processed through Thermal Destruction type technology as an alternative to landfilling. Incineration is the only technology market ready at appropriate scale at present. However, we understand obtaining approval for implementation (e.g., planning permission) can be a challenge. It is also worth noting it is ranked consistently the worst on our qualitative analysis and our customers consider this would be taking a backward step (**Appendix 4.b**).

Should these restrictions come into force in AMP8 for example, the uncertainty mechanism discussed below would be triggered and would enable us to start design and planning work in AMP8, with the view to have functioning unit(s) built potentially in AMP9.

It is worth noting that the work undertaken in AMP8 as part of our core pathway is a no-regret solution as it is very adaptive depending on the size of the issue. Current projections (**Appendix 5**) suggest we will still be able to recycle a proportion of our biosolids to agriculture, especially if it is of good quality and can be used on a wider range of crops (i.e., AAD biosolids). However, in the extreme case of a complete and total shut-down of the landbank, this same biosolids could still be incinerated.

Ultimately the decision to curtail or prohibit biosolids recycling to land is out of our direct control. We will continue to work extensively with regulators, scientific advisors, technical consultants, and other WaSCs to bring the discussion to a constructive conclusion.

5.6. Uncertainty mechanism

As discussed above (**Section 3** – Environmental and in **Section 5 -** Landbank Risk Mitigation), because of the uncertainty surrounding the full application of Rule 1 of the Farming Rules for Water, including its timing and impact, we are keen to put an uncertainty mechanism forward (**Table 8)**. Further information can be found in our SRN58 Uncertainty Mechanisms Technical Annex.

Based on the national landbank modelling assessment (**Appendix 5**) discussed further in our Cost Adjustment Claim (Ashford & Ham Hill AAD) as well as the Bioresources Section of our WINEP Enhancement Business Case suggests c. 2/3 of our sludge would need to find an alternative route, other than recycling to agriculture.

The short-term solution would be to send our biosolids to landfill whilst we start developing our plans for thermal destruction type of technologies (e.g., incineration) in AMP8 (design, planning), with the view to start construction in AMP9.

The estimated value of the uncertainty has been calculated at high-level as follows:

- The cost to landfill 2/3 of our sludge has been modelled to increase our yearly OpEx by about £12.5m pa in AMP8
- If 2/3 of our sludge would need to be eventually incinerated, the high level CapEx for such plant has been estimated to about £200m. Assuming typical 10% of this cost would be required in AMP8 to start design and planning process (as indicated by our internal design team), the estimated cost in AMP8 would be £20m

Table 8: Uncertainty mechanism summary

	Value in the business plan	Estimated value of uncertainty across AMP8	Price Control affected	Date of uncertainty determined
Reduction and Prevention of Agricultural Diffuse Pollution (England) Regulations, more commonly referred to as Farming Rules for Water (FRfW)[9]		£82.5m	Bioresources	2025

Note: the estimated value of uncertainty is calculated as follows: 12.5 (£m/y) x 5 (years of AMP8) + 20 (£m) = 82.5 (£m)

6. Review of Market Opportunities

The bioresources regulatory pricing landscape is evolving; separate price controls for bioresources were introduced at PR19 because of Ofwat's drive to develop a competitive market for bioresources (sewer and wider organic waste market) and greater scrutiny of sludge treatment costs.

Historically, all funding of investment in Bioresources was through the regulatory price control route (econometric models for botex, growth and enhancement cases) but recently, OFWAT have explained that the econometric models are being revised to include botex and growth funding. Given the current financial constraints around the affordability and financeability of our plan plus the uncertainty around inflation, we do not believe that our required investment will be delivered in totality from the regulatory models and will likely require market delivered solutions.

We are looking at alternative mechanisms that are available to us to ensure the appropriate solutions presented above are implemented to mitigate the risks and seize opportunities highlighted. These alternatives mechanisms include six potential market opportunities as described in Jacobs' Bioresources Market Review[3] commissioned by OFWAT in 2021. Each come with their own benefits and constraints and provide opportunities to fund the implementation of our proposed strategy.

To support the market development to deliver solutions for the transport, treatment & disposal of sludge we have published our Bioresources bid assessment framework[23] as per Ofwat's guidance. The document clearly sets out our expectations and the process we will follow to assess any opportunities arising.

6.1. Headroom trades

Whilst our bioresources market information published on our website have reported no headroom or tradable capacity availability, we have continued our dialogue with neighbouring Water and Sewerage Companies (WaSCs). This includes Thames Water and Wessex Water on an ad-hoc basis to maintain understanding of their available capacity and need for additional treatment services at specific times, especially when significant reactive or planned maintenance work needs to be undertaken at a specific location. **Table 9** summarises the amount of sludge traded between Southern Water and neighbouring WaSCs over AMP7. We are a net exporter which is consistent with figures stated in Market Information records.

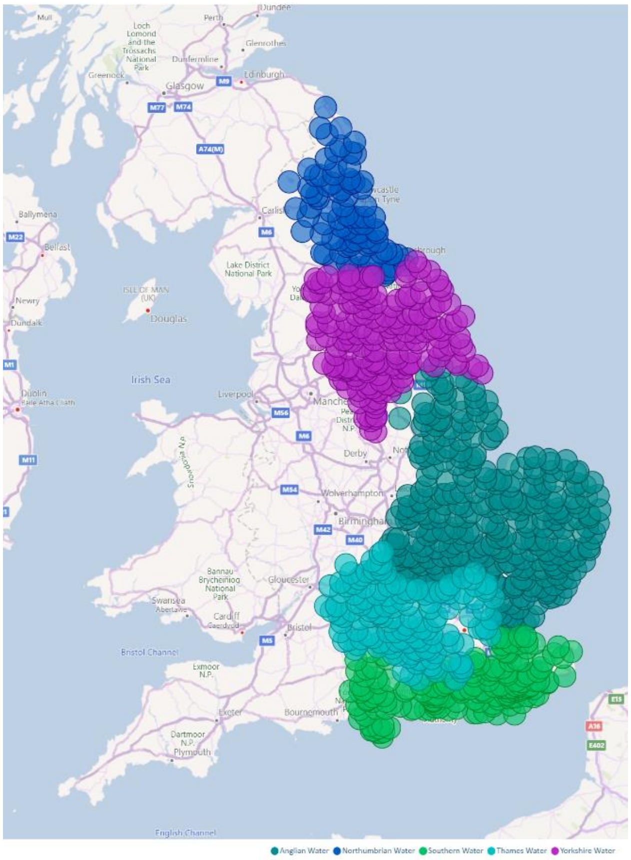
Table 9: Sludge traded with neighbouring WaSCs on ad-hoc basis (TDS pa)

	2020/2021	2021/2022	2022/2023
Wessex Water to Southern Water	0	0	114
CSG to Southern Water	0	6	6
Total Import to Southern Water	**0**	**6**	**120**
Southern Water to Thames Water	0	0	60
Southern Water to Non-appointed waste company	18	17	99
Total Export from Southern Water	**18**	**17**	**159**

Wessex Water and ourselves now have formal Intercompany Resilience Agreement in place (**Appendix 7**). In the interests of cost efficiency and maintaining essential services both parties have recognised the benefit in providing non-exclusive contingency support in the event of a loss of capacity for wastewater sludge treatment. Such support can reduce the need for unilateral capacity increases to deal with contingency situations, provide greater flexibility in managing temporary asset downtime and provide greater levels of resilience.

In 2022, we took part in the OFWAT Water Innovation Breakthrough project lead by Anglian Water and Business Modelling Applications which looked at Unlocking Bioresources Market Growth and assessed the potential opportunities for sludge treading as well as joint investment. Participation from companies such as Northumbrian Water, Yorkshire Water, Anglian Water, Thames Water and ourselves allowed for a useful assessment of opportunities across a significant North-East / South-East axis, including London (**Figure 6)**.

Figure 6: Geographical locations of all WaSCs and respective sites included in Market Trading Assessment



The work which was presented to OFWAT and the Environment Agency in July 2023 suggested that without applying any stress to the system (e.g., restriction to the landbank, higher capital costs or carbon impact), headroom trades offer negligible benefits across the region tested for companies' customers. The data showed that about 10% of the total sludge produced across the region tested would benefit from trading (a higher 30% for Southern Water, with trading centered around Southern Water's northern border with Thames Water), this would only result in a reduction of the average cost of managing sludge from [redacted]. It is worth mentioning that the costs presented are currently purely operational and do not include – for example - risks and any other overhead costs companies are likely to include into their gate fees. The model also assumes an idealised solution approach where all companies work as one well integrated system.

This specific analysis resonates with our current strategy regarding headroom trading which essentially focuses on ad-hoc cross-border trading, based on our specific requirements at any given time, or to support a neighbouring WaSCs if our operation allows. However, we appreciate some future demand could be met through cross border trading hence our support to build on this work and open the assessment to additional water companies to highlight full benefits across the UK.

6.2. Joint capacity

Discussions are on-going with Thames Water for potential sludge cross-border trading with inclusion of additional joint capacity. As the resilience and headroom of our assets is a challenge in our Kent region, there could be an opportunity to use some of the spare capacity in their South-East London sites in the short to medium-term, especially as start our conversion to AAD in that region. This trade would however require significant additional capital expenditure to increase the capacity of key assets pre- and post-digestion facilities as they are currently constrained. This would also increase transport costs and sludge would need to be driven into London area to be treated and back again to be disposed to land. Potential gate-fees are still being assessed and to this date, no formal agreement has been discussed. An important point to consider would be the management of the resulting biosolids post-digestion treatment if the landbank challenge materialises and it becomes impossible to dispose of the sludge through agricultural routes.

The potential of building joint capacity between WaSCs was also considered as part of the Unlocking Bioresources Market Growth project discussed above. The scenarios tested were as follows:

1. Baseline – Current operating context
2. 80% asset availability across all companies
3. Closed landbank
4. High capital costs (2x compared to scenario 1)

Results are summarised in **Table 10**. For all scenarios, the difference in resulting operating costs between allowing the model to build joint capacity ("Open" network) or not ("Closed" network) is less than 2% which is quite negligeable considering no risk, overhead or any other fees have been included in the unit cost for the open network option.

However, the benefits could be in the Capital Expenditure avoided by allowing the model to build joint capacity. Whilst the benefits are minimal for scenario 1 (Current Operating Context), the difference becomes more prominent once limitations or stresses are added to the model. Whilst Scenario 2 highlights a higher CapEx avoidance benefit, we don't believe it is realistic as it seems unlikely all companies included in the model would have their asset availability reduced so significantly all at the same time.

However, results for Scenario 3 are particularly interesting in the context described in **Sections 3 (Risks) and 5 (Solutions and Long-term Strategy).** The CapEx avoided is mainly focused on incineration assets. This aligns with our view (as well as the industry's to some extent) that because of the new need created by the landbank challenge, implementation of Thermal Destruction technologies (either incineration or ATC, depending on the timeline) would benefit from a UK-system approach, rather than isolated, uncoordinated approach.

Table 10: Joint capacity opportunities

Scenario	End-to-end Fully built Unit cost (£/TDS)		CapEx avoided (£m - over 15y)
	Closed	Open	-
1. Baseline	307.5	306.6	10.8
2. 80% asset availability	323.2	317.0	82.4
3. Close landbank	340.4	335.6	63.5
4. High capital costs	313.3	310.3	40.0

6.3. Co-treatment

We have identified limited opportunities for co-treatment with other organic wastes (e.g. food waste) which can be hindered by the differing regulatory regimes and further restrictions related to applying treated biosolids to agricultural land as a result as sewage sludge is not currently an accepted feedstock under PAS110 which sets the standards for digestion of organic wastes and use of treated digestate. However, we continue to engage with the Environment Agency in developing their Sustainable Sludge Strategy which may address some of these barriers. We had been anticipating the publication of this strategy in 2023, but the publication date has recently been deferred to an unknown date in the future.

Albeit the regulatory barriers, sludge is usually a less attractive material as it offers limited benefits in comparison to other organic materials (lower solids content leading to lower biogas potential and lower nutrient value for farmers).

Going forward, we will continue to investigate any options with other organic waste specialists within or close to our operational boundaries. In addition to the possible change in legislation discussed above, as our long-term strategy for bioresources develops and potentially moves away from biosolids recycling to agriculture with the emergence of Advanced Thermal Conversion technologies, this would open up our operation to the use of other feedstocks.

6.4. Co-location with other waste processing

A report we commissioned in 2019 highlighted a potential opportunity at our Horsham WwTW raw sludge dewatering facility. The site is located only 4 miles from a commercial facility which has 4.5 MW generating capacity. At the time, it was only operating at 3.5 MW, and therefore had capacity to take more imports. At the time, the option to send sludge was discounted as co-treating our waste with theirs would adversely impact the operator's End of Waste Status. Additionally low Biomethane Potential of our sludge would make it a less attractive feedstock.

However, in 2023, two interested parties have approached us with particular interest in taking a proportion of our sludge to treat it in their facility (usually throughput of up to 10-15TDS per day - up to 5% of our total throughput), especially around our Solent region (near our facility at Budds Farm). Whilst this would allow us to delay potential impact of growth in that region, it will not help mitigate the issue in Kent described above. To this date, although no official contract has been agreed (which is the reason why these companies have requested to remain anonymous), we are keen to progress the discussion and understand some key challenging commercial and compliance issues (e.g. demonstration of duty of care).

6.5. Project finance & outsourcing

One option would be to fund some aspects of the strategy through non-regulated investment, through either our shareholders or a third-party. Non-regulated invested is likely to be more flexible both in terms of the level and pace of investment/benefits required. Further work is being undertaken to explore the non-regulated capital investment options. For significant projects we could look at Alternative Funding mechanisms (akin to Direct Procurement for Customers (DPC) but without the security of the return) as well as wider PFI (Private Finance Initiatives).

Funding options also include the potential for us to outsource through leasing of some (or all) of our STCs to a third-party who would in return invest, build, and operate parts (or all) of our bioresources assets in return for a gate fee over an agreed year term. Whilst this option would shift the challenging task of designing a sustainable strategy for bioresources in the South-East to another entity, we would still retain a 'Duty of Care' and legal obligation for our waste to be managed correctly. We would need to understand how much control we would retain on the level of investment but also on ensuring compliance, Outcome Delivery Incentives (ODIs) and legislations/regulations are adequately dealt with on our sites. Another crucial point to consider when developing the contract between the different parties would be the management of the resulting biosolids post-digestion treatment if the landbank challenge materialises and it becomes impossible to dispose of the sludge through agricultural routes.

To this effect, we have started engaging with the market and discussed our plans for Kent especially Whilst the type of treatment, type of contract and location of the work is left open, based on the information developed throughout this document, our preference would be to convert our operation to more advanced type of treatments (Advanced Digestion and/or Advanced Thermal Conversion), starting in our Kent region.

As we recognise our experience with this type of mechanism is limited, we are in the process of setting ourselves up and gathering required capabilities from a commercial, legal and procurement perspective. We understand the timescales associated with this mechanism are different than our traditional delivery method as a commercial model and contract needs to be agreed ahead of delivery.

6.6. Engagement activities/initiatives

In addition, we have undertaken the following engagement activities/initiatives to stimulate interest from third parties who could provide bioresources services, including:

- As described previously, we have actively been engaged in the OFWAT Water Innovation Breakthrough project lead by Anglian Water and BMA which looked at Unlocking Bioresources Market Growth and assessed the potential opportunities for sludge trading as well as joint investment. Again, this included participation from a number of WaSCs and allowed for a useful assessment of opportunities across a significant North-East / South-East axis, including London.

- We continue participating in Jacobs' Bioresources Market Development Working Group and attend quarterly meetings to discuss potential capacity availability and trading opportunities across the industry.

- We continue working with UK Water Industry Research (UKWIR) to find innovative solutions to mitigate risks and better understand potential new market avenues. As an example, we sponsored the UKWIR project on Converting Sewage Sludge to Biochar which gave an overview of the type of technologies readily available, benefits and limitation of current operations, existing and potential market for Biochar, as well as companies operating in this space. We've used the outputs of this piece of work when engaging with third party service provider to understand appetite to the use of more advanced technologies.

7. Summary

The sustainability and resilience of our current Bioresources operation needs to be improved. It is also unlikely to mitigate some of the risks which are likely to materialise over the coming years.

To mitigate short term weaknesses and longer-term risks whilst maximising renewable energy generation, the solution proposed as part of our core pathway for the treatment of our sludge is the consolidation of our sludge treatment centres (fewer larger sites) and adoption of Advanced Anaerobic Digestion (AAD) as the primary means of sludge treatment, supported by a combination of combined heat & power (CHP) engines and potentially biomethane plants (allowing gas supply into the grid) as technologies of choice to maximise value recovery from biogas.

Advanced Anaerobic Digestion will strengthen our operation and mitigate immediate threats as it reduces the amount of biosolids we have to manage, unlocking additional farmland for spreading and is a more stable product less likely to cause public nuisance or environmental damage. Together these technologies act as a no-regrets stepping-stone for advanced thermal conversion (ATC) technologies and bio-hydrogen development.

In AMP8 we are proposing to upgrade our operation in Kent - where it is the most challenged - by consolidating the STCs into 2 large AAD facilities. We are also proposing to increase the capacity of our biosolids storage across our patch to improve our resilience to seasonal fluctuations in demand and weather that is not favourable to land stockpiling/spreading activities. Additional cake storage will also help in the short-term with increasing challenges related to the availability of the landbank. We are also aiming at undertaking trials on ATC concept to inform potential implementation in subsequent AMPs. We are also proposing to carry out major capital work on all of our 16 STCs to ensure we comply with IED and reduce risk of pollution to air, water and land,

In AMP9/10 our focus will shift to Sussex and Hampshire where we continue our transition to AAD processes whilst we start to roll out ATC to mitigate land recycling risks. Thermal disposal will allow us to diversify away from agricultural recycling, providing resilience to this outlet, however, ATC is still am emerging technology and as such we will need to start to develop this in AMP8.

As it is crucial that we remain adaptive, should the landbank become a significant issue in the short-term, the only proven alternative to ATC at present which is likely to be implemented is incineration. However, until this process can be developed, approved (i.e. planning permission and other permits) and implemented, the landfill option is also likely to be used.

In parallel of the above, we have also engaged with the market under various forms:

- Whilst headroom trades with our neighbours can be a critical opportunity to reduce costs, our experience with it is very ad-hoc and usually occurs when operational difficulties arise
- Similarly our work with [redacted] has highlighted little benefit from trading or implementation of joint capacity
- However, the benefits could be significant if the industry was to build similar type of assets all at once (e.g. incineration or ATC to mitigate the landbank availability challenge)
- Co-treatment or co-location with other waste processing is currently not a viable option due to the regulations surrounding the fate of the product(s) generated. However, a potential move to Thermal Destruction Technologies in lieu/addition of digestion processes could change the way this is managed

- We are progressing with a formal approach to the market to understand how our Kent plans could be delivered though Project Finance or Outsourcing

Glossary

Term	Description
AAD	Advanced Anaerobic Digestion
AD	Anaerobic Digestion
APR	Annual Performance Report
ATC	Advanced Thermal Conversion
BAT	Best Available Techniques
BREF	Best Available Techniques Reference Documents
CAD	Conventional Anaerobic Digestion
CAW	Carbon Accounting Workbook
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DPC	Direct Procurement for Customers
DST	Decision Support Tool
EA	Environment Agency
ELVs	Emission Limit Value
EPR	Environmental Permitting Regulations
FRfW	Farming Rules for Water
GHG	Greenhouse Gases
HpH	Heating-Pasteurisation-Hydrolysis process
IED	Industrial Emissions Direction
LCA	Lifecycle Assessment
MCP	Medium Combustion Plant
ODI	Outcome Delivery Incentive
P	Phosphorous
PFAS	Per- and polyfluoroalkyl Substances
PFI	Private Finance Initiatives
SEA	Strategic Environmental Assessment
SUiAR	Sludge Use in Agriculture Regulations
SWS	Southern Water Services Ltd
STC	Sludge Treatment Centre
TDS	Tonnes Dry Solids
UK	United Kingdom
WaSC	Water and Sewerage Company
WWTW	Wastewater Treatment Works

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Appendix 1: The Future of Southern Water's Sludge – Farmer Survey (Yonder for SWS - 2022)

SOUTHERN WATER

The future of Southern Water's sludge

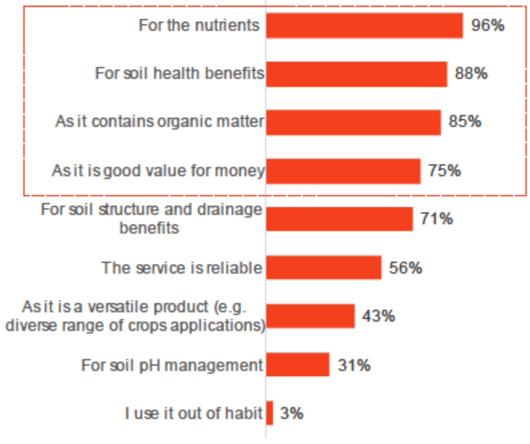
.YONDER

Qualitative & Quantitative research debrief

a. Biosolids seen as a value material

The main advantages of biosolids are the nutritional benefits to soil health, alongside being good value

REASONS TO USE BIOSOLIDS - PROMPTED



REASONS TO USE BIOSOLIDS – SPONTANEOUS COMMENTS

Improves soil health/ organic benefits

"Good source of organic fertiliser/improves soil health, greater than its technical nutrient value"

Phosphate and nitrogen:

"Biosolids supply important key nutrients including phosphate and nitrogen. It also is very important as a soil conditioner and enhancer to maintain and improve my soil organic matter"

Good value

"Because it's cheap organic/nutritional content. Also, a belief that a society ought to be returning its waste to the soil"

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Q7. Why do you use biosolids ("treated sludge / treated cake") on your land? / Q8. Below are some reasons others have provide d for using biosolids ("treated sludge / treated cake") on their land. Which of the following are reasons that you use biosolids?
All respondents (68)

.YONDER

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b. Limitations of current Biosolids from SWS

Additional external factors are also identified as downsides to sludge

Smell	Inconsistent product	Spreading and cultivation	Delivery of the sludge	Microplastics
• The potent smell is consistently cited as a negative • Can lead to complaints from neighbours. This can be exacerbated upon learning what sludge is	• That the product can vary from being sludge-like to cake-like is a source of frustration • Sludge-like is much harder to store and cultivate	• The requirement to cultivate soon after spreading can be a challenge with unpredictable weather • Heavy machinery is at odds with a regenerative approach	• Large haulage delivery trucks can impact the local community and local road networks	• Concerns are increasing around the digestion of microplastics • Microplastics risk damaging crops and soil quality

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c. Benefits expected from Advanced Digested cake

Whilst confusion exists over what Advanced Digestion is, a drier product has clear advantages

Less smell	Easier to cultivate	More concentrated product – cheaper to transport	Easier to stack and store	Better for the environment
• Drier is less odorous • Significant improvement for locals (and farmers) • Supported by Thames sludge users and those who used to use pellets	• Far better for the soil when cultivating as requires less heavy machinery • Granules could be easily 'sprinkled' down tram lines and top dressed	• Transporting organic matter rather than water • Anticipated this will impact costs and operations – easier to transport dry product than a liquid	• A drier product can be more easily protected against rain/snow and stored for longer • Locals would be happier not to have a sludge heap	• Easier cultivation and transportation means fewer trucks / heavy machinery • Easier cultivation is better for soil regeneration

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Appendix 2: Summary of Key Legislation Affecting Sludge Operation

Driver	Impact on Sludge
Urban Waste Water Treatment (England and Wales) Regulations 1994 (SI 1994 No. 2841) implementing the Urban Waste Water Treatment Directive (UWWTD) 91/271/EEC	Due to practical implementation of the Directive, and the cessation of sea disposal, sewage sludge quantities requiring disposal have increased due to the increased level of wastewater treatment and tighter discharge consents.
Waste Framework Directive 75/442/EEC (as amended)	This Directive forms the backbone of most of current legislation and sets the framework for waste management and most significantly defines the waste hierarchy as the hierarchy of all waste management options. The Directive is currently being revised – the effect of this revision will be felt through most of the forthcoming UK legislation.
Sludge (Use in Agriculture) Regulations 1989 implementing the Sewage Sludge Directive 86/278/EC	These Regulations lay down the requirements for applying sewage sludge to agricultural land and are supported by a Code of Practice, which details all aspects of sludge recycling to land. The regulations set permissible limits for soil concentrations and rates of annual additions of Potentially Toxic Elements (PTEs). The allowable limits for Zn, Cu and Ni in soils vary with the pH of the soil. There are no restrictions on the concentrations of PTEs in sludge.
The Safe Sludge Matrix 1998 (3rd edition 2001)	This voluntary agreement made between the UK water and sewage operators and the British Retail Consortium came into force in 1998(revised in 2001). The matrix requires strict microbiological controls on the quality of Sludge and the correct procedures to be adopted for its application to agricultural land used to grow food crops. The provisions of the Matrix go beyond the requirements of the Sludge (Use in Agriculture) Regulations as they currently stand. It was originally envisaged that the Safe Sludge Matrix would be incorporated into the Revised Sludge (Use In Agriculture) Regulations and Code of Practice for Agricultural Use of Sewage Sludge. These amendments have been delayed and are still not embedded into the regulations.
The Nitrates Directive (91/676/EC) and The Nitrate Pollution Prevention Regulations 2008 (SI 2008/2349)	The Nitrates Directive aims to tackle pollution of waters caused by nitrogen from agricultural sources. This limits application of nitrogen (and hence the amount of sludge) able to be applied to land in designated Nitrate Vulnerable Zones (NVZs). The Nitrate Pollution Prevention Regulations establish the Action Programme measures which establishes NVZs inside which organic manure and sludge applications are limited and also includes soil type and application date restrictions to reduce the risk of diffuse nitrate pollution of watercourses. The impact of this is the need to find more land suitable for recycling sludge and the increased number of sites designated as NVZ will effectively reduce the amount of land available to spread sludge. From 1 January 2009, the areas covered by Nitrate Vulnerable Zones (NVZs) will increase to approximately 70% of England.
Water Framework Directive (2000/60/EC)	The Water Framework Directive sets out to achieve a good ecological status in all waterbodies in Europe. To achieve this, additional controls over water management activities will be required, including measures to limit point and diffuse source pollution. Some measures, such as Catchment Sensitive Farming and the establishment of Water Protection Zones, are expected to introduce additional limits on quantities of nutrients that can be applied to certain catchments. In addition, measures to improve the quality of treated effluent from sewage treatment works is likely to increase the quantity of sludge generated and could increase concentrations of priority and priority-hazardous substances found in sludge.
Environmental Permitting (England & Wales) Regulations 2007 incorporating the Waste	The new Environmental Permitting (EP) system replaces over 40 statutory instruments with a single set of Regulations. The Environmental Permitting (England and Wales) Regulations 2007 (EP Regulations) came into force in April 2008 and introduce a single environmental permitting and compliance

Management Licensing (WML) Regulations 1994 (as amended 2005) The Pollution Prevention and Control (PPC) (England and Wales) Regulations 2000 (as amended) (implementing EU Directive 96/61/EC and 2000/76/EC)	regime to apply in England and Wales. This regime streamlines and combines Waste Management Licensing (WML) and Pollution Prevention and Control (PPC) to create a single environmental permit with a common approach to permit applications, maintenance, surrender and enforcement. The EP Regulations identify the types of facilities which require an environmental permit. These include: • An installation, being (a) a stationary technical unit where one or more activities listed in Schedule 1 of the EP Regulations are carried on; and (b) any other location on the same site where any other directly associated activities are carried on; • Mobile plant (other than waste mobile plant) which is used to carry on an activity listed in Schedule 1 or a waste operation; • Waste mobile plant, being mobile plant which is used to carry on a waste operation, but which is not mobile plant used to carry on certain activities listed in Schedule 1; and • A waste operation (ie. recovery or disposal of waste) not carried on at an installation or by means of mobile plant – any disposal or recovery of waste which is not exempt under the EP Regulations, or These types of facilities were previously regulated under the Waste Management Licensing and Pollution Prevention Control legislation which the EP Regulations replace. Certain waste operations are exempt from the requirement for an environmental permit. An operation will be an "exempt waste operation" under the EP Regulations if: a) it falls within a description of operations in Part 1 of Schedule 3 of the EP Regulations; b) certain registration, notification and consent requirements are satisfied; and c) the type and quantity of waste submitted to the waste operation, and the method of disposal or recovery, are consistent with the objectives of the Waste Framework Directive. For installations formerly under the PPC system, there is very little change. The EA set permit conditions that include a wide range of energy, waste and raw material efficiency measures. The permit also includes emission limit values and emission monitoring requirements for pollutants likely to be emitted from the installation in significant quantities and measures to prevent accidents and limit their environmental consequences. Permits are required for facilities from which sludge goes for disposal, or at which sludge is dried, gasified or burnt.
Waste Incineration Directive (WID) 2000/76/EC implemented by the Waste Incineration Regulations (S.I. 2002 No. 2980)	Impacts on all thermal processes for the thermal destruction of wastewater sludge. The disposal of sewage sludge by incineration or gasification/pyrolysis is required to meet the standards specified by the Waste Incineration Directive given in Annex I & V and emission limit values for discharges of wastewater from the cleaning of exhaust gases given in Annex IV. For co-incineration, fuel substitution in power generating plant or cement manufacture the emissions limits are given in Annex I & II.
Part III of the Environment Protection Act 1990 (EPA), The Noise and Statutory Nuisance Act 1993, and Section 17 of the Environment Act 1995	It is an offence to create a statutory nuisance and under section 79(1)(d) of the EPA the definition of statutory nuisance includes: "any dust, steam, smell or other effluvia arising on industrial, trade or business premises and being prejudicial to health or a nuisance". Local Authority Environmental Health Departments have the power to serve an Abatement Notice on any person causing or likely to cause a statutory nuisance.
Defra Code of Practice on Odour Nuisance from Sewage Treatment Works 2006	The Code of Practice aims to provide a framework under the statutory nuisance regime within which the appropriate regulators and sewerage undertakers can operate, to minimise the likelihood and impact of nuisance from odours. The code provides practical advice and a framework for

	local authority Environmental Health Practitioners who enforce the statutory nuisance regime and sets out for the public what they can expect during an investigation of a complaint of odour nuisance from sewage treatment works. Sewage treatment works operators have the responsibility and ability to put in place the measures to control or abate odour problems from their plant.
The Landfill Directive (99/31/EC), The Landfill Regulations 2002	Landfills are categorised into one of three groups; inert, non-hazardous and hazardous. Waste is categorised into these groups by using the European Waste Catalogue (EWC codes). Hazardous and inert wastes must meet Waste Acceptance Criteria (WAC) which specifies a series of leachable, inorganic and organic parameters (these are maximum limits) in order to be accepted to landfill. Each waste stream must undergo periodic checks to ensure its compliance. As of October 2007, landfill sites are unable to accept untreated waste with the aim to encourage the recovery of waste and to reduce the impact of the waste. An increase in gate fees, reduction in void space available in England, limitations on the biodegradability of the sludge cake/pellets disposed of and the prevention of liquid sludge disposal mean that the disposal of sewage sludge to landfill should only be regarded as the final option.
The Hazardous Waste Regulations 2005	The term "Hazardous Waste" refers to waste that has toxic or dangerous properties. Hazardous waste is classified by its entry found in the European Waste Catalogue (EWC) 2002. These regulations should not affect sewage sludge, as it is not classified as a hazardous waste. Although, this may affect dedicated processing plants such as incineration or gasification/pyrolysis where the ash may be classified as a hazardous waste dependent upon its physical characteristics and composition.
National Emissions Ceiling Directive (2001/81/EC)	Establishes national emission limits for releases of NOx, SO2, VOC and NH3 from all sources and impacts most forms of sludge treatment.
Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal energy market.	Promotes the generation and use of electricity from renewable sources.
The Renewables Obligation Order 2006 (Statutory Instrument (SI) 2006 No. 1004)	A Renewables Obligation Order is issued annually detailing the precise level of the obligation for the coming year-long period of obligation and the level of the buy-out price. This order provides a market based system giving increased financial returns from the generation of electricity from renewable sources when there is less renewable generating capacity than the obligation placed upon companies licensed to supply electricity. The order allows for the power generated from the co-firing of wastewater sludge with fossil fuels to receive Renewable Obligation Certificates (ROCs) up to 31st March 2009 without the introduction of biomass as energy crops.
The Climate Change Levy (General) Regulations 2001 and subsequent related legislation.	The climate change levy is a tax on the use of energy in industry, commerce and the public sector with additional support for energy efficiency schemes and renewable sources of energy. The aim of the levy is to encourage users to improve energy efficiency and reduce emissions of greenhouse gases.
SI 2001 No.1139 The Climate Change Agreements (Energy-intensive Installations) Regulations 2001.	This reduces the levy on electricity used on energy efficient installations and which come from renewable sources.
Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community	This directive essentially sets greenhouse gas emissions limits for installations to meet the Kyoto agreement. Installation may be given credits from performance better than specified limits, these credits may be traded against poor performing installation.

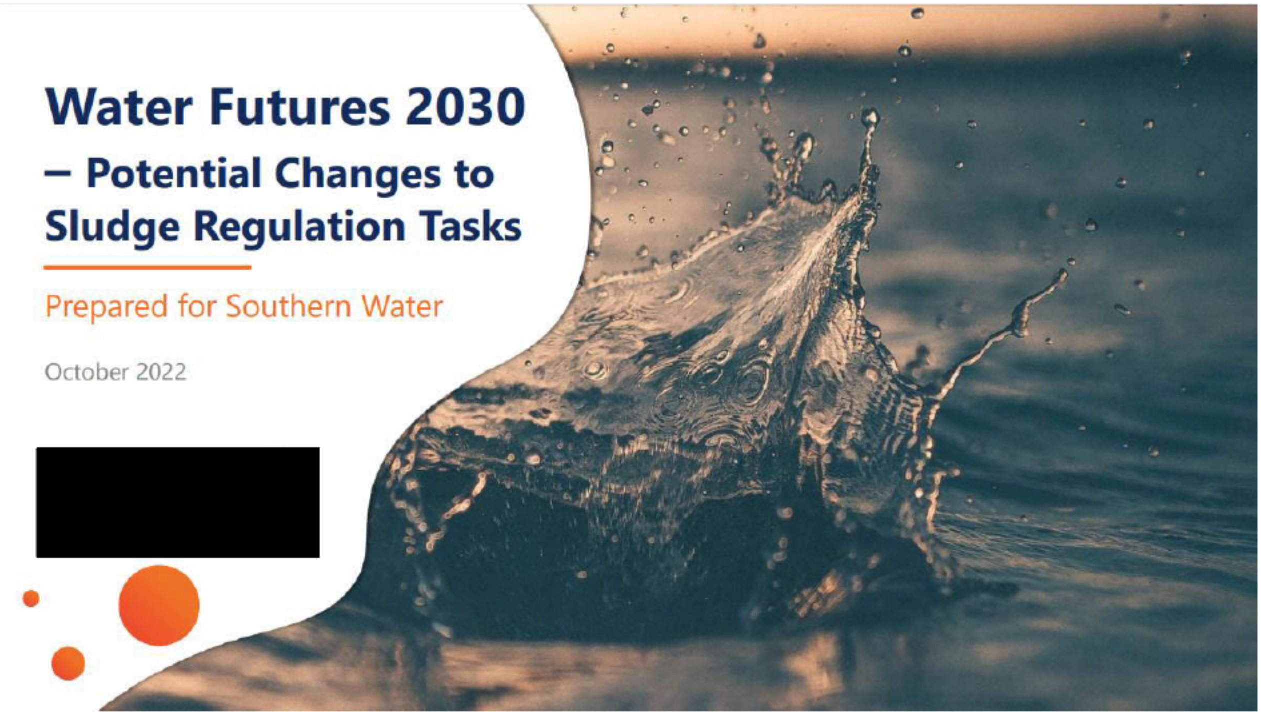
The Climate Change Act 2008	The Climate Change Bill was introduced into Parliament on 14 November 2007 and became law on 26th November 2008. The Climate Change Act 2008 creates a new approach to managing climate change with an increasing requirement to manage/reduce carbon footprint and an increasing focus on GHG emissions other than CO2 i.e. N2O, CH4 The Climate Change Act will require the UK to cut its greenhouse gas emissions by 80 per cent (based on 1990 levels) by 2050. A series of five year interim 'targets' will also be set.
Farming Rules for Water	
Biosolids Assurance Scheme	
Safe Sludge Matrix	
Health and Safety at Work etc. Act 1974	
The Control of Major Accident Hazards Regulations 2015	storage of toxic gases (eg biogas, methane, chlorine etc), applicable to many sludge treatment facilities
The Dangerous substances and explosive atmospheres regulations 2002	

Appendix 3: Stakeholders Technology Questionnaire

Option	Process	Short-listed in Survey & Workshop? (if not, why?)	Technology Description	Main Product	Indicative Product Quality	Allows agricultural recycling	Energy Recovery Potential
1	Mesophilic Anaerobic Digestion (MAD)	Yes	- sludge blending - mesophilic 1° digestion (38°C @ 15d HRT) - 2° digestion (7day HRT) - dewatering - cake storage - biogas storage (350Nm3/tDS) - biogas utilisation (CHP or G2G)	Dewatered biosolids @ >21%	Conventional	Yes	Yes - medium
2	Advanced Anaerobic Digestion (AAD) - pasteurisation (PAS)	Yes	- sludge blending - pre-treatment (70°C for 30mins) - mesophilic 1° digestion (38°C @ 14d HRT) - dewatering - cake storage - biogas storage (380Nm3/tDS) - biogas utilisation (CHP or G2G)	Dewatered biosolids @ >23%	Enhanced	Yes	Yes - medium
3	Advanced Anaerobic Digestion (AAD) - thermal hydrolysis (THP)	Yes	- sludge blending - pre-treatment (160°C at 6bar for 30mins) - mesophilic 1° digestion (38°C @ 14d HRT) - dewatering - cake storage - biogas storage (450Nm3/tDS) - biogas utilisation (CHP or G2G)	Dewatered biosolids @ >30%	Enhanced	Yes	Yes - medium
4	Advanced Anaerobic Digestion (AAD) - HpH system	Yes	- sludge blending - pre-treatment (70°C for 30mins) - mesophilic 1° digestion (38°C @ 14d HRT) - dewatering - cake storage - biogas storage (380Nm3/tDS) - biogas utilisation (CHP or G2G)	Dewatered biosolids @ >25%	Enhanced	Yes	Yes - medium
5	Lime Stabilisation	Yes	- blending tanks - centrifuge dewatering - ploughshare mixer where hydrated lime (Ca (OH)2) or as quicklime (CaO) is added to the sludge, which raises the pH to 11 or above. - lime silo - slewing conveyor to storage facility	Dewatered biosolids @ >25%	Enhanced	Yes	None
6	Thermal Treatment - incineration	Yes	Dewatered sludge is fed into a furnace at >800°C along with large volumes of air. Heat recovery from hot flue gases through a turbine to generate power. Flue gases emitted to atmosphere following extensive clean up	Ash	Enhanced	Yes - potentially	Yes
7	Thermal Treatment - advanced thermal conversion	Yes	Dewatered sludge is fed into a furnace at >800°C with NO air. Organic material volatilised to produce a syn-gases with is cleaned and passed to CHP or gas use.	Biochar	Enhanced	Yes - potentially	Yes

8	Drying and pelletizing	Yes	Dewatered sludge fed onto a low temperature belt dryer	Pellet/Granules @ >75%	Enhanced	Yes	No
9	Drying	Yes	Dewatered sludge is dried	Dried sludge/biosolids @ >50%			
10	Composting	Yes	Dewatered sludge blended with other organic materials and allowed to mature in windrows	Dried sludge/biosolids @ >50%	Enhanced	Yes	No
11	Thermophilic Anaerobic Digestion (TAD)	Not generally used in the UK. Heat requirements are higher than MAD and therefore unlikely to be more economic.	- sludge blending - thermophilic 1° digestion (50°C @ 7d HRT) - 2° digestion (7day HRT) - dewatering - cake storage - biogas storage (380Nm3/tDS) - biogas utilisation (CHP or G2G)	Dewatered biosolids @ >21%	Conventional / enhanced	Yes	Yes - medium
12	Advanced Anaerobic Digestion (AAD) - acid hydrolysis (APH)	Not generally used in the UK. The principal supplier is no longer marketing the equipment and other technologies are now more readily available.	- sludge blending - pre-treatment (xx°C for xx days) - mesophilic 1° digestion (38°C @ 14d HRT) - dewatering - cake storage - biogas storage (380Nm3/tDS) - biogas utilisation (CHP or G2G)	Dewatered biosolids @ >23%	Enhanced	Yes	Yes - medium
13	Advanced Anaerobic Digestion (AAD) - enzymic hydrolysis (EH)	Not generally used in the UK. The principal supplier is no longer marketing the equipment and other technologies are now more readily available.	- sludge blending - pre-treatment (70°C for 30mins) - mesophilic 1° digestion (38°C @ 14d HRT) - dewatering - cake storage - biogas storage (380Nm3/tDS) - biogas utilisation (CHP or G2G)	Dewatered biosolids @ >25%	Enhanced	Yes	Yes - medium

Appendix 4: Water Future 2030 – Potential Changes to Sludge Regulations ([redacted] for SWS - 2022)



a. *Positive feedback on AAD from customers*

Advanced Digestion feels like the next logical step, however, there are concerns over timescales and in turn, future proofing

Impressions of Advanced Digestion

Advanced Digestion
- Wastewater is treated to a high standard with lots of regulations and criteria we need to meet. An end product called 'sludge' or 'cake' is provided to farmers and spread on their crops.
-
- There is a process called '**advanced digestion**' which is essentially a more advanced type of treatment.
- This means that the end product (sludge) is of higher quality.
- It can then be spread on more and different types of crops – so is more versatile and better used by farmers.

- Southern Water are currently planning to propose to introduce advanced digestion across their sites.
- It is likely to take between 10-15 years to complete – partially due to the spreading the cost but also the resource needed to upgrade sites.
- The current proposal being worked up is to focus on Kent in 2025-2030, and then across to Sussex and Hampshire after this.
- Southern Water have been working with famers – who are supportive of the plans.

✓ Initial reactions are positive, with many feeling that anything more advanced or that produces a higher quality product is beneficial

✓ Being able to use this more broadly across more types of crops feels like we are making the most of what we have already got, again fitting well with sustainability

✓ It is assumed that this would have potential to replace current, harmful fertilisers and chemicals and as such, feels like a logical step to take

As such, overall customers are supportive of Advanced Digestion, however …

‼ Timescales do raise some concern, especially considering farmers are supportive – *if it is so good, we need to be doing this as soon as possible!*

‼ Although the need to plan resources and keep costs low is understood, there are worries that the technology may be out of date by the time it is implemented - *could it be a waste of time and money? And who is paying for this – farmers, customers?*

I think it is a good thing, making better use of what is probably, technically a waste product. Hopefully over the course of the expected 15 year timescale, technology will also improve/adapt to assist.

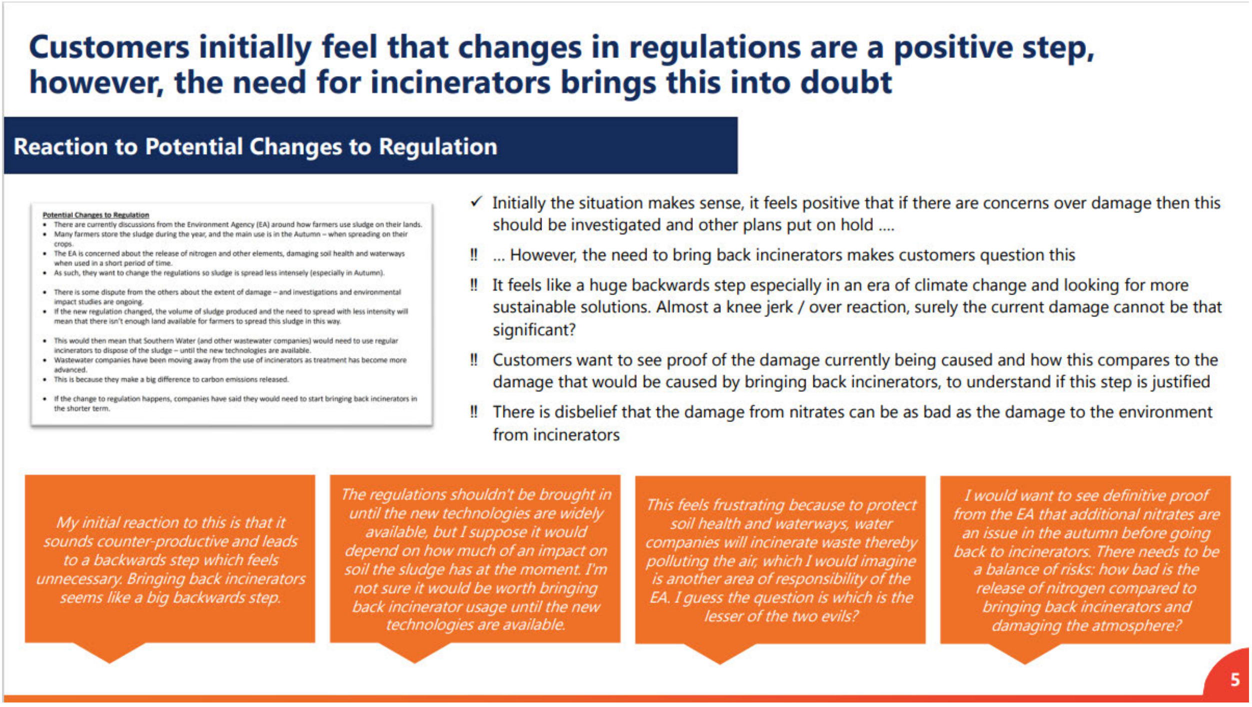
Seems like a good idea and if this is good for the environment, then I can't see why they wouldn't put this in place. I understand the need to do this slowly but it does feel like a long, long time.

My concern is who pays. The farmers should be paying a contribution here and not customers as it is they who directly benefit. The lead time of 15 -20 years seems very long though, and could be costly, is it worth the wait?

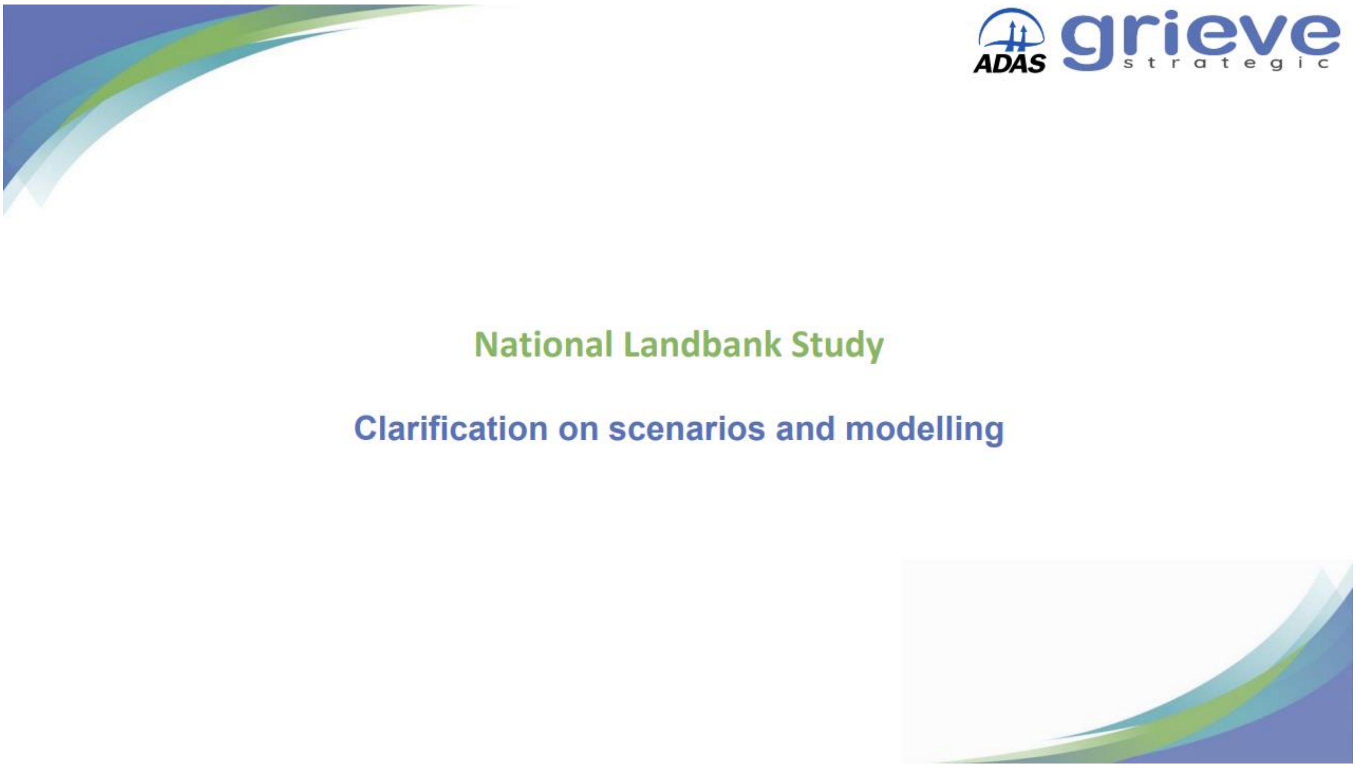
This sounds great I would be supportive of this. I would want to know though whether this means there are other more harmful products/ chemicals that can be used less?

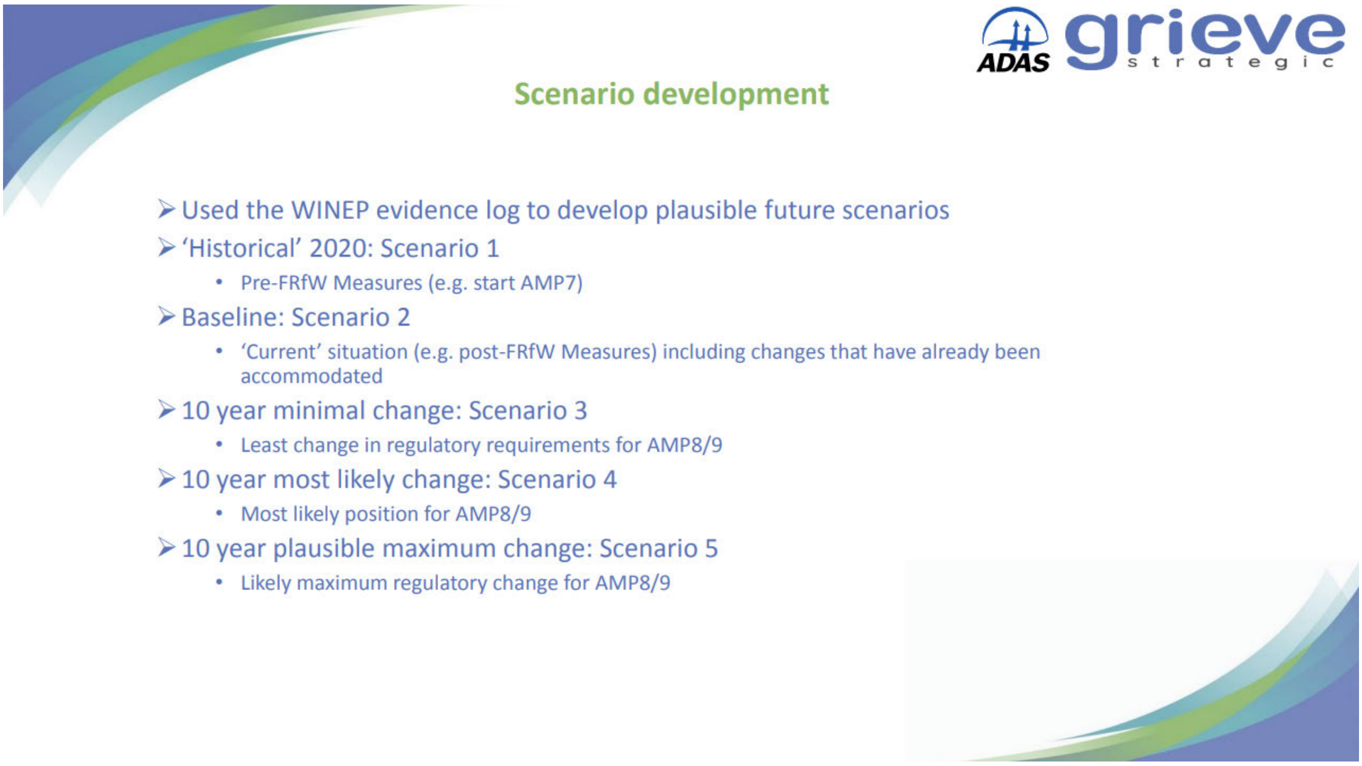
4

b. Customers views on Incineration as a potential answer to mitigate impact of FRfW in the short-term



Appendix 5: National Landbank Assessment



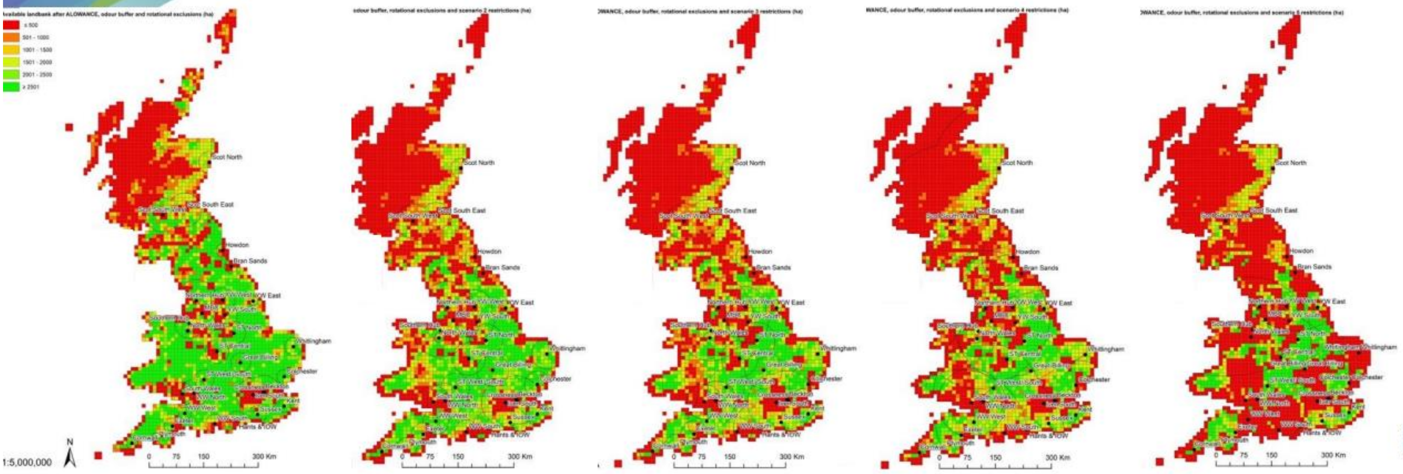


Key details of the scenarios[1]

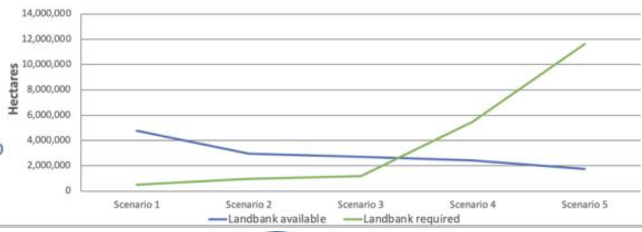
Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Farmer acceptance	Baseline	5% reduction	15% reduction	25% reduction	40% reduction
Arable restrictions	Baseline	Reduction in autumn applications on sandy soils	Further reduction in autumn applications on sandy/shallow soils	No autumn applications except to oilseeds	No autumn applications except to oilseeds and limits in spring
Grassland restrictions	Baseline	Baseline	Reduction on conventionally treated biosolids to grassland and longer return periods	Severe limit on conventional, limits on autumn applications and longer return periods	No conventionally treated biosolids and increased restrictions for enhanced treated, including no autumn applications
Phosphorus restrictions	Baseline	Increased restrictions at index 3 (c.1 in 2) and 4 (c.1 in 6)	No application at index 4, index 3 consistent with S2 (c.1 in 2)	No application at index 4 and increased return period at index 3 (c.1 in 6)	No application at index 4, long return period at index 3 (c.1 in 7) and increased return period at index 2 (c.1 in 2)
Designated sites/priority habitats	Baseline	5% reduction in land available near sensitive sites and in sensitive catchments and SPZ2	15% reduction in land available near sensitive sites and in sensitive catchments and SPZ2	25% reduction in land available near sensitive sites and in sensitive catchments and SPZ2	No spreading near sensitive sites and in sensitive catchments and SPZ2
Biosolids quantities[2]	2020	2025 predictions	2030 predictions	2040 predictions	2050 predictions
Biosolids quality[2]	Baseline	10% increase in P	20% increase in P	40% increase in P	50% increase in P

[1] Full spreadsheet will be shared detailing all factors considered within the scenarios
[2] Companies have used their predicted date, percentages/set years have only been used where this data was not available

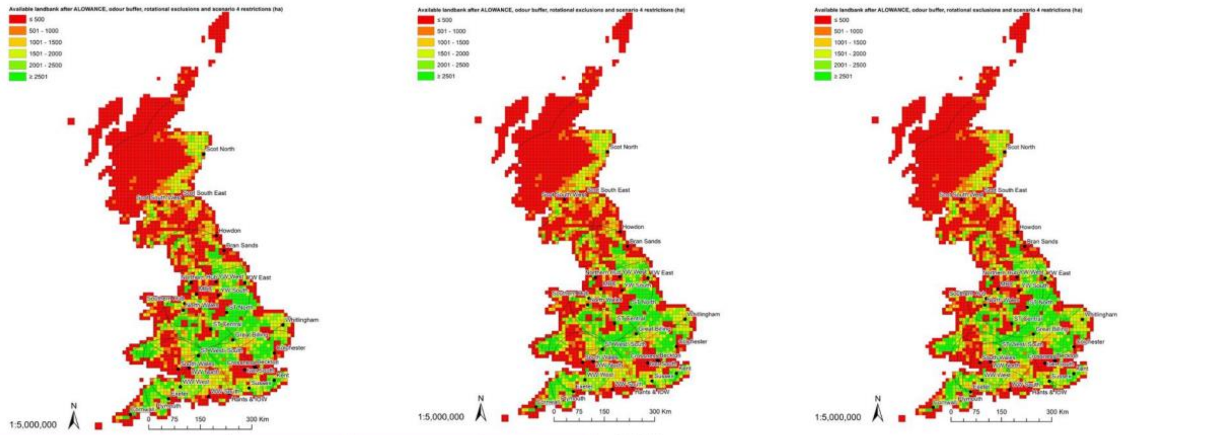
Summary results



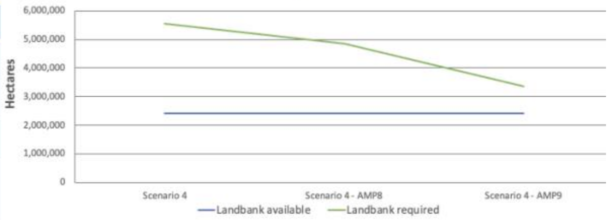
- For scenarios 1, 2 and 3 there is sufficient available agricultural land to recycle all GB biosolids via the modelled STC configurations
- For scenarios 4 and 5 there is insufficient available agricultural land to recycle all GB biosolids via the modelled STC configurations
- The two key areas of sensitivity driving the change between S3 & S4 are no autumn applications before winter cereals and increased restrictions on P additions



Effect of WINEP submissions



Scenario	Scenario 4	S4 – AMP8	S4 – AMP9
Quantity to land (TDS)	1,138,000	1,040,000	813,000
Required land (ha)	5,560,000	4,860,000	3,350,000
Landbank available (ha)		2,410,000	
Percentage of biosolids requiring an alternative outlet	67%	60%	35%



Appendix 6: Assessment of Biomethane Upgrade vs Combined Heat & Power Engine Options

"Ofwat Operational greenhouse gas emissions performance commitment."

Proposed amendment to definition to ensure greater GHG benefit of choosing Biomethane over CHP is recognised and rewarded.

19/05/2023

Exec. Summary

- SWS Bioresources PR24 plan includes 2 large projects that will replace 7 existing "Conventional" AD plants with 2 new much larger "THP" AD plants
- The existing plants are equipped with CHP and the new plants will be of sufficient size to be equipped with biomethane upgrading and injection or CHP
- We have modelled the GHG savings and net revenue impact for both options considering Ofwat's "Operational greenhouse gas emissions performance commitment" v3 published in March 2023 and the further changes outlined in the April 2023 consultation response.
- Choosing Biomethane injection over CHP will delivers 100kTCO2 reduction over the 20 year M&E asset life of the Ham Hill project because electricity grid decarbonises quicker than the gas grid.
- BUT choosing biomethane results in an additional £1.4m annual revenue cost compared to CHP due to the impact of the GHG PC. It cannot therefore be chosen.
- The GHG PC allows WASC's to forgo the value of biomethane RGGO's for their exported biomethane and claim the GHG PC incentive associated with reduction in emissions.
- BUT this cannot be achieved because there is currently no method of retiring RGGO's associated with new biomethane plants in AMP 8 without losing the subsidy.
- Slide 4 explains in detail why there is no method of retiring today and that the future is uncertain. In summary:
  - RHI scheme which allows retirement of RGGO's is closed to new applicants.
  - GGSS scheme only supports new build AD and most WASC AD assets are not life expired.
  - RTFC Market is open but RGGO cannot be separated from RTFC's.
  - Looking forward to AMP 8, Government recognise in its recently published "Independent Review of Net Zero", that biomethane will continue to play an important role in achieving the government's Net Zero obligation. DESNZ are working to develop a future policy framework to follow the GGSS and have requested views as part of the GGSS mid scheme review consultation which closed on 18th May 2023.
- We proposed that performance commitment is amended to create a system that can work independently of the biomethane subsidy scheme.
- We propose an option to purchase RGGO's from the market up to the value of biomethane exported. Currently RGGO's can only be retired from own production.
- The minor amendment balances the net revenue for Biomethane and CHP and will result in the GHG PC objective being achieved.

PR24 operational greenhouse gas emissions performance commitment (wastewater) Ofwat

We have modelled the GHG emissions and “Energy“ net revenue impact of CHP against Biomethane on our Ham Hill THP project

- Changing from “Conventional” to “THP” AD creates a net increase in heat demand for the same quantity of sludge but It also provides a net increase in biogas production.
- One large site has sufficient biogas to fall within biomethane upgrading plant design range.
- Net GHG and Revenue are calculated using the new Operational GHG Performance commitment definition assuming £200/tCO2e tariff.
- Net revenue is dependent on the biomethane financial support option that it is accredited to.
- Options 2 and 4 show CHP and best GHG saving fuel configuration for biomethane respectively

	Option	Biogas Utilisation	Natural Gas Utilisation	CHP Electrical Output	CHP Heat Recovery
Transfer Sludge from 4 AD sites to Ham Hill and Build New THP AD Plant	2	100% CHP	Steam Boiler to supplement heat demand	Embedded demand and surplus exported.	Hot water and steam to satisfy THP demand
	4	Steam Boiler then Biomethane Export	n/a	n/a	n/a

Proposed Amendment to Operational GHG PC

- Biomethane delivers 100 kTCO2e more GHG savings than CHP
- BUT CHP is the compelling choice whilst only the RTFC scheme is available to biomethane making the PC counter productive.
- Government recognise in its recently published “Independent Review of Net Zero”, that biomethane will continue to play an important role in achieving the government’s Net Zero obligation.
- DESNZ are working to develop a future policy framework to follow the GGSS from 2025 and have requested views as part of the GGSS mid scheme review consultation which closed on 18th May 2023.
- In view of the uncertainty that retirement of RGGO’s will be available in a future framework it is proposed that the performance commitment is amended.
- Currently only RGGO’s derived from their own production may be retired.
- We propose an amendment to allow purchasing and retiring RGGO’s from the **market** up to the value of biomethane that we export.
- This minor amendment ensures the PC support for biomethane over CHP is identical regardless of the rules of the subsidy scheme.

Appendix 7: Bioresources – Intercompany Resilience Agreement

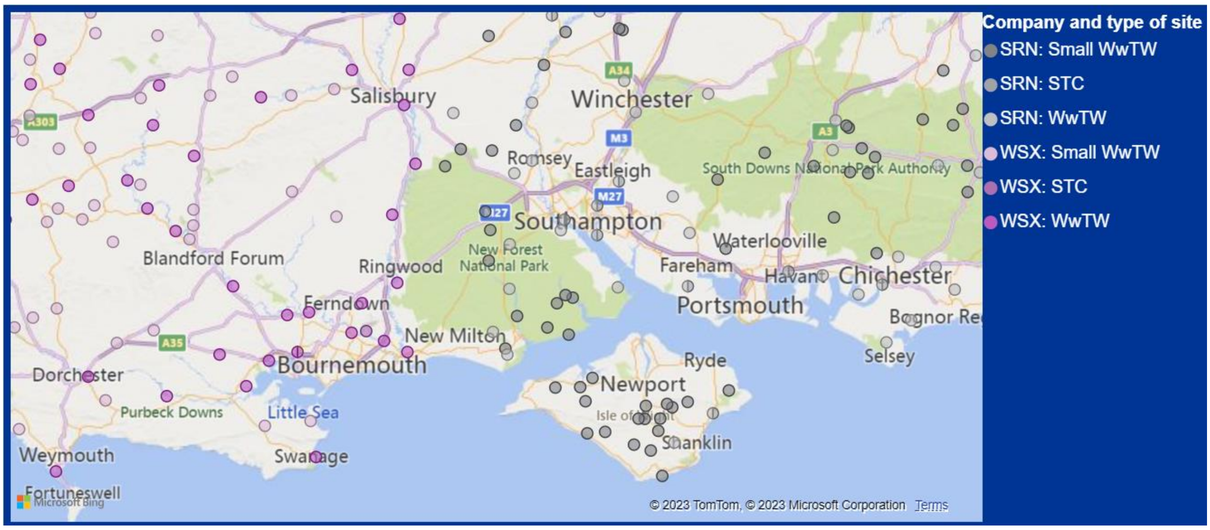
This note sets out the principles of an approach to improved bioresources resilience support between **Wessex Water** and **Southern Water**.

- Non-exclusive, annual framework agreement (parties are free to appoint other suppliers at any time);
- Call-off services requested by either party on an 'as and when' basis;
- No commitment to minimum spend.

Background

Bioresources is the collective name given to wastewater sludges, the by-product of wastewater treatment, which when treated for recycling are known as biosolids. Wessex Water and Southern Water are statutory water and sewerage service providers who share a common boundary between their operating areas (see Figure 1 below). In the interests of cost efficiency and maintaining essential services both parties have recognised the benefit in providing non-exclusive contingency support in the event of a loss of capacity for wastewater sludge treatment. Such support can reduce the need for unilateral capacity increases to deal with contingency situations, provide greater flexibility in managing temporary asset downtime and provide greater levels of resilience.

Figure 7 - Illustration of common boundary between Wessex Water (WSX) and Southern Water (SRN).



Scope

The principles here cover the loss of wastewater sludge treatment management capacity (including dewatering and treatment) due to operational issues or temporary downtime. Neither party is required to provide assistance unless it determines that it has sufficient resources to do so, and any support will be supplied on a non-exclusive, call-off basis where each individual call-off contract will set out details of the service(s) to be provided, payment arrangements, responsibilities, etc. The parties agree that when contacted, by an authorised representative under the agreement, they will assess their capacity to respond considering the location of the need, the availability of appropriate personnel, equipment, and other assistance. Both parties will then agree what services are to be provided, by when and ensure that all environmental legislative requirements are met with regards to the transfer of material, the treatment of material, and its subsequent recycling, as applicable.

Timescale

The approach will be jointly reviewed annually by the authorised contacts and will expire unless renewed by 31st March each year.

Authorised contacts

Wessex Water: [redacted] (Strategy & Regulation) and [redacted] (Operations)
Southern Water: [redacted] (Asset Strategy & Planning) or [redacted] (Operations – Biorecycling)