December 2015

Trust in water

Water 2020: Regulatory framework for wholesale markets and the 2019 price review

Appendix 1: Sludge treatment, transport and disposal – supporting evidence and design options

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Introduction

In this appendix, we set out our analysis of the regulatory design options for sludge treatment, transport and disposal. We address in turn:

- our definition and description of the sludge value chain;
- a description of how the markets currently function, and the current broader regulatory framework they operate within;
- our assessment of the scope for, and benefits from, making greater use of markets;
- implications of evidence for market design;
- potential regulatory design options;
- our assessment of the design options; and
- our preferred design option.

Definition of services and functions

In this section, we provide a definition of sludge treatment, transport and disposal; and describe the activities undertaken in this part of the water and wastewater value chain, as highlighted below.

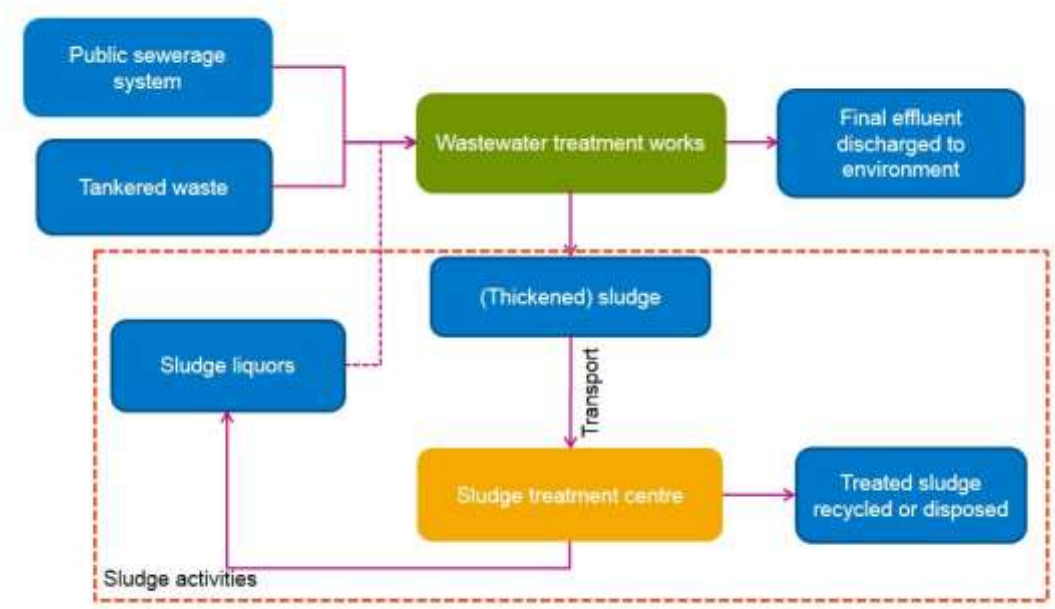
Figure 1: Water and wastewater value chains – sludge

Sewage sludge (sludge) is a semi-solid residual, or by-product, arising from the treatment of municipal wastewater. The activities associated with the treatment, transport and recycling/disposal of sludge are predominantly carried out by the ten water and sewerage companies (WaSCs) in England and Wales.

At sewage treatment works, sludge is separated from the wastewater. It is then taken to a sludge treatment centre, where it is treated to allow for safe recycling or disposal. It is often the case that the sludge treatment centre is on the same site as the wastewater treatment works (in 2011, this was the case for 60% to 70% of all sludge volumes)[1]. Where the sewage treatment works is not on the same site as a sludge treatment centre, the sludge produced there is typically transported by road tanker (although other means of transportation are also used). The following figure illustrates the sludge treatment, transport and disposal value chain.

[1] 'Organic Waste: An OFT Market Study.' (September 2011). See page 18.

Figure 2: Sludge treatment, transport and disposal value chain



The main activities in the **treatment**, **transport** and **disposal** sludge value chain include the following.

Sludge treatment: relates to various treatment processes, typically at sludge treatment centres, prior to transferring treated sludge to where it is collected for recycling or disposal. The most common processes used to treat sludge are anaerobic digestion (AD), lime stabilisation and incineration. Of these, AD is the most popular, partly because it generates energy (heat, transport fuel, and electricity). More than 75% of sludge is now processed this way. For smaller AD facilities, the resultant biogas may be used to heat the digesters themselves. At larger facilities, biogas can be conveyed off-site and injected into the national grid, used to generate electricity in CHP engines, or used as a vehicle fuel.

Sludge transport: relates to transporting untreated sludge from wastewater treatment works to sludge treatment centres and transporting treated sludge to points of disposal. Transport is typically by:

- pumping through pipes;
- road haulage (tanker); and
- boat (this is used less frequently).

Sludge disposal or recycling: sludge can be disposed of in a number of ways. These include:

- recycling through spreading on agricultural land, where it is used as a soil enhancer and fertiliser;
- disposal by means of incineration; and
- disposal to landfill.

The majority (some 80%) of sludge in the UK is recycled to agricultural land.

Liquor treatment: Treating sludge and preparing it for recycling to land often produces sludge liquors, which require treatment because they are not suitable for direct discharge to a watercourse. Where sludge treatment centres are co-located with sewage treatment works, liquor treatment can be provided by the sewage treatment function. However, in some cases, WaSCs may choose to install discrete liquor treatment facilities to either fully, or partially, treat the liquors to reduce the load on the sewage treatment works. We consider that any assets and costs for treating liquors should be included in our list of sludge activities. For regulatory accounting purposes, we have more detailed definitions of sludge treatment and disposal services, and these are set out in annex 1.

Each WaSC has statutory duties that include a requirement to provide a network of sewers and to make provision to empty and deal with the content of those sewers[2]. Sludge is a by-product of a WaSC's sewage treatment activities and therefore it has an obligation to dispose of sludge safely. Being an obligation, safe sludge disposal could be considered to be a cost. However, sludge is also a resource that increasingly has a value. WaSCs can realise value from sludge by:

[2] See section 94 (General duty to provide sewerage system) of the Water Industry Act 1991.

- selling it as a form of fuel (biogas);
- generating income from government incentives for renewable energy generation through Renewable Obligation Certificates (ROCs); and
- selling sludge as biosolids to farmers as a form of fertiliser.

Importantly, the balance between cost and value has changed considerably over time, which is reflected in the large changes in disposal patterns, as shown in the following table[3].

[3] Data sourced from 'Waste water treatment in the United Kingdom – 2012.' Defra (2012).

Table 1: Sludge re-use and disposal routes – tonnes dry solids

Reuse or disposal route	Others			Sludge reused		Sludge disposed			Total
	Pipelines	Ships	Others	Soil and agriculture	Others	Landfill	Incineration	Others	
1992	8,430	273,158	–	440,137	32,100	129,748	89,800	24,300	997,673
2008	–	–	–	1,241,639	90,857	10,882	185,890	1,523	1,530,779
2010	–	–	–	1,118,159	23,385	8,787	259,642	2,863	1,412,836

Current approach to regulation and the role of market(s)

While WaSCs undertake the majority of sludge activities in their supply areas, there is already some, albeit limited, use of markets. For example, WaSCs typically outsource road tankering to specialist haulage companies[4]. We are also aware that there are isolated cases when WaSCs contract with each other for sludge treatment and disposal.

Changing patterns in sludge disposal over time reflect not only environmental regulatory drivers, but also the emergence of new uses and technologies, which are fundamental to the development of markets for treatment and disposal. Treatment innovation has the potential to materially impact the future value of these markets, which is critical to our assessment of appropriate regulatory design options. Importantly, **increases in value (demand) increase the scope for entry. Relating to this, our survey of WaSCs indicates that most expect the value of sludge to continue to increase over time** (see annex 4 for details).

How sludge fits into the wider waste market

In considering the scope for making greater use of markets, it is important to understand how sludge treatment, transport and disposal fit within a wider waste industry context.

The wider waste and recycling sector in the UK generates a total turnover of some £18.3 billion, with a gross value added (GVA) of £5.5 billion[5]. In 2012, the UK generated a total of 200 million tonnes of waste, 117 million tonnes of which was organic waste[6]. Of particular relevance to considering the scope for markets for sludge treatment and disposal, there are a range of firms that provide services in relation to the treatment and disposal of other forms of organic waste (OOW). This includes:

[4] See annex 4 – WaSC survey.
[5] As reported in the ONS 'Annual Business Survey' for 2013. Figures relate to SIC 38 'waste collection, treatment and disposal activities'.
[6] Data on waste volumes from 'UK Statistics on Waste 2010-12' Defra (2015). Estimates exclude secondary waste (that is, waste leaving treatment facilities).

- manure;
- slurries;
- food waste;
- animal by-products; and
- green garden waste.

OOW can be treated using techniques similar to those for sludge, although AD tends to be less used relative to sludge. Historically, the majority of OOW has been returned to the environment via spreading directly to land (slurries and manures, paper mill sludge, etc) or disposal to landfill (food waste). Recent government policy has incentivised a reduction in the amount to landfill.

Treatment and recovery of OOW is undertaken by private enterprises. These range from large multinationals, to small firms operating from farms and local facilities. When considering the regulatory design options for sludge, these OOW businesses are relevant because:

- some characteristics of OOW treatment and disposal are likely to be similar to sludge and therefore firms treating OOW could provide helpful evidence to inform our assessment of the scope to make greater use of markets for sludge; and
- the extent to which OOW firms might be able to provide efficient sludge services also informs our assessment of markets.

Current regulatory framework

Within the PR14 regulatory framework, the revenues WaSCs can earn from sludge services are included within the overall ‘allowed revenue’ we set as part of our binding wastewater wholesale price control. Therefore, while we do not directly set the individual ‘prices’ WaSCs charge for specific sludge service elements, the total amount of income they can generate is capped.

Related to the above, **an important consideration for us as we consider potential reforms to our framework is the incentives present under our prevailing regulatory approach – and importantly, whether these incentives create any distortions** that lead to sub-optimal outcomes. For example, where WaSCs generate revenues from activities that are outside of the regulatory ring fence, these are subject to transfer pricing. However, WaSCs have previously highlighted that there are uncertainties relating to how these operate in practice, which may in part discourage them from making investments outside of their core sludge activities (or indeed, in trading with other out-of-area WaSCs)[7].

Further to the above, the OFT found that:

> "the operation of the current economic regulation framework can represent a barrier to competition between WaSCs and can also hinder competition from waste companies in the treatment of SS [sewage sludge]. In addition, it can distort competition between WaSCs and waste companies in the treatment of OOW [other organic waste], by providing an advantage to WaSCs." [8]

While one issue identified by the OFT (specifically capex bias) should, in principle, be mitigated by our adoption of a totex approach to cost assessment at PR14, other potential distortions remain. These include the distortion of capital value associated with sludge due to the RCV discount at privatisation and the shielding from market risk around new investment decisions due to the ability to recover sludge investment from wider RCV associated with wastewater business.

In addition to the economic framework, there is a broader spectrum of regulation that applies across the sludge value chain. This has implications for the potential scope for (and benefits of) markets. A more detailed description of relevant regulations is set out in annex 2 of this appendix, but they broadly consist of:

[7] Organic Waste: An OFT Market Study.' (September 2011). See page 8.
[8] Organic Waste: An OFT Market Study.' (September 2011). See page 79.

- **environmental and safety regulations** relating to the production and use of sludge in agriculture;
- **codes of practice** relating to the use of sludge in agriculture (including the ADAS sludge safety matrix); and
- **environmental permitting regulations**, which apply to both the non-agricultural use of sludge and transporting sludge (that is you cannot transport sludge unless you are a registered waste carrier).

The current framework of environmental regulations deters the co-digestion of sludge with OOW. For AD of source segregated biodegradable waste there is a quality protocol that sets out end of waste criteria for the production and use of quality outputs from the process. Co-digestate is not covered by any such approved quality protocol, and thus remains classified as waste. This is relevant when considering the scope for OOW businesses to enter the market for sludge treatment and recycling. However, there are no such barriers to treating OOW and sludge on the same site and dealing with each digestate product under the appropriate regulations and indeed, we are aware of this taking place in at least one instance.

Scope for making greater use of markets

In this section, we examine the scope for making greater use of markets and market mechanisms for sludge activities, which starts from considering the forms of constraint on markets that may exist in relation to sludge treatment, transport and disposal.

Forms of constraint on sludge markets

In considering the evidence in relation to the scope for markets, it is helpful to have in mind the potential forms of market constraint that could arise. For sludge, there are two main forms of relevance.

- **Market between existing WaSCs.** This could occur where one WaSC's treatment and disposal (or recycling) costs were sufficiently lower than those of another WaSC, and the sludge produced was within close proximity to the border between WaSCs to offset any additional transport costs.

- **Market between WaSCs and wider waste businesses.** This possibility was identified in the Cave Review and the OFT market study, and could arise in circumstances where a third party provider is able to treat and dispose of sludge at a lower cost than the local incumbent[9]. The Water Act 2014 contains provisions for markets in relation to the removal of 'matter' from sewerage systems, which allows the regulatory regime to evolve to accommodate this form of competition further (although we expect that the relevant provisions will only be applied to English WaSCs).

[9] 'Independent Review of Competition and Innovation in Water Markets.' Martin Cave (2009). See para 4.41.

A related matter that could have an impact on the extent to which a well-functioning market in sludge develops is the **impact of biosolids product value.** For example, farmers who use sludge recycled to agricultural land could substitute that sludge with other fertilisers. Similarly, in energy markets, there could be some substitution between forms of energy generated through sludge (biogas) and other forms of energy, depending on the price differentials. Therefore, these alternatives could impact on the 'end' price for sludge on a forward-looking basis.

Investment requirements and capital intensity

The extent to which a well-functioning market could develop for sludge activities will depend in part on the investment required to enter and supply the markets in question. The need to invest capital is not itself a barrier to entry. However, it could give rise to entry barriers either where investment is sunk, or where there are issues of access to finance. Where the assets required are long lasting, the downsides associated with asset stranding risk may be greater, which could also deter entry. Below we briefly describe the types of investment required to undertake sludge related activities.

For sludge treatment, suppliers need to invest in treatment facilities. These costs would be partially sunk, in that there is likely to be equipment used that is designed specifically for handling sludge, but it may be possible to reuse some assets for treating other organic waste (for example, an AD tank). We note that the OFT found that there are "relatively high entry costs"[10] in relation to sludge treatment.

Sludge transport is likely to require comparatively little capital investment because:

- the majority of transportation can be outsourced and so can be managed as an operating cost; and/or
- transport assets can themselves be leased – any tankers purchased by a new entrant could be reused for transporting other waste, if the handling properties of the two materials allow.

[10] 'Organic Waste: An OFT Market Study.' (September 2011). See page 44.

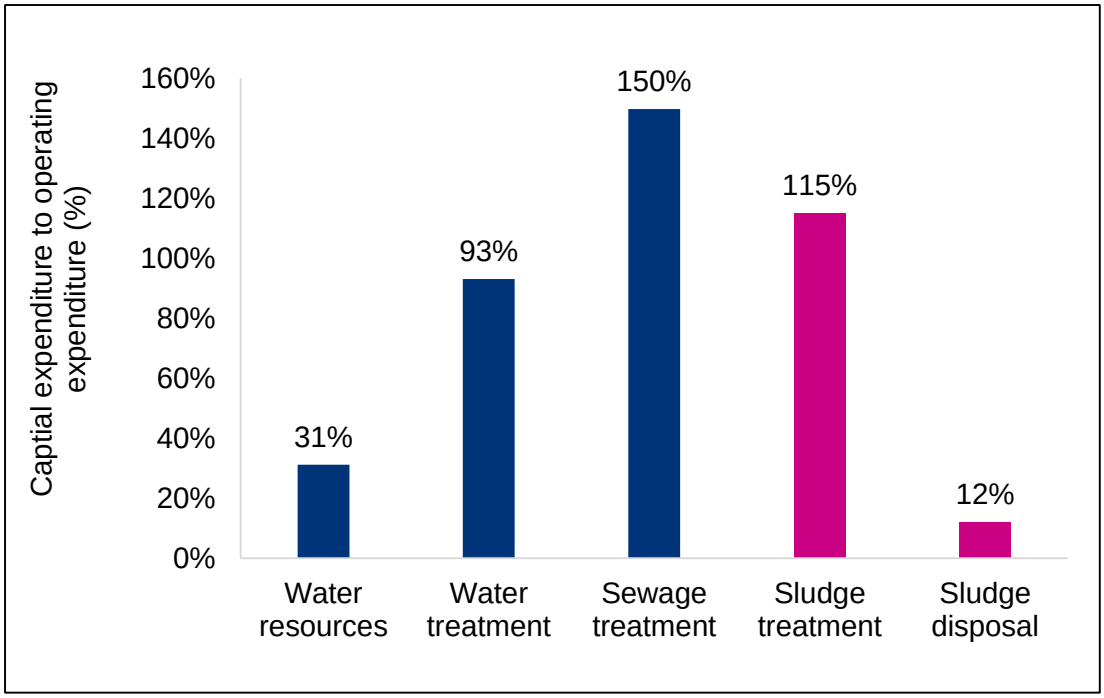
Sludge disposal (or recycling) requires specialist vehicles, agronomic services and systems for recycling sludge to land, or investment in other disposal technologies, such as incineration. Any specialist vehicles for sludge spreading could potentially be used to spread OOW to agriculture. More technically complex disposal technologies may be difficult, but not impossible, to adapt to treat/dispose of other organic wastes.

To further inform the above, we have examined the average asset lives, and capital intensity (measured in terms of the ratio of capex to opex) for sludge activities. The results of this are shown in the following two charts[11], which reveal that:

- relative to other parts of the water supply chain, sludge assets have relatively short asset lives, with average asset lives of 30 and 13 years[12] respectively for treatment and disposal. This compares with an average asset life of 49 years for water resources (we note that in some cases asset lives for water resources can be much longer). Relatedly, we are aware that, due to the pace of technological change in sludge, assets are sometimes replaced prior to the end of their physical operating life (and consequently the sludge asset lives quoted here may somewhat overstate their true economic lives);
- sludge disposal is particularly asset light, with a capex to opex ratio of just 12% in 2013-14; and
- sludge treatment requires more material capital investment, with a capex to opex ratio of 115% in 2013-14.

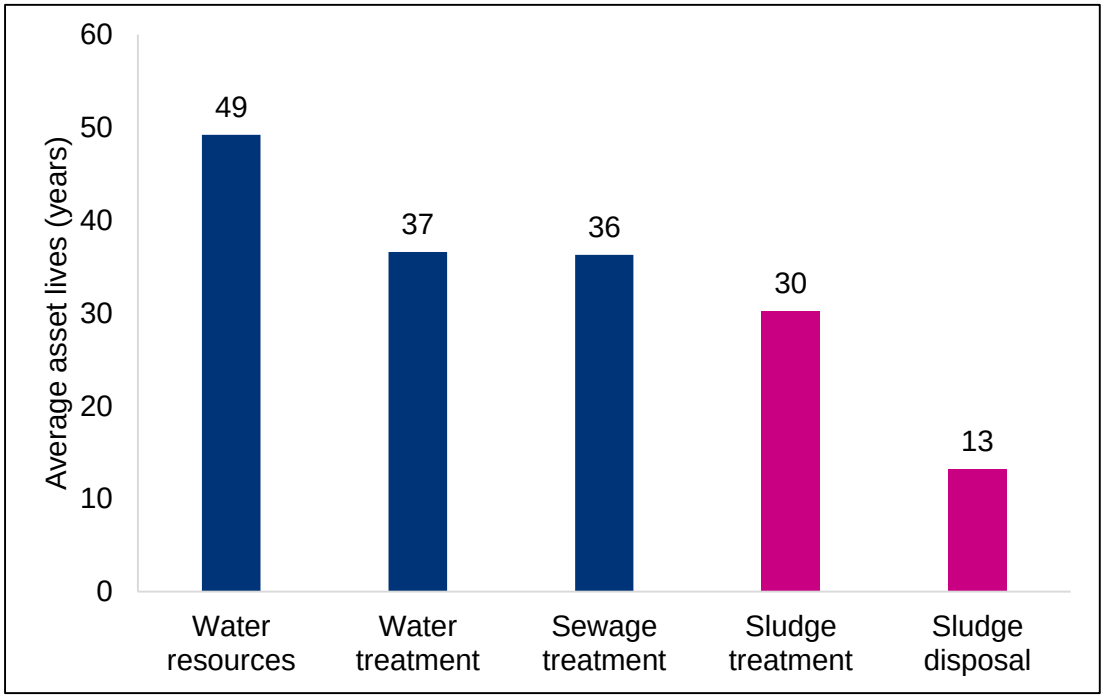
[11] All data sourced from company regulatory accounts.
[12] Thames and Wessex are excluded from this average, as their implied average asset lives for sludge disposal are outliers.

Figure 3: Comparison of the ratio of capital expenditure to operating expenditure



Source: Ofwat analysis of company regulatory account data.

Figure 4: Comparison of average asset lives across the wholesale value chain, 2013-14



Source: Ofwat analysis of company regulatory account data.

Access to finance

There remains a question as to whether new entrants would be able to access finance at an equivalent cost to existing WaSCs. Wessex Water directly addressed this issue in its Water 2020 paper on the potential commercialisation of sludge markets[13], where the company highlighted that:

- entrants may be hampered by less favourable cost and terms of finance than WaSCs;
- capital markets might perceive WaSCs as benefitting from a 'perpetual licence', meaning that debt will be rolled, rather than repaid; and consequently; and
- such conditions could reduce investors' willingness to enter sludge treatment if they are expected to either buy or build assets.

We acknowledge the potential concern that the current regulatory framework may distort the cost of capital for WaSCs providing sludge services, due to the ability to recover costs from sewage treatment and for cross-subsidies between two services. Whether the issues raised by Wessex discourage wider entry depends on a number of factors. In particular, Wessex refers to entrants investing solely in sludge treatment. In practice, the most likely entrants are OOW businesses, and there may be synergies across their existing businesses they could realise as a result of treating sludge. This might also mean that the investments they make are not solely related to sludge. In addition, the extent of any financing advantage a WaSC enjoys might also depend on whether the entrant is considering 'new' treatment capacity, or is displacing existing capacity. It is not clear, therefore, that incumbent WaSCs would necessarily have a financing cost advantage over entrants.

Related to the above is our approach to the allocation of the regulatory capital value (RCV) – were we, in fact, to allocate the RCV. In particular, if incumbent WaSCs were able to use existing assets and capacity for treating OOW, we might be concerned that they would benefit from the 'privatisation discount' to the RCV, were we to allocate the RCV on an unfocused basis.

[13] 'Water 2020' Potential developments in the commercialisation of the sludge treatment and recycling market.' Wessex Water (June 2015).

Economies of scale

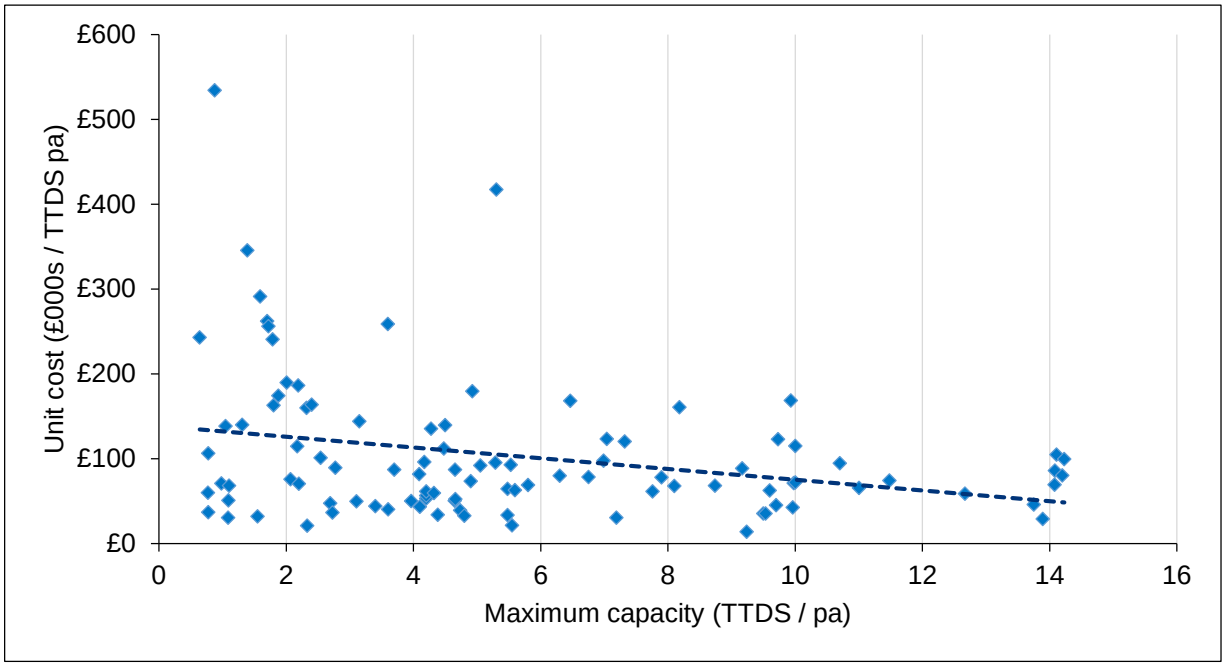
There is some evidence that there are economies of scale in sludge treatment. In 2011 the OFT found that companies with larger plants benefitted from lower processing costs per tonne of dry solids. It stated that, for AD plants, an increase in throughput from 5,000 to 10,000 tonnes of dry solids decreased unit operating costs by some 20%[14]. A study by London Economics in 2010 also found that there are economies of scale at the site level. London Economics further stated that:

> "due to the economies of scale in sludge treatment, many small sewage treatment plants will transport sludge to a central large scale sludge treatment facility."[15]

We examined the relationship between plant size (measured in terms of capacity in thousand tonnes of dry solids (TTDS) per year) and operating costs on a unit cost (per tonne) basis across all the WaSCs. The following chart shows the results of our analysis (including a linear trend line)[16]. This reveals that unit operating costs generally decrease with plant size, suggesting (and consistent with existing evidence) there are economies of scale.

[14] 'Organic Waste: An OFT Market Study.' (September 2011). See page34.
[15] 'Competition in upstream sewage and sludge markets.' London Economics (2010).
[16] Analysis excludes those sites where capacity is greater than 15 TTDS / pa.

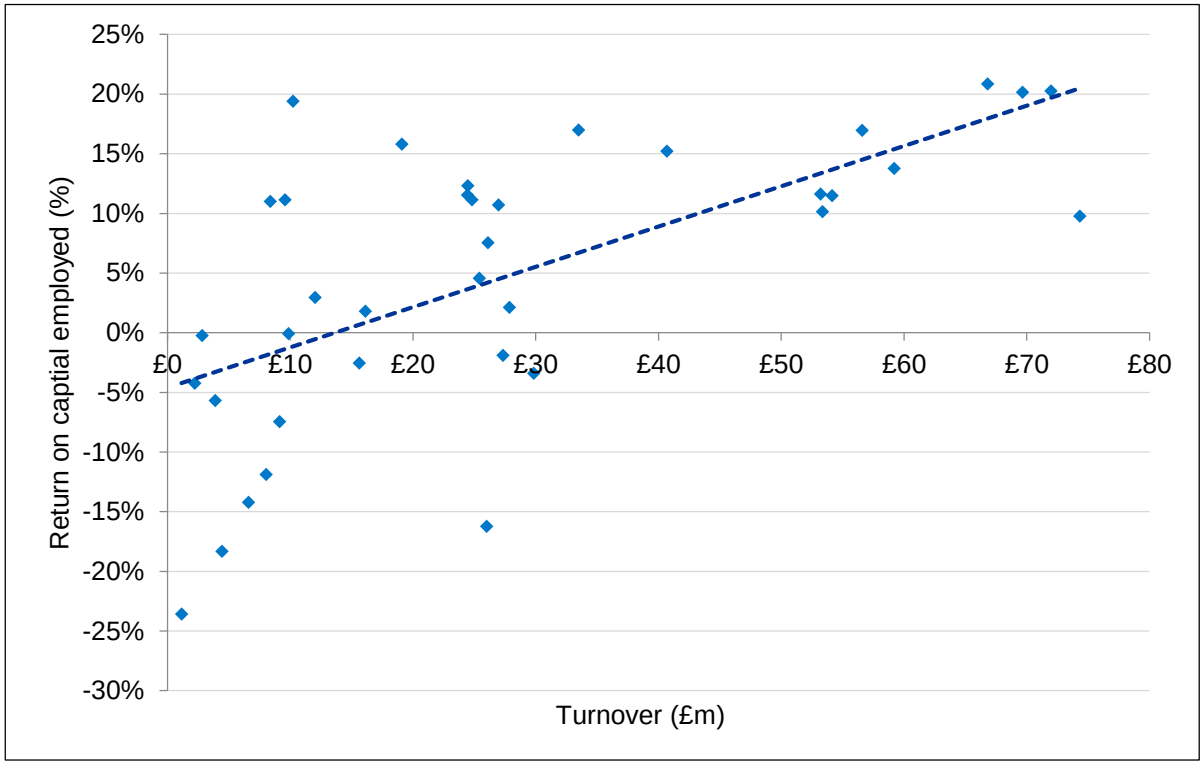
Figure 5: Scatterplot of sludge treatment centre capacity and unit opex



Source: Ofwat analysis of OFT data.

We have also investigated **economies of scale** in the market for OOW, by examining the relationship between turnover (a measure of size) and profitability for a range of OOW companies. We have done this using two alternative profit measures: return on capital employed (ROCE) and earnings before interest and tax (EBIT). The results under both approaches were similar, and so we only show the ROCE analysis (see next chart).

Figure 6: Scatterplot of ROCE and firm size (turnover)



Source: Ofwat analysis of company account data.

Our analysis suggests that profitability is positively correlated with firm size. This is also in line with the existing evidence suggesting that **economies of scale** are a feature of waste processing. We should be cautious in our interpretation of this data, because a number of other factors may influence profit across companies and there are relatively few data points.

Economies of scale in sludge treatment have the following implications.

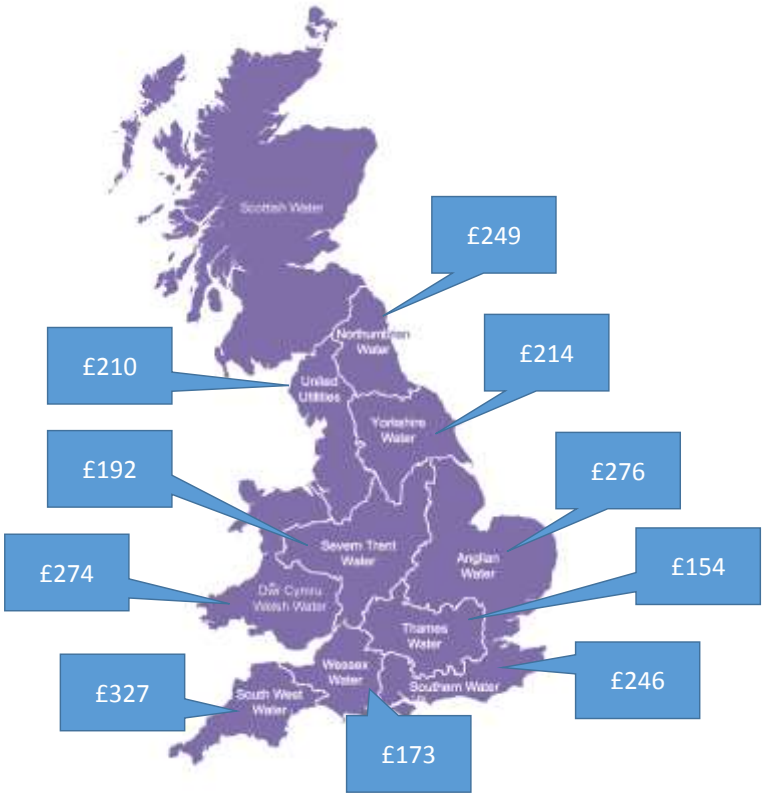
- The scope for entry and rivalry with many small players, is likely to be limited.
- However, the extent of fixed costs is not so large as to preclude increasing use of markets, either between WaSCs or between WaSCs and OOW providers.
- Economies of scale may mean that it is economic to transport sludge longer distances to centralise processing and so it is not clear whether economies of scale in sludge processing increases or reduces the scope for well-functioning markets.

- Apparent site level scale economies suggest market development is likely to be local in nature. We discuss this further below in relation to transport costs. In addition, it might suggest that markets would drive consolidation.

Differences in sludge activity costs between WaSCs

One indication of the potential scope for better use of markets is the prevailing level of cost differences across the WaSCs. The map below shows the 'per unit' sludge costs in £s per tonne dry solid (£/TDS) by company, as reported by the OFT in 2011[17].

Figure 7: Sludge transport, treatment and disposal unit costs (£/TDS)



Source: OFT.

[17] Figures as reported by the OFT, using 2009-10 June return data. We note that more up-to-date data will be available from separated accounts for 2015-16 in the next year.

The key point to note is that unit costs vary materially across the companies. The difference between the highest and lowest cost companies is some 52%. We also note that the cost differences between neighbouring WaSCs can be significant – for example, the difference between South West Water and Wessex Water of 47%.

The above differences in unit operating costs are sufficiently large to suggest that there may be potential unrealised gains from commercial trading and markets. However, we note that some of the variation in unit costs across the firms may be for reasons unrelated to economic efficiency, such as differences in the mix of activities undertaken, or underlying differences in geography and so on. The importance of transport costs further means that comparisons of unit costs alone are not a sufficient basis to reach a definitive conclusion. Here we note that there are some limitations in the comparability of existing data across the WaSCs, and this is something we would like to address collaboratively with the industry going forward.

Transport costs and implied overlaps between WaSCs

The scope for increased use of markets in sludge treatment is a function of transport costs. Specifically, for it to be 'economic' for an incumbent WaSC to contract with a rival for sludge treatment and disposal, the associated transport costs will need to be lower than the benefits generated by the transaction.

Accurate information regarding the cost of transporting sludge is difficult to obtain. Unit costs of transport vary depending on the volume of sludge being transported, its density, the distance travelled and geographic factors, such as the type of roads being used. The OFT collected typical transport costs over 30 km and 50 km and used this to identify the extent of overlap between WaSC facilities. London Economics assumed 54 km was the maximum distance over which it would be economic to transport sludge[18]. We note that economic transport distances may increase as site economies of scale increase with potential greater use of different types of organic waste processing on single sites.

[18] 'Competition in upstream sewage and sludge markets.' London Economics (2010), pages 56-57. Example was based on the distances sludge was transported to the Great Billing STWs, operated by Anglian.

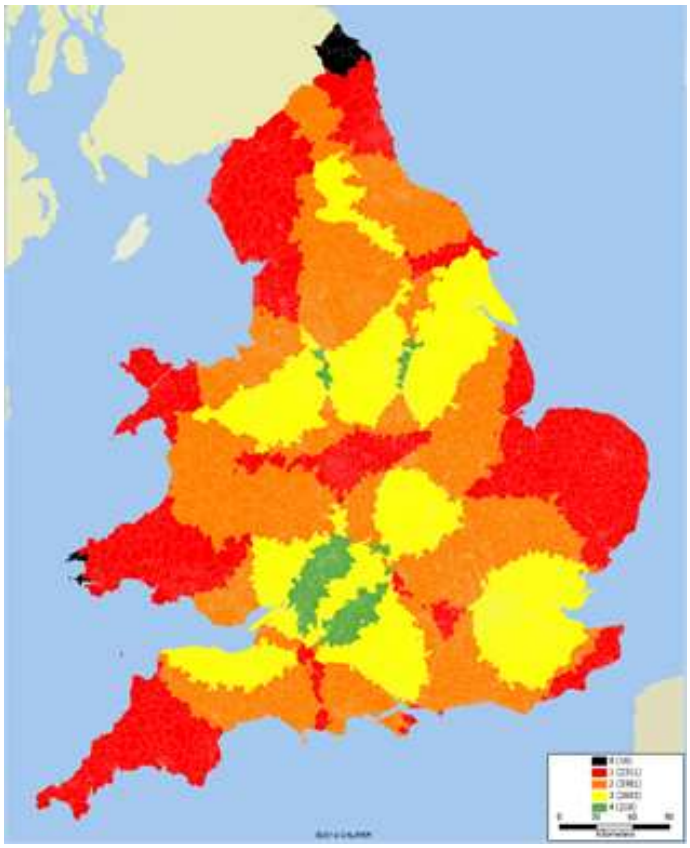
Since the OFT report we are aware that the WaSCs have changed the configuration of their wastewater treatment works and sludge treatment centre operations. Given this, we have undertaken our own analysis – and in particular, we have:

- updated the OFT's approach, assuming that 50 km is the maximum distance for which it is economic to transport sludge (this was the OFT's central assumption). Our update reflects new sludge assets developed since 2011;
- as above, but where we use 50 km reflecting road layouts, rather than assuming a straight line; and
- analysed drive times, rather than distances, based on a range of scenarios regarding the time over which transport might be economic.

A full explanation of our methodology and results is contained in annex 5. However, the following figure shows the results of the first of our above three approaches (that is an update of the OFT's method). The analysis shows the number of WaSCs operating sludge treatment centres (STCs) within 50 km of another (rival) WaSC's STC, by electoral ward area. In interpreting the chart, note:

- wards that are coloured red have only one WaSC operating STCs within a 50 km radius. That is, all STCs within a 50 km radius of the boundaries of the ward are operated by the same WaSC (the implication being that in these areas, there would be no existing scope for trades);
- wards coloured orange have two different WaSCs operating STCs within a 50 km radius;
- yellow wards have three WaSCs operating STCs within a 50 km radius;
- green wards have four WaSCs operating STCs within a 50 km radius; and
- black wards have no STCs within a 50 km radius.

Figure 8: Extent of 'overlap of sludge treatment facilities across WaSCs



Source: Ofwat analysis of updated OFT data

To indicate what the above implies regarding the **total extent of the scope for 'trades' between WaSCs**, the following table shows the proportion of STCs for which there are rival sludge facilities within a 50 km radius.

Table 2: Number of WaSC STCs which are within 50km of a rival's STC

Number of rival WaSCs with STCs within 50 km	Proportion of STCs
0	33%
1	42%
2	23%
3	2%

Source: Ofwat analysis of updated OFT data.

Table 2 implies that for 67% of STCs, there could be scope for trade (this is the % of STCs for which there is **at least one** rival facility within a 50 km radius, based on the sum of rows 2 to 4 above). If the same analysis is repeated on a drive distance (rather than a straight line/radial) basis, the scope for trades reduces to 42% of STCs being close enough to rival facilities for trades to potentially be economic (see annex 5 for more details). Our analysis examines the scope for trade as a function of transport cost proxied by assumed distance. In practice, the total scope for trades would also depend on differences in capacity, relative efficiency across WaSCs and by facility (which may not be reflected in unit costs), and on the extent to which existing sites are co-located with sewage treatment works (STWs). **Consequently, the 42% should be regarded as an upper bound.**

Wessex Water's paper on the commercialisation of sludge also discusses the scope for transporting sludge. The company states:

> "Sludge treatment does not occur at every sewage treatment works, rather it is largely focused at large treatment centres with raw sludge being "trucked in" from smaller sewage works. Typically, fewer than 5% of sewage treatment works are also sludge treatment centres."[19]

Although the number of sewage treatment works that are also sludge treatment works are few, they are the larger sites and therefore, as found by the OFT in 2011, around 60% to 70% of sludge is treated at the site where it was produced. That leaves 30% to 40% which is transported to STCs – although no information on distances is provided within the Wessex paper.

When subsequently discussing the potential for market entry in relation to providing new capacity, Wessex also states:

> "… it is infrequent that such an opportunity occurs. Whilst growing, sludge volumes are relatively mature. Moreover, when new capacity is created it frequently occurs on or adjacent to existing assets."[20]

[19] 'Water 2020' Potential developments in the commercialisation of the sludge treatment and recycling market.' Wessex Water (June 2015), page 2.
[20] 'Water 2020' Potential developments in the commercialisation of the sludge treatment and recycling market.' Wessex Water (June 2015), page 10.

One possible interpretation of these two statements is that the existing configuration of STCs and STWs is not necessarily optimised, given prevailing transport costs (reflecting the legacy nature of certain assets). Consequently, and as per Wessex's first above statement, companies do, at present, truck sludge between sites. However, because "new" investment can be optimised to take advantage of economies of scope between STWs and STCs, there may be less scope for such a market in relation to green field entry.

We have also analysed 2012 EU data on sewage treatment works that fall under the Urban Wastewater Treatment Directive (UWWTD)[21]; specifically, those serving more than 2,000 people. At an industry level, 34% of the population served (and hence sludge produced) by these UWWTD sites is at sites which do not have sludge treatment facilities, and the sludge is therefore transported offsite for treatment. However, at a WaSC level this ranges between 11% and 57%.

In summary, it is clear that the presence of transport costs is a key feature and means that the scope for better use of markets will be localised. While determining the extent of this is not straightforward, the evidence here provides a reasonable guide. In addition (and as set out in annex 4) most respondents to our survey of WaSCs indicated that there is some scope for optimisation across the companies. Here, a key issue is that (at present) there are no price signals that could inform players and potential entrants as to where optimisation opportunities might arise. Consequently, this might imply a need for informational solutions, which we discuss below.

The scope for markets between WaSCs and firms operating in wider waste markets

The second key form of market constraint we have identified relates to the scope for markets between WaSCs and firms operating in wider waste markets (and specifically, other organic waste – OOW, markets). This possibility arises because the skills and assets required to undertake the treatment and disposal of organic waste are similar to those required for sludge treatment and disposal.

[21] http://www.eea.europa.eu/data-and-maps/data/waterbase-uwwtd-urban-waste-water-treatment-directive-3

Relating to the above, the volumes of digestates produced from other organic waste have been increasing in recent years and are likely to continue to increase. According to a 2015 report produced by NNFCC[22] there are over 180 operational AD plants in the UK outside of the sewage treatment sector, with a further 500 projects currently under development.

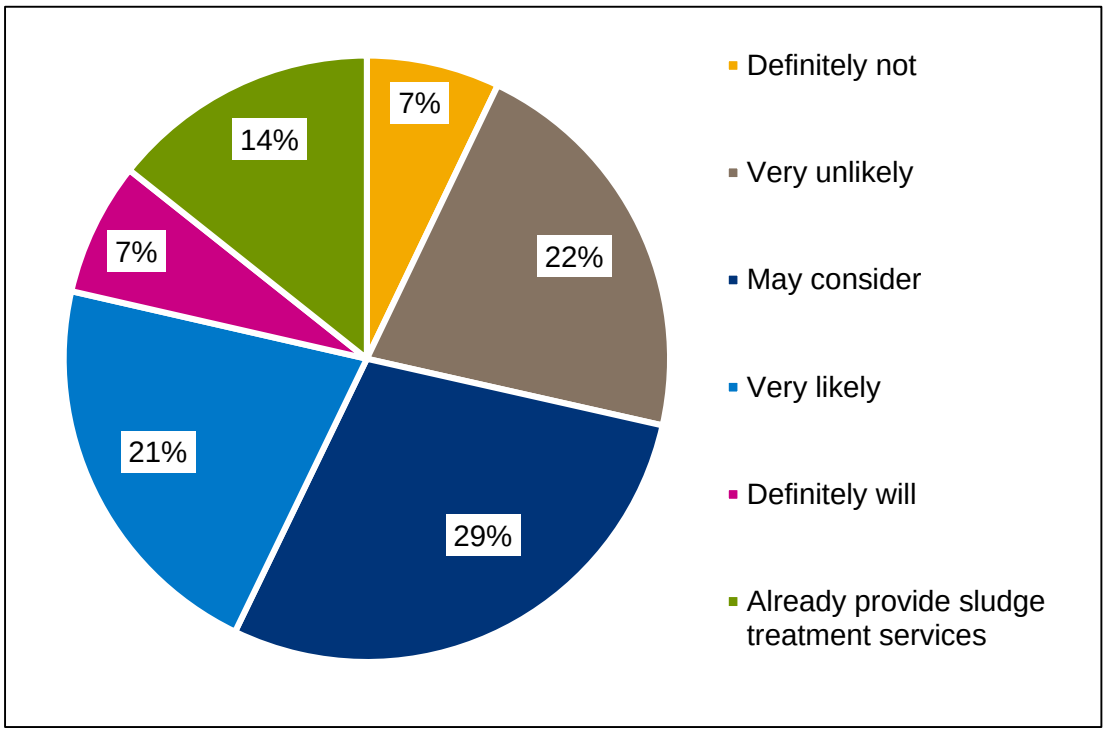
The potential for competition between WaSCs and wider waste firms was identified by the OFT in 2011, who found that:

> "Given the similarities in the technologies and systems used to treat, and recover or dispose of SS [sewage sludge] and OOW, there is clear potential for competition between suppliers of treatment for each type of waste."[23]

Our own evidence is also supportive of this. In particular, and as described in annex 3, we surveyed firms operating in wider waste markets, and found that 28% of respondents would "definitely" or are "very likely" to consider entering into sludge treatment.

[22] http://www.nnfcc.co.uk/tools/nnfcc-report-anaerobic-digestion-deployment-in-the-uk
[23] 'Organic Waste: An OFT Market Study.' (September 2011). See page25.

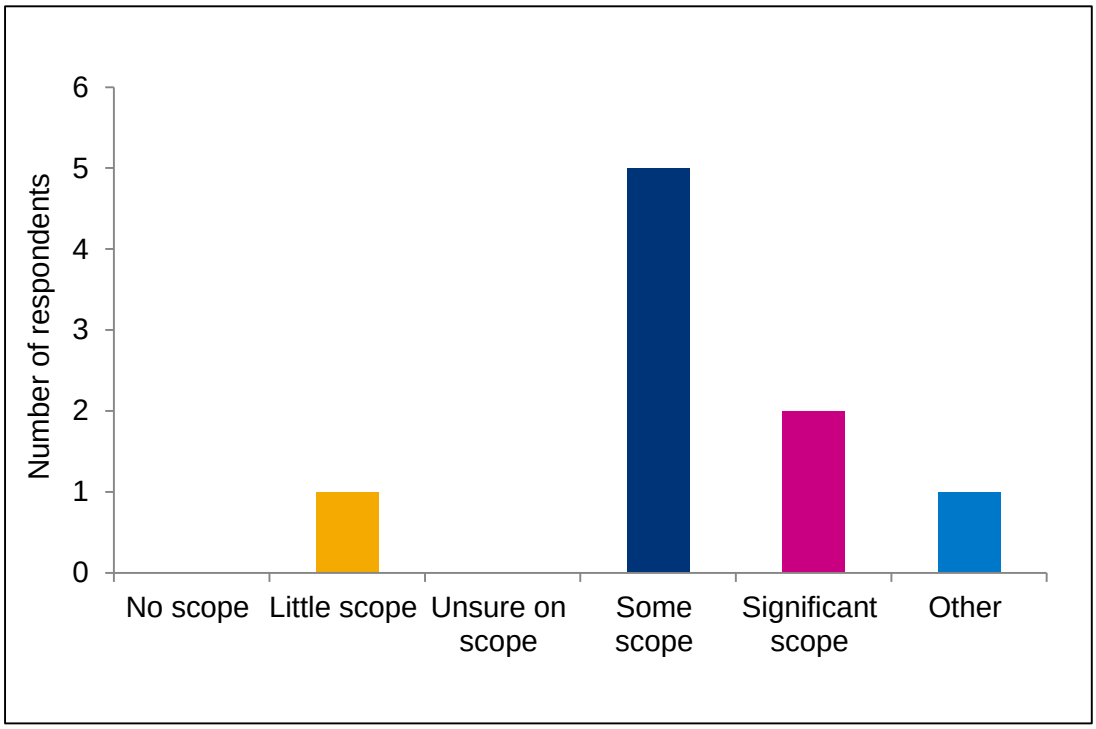
Figure 9: To what extent do you think it is likely your organisation would, during the next five years, consider entering the market for the treatment of sludge?



Source: Ofwat analysis of responses to survey of potential sludge entrants.

Similarly, seven out of nine respondents to our survey of WaSCs (described in annex 4) indicated that there was either 'some scope' or 'significant scope' to provide services in wider waste markets.

Figure 10: To what extent do you think there is scope for you to provide services in relation to wider waste markets (in particular, the treatment and disposal of other organic waste), either by utilising your existing assets, spare capacity and skills, or through developing these where required?



Source: Ofwat analysis of responses to survey of WaSCs.

Finally, the scope for firms to provide services across both OOW and sludge markets is self-evident from the fact that some firms are already active in both spaces. This includes GENeco (Wessex Water).

Impact of biosolids product value on market development

In principle, as sludge increasingly becomes a resource with an economic value, then so too the overall scope for market entry should increase. The scope for substantial and rapid increases in demand is a key differentiator from water resources, where demand is primarily linked to underlying population growth (and therefore is steadier).

Related to the above the 'end-price' of sludge could impact on the how quickly well-functioning markets develop. For example, how much farmers who obtain biosolids from WaSCs are willing to substitute them with alternative products could change the price WaSCs could charge for their biosolids. Similarly, to the extent that sludge is converted into a biogas, there could be some price substitutability in relation to other forms of energy. In turn, WaSCs would be further motivated to minimise their sludge treatment costs in order for the disposal price to be competitive. In practice, changes in the cost and value of sludge may be passed onto customers. The extent of pass on will depend on various issues, including how buoyant the relevant markets are.

Over time, the impact on the 'end price' of sludge will depend on a range of factors. For example, in relation to the use of sludge as a form of fertiliser, it will turn on:

- how readily rival products can be substitutes for biosolids, in terms of characteristics and price; and
- the likely future size and value of the biosolids market.

There is already evidence that farmers regard biosolids as a substitute for manufactured fertilisers. For example, a report on digestate distribution models by WRAP in 2010 stated that:

> "Demand on-farm [for biosolids] currently remains strong, as manufactured fertiliser prices are high."[24]

In other words, relative price changes for manufactured fertilisers do drive farmers to substitute towards biosolids. We also note that some WaSCs actively market their biosolids as a substitute for manufactured fertiliser, where price is explicitly mentioned as a factor. For example, Severn Trent's website has a dedicated page for biosolids sales, where it states:

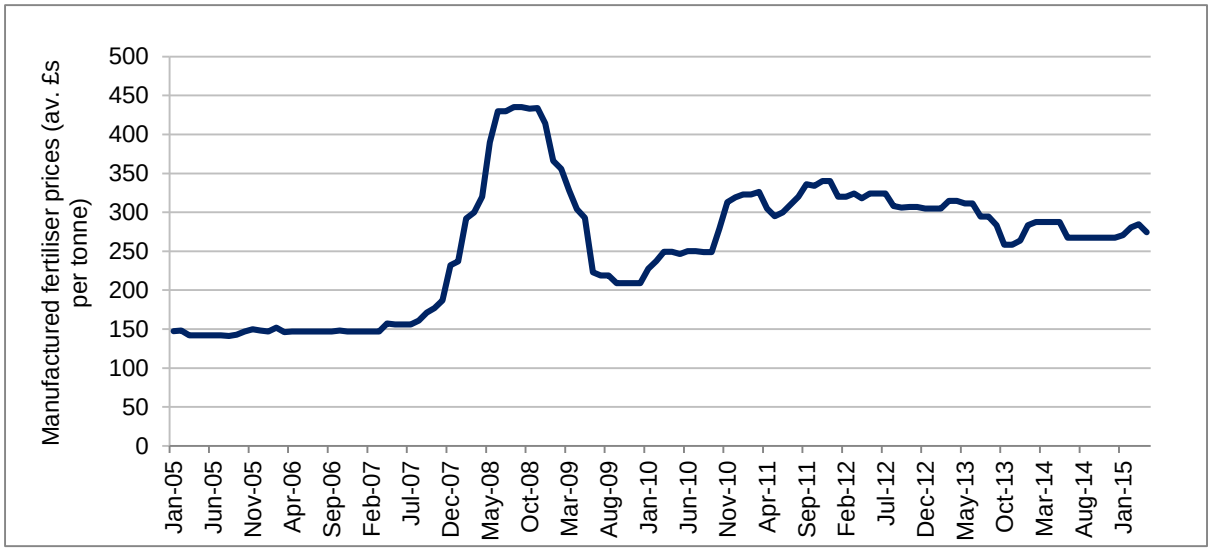
> "For farmers, these biosolids are a high-quality alternative to manufactured fertilisers – at a competitive price – and play a vital role in enhancing soil quality and fertility."[25]

[24] 'Digestate distribution models.' WRAP (2010). See para 3.2.3.
[25] http://www.stwater.co.uk/businesses/waste-water-services/biosolids-recycling/

There are also some factors likely to limit the scope for substitution between biosolids and manufactured fertilisers. The WRAP report indicates that not all participants across the wider food supply chain would actively 'endorse' the use of biosolids. This might limit substitution, so that farmers' demand for biosolids will be influenced by preferences elsewhere in the food supply chain[26].

The price of manufactured fertiliser in the UK has risen materially over the last decade, which may have increased the scope for substitution to biosolids for farmers. Specifically, the average price per tonne for a blended bag of fertiliser in the UK has increased from £148 per tonne in January 2005 to £275 per tonne in April 2015 (in nominal prices), an increase of 86%[27].

Figure 11: UK manufactured fertiliser prices (average £s per tonne)



Source: FARM BRIEF, by permission.

The previous figure illustrates how volatile the price of conventional manufactured fertiliser can be, which is closely linked to the price of oil. While the increase in fertiliser prices may have helped grow demand for biosolids, comparing the price of the two is not straightforward. This is for a number of reasons.

[26] For example, there could be negative media coverage of the use of human sludge in the food supply chain, which may influence food retailers in their purchasing decisions.
[27] Data sourced from FARM BRIEF as given by Agriculture and Horticulture Development Board. Blended bags include ammonium nitrates and urea. Prices are in nominal terms.

- The price of biosolids may include a range of activities, including soil analysis, delivery, spreading and soil management services.

- Biosolids products may be delivered to farmers in advance of spreading and are sometimes stored in temporary field heaps. This means that delivery can be spread throughout the year and does not have to be concentrated into the period just prior to land application.

- We understand that the price paid by farmers for biosolids does not typically capture its full nutrient value as would be reflected in the price of manufactured fertiliser[28].

One WaSC explains on its website that the nutrient value for one tonne of its biosolids ranges between £5.00 and £11.00 per tonne, but costs the farmer around £1.50 per tonne. These values are not directly comparable to those for fertiliser prices per tonne due to the difference between the concentrations of nutrients in fertiliser and biosolids. Fertilisers can be dry products with typically 25% by weight nitrogen, so one tonne of fertiliser contains 250 kg of Nitrogen. Digested sludge cake is around 75% water and one tonne of sludge cake may contain around 11 kg of nitrogen. Another company provides information on the nutrient value of sludge of between £141 and £164 per hectare based on an application of 250kg/ha of total nitrogen[29] .

In terms of the size of the biosolids market, the evidence suggests that this is still relatively small. For example, the British Survey of Fertiliser Practice indicates that, in 2013, only 3% of the volume of 'manure' spread to farm land related to biosolids (see next table)[30].

[28] 'Digestate distribution models.' WRAP (2010). See executive summary, page 1.
[29] http://media.aws.stwater.co.uk/upload/pdf/Making-Good-Use-of-Biosolids.pdf
[30] 'British Survey of Fertiliser Practice: Fertiliser use on farm crops for the year 2013.' ONS (2014). Data reported in table D1.1a.

Table 3: Numbers and percentage (%) of farms using each type of manure in Great Britain, 2013

	Percentage of farms (%)	Percentage of volume (%)
None	35%	NA
Cattle farm yard manure (FYM)	51%	40%
Cattle slurry	17%	47%
Pig FYM	2%	2%
Pig slurry	1%	2%
Layer manure	3%	1%
Broiler / turkey litter	2%	1%
Other FYM	5%	2%
Other farm	0%	1%
Biosolids	2%	3%
Other non-farm	1%	1%
Total using manure	65%	100%

While the biosolids market would seem to be relatively modest at present, there are a number of factors that would indicate that there is potential for it to expand. In particular: population growth will further increase demand for food production; over the long run the cost of manufactured fertiliser is likely to continue to rise in line with its main input prices; and continued technological change is likely to further improve the cost effectiveness of biosolids to end users.

The overall scope for growth in the use of sludge as a fertiliser will, on the other hand, be mitigated by the fact that a high proportion, around 80%, is already being recycled to agricultural land. Therefore, further increases in demand in relation to use as a fertiliser might translate to increases in the price (value) of sludge.

When considered in the round, our view is that the **impact of biosolids product value on the development of a well-functioning market is likely to be somewhat limited**, with large price differentials required to motivate substitution to other products. This is likely to reflect a number of factors, including differences in the suitability of fertiliser and biosolids across different land types and their different impacts on crop yields.

Other issues impacting the scope to use markets

There are a range of other issues that may also impact the scope for making use of markets.

- **Features of the historical regulatory framework.** To the extent that there may have been historical 'capex bias', this may have discouraged incumbent WaSCs from contracting with rival companies or new entrants for sludge treatment and disposal. In principle, our adoption of a totex approach to cost assessment and recovery at PR14 should help to mitigate this.

- **Environmental regulations and quality standards.** The scope for OOW businesses to start treating and disposing of sludge depends to a large extent on them being able to 'co-treat' sludge and OOW on the same sites. However, we understand that the prevailing legal and environmental framework may be a barrier to this. In 2011 the OFT reported that, if a waste business was to co-treat sludge and OOW in the same facility they would face substantially higher costs associated with environmental permits compared to WaSCs treating sludge only (which the OFT estimated to be £0.5 million to £1 million for an average sized plant)[31] . We are not aware of any material relevant changes to environmental regulation since the OFT report in 2011.

- **The planning system.** Evidence suggests that the planning system may mitigate scope for markets to develop between WaSCs and other waste businesses. The OFT report suggests that planning applications for sludge facilities are more likely to be successful where they are co-located with existing facilities, for two key reasons:

    i. local communities are more likely to regard sludge treatment facilities as 'essential', and so were more likely to be supportive of planning applications made by WaSCs relative to potential entrants; and
    ii. that such planning applications are more likely to be successful where they relate to expansions of an existing site (co-location)[32].

[31] 'Organic Waste: An OFT Market Study.' (September 2011). See page 68.
[32] 'Organic Waste: An OFT Market Study.' (September 2011). See page 56.

These issues may have been slightly mitigated in recent years, due to the publication of guidance by the Environment Agency in October 2012. This provided greater clarity to planning committees when assessing waste treatment applications and may have contributed to the significant growth in the number of (non-sewage) AD sites in the UK in 2011 to more than 180 in 2015.

- **Corporate culture.** Writing in 2011, the OFT found some evidence of a "culture of over-reliance on guidance from the regulators and an apparent lack of consideration of the relevant market instruments"[33] among the WaSCs. The OFT suggested that the presence of this culture might manifest itself in the WaSCs not properly considering outsourcing solutions in the sludge space.

Further to the above, we conducted two surveys – one of firms operating in wider waste markets, and one of WaSCs – in order to further understand the scope for markets. The results of these can be found in annexes 3 and 4 of this appendix.

[33] 'Organic Waste: An OFT Market Study.' (September 2011). See page 69.

Key implications for design

Based on the evidence set out here, we think there are a number of reasons to suppose that there is scope to make greater use of markets for sludge treatment, transport and disposal. In principle, markets could deliver material benefits.

- Over time, **there are good reasons to suppose that the 'value' of sludge might increase**, which means the scope to make use of markets may also increase with time (increases in demand increase the scope for entry). This is driven by a number of factors, not least technological change, which has the potential to continue to unlock new uses for sludge. In addition, should manufactured fertiliser prices continue to rise, so the extent to which sludge could substitute for this also increases. Our survey of WaSCs revealed that the majority of companies are of the view that the value of sludge will continue to rise.

- Evidence suggests that **there is scope for trades between WaSCs** for treatment and disposal. This could lead to a more efficient use – and allocation – of capacity across existing providers. Market mechanisms that could facilitate this, for example, by finding ways to help reveal capacity or cost information, might be of particular benefit. The scope for such trades is likely to be localised (as reflected in our update of the OFT's analysis, but also as highlighted by WaSCs in their response to our survey). The localised nature of the scope for markets would tend to suggest that a progression towards full-scale deregulation is not appropriate at this time.

- Evidence also suggests that **there may be some scope for entry and expansion from OOW providers**, as the skills and activities required to treat and dispose of OOW are similar to those for sludge. Indeed, our survey of wider waste firms revealed an appetite for entry – and there are already firms that provide services in both OOW and sludge, indicating that such a market is possible. However, the extent of this is subject to uncertainty. This implies, however, that market mechanisms that address potential entry barriers may be of merit. In particular, addressing information and/or cultural issues would seem to be appropriate issues to consider (especially given the lack of price signals at this time). This type of market could deliver both allocative and dynamic efficiency gains. In particular, dynamic gains could be delivered through increased innovation and technological progress. For example, new treatment technologies for sludge, such as wet air oxidation, gasification or pyrolysis, may emerge as alternatives to AD, which OOW treatment companies may be more familiar with than WaSCs. For example, following an award in 2013 under the DECC Energy

Entrepreneurs Fund, Yorkshire Water has commissioned a 1MWe development CHP gasification facility, operated by Intervate Ltd, using wood pellets and sludge as feedstock to generate renewable energy[34].

- Short asset lives and relatively low capital (for disposal) intensity mean that **some of the risks and trade-offs associated with making use of markets will be somewhat less pronounced for sludge** than other wholesale areas. In particular, they might suggest that asset stranding risks are less pronounced in this area.

- Given the environmental impact from treating, transporting and recycling sludge, there is **scope for environmental gains associated with an increased use of markets**. These gains could be from technological developments and adopting more environmentally beneficial processes.

[34] http://www.intervate.co.uk/#/about-us/4533845119

Market design options

In our July discussion document, we expressed the view that there is scope to make more use of markets for sludge treatment and disposal, compared with other parts of the water value chain.

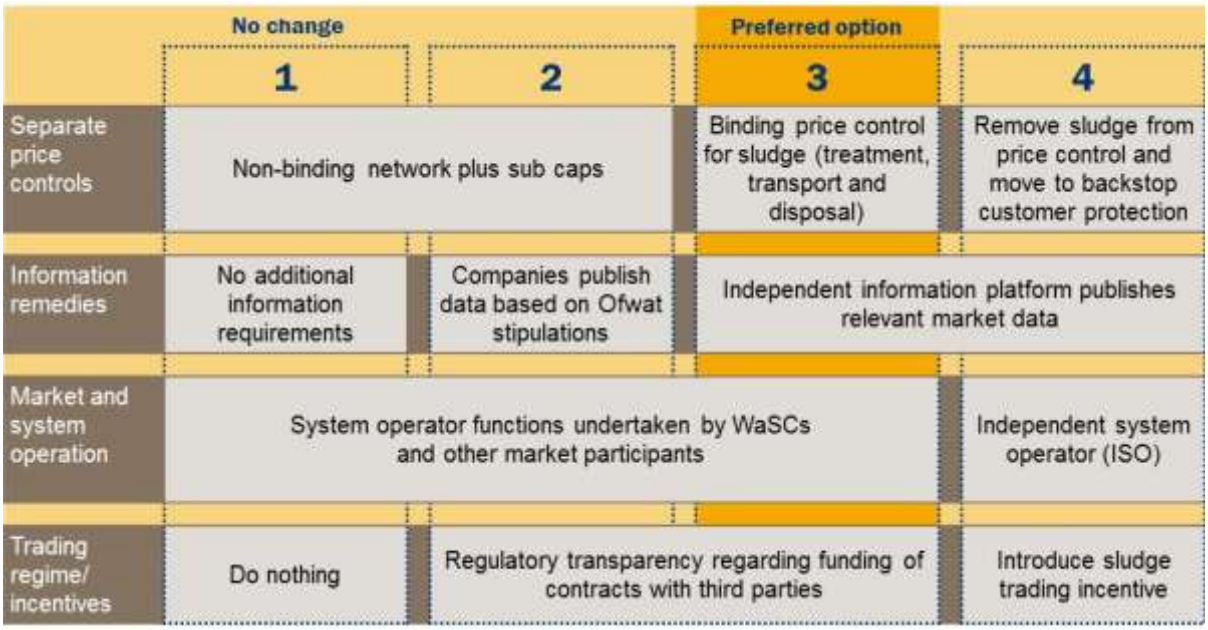
> "The current regulatory framework incorporates sludge as part of the wider wastewater price control, based on the assumption that cost minimisation will be incentivised for sludge as part of the integrated network. The development of markets could reveal information on available capacity and costs and allow optimisation between regions, as well as provide incentives to maximise value from sludge."

The evidence we have gathered since July, including responses to our discussion document, further reinforces the above position. Consequently, we have given consideration as to what the appropriate market design should be – which we set out below.

Our proposed market design options

We have considered a range of market design options across four different dimensions: price controls; information remedies; system operation; and trading regime / incentives. We present these as **four alternative packages** (illustrated in the following figure), and in the remainder of this section we further explain these options, and set out our evaluation of them.

Figure 12: Potential regulatory design options



Option 1

Option 1 **assumes a continuation of the status quo** (that is, it assumes no changes, other than those we have already committed to). Therefore, it consists of the following features.

- **Non-binding network plus sub cap price control.** As previously mentioned, we do not currently set the individual 'prices' WaSCs charge for specific sludge service elements. In developing our design options, we considered the extent to which disaggregated price limits should be binding on the companies, as there are varying degrees to which a control may be binding[35]. Under option 1, Ofwat would set a non-binding indicative wastewater network plus sub-cap, which companies would report against, but in effect, the price control would continue to apply to the total wholesale wastewater business. This represents 'no change', because Ofwat has already committed to non-binding network plus sub-caps at PR14.

[35] The form of the price control for monopoly water and sewerage services in England and Wales – a discussion paper. http://www.ofwat.gov.uk/future/monopolies/fpl/prs_inf_1010fplform.pdf

- **No additional information proposals.** Other than the information required to support the non-binding network plus sub-cap (as above) and relevant accounting separation data, no further information to be required. Therefore, 'no change'.

- **System operation functions undertaken by WaSCs and other market participants.** Responsibility for managing and operating the network infrastructure used to supply sludge services, would remain with the WaSCs. Ultimately, this would see the existing regime maintained ('no change').

- **No change to trading incentives regime.** We are aware of the potential bias against WaSCs using third party services; however, under this option there would be no additional incentives to facilitate trading in sludge treatment and disposal.

Option 2

Option 2 includes the implementation of a number of features over and above the status quo. As it stands there is no visibility of a market price for providing sludge services. Given the absence of such price information, our proposals on information are based on using cost information as a substitute for price. We recognise there are risks associated with publishing detailed cost information and so we will consider developing alternatives, such as collating "price to beat" information, if it can be transparently and consistently calculated.

- **Non-binding network plus sub cap price control.** As above in option 1 (therefore 'no change' on this element).

- **Companies to publish a range of data based on Ofwat stipulations.** In order to address informational issues described in this appendix, we could ask companies to publish information relating to sludge treatment costs and capacity, and transport costs – this would need to be on a localised (site level) to be effective.

- **System operation functions undertaken by WaSCs and other market participants.** As above in option 1 ('no change').

- **Regulatory transparency regarding funding of contracts with third parties.** In order to facilitate trade by providing transparency to trading processes, this option would require companies to report trading activities and demonstrate due process when assessing any proposed bids from third parties.

Option 3

Design features of option 3 would require further changes to the existing regulatory framework compared to those under option 2 above (namely, the addition of a separate price control).

- **Separate binding price control for sludge (treatment, transport and disposal).** Under the existing framework, there is a degree of cost allocation (and estimation) between the different wastewater wholesale activities costs, and particularly between sludge and sewage treatment. However, by having a binding price control for sludge there will be more focus and clarity on the costs associated with sludge activities (for example, because it may increase scrutiny). In addition, a separate binding control would mitigate the potential for cross-subsidisation, which is a particular concern given the potential for markets both between WaSCs and between WaSCs and OOW firms. We also think a binding separate control would help address potential cultural issues, as identified by the OFT.

- **A third party (potentially Ofwat) publishes data in a centralised information platform.** Under this option, the data listed under option 2 (for example costs and capacity) would be collated and published centrally, rather than by individual companies. The benefit of this is that it would reduce information search costs for market participants and entrants and might also help improve the comparability of data. In addition, under this option we would propose to **issue guidelines** on how 'bids' from third parties should be assessed by incumbents, in order to help mitigate potential discrimination concerns.

- **System operation functions undertaken by WaSCs and other market participants.** As above in options 1 and 2 ('no change').

- **Regulatory transparency regarding funding of contracts with third parties.** As above in option 2.

Option 4

Option 4, the most radical option, would see more material changes from the current regulatory framework. Design features of option 4 are as follows.

- **Remove sludge from price control.** Sludge treatment and disposal would be completely removed from the price control. In order to ensure the protection of customers, some form of pricing safeguard mechanism could be introduced as a backstop.

- **A third party (potentially Ofwat) publishes data in a centralised information platform** (as per Option 3 above – including use of guidelines).

- **Independent system operator (ISO).** An ISO would coordinate sludge trades across all market participants.

- **Introduce sludge trading incentive.** In order to encourage active sludge trading market participation for incumbent WaSCs, we would introduce additional incentives (given this option removes price controls).

Assessing the options

In this section, we summarise our assessment of design options for sludge treatment, transport and disposal; and set out our preferred option. Our assessment of the above options is based on three high level criteria:

- how well the option will help us achieve our objectives;
- how well the option addresses known problems; and
- how practical it is to implement.

Additionally, there are a number of wider considerations we would need to address when implementing any regulatory tools (in particular, our approach to the RCV). Our approach to these wider issues is addressed in our main consultation document. The next figure summarises our assessment of the options against the three assessment bullets described above.

Figure 13: Assessment of design options against our criteria

			Preferred option	
	1	2	3	4
Achieving our objectives	Pro-markets with low regulatory input	Pro-markets with low regulatory input. Additional transparency provided on how contracts with third parties funded	Pro-markets in a proportionate and targeted way. Separate price cap would provide more focus on sludge and relationships with rest of business/other businesses	Price cap protection will always be needed in geographic monopolies. ISO disproportionate. But moving to backstop protection would encourage ownership and innovation in sludge
Addressing known problems	No change relative to status quo and therefore does not address identified problems	Information transparency identified as market stimulant by potential entrants. Build versus buy bias addressed through regulatory transparency	Information transparency that is more independent is more effective. Separate price control can solve the 'negative costs' issue. Appropriate because of short asset lives and addresses related market cross subsidy concerns	Removing price cap incentivises use of assets for treating OOW. More independent information is more effective in addressing information asymmetries. ISO removes any actual or perceived dispatch bias, but overrides appointees' ability to decide how to optimise processing of sludge.
Practicality	Avoids creating additional regulatory burden. Quick to implement and low cost.	Avoids cost and licence changes necessary for setting separate sludge price controls. Practical issue of how information transparency is implemented.	Higher regulatory burden due to separate price control. Licence change required for separate price control. Practical issue of how information transparency is implemented.	Benefits of ISO limited relative to significant costs of introducing one in context of sludge. Practical issue of how information transparency is implemented.

Preferred option

After assessing our four options above, our preferred option for regulatory design of the market for sludge treatment and disposal is option 3. Under this option, market design features would include:

- separate binding price controls for sludge (treatment, transport and disposal);
- a third party (potentially Ofwat) publishing data on sludge costs, capacity and other relevant data (through a centralised information platform) supported by guidelines to mitigate discrimination concerns – these are discussed further in our main consultation document;
- system operator functions undertaken by WaSCs and other market participants; and
- regulatory transparency regarding funding of contracts with third parties.

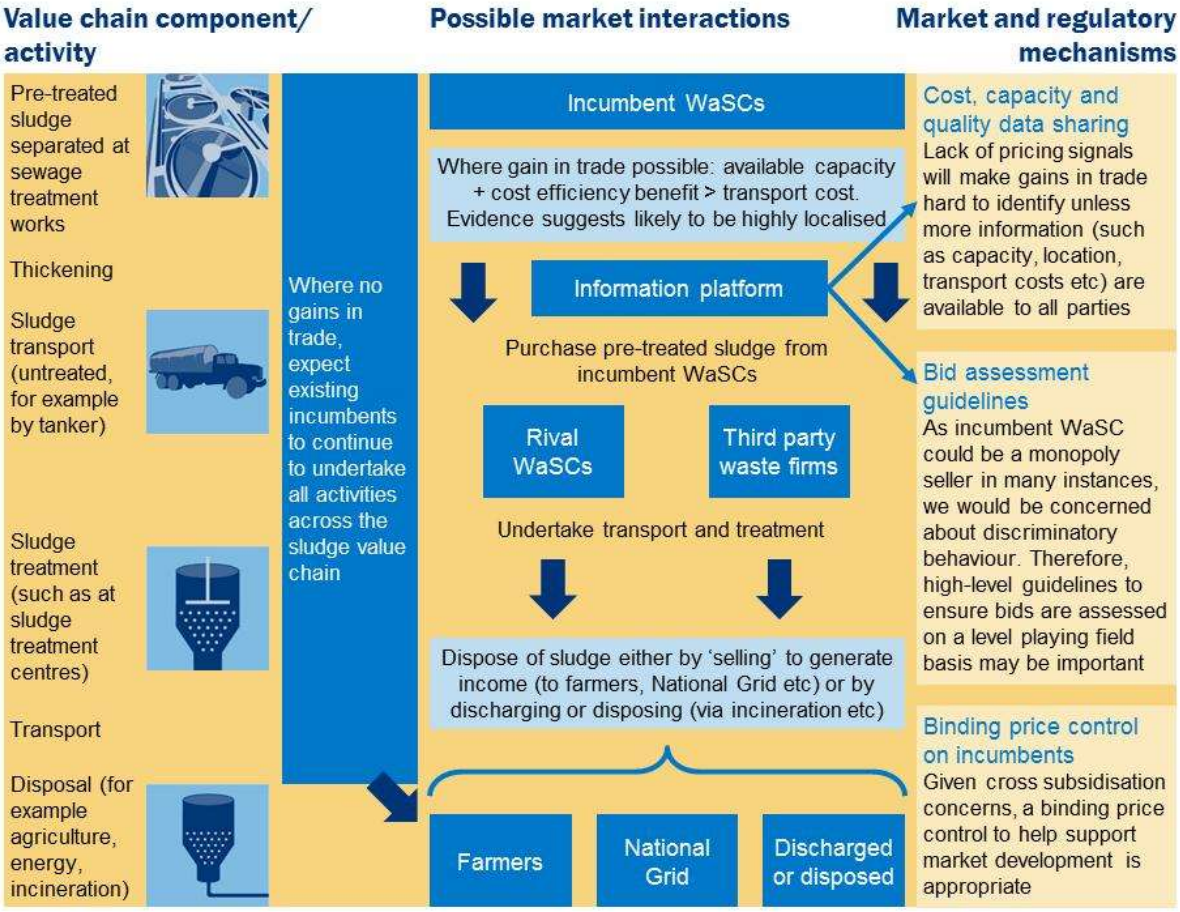
The table below provides further rationale for the key elements of our preferred option.

Table 4: Rationale for using regulatory tools

Regulatory tool	Rationale
A separate, binding sludge price control for incumbents.	The possibility of cross subsidisation particularly between sewage treatment and sludge would be removed through a binding price control, and such a tool would help to support market development by revealing the true costs of sludge. This is a particular concern given the potential overlap with wider waste markets. Note, our survey of potential entrants indicated that cost transparency would increase the likelihood of entry.
Information remedies (including guidelines).	A useful tool to reveal and share information. The lack of pricing signals within the sludge market will make gains in trade hard to identify unless more information (such as capacity, sludge quality, location, and transport costs) is available to all parties. Our survey of potential entrants identified support for such information measures. An incumbent WaSC could be a monopoly seller in many instances and we would be concerned about the potential for discriminatory behaviour. It is therefore important that there is transparency in how bids are assessed by the WaSCs. We consider that issuing high level guidelines as to how incumbents should evaluate third party bids to be a proportionate / low cost means of addressing this.
No change in system operation functions.	The evidence we have developed does not suggest that any change in terms of 'who' undertakes system operation functions would benefit market development. However, we consider that the combination of our other proposals should encourage companies to adopt a wider, 'out of area' perspective to sludge activities.
No specific (financial) incentives to promote trades.	At present, the evidence is most supportive of solutions targeted at informational and cultural issues – and so at this time we do not consider any specific incentive mechanism for sludge to be appropriate.

The following figure illustrates the potential market interactions that we envisage under our proposals.

Figure 14: Possible market interactions under our preferred option



Annex 1: RAG definitions

Our regulatory accounting guidelines (RAG 4.05[36]) have defined boundaries regarding the services and activities associated with sludge treatment and disposal. The following tables provide further details.

Table 5: RAGs

Imported liquor treatment	
Description	Includes all activities in transporting and treating liquors at a sewage treatment plant that have been generated during the sludge treatment process. Excludes liquor treatment which is done at a self-contained sludge processing centre.
Boundary points	**Start:** Pipework from sludge treatment process to liquor treatment plant or sewage works. **End:** Discharge of treated liquor to receiving watercourse.
Assets	Liquor pipework from sludge treatment to sewage treatment site. Liquor plants. Pumps, valves and other ancillary assets. Vehicles. IT assets. Premises.
Unit cost description	Biochemical oxygen demand (BOD) in tonnes.
Sludge transport	
Description	This service includes the transport of sludge from the sewage to the sludge treatment plant. All types of transport, and associated fuel costs, are included within this service. However, transport within the treatment plant or between sludge treatment plants is not included in this service, which is instead an activity of the 'sludge treatment' service.
Boundary points	**Start:** point of discharge of sludge from holding tanks or sewage treatment process into pipework or tankers for transport to sludge treatment processes. **End:** input of sludge into sludge treatment works.

[36] http://www.ofwat.gov.uk/regulating/compliance/assurance/regreporting/gud_reg405.pdf

Assets	Pipework from sewage treatment site to sludge treatment site. Pumps, valves and other ancillary assets. Vehicles. IT assets. Premises.
Unit cost description	Volume transported (m^3).
Sludge treatment	
Description	This service includes all the activities related to sludge treatment. While different technologies exist for sludge treatment, sludge treatment is defined as a technology-neutral service for the purpose of accounting separation.
Boundary points	**Start:** storage of sludge in holding tanks and input into sludge treatment sites. **End:** Point at which the treated sludge is collected for disposal.
Assets	Pre-treatment sludge blending tanks. Sludge treatment plants – thickeners, digesters, centrifuges, vacuum presses, belt presses, other dewatering assets, sludge dryers, drying beds. Composting vessels and facilities. Incinerators. Pumps, valves and other ancillary assets. Treated sludge storage facilities. Vehicles. IT assets. Premises. Gas treatment and energy generation equipment such as combined heat and power (CHP) plants. CHP electrical connection to the electricity grid. Gas connections to gas grid.
Unit cost description	Dried solid mass in tonnes of dried solids (ttds). This is equivalent to the June return 2011 definition for table 15 line 14.
Sludge disposal	
Description	The collection of treated sludge from collection point, onward transport and disposal to landfill, agricultural land, land reclamation sites and to other end users in various forms including; • treated sludge • incinerated sludge ash (ISSA), • composted sludge, • sludge cake. Where income is received for treated sludge then this should be shown as 'negative expenditure' in table 4E.
Boundary points	**Start:** storage of sludge in holding tanks and input into sludge treatment sites. **End:** Sludge disposed or recycled to land.

Assets	Vehicles. IT assets. Premises. Landfill sites or sludge tips
Unit cost description	Dried solid mass in tonnes of dried solids (ttds). This is equivalent to the June return 2011 definition for table 15 line 15.

Annex 2: Further information on relevant environmental regulations and best practice codes

In this annex, we provide further details of relevant environmental regulations and codes of practice.

Producing sludge and using it in agriculture

- Urban wastewater treatment Directive, defines sewage collection and treatment standards for works treating more than 2,000 population equivalent, and banned sludge disposal to sea from 1998. The sludge generated and subsequently treated is included in the definitions of the urban wastewater treatment directive

- Sludge Use in Agriculture Directive 86/278/EEC regulates sludge production and management to prevent harmful effects on soil, vegetation, animals and people when that sludge is used spread on to agricultural land.

- Nitrate Pollution Prevention Regulations 2008. If farms are in Nitrate Vulnerable Zones (NVZs) there are limits on the amounts of nitrogen that can be applied to farmland, and seasons when it cannot be applied. Sludge is a source of nitrogen, so NVZs limit how and when sludge can be applied. Around 58% of England and 2.4% of Wales is in a NVZ.

Associated codes of practice for sludge use in agriculture

- Code of Practice For Agriculture Use Of Sewage Sludge, Defra.

- The use of sewage sludge on farms is covered by Statutory Management Requirement (SMR) 3 under Cross Compliance. Statutory Management Requirements (SMR). 'Cross compliance' is a set of rules that tells applicants what they must (and must not) do to receive rural payments for example for countryside stewardship.

- ADAS safe sludge matrix.

- Currently in production by Water UK Biosolids Network: Biosolids assurance scheme, with the aim "To assure the food supply chain and consumers that recycling biosolids to agricultural land where food crops are grown is a sustainable practice which is safe for both consumers and the environment".

Non-agricultural sludge use

- Non-agricultural use of sludge is governed by the Environmental Permitting Regulations 2010.

Environmental regulation of anaerobic digestion of wastes

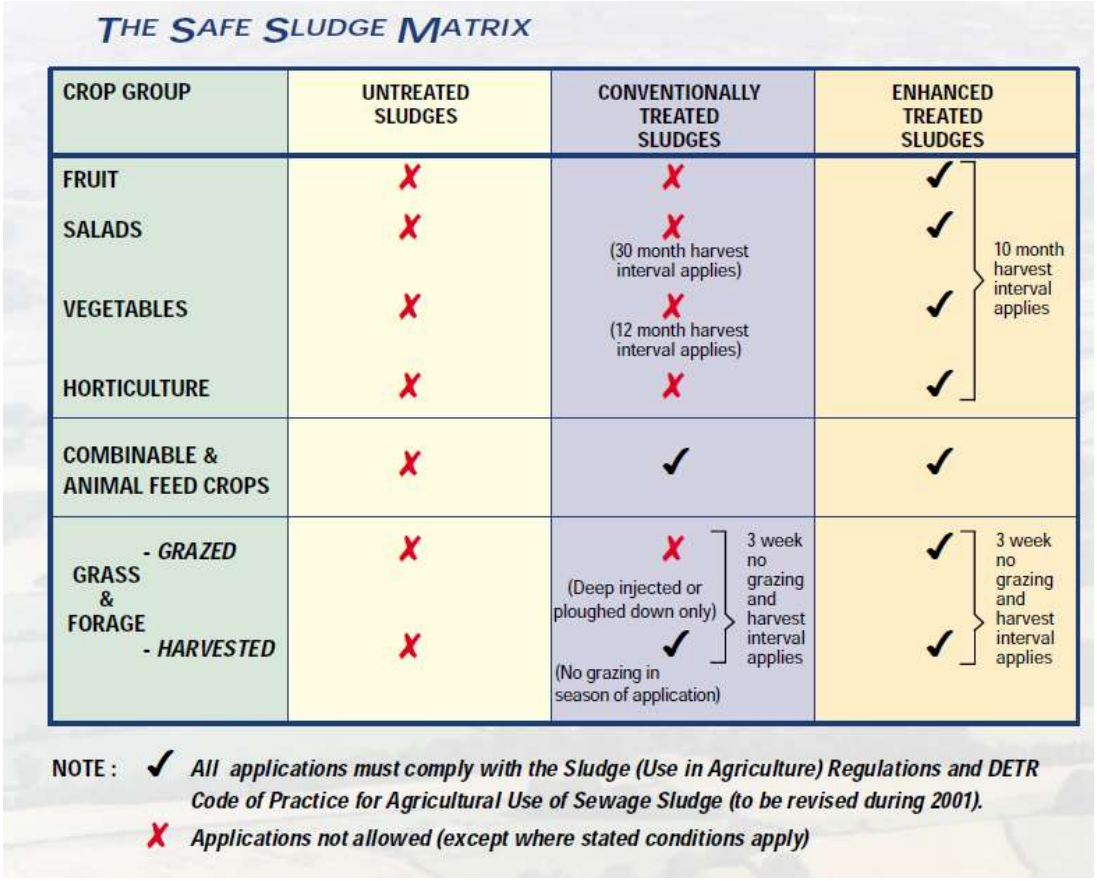
- Digestate from source-segregated biodegradable waste is controlled under the Environmental Permitting Regulations and its production may also be subject to requirements under the Animal By-Products Regulations (ABPR). Spreading to agricultural land requires an environmental permit or appropriate exemption for certain waste types. However, an output produced adhering to the requirements of approved quality protocols for compost or anaerobic digestate (for example, PAS 100 and PAS 110) may be classified as a non-waste for re-use and not be subject to waste regulation control.

Biosolid disposal: the sludge safe matrix

- The disposal of sludge by disposal it to agriculture as biosolids is regulated by the Sludge Use in Agriculture regulations, 1989 and there are numerous other pieces of legislation and best practice guidance that apply, most notably the ADAS Safe Sludge Matrix (2001)[37]. The matrix was formed by agreement between Water UK (representing the water industry) and the British Retail Consortium (BRC) (representing the major supermarket retailers).

[37] http://adlib.everysite.co.uk/resources/000/094/727/SSMatrix.pdf

Figure 15: Safe sludge matrix



Annex 3: Sludge treatment and disposal survey of potential entrants

In order to inform our approach to promoting markets in sludge, we conducted an online survey of businesses that we understood operated within related wider waste markets.

The purpose of the survey was to understand the views of these businesses regarding the potential scope for entry into the treatment and disposal of sewage sludge waste – and to identify what barriers might prevent entry, and what forms of regulatory design or tool might help mitigate these.

Our approach

We identified firms for inclusion in our survey by reviewing previous responses to (and engagement with) the OFT's 2011 market study and by undertaking desk-based research. A total of 70 firms were identified for inclusion and a response rate of 20% was achieved, that is there were 14 responses.

For the purpose of the questionnaire we defined **'sludge treatment'** as the collection of sludge from sewage treatment processes (typically wastewater treatment works), and the undertaking of various treatments, usually at sludge treatment centres, prior to transfer of treated sludge to the collection point for disposal (or recycling). This may involve the treatment of sewage sludge using lime stabilisation, incineration and AD.

Similarly, we defined **'sludge disposal'** as the means by which the sludge can be disposed of or recycled. This predominantly includes:

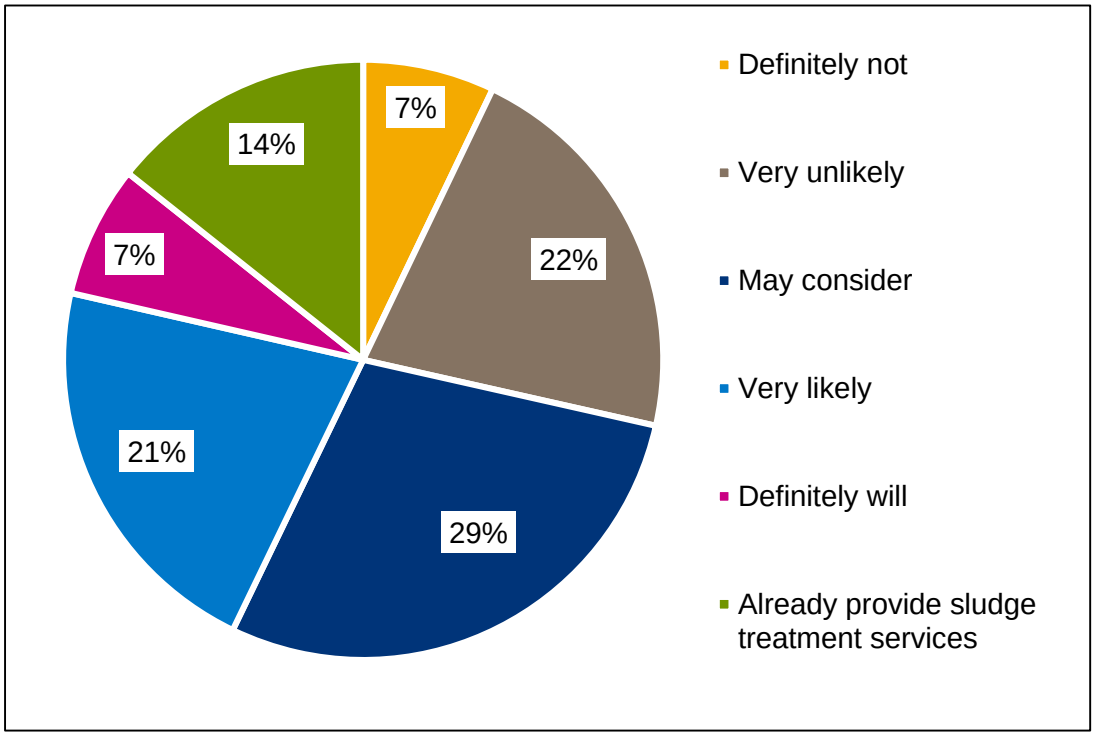
- spreading on agriculture land, where it is used as a soil enhancer and fertiliser;
- disposal by means of incineration; and
- disposal to landfill.

The results of our survey are set out in the remainder of this annex – and we are grateful to those firms that participated. In reviewing the results, it is important to note that, given the relatively small sample size, we cannot draw overly strong conclusions. However, we consider the survey to be a valuable source of evidence that provides a range of new insights that have informed our thinking.

Survey results

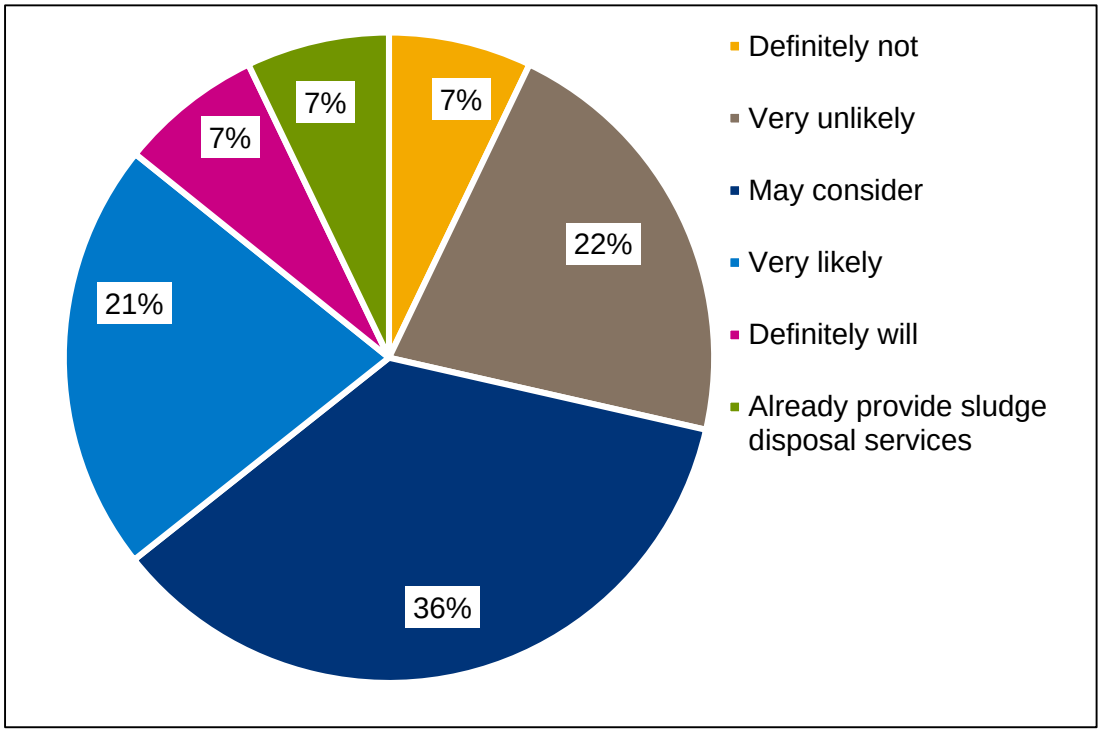
We asked businesses the likelihood that they would enter sludge treatment and disposal markets within the next five years. Of the 14 respondents, 29% indicated they would either **'definitely'** or **'very likely'** enter these markets. Additionally, only one respondent specified they will **'definitely not'** enter sludge treatment and disposal markets. The results are shown in the following two figures.

Figure 16: To what extent do you think it is likely your organisation would, during the next five years, consider entering the market for the treatment of sludge?



Source: Ofwat analysis of responses to survey of potential sludge entrants.

Figure 17: To what extent do you think it is likely your organisation would, during the next five years, consider entering the market for the disposal of sludge?



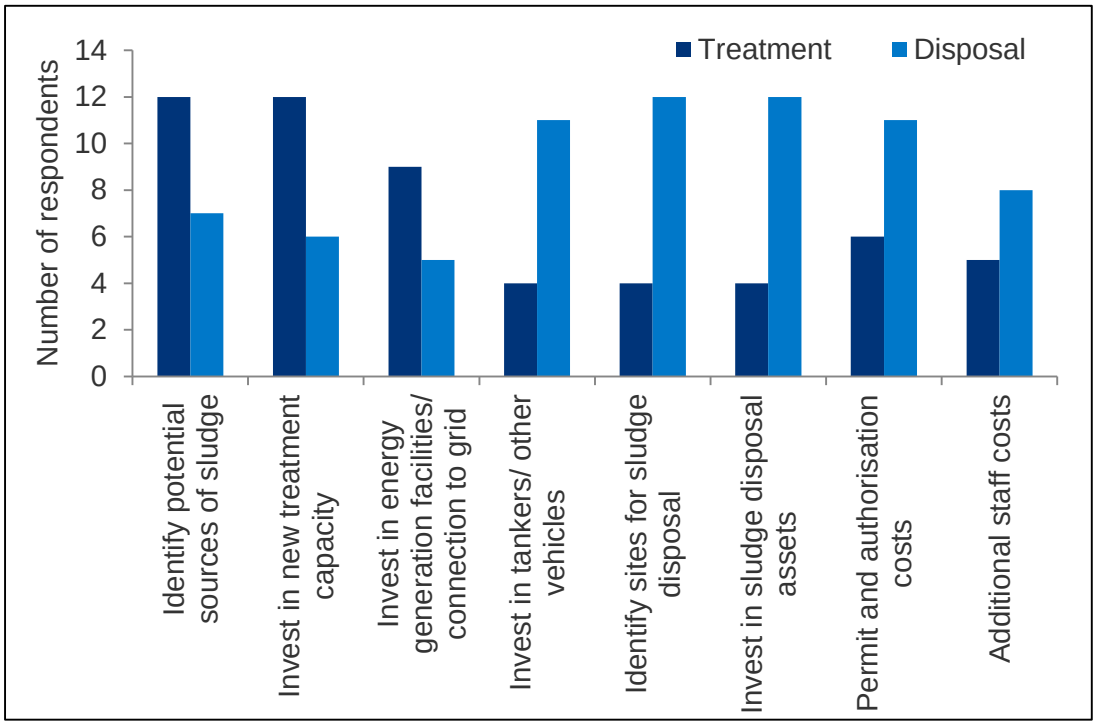
Source: Ofwat analysis of responses to survey of potential sludge entrants.

We then asked businesses, if they were to enter the markets for sludge treatment and disposal, what tasks and activities they would have to undertake (and what investments might be required) in order to do so.

In relation to treatment, 12 respondents indicated they would need to **'identify potential sources of sludge'** and **'invest in new treatment capacity'**, compared with seven and six respondents respectively, indicating that the same was required for entering the disposal market.

Additionally, a further nine respondents indicated **'investment in energy generation facilities/connection to the grid'** as a required activity for entering sludge treatment. In comparison, 12 respondents indicated that **'identifying sites for sludge disposal'** and **'invest in sludge disposal assets'**, were activities required to enter the sludge disposal market (see below).

Figure 18: If you were to enter the market for sludge treatment and / or disposal, what tasks and activities would you have to undertake and invest in to do so?

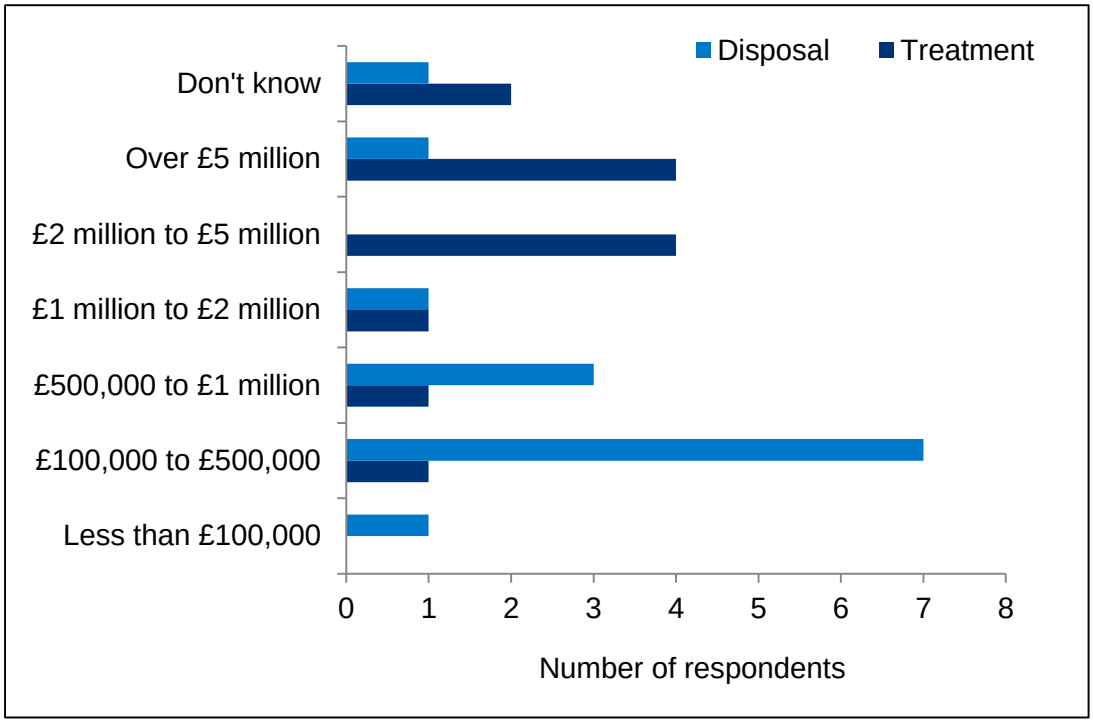


Source: Ofwat analysis of responses to survey of potential sludge entrants.

We also asked businesses to estimate the amount of upfront costs they would incur if they were to enter the sludge market. For disposal, 79% of the respondents estimated upfront investment would be relatively modest (**under £1 million**), compared to the treatment costs, where 79% respondents estimated that investment of **over £1 million** would be required (with four of those, indicating it could cost **upwards of £5 million** to enter).

This is consistent with our own analysis, which shows sludge treatment is more capital intensive compared to sludge disposal. The following chart illustrates respondents' views of entry costs.

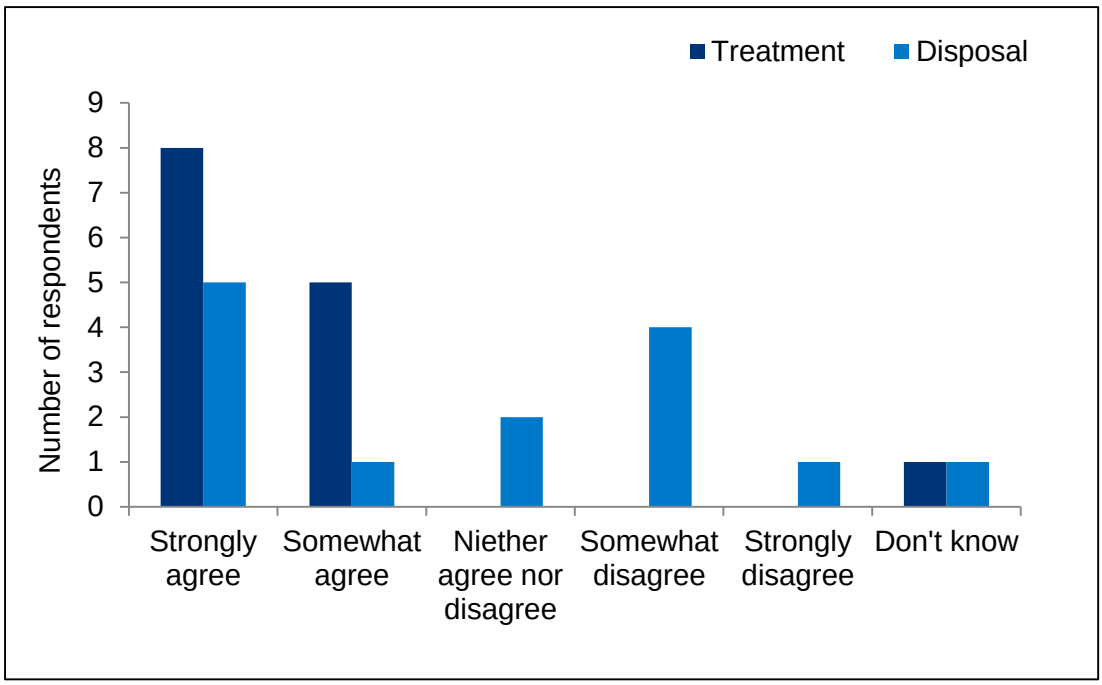
Figure 19: If you were to enter the sludge market, can you estimate the likely size of upfront costs you would incur?



Source: Ofwat analysis of responses to survey of potential sludge entrants.

We sought respondents' views as to the extent of entry barriers relating to sludge markets. The results indicate respondents considered barriers to be greater in relation to sludge treatment than for disposal, with 57% of respondents indicating they **'strongly agree'** that hurdles exist in relation to treatment, compared to 36% for disposal. The results are shown in the next figure.

Figure 20: To what extent do you agree that there are high hurdles to get into the sludge market?



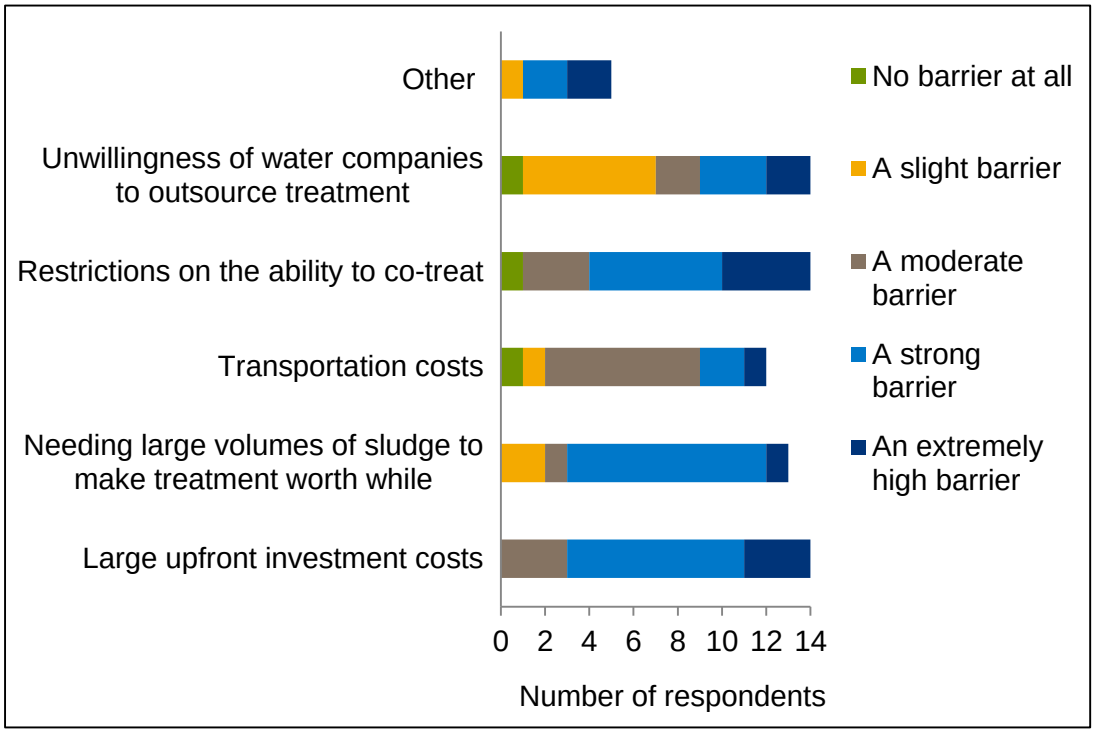
Source: Ofwat analysis of responses to survey of potential sludge entrants.

We next asked companies about 'what' factors most affected the likelihood and attractiveness of market entry. In relation to **sludge treatment**, the following figure shows that the most material factors identified included:

- upfront investment costs;
- large volume requirements to process sludge; and
- restrictions on the ability to co-treat materials.

Interestingly, transportation costs were not seen as being so important, with around half of respondents identifying this as being a 'moderate' barrier.

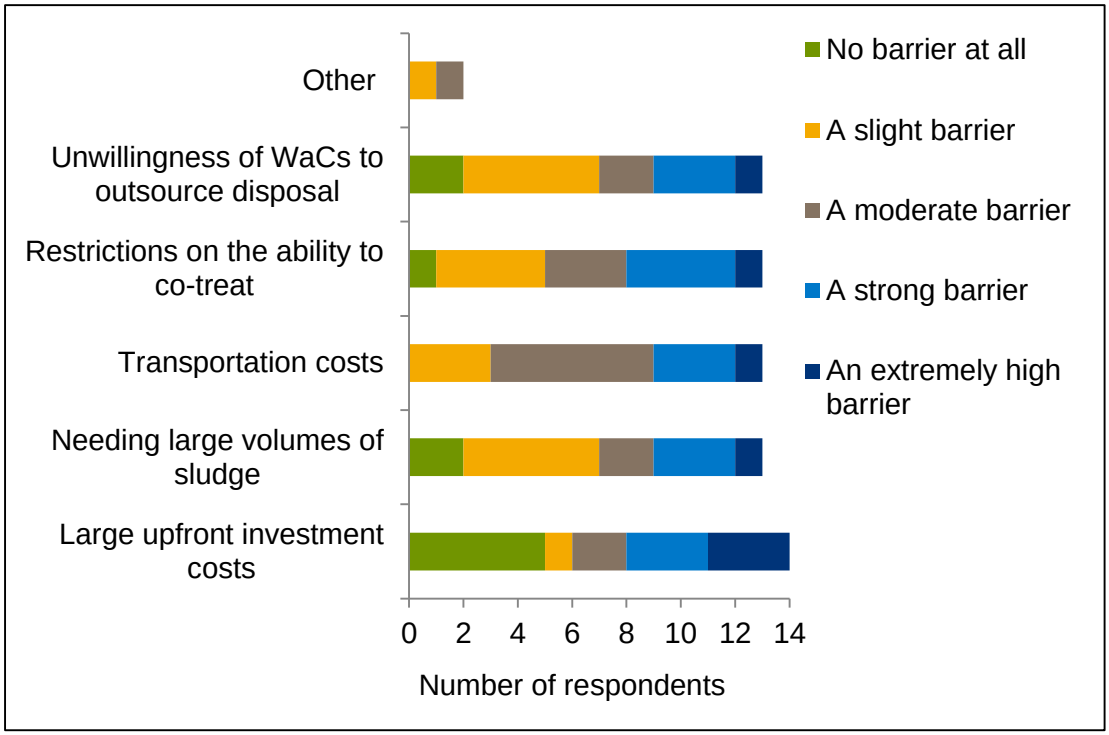
Figure 21: Which of the following do you think limit the commercial attractiveness of entering the sludge treatment market, or act as a hurdle to entering?



Source: Ofwat analysis of responses to survey of potential sludge entrants.

We asked companies the same question in relation to **sludge disposal**. Here respondents' views on barriers differed relative to sludge treatment. In particular, it is clear that across the board, respondents considered the listed factors to be less material deterrents to entry. Indeed, more respondents considered a number of the options to be no barrier at all (compared to treatment), and the majority of respondents indicated the specified factors to be only 'slight' or 'moderate' barriers.

Figure 22: Which of the following issues do you think limit the commercial attractiveness of entering the sludge disposal market, or act as a hurdle?



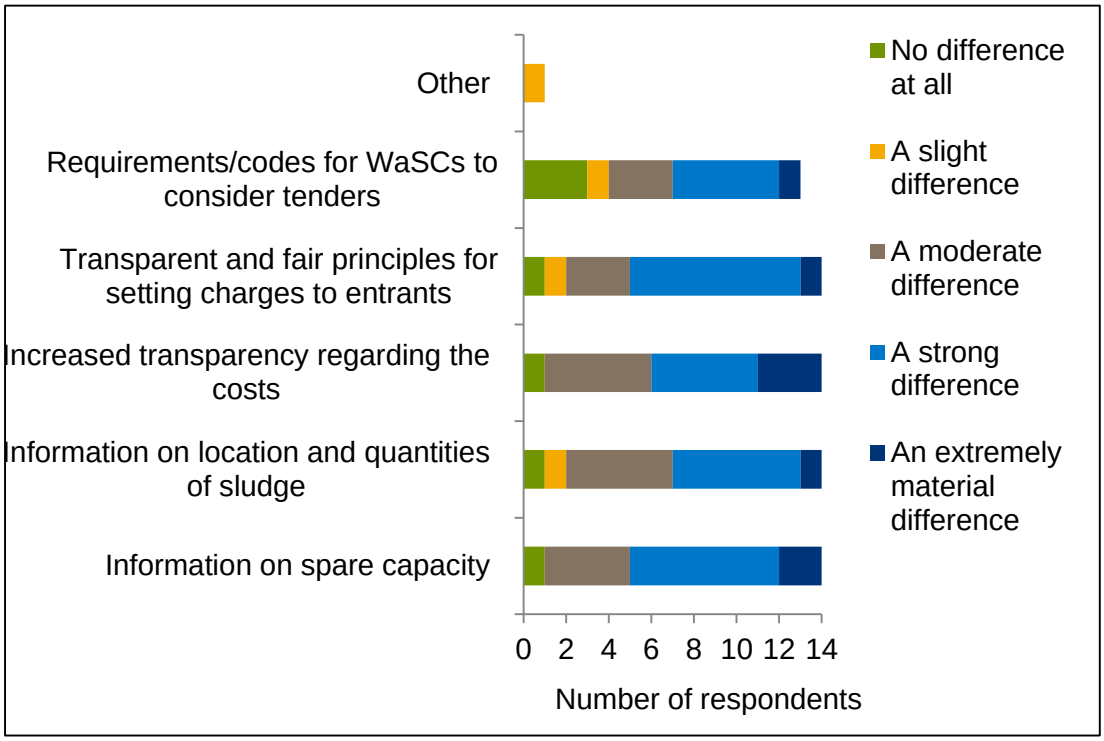
Source: Ofwat analysis of responses to survey of potential sludge entrants.

Finally, to assist our policy development, we asked businesses to what extent various options might increase the attractiveness and likelihood of entering – responses to which are summarised in the next figure.

A high proportion of respondents indicated that all the potential options listed would make an ‘extremely material’ or a ‘strong’ difference to the likelihood of entry. However, in order, the factors with the highest proportion of companies giving those responses were:

- transparent and fair principles for charging entrants;
- information about spare capacity;
- increased cost transparency;
- information about site location; and
- requirements or codes for companies to consider tenders.

Figure 23: To what extent might the following increase the attractiveness or likelihood of you entering the sludge treatment and disposal markets?



Source: Ofwat analysis of responses to survey of potential sludge entrants.

Annex 4: Sludge treatment and disposal survey of WaSCs

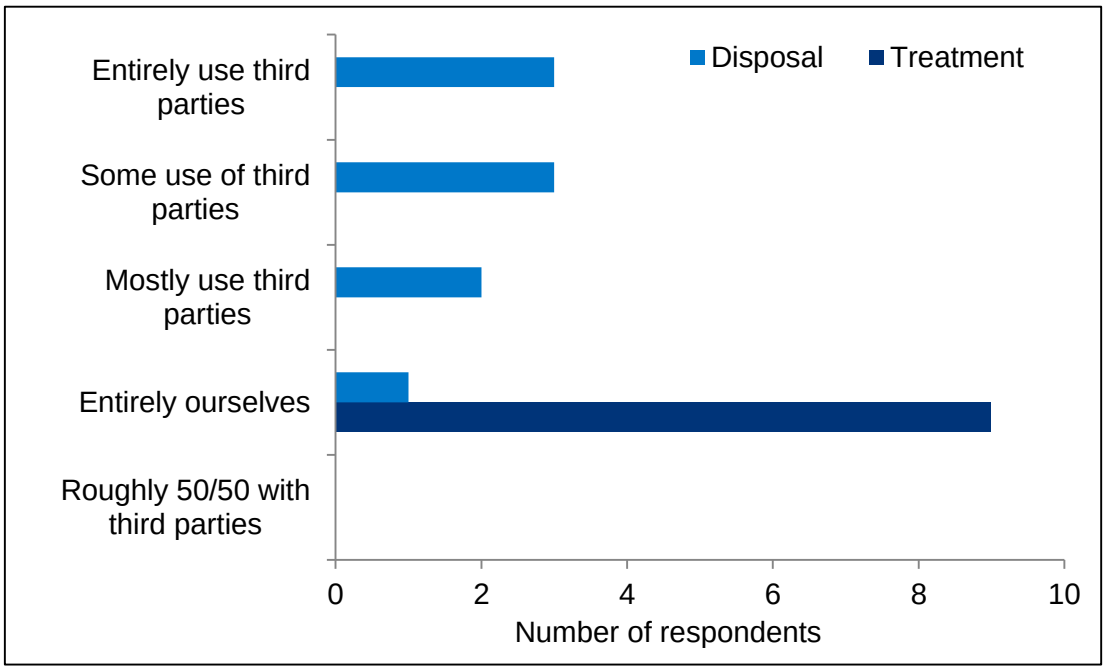
To inform our regulatory design for sludge we conducted a short online survey of the WaSCs. The purpose of this was to understand WaSCs' views as to the potential scope for the development of markets in sludge and the scope for WaSCs to participate in wider waste markets in future.

All ten WaSCs in England and Wales were offered the opportunity to complete the survey, nine responded. The results of the survey are set out below.

Survey results

We asked WaSCs about the extent to which they currently undertook sludge treatment and disposal activities themselves (in house) as opposed to contracting out to third party firms (including other out of area WaSCs). The following chart summarises the responses.

Figure 24: To what extent do you currently undertake the following activities yourself (as a company), as opposed to contracting/outsourcing with third party firms, including other WaSCs, but also firms operating in the wider waste treatment and disposal markets – such as other organic waste?

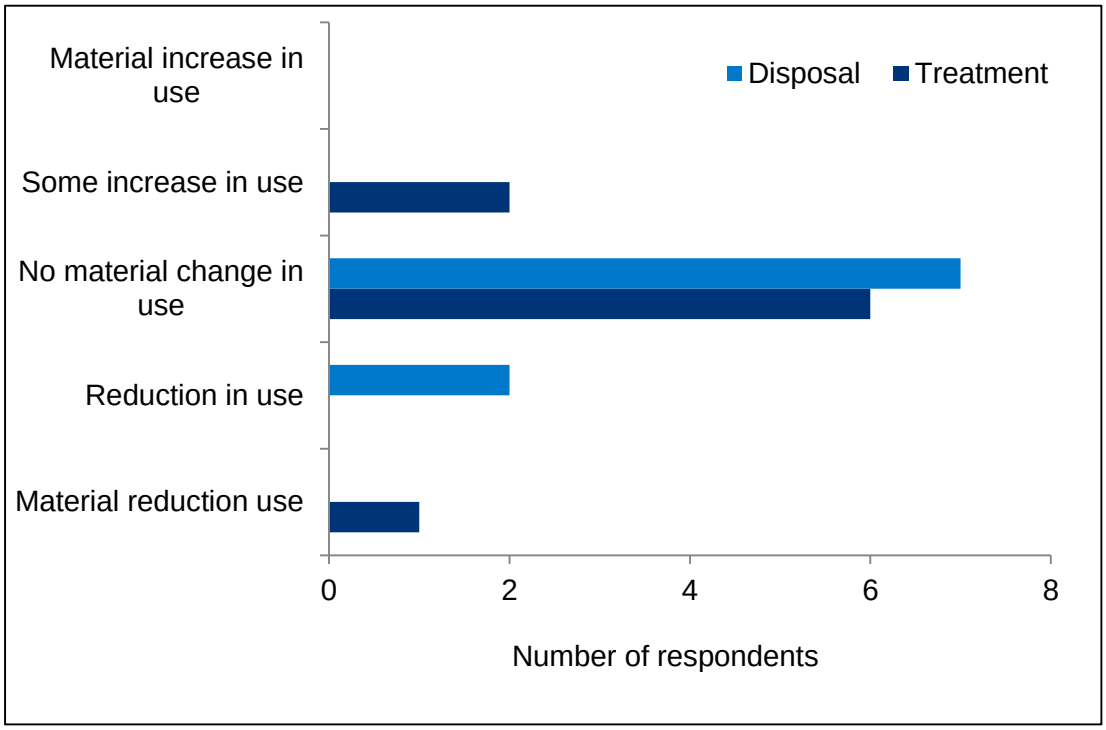


Source: Ofwat analysis of responses to survey of WaSCs.

Responses indicate that, at present, no WaSCs outsource sludge treatment activities. However, outsourcing is used extensively in relation to sludge disposal.

We next asked WaSCs whether they were considering any change in the extent to which they make use of third party firms over the next five years (again, here referring both to other WaSCs, but also firms operating in the wider waste markets). The chart below summarises the responses.

Figure 25: Are you actively considering/planning on changing the extent to which you contract with third party firms (both WaSCs and other firms operating in the wider waste markets) in relation to sludge treatment and disposal over the next five years?

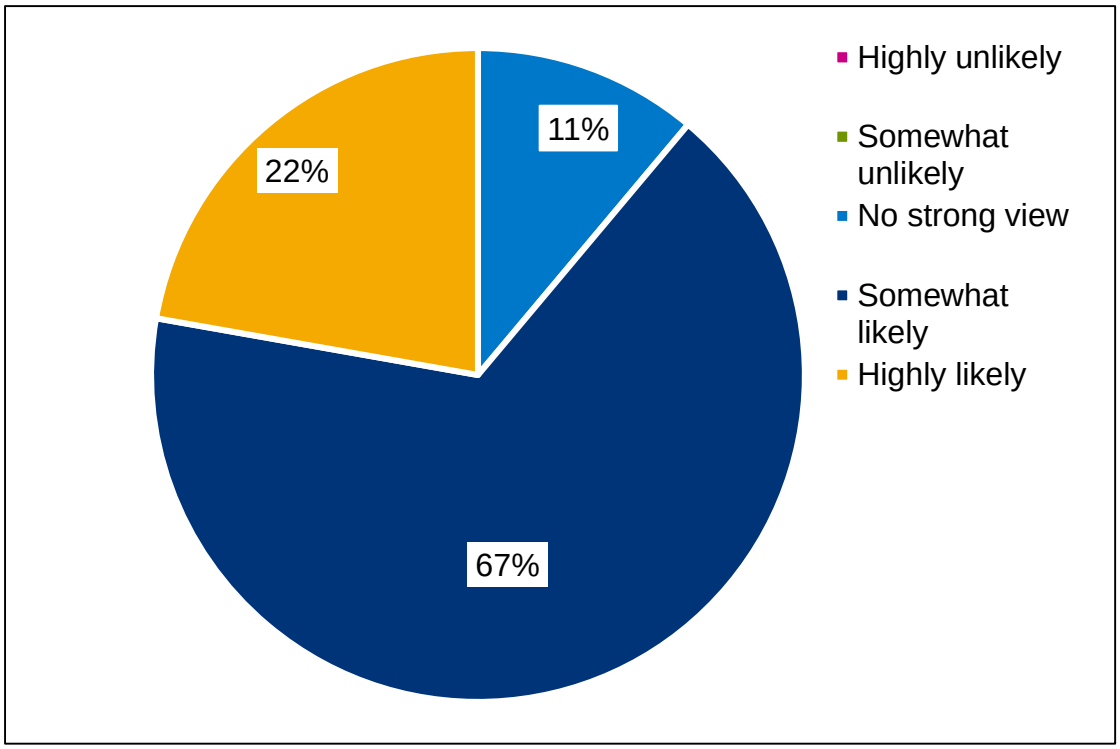


Source: Ofwat analysis of responses to survey of WaSCs.

Most respondents told us they had **'no material changes planned in the split of current activities'** for both sludge treatment and disposal (six and seven respondents respectively), although two respondents indicated that they were considering 'some' increase in the use of third parties in relation to sludge treatment.

As noted elsewhere, evidence suggests that sludge has increasingly become a resource with a value over time. We therefore asked WaSCs whether they expected this trend to continue going forward. Roughly 90% of respondents indicated they consider it **'somewhat'** or **'highly likely'** that the value of sludge will increase in the medium term, as shown in the following chart.

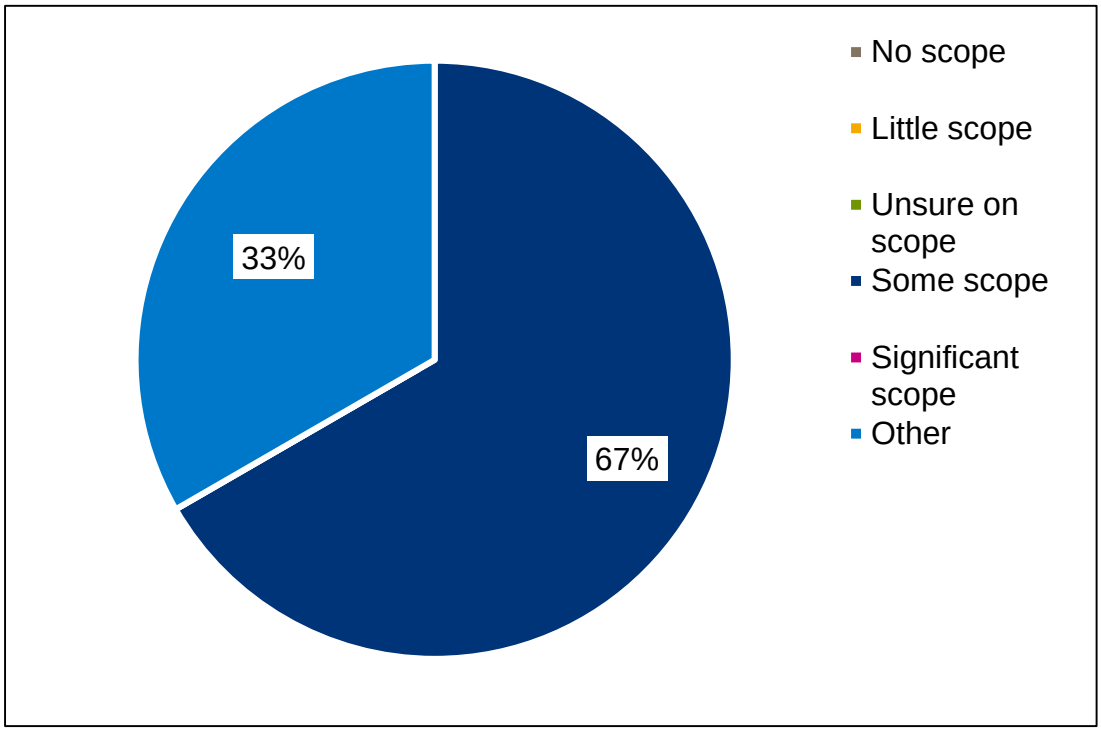
Figure 26: Sludge usage patterns have changed substantially over a relatively short space of time and, relatedly, sludge increasingly generates value (for example, as a biofuel, or fertiliser), rather than simply being a by-product. To what extent do you anticipate this trend continuing over the medium-term, and for innovation and technological change to continue to unlock new ways of realising value from sludge?



Source: Ofwat analysis of responses to survey of WaSCs.

In 2011, the OFT study found that there was some scope for trading between WaSCs in relation to sludge treatment and recycling that was not being realised. We therefore asked WaSCs whether they considered there was scope to further optimise their sludge treatment and disposal activities. Here, 67% indicated that there was **'some scope for optimising sludge treatment and disposal across WaSCs'** with the remainder indicating 'other', as shown in the next pie chart.

Figure 27: In 2011 the OFT found that there was some scope for trading between WaSCs in relation to sludge treatment (and disposal) that was not being realised. To what extent do you think there is more scope to make greater use of contracting with other WaSCs in order to further optimise your sludge treatment and disposal activities, where their treatment / other relevant facilities are sufficiently close to your sludge production sites to make this viable?



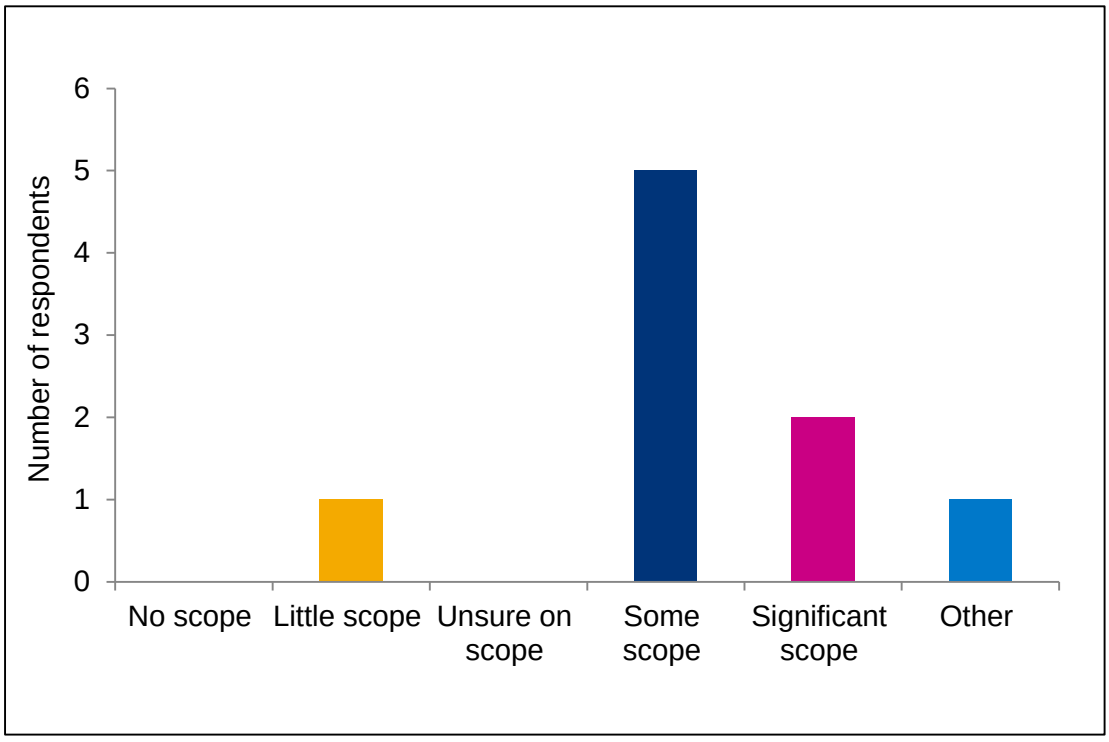
Source: Ofwat analysis of responses to survey of WaSCs.

Where respondents selected 'other', we asked them to elaborate. All the comments indicated that **in theory** there is scope for sludge trading between WaSCs. However, transport costs, and geography were listed as key factors that limit this in practice.

> "Less than 10% of our total sludge production originates close to our borders with other companies where trading will be most practicable, without more substantial incentives to overcome the additional transportation costs."

We then asked WaSCs for their views as to the scope to provide services in wider waste markets (either by utilising their existing assets and capacity, or through investing in new assets). **Seven of the nine respondents indicated that there was 'some' or 'significant scope' for providing services in wider waste markets.** None of the WaSCs considered there to be 'no' scope for such entry – as shown below.

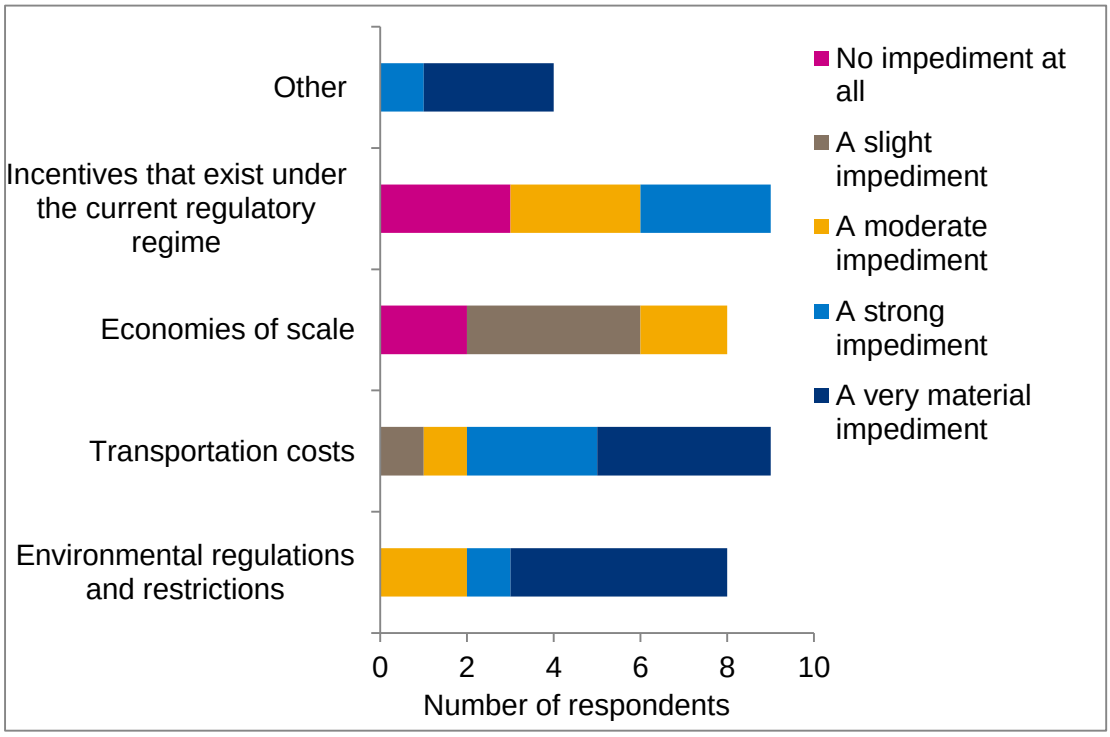
Figure 28: To what extent do you think there is scope for you to provide services in relation to wider waste markets (in particular, the treatment and disposal of other organic waste), either by utilising your existing assets, spare capacity and skills, or through developing these where required?



Source: Ofwat analysis of responses to survey of WaSCs.

We were interested in the extent that WaSCs considered there to be impediments to them trading with other WaSCs (in relation to sludge services) or to providing services in wider waste markets. The following chart shows the results.

Figure 29: To what extent do you consider the following to be impediments to your ability and/or appetite to: (i) increase (begin) trading with other WaSCs in relation to sludge treatment and disposal and/or (ii) provide treatment and disposal services in wider waste markets – in particular other organic waste?

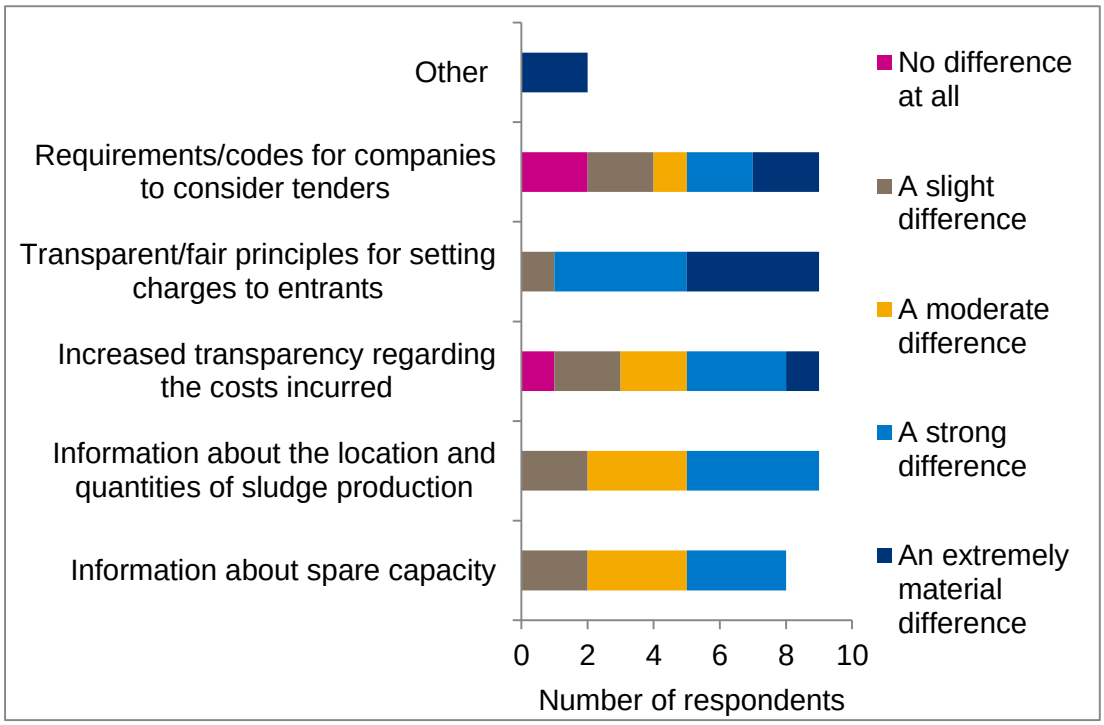


Source: Ofwat analysis of responses to survey of WaSCs.

WaSCs indicated that, in line with our evidence, environmental regulations, and restrictions (six respondents), and transport costs (seven respondents) were the main (very material or strong) impediments to increasing trades and providing treatment and disposal services in wider waste markets. However, the 'incentives' associated with the existing regulatory regime were also identified as a factor.

Finally, we asked WaSCs for their views as to what factors might increase the likelihood of them trading/providing services in wider waste markets. Again, the responses are shown below.

Figure 30: To what extent might the following increase your likelihood/appetite for: (i) increasing trading with other WaSCs in relation to sludge treatment and disposal; and/or (ii) providing treatment and disposal services in wider waste markets, such as other organic waste?



Source: Ofwat analysis of responses to survey of WaSCs.

The factors for which the greatest number of respondents indicated would make a 'strong' or 'extremely material' difference to the likelihood of entry was 'transparent and fair principles for charging'. However, four indicated that each of: information about site location; increased cost transparency; and codes of conduct, would also make a 'strong' or 'extremely material' difference.

Annex 5: Geographic analysis of the scope for trading within the market for sludge

In this annex, we examine the scope for trading between WaSCs in the market for sludge treatment and disposal. Our approach is an update to an analysis previously undertaken by the OFT.

Introduction

In 2011, the OFT considered the scope for competition between WaSCs with regards to sludge treatment and disposal.[38] The OFT concluded that due to transport costs, high entry costs, economies of scale and the existing location of sludge treatment centres (STCs), potential competition may be limited to specific local geographic areas. Furthermore, the OFT found that a substantial number of areas are served by only one WaSC (meaning that in those cases, there would be no scope for trade).

This note sets out an updated version of the OFT's analysis, based on revised data reflecting new sludge treatment assets that are assumed to have been developed since 2011[39]. In addition to undertaking a straight update of the OFT's original analysis we:

- examined alternative methodological approaches to determining the scope for trading by geography; and
- reviewed relevant evidence relating to sludge transport costs.

Context and methodological approach

In 2011, the OFT showed that there were substantial differences between WaSCs in operating expenditure per tonne of sludge. In principle, this might suggest that there could be scope for trades between WaSCs in relation to sludge treatment and disposal. However, in practice this would clearly depend upon:

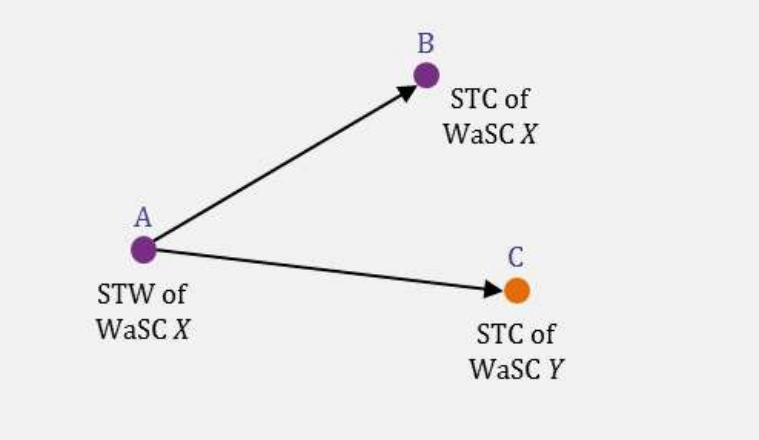
[38] 'Organic waste.' OFT (2011).
[39] A validation of the underlying data has not been within the scope of our work.

- how much the observed differences in unit costs reflect genuine differences in cost efficiency between the WaSCs, rather than external factors outside of management control; and
- whether the costs of transporting sludge between WaSCs were too high to offset the efficiency gains from trade.

The OFT's 2011 analysis did not consider the first of these issues; but rather, sought to assess the geographic scope for trades given assumed levels of transport costs. Similarly, this updated analysis is also focused only on the geographic issue.

Where a WaSC does not trade sludge with another company, it transports its sludge from a sewage treatment works (STW) to its own STC. In many cases though, WaSCs co-locate STWs and STCs so that no road transport is needed[40]. In a scenario where there is trade between WaSCs, sludge may be transported from one WaSC's STW to another WaSC's STC (or potentially between STCs). This is illustrated in the following figure.

Figure 31: Movement of sludge



In the above stylised example, trade would be profitable if:

Cost(transport A to B) + Cost(treatment at B) > Cost(transport A to C) + Cost(treatment at C)

[40] 'Organic waste.' OFT (2011) paragraph 3.17 reports the OFT estimate of 60-70% of sludge produced in the UK is treated on the same site that it is produced.

Our update of the OFT's analysis focused on identifying the number of circumstances under which the above condition is likely to be met – as this provides an indication of the total scope for trading between WaSCs in relation to sludge treatment and disposal.

The OFT's approach

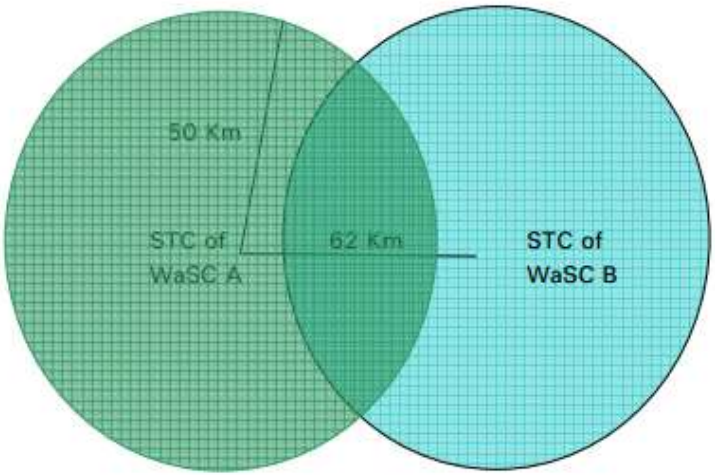
The OFT considered the transport costs between STCs owned by different WaSCs. That is, the cost of transporting sludge from B to C in the above figure. This is because the OFT considered assessing transport costs between STCs (rather than between STWs and STCs) to be more robust.

The OFT assumed that 50km was a viable range for transporting sludge of concentration levels 3.5% to 4.0% dry solids. For lower concentration sludge they stated that the difference in operating costs will outweigh the transport costs up to 30km, and for dewatered sludge up to 75 km[41]. This was based on information provided by WaSCs. The OFT also reported that the average distance sludge is transported by individual WaSCs varies from around 11 km to 50 km[42].

The OFT's analysis therefore focused on whether rival WaSC STCs are within a 50 km radius of each other (50 km 'as the crow flies'). The OFT illustrated its approach with the following diagram.

41 'Organic waste.' OFT (2011) footnote 54.
42 'Organic waste.' OFT (2011) paragraph 3.28.

Figure 32: OFT approach to assessing the potential for trade



Source: OFT[43].

Updating and extending the OFT's analysis

We used our updated information about STCs to update the OFT's analysis of how many 'rival' WaSCs operate STCs within a 50 km radius of each 'incumbent' WaSC's STC.

We have then reassessed what 'reasonable' transport distances could be, given the available evidence relating to transport costs, and differences in sludge operating costs across WaSCs at STCs. Here we note that the OFT tested a range of transport distances, although (as above) it primarily focused on a 50 km radius, taking the view that the costs of transporting sludge over this distance were sufficiently low to enable trade.

WaSCs often contract out sludge transport and costs can be based on unit rates for volume-miles, tonne-miles or tanker-days[44]. Using updated assumptions of transport costs, we assessed the degree of overlap between rival STCs based on a range of:

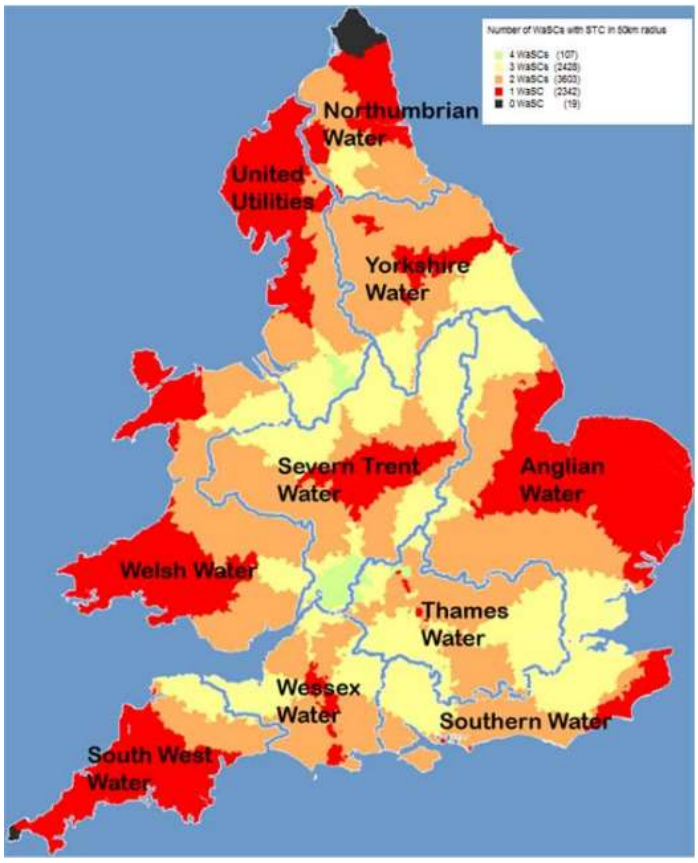
[43] Source: OFT 'Organic waste.' OTF (2011) figure 4.5.

- radii;
- drive distances; and
- drive times.

Update of 50 km radius analysis

The OFT produced the map below, which shows how many WaSCs operate a STC within a 50 km radius ('as the crow flies') of another WaSC's STC within each ward in England and Wales.

Figure 33: Number of WaSCs with STCs within 50km radius (OFT)



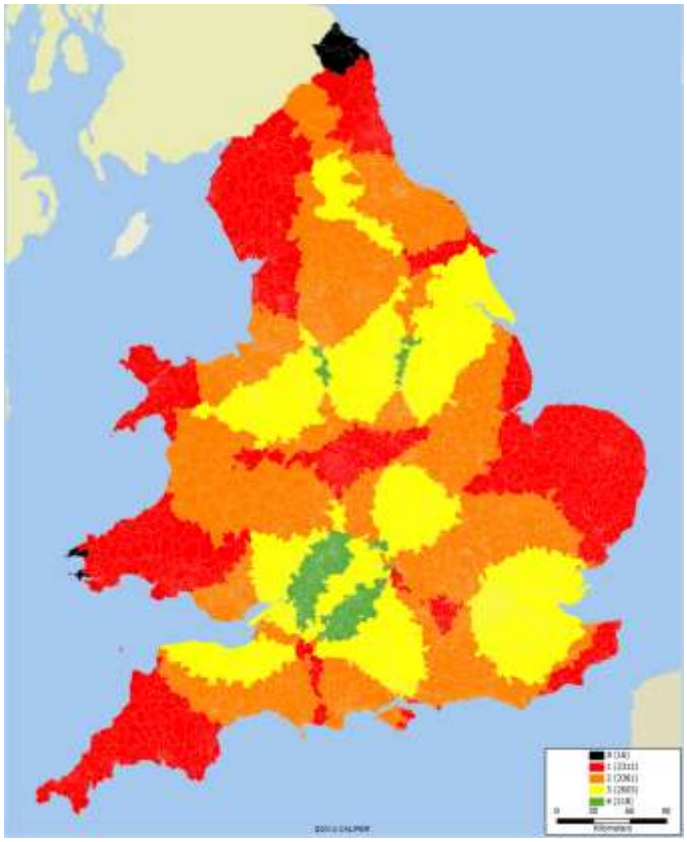
Source: OFT[45]

[44] 'Competition in upstream sewage and sludge markets.' Ofwat prepared by London Economics (2010) section 6.1.
[45] Source: OFT 'Organic waste.' OFT (2011). See figure 4.3.

Areas that are coloured red have only one WaSC operating STCs within a 50 km radius. That is, all STCs within a 50 km radius of the boundaries of the electoral ward are operated by the same WaSC, the implication being that in these areas, there would be no existing scope for trades. Areas coloured orange are within a 50 km radius of two WaSCs operating STCs; yellow areas have three WaSCs; and green areas have four WaSCs.

Our updated map is shown below.

Figure 34: Number of WaSCs with STCs within 50 km radius



Source: Ofwat analysis of updated OFT data.

The original and updated diagrams largely align. Consistent with the OFT's 2011 findings, there are areas where there are multiple WaSCs operating sludge facilities within a sufficiently close distance to facilitate trades. Equally, however, we also see that there are a number of large areas that, at present, could only be served by the incumbent WaSC.

The table below shows the proportion of STCs that are within a 50 km radius of a rival-operated STC.

Table 6: Rival WaSCs operating STCs within 50km radius

Number of rival WaSCs with STCs within 50km	Proportion of STCs
0	33%
1	42%
2	23%
3	2%

Source: Ofwat analysis of updated OFT data.

As is shown in the table, a third of STCs do not have another STC within a 50 km radius owned by a different WaSC. Put simply, for one third of STCs, there would be no scope for trades. **Conversely, this implies that for 67% of STCs, there could be scope for trade**, depending on the relative differentials in operating cost efficiency. In particular, we find that:

- 42% of STCs are within a 50 km radius of a STC operated by a different WaSC;
- 23% have two rival WaSCs operating STCs within 50 km; and
- 2% have three.

These results could be interpreted as a third of STCs could not engage in profitable trade with STCs owned by other WaSCs because they are geographically too far away.

Transport costs

As recognised by the OFT, available data on sludge transport costs is sparse. In the original OFT data there is limited information, the definitions applied are not always clear and estimates of transport costs vary significantly. For example:

- one WaSC reports transport costs of £4.30 per tonne dry solid (TDS) per km;
- another of £0.03 per TDS per km; and
- another of £0.04 per TDS per km.

We reviewed information on transport costs from publicly available sources.

OECD (2004)[46] models wastewater infrastructure and assumes sludge transport costs of €0.34 per tonne per km. Converting this cost into £s and uprating by inflation to current price levels gives a cost of **£0.32 per tonne per km**.

WRAP (2013)[47] examines different supply and distribution models for companies operating AD facilities. It reports the cost for transporting liquid organic materials as **£60 to £80 per hour**. We assume this is in relation to one full tanker.

To determine a 'reasonable' distance over which sludge may be transported we compare transport costs with the difference in operating expenditures of STCs. Based on figures in the OFT paper, we have calculated a 'typical' difference in opex of £70 per TDS. This is calculated as 30% of the average opex related to sludge treatment and disposal by WaSCs[48].

Taking the £0.32 per tonne per km figure from above and combining it with the difference in opex of £70 per TDS suggests that a 'reasonable' distance is about 220km. Alternatively, taking the £4.30 per TDS per km would suggest a (much shorter) distance of about 16 km.

The above illustrates that any assessment of the distance over which trades might be economic is highly contingent on assumed transport costs, for which there are widely differing estimates. This is consistent with the OFT's findings, and is likely to reflect a range of factors – but not least the fact that transport costs can vary depending on sludge thickness.

Given the above uncertainty, when conducting our 'drive distance' (in the following section) we do so based on a range of 'reasonable' distances for which trades might be economic. This is consistent with the OFT's approach in 2011, where various distances were modelled.

46 'Appendix 3: Documentation of Expenditure Functions – Wastewater.' OECD (2004).
47 'Digestate distribution models.' WRAP (2013).
48 Figures based on figure 4.1 in 'Organic waste.' OTF (2011) and the OFT's observation that many neighbour WaSCs face a 30% cost differential.

Drive distance analysis

Transport costs may be more closely linked to drive distances, rather than the 'as the crow flies' distances. Therefore, as an extension to the OFT's analysis, we have calculated the proportion of STCs that are within a reasonable distance of STCs owned by other WaSCs using drive distances.

The following diagram illustrates this analysis. Each of the red STCs has two 'drive distance rings' around it. The darker green area denotes a 25 km drive and the lighter green area represents a 50 km drive. Some of the STCs in blue (not owned by the same WaSC as the red ones) fall within a 25 km or 50 km drive. The next figure shows the analysis just for certain sites, but we have replicated this across all sites.

Figure 35: Illustration of drive distances

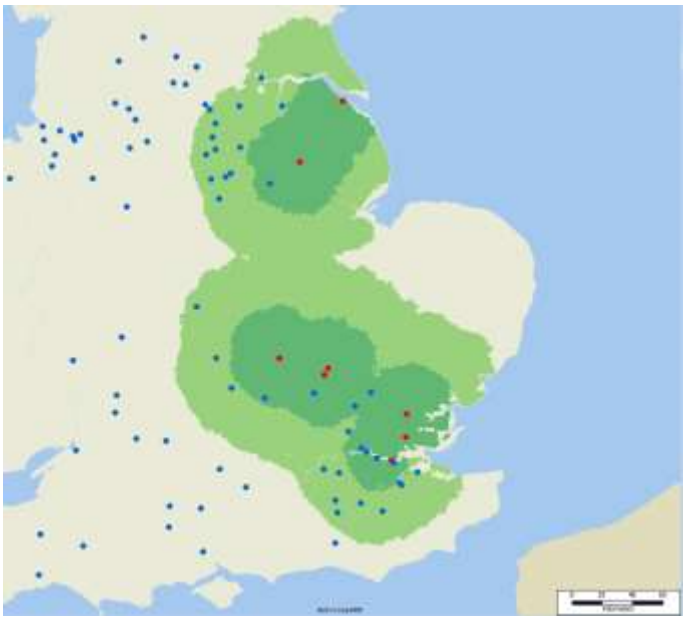


Table 5 gives the proportion of STCs that have STCs owned by rival WaSCs within given drive distances. This allows for a direct comparison between the radial distances and drive distances. The proportion of STCs that do not have an STC owned by a different WaSC within 50km **drive distance** when compared to straight line distance increases from 33% to 58%. Put another way, **the two alternative methods imply that the maximum scope for trading could range from 42% to 67% of STCs**. The scope for trade is significantly less if drive distances are considered, rather than the same distance in a straight line.

An STC not having a suitably close trade partner is highly dependent on drive distance – the proportion decreases from 90% to 14% when moving from a 25 km drive distance to a 100km drive distance.

Drive time analysis

We have also assessed how close STCs are in terms of drive times. The chart below illustrates drive times (in 15-minute intervals) from the two STCs coloured red. Again, the map is illustrative for certain sites, but we have run the analysis for all sites. Along with drive distances, 'reasonable' drive times depend heavily on assumptions. We therefore present a range of possible drive times in Table 8 (see next page).

Figure 36: Illustration of drive times

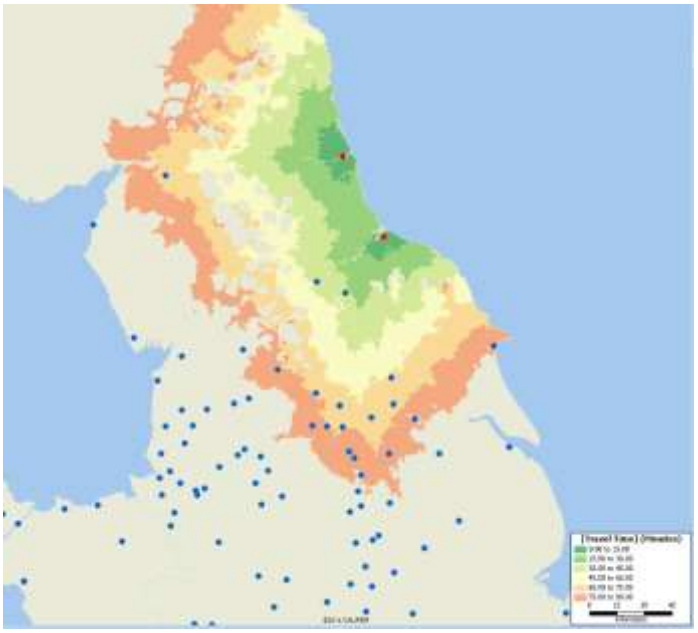


Table 7: Rival WaSCs operating STCs within drive distances

Number of rival WaSCs with STCs within drive distance	Proportion of STCs based on 25 km drive distance	Proportion of STCs based on 50 km drive distance	Proportion of STCs based on 75 km drive distance	Proportion of STCs based on 100 km drive distance
0	90%	58%	27%	14%
1	10%	35%	36%	16%
2	0%	7%	30%	43%
3	0%	0%	7%	24%
4	0%	0%	0%	3%

Source: Ofwat analysis of updated OFT data.

Table 8: Rival WaSCs operating STCs within drive times

Number of rival WaSCs with STCs within drive times	Proportion of STCs based on 30-minute drive time	Proportion of STCs based on 45-minute drive time	Proportion of STCs based on 60-minute drive time	Proportion of STCs based on 90-minute drive time
0	69%	32%	16%	6%
1	27%	40%	20%	10%
2	4%	27%	40%	16%
3	0%	2%	21%	29%
4+	0%	0%	3%	40%

Source: Ofwat analysis of updated OFT data.

Ofwat (The Water Services Regulation Authority) is a non-ministerial government department. We regulate the water sector in England and Wales. Our vision is to be a trusted and respected regulator, working at the leading edge, challenging ourselves and others to build trust and confidence in water.

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Printed on 75% minimum de-inked post-consumer waste paper.
December 2015

This document is also available from our website at www.ofwat.gov.uk.

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