25 May 2016

Trust in water

Water 2020: our regulatory approach for water and wastewater services in England and Wales
Appendix 2 Moving beyond waste - further evidence and analysis

Ofwat

www.ofwat.gov.uk

Contents

1 Introduction

Our decision document sets out the sector challenges, market opportunities and our objectives for changing the way we regulate sludge transport, treatment, recycling and disposal. The document describes our approach to facilitating markets in sludge and the high-level decisions for our regulatory framework for the 2019 price review (PR19).

This appendix explains some of the background to our decisions and provides further detail to support our proposed regulatory approach. Specifically:

- **Section 2** provides additional supporting detail on sludge services and how they fit within wider waste markets and discusses market interactions between licensees as envisaged by the Water Act 2014
- **Section 3** provides additional supporting detail regarding decisions on the informational remedies, a separate price control, RCV protection and transitional impacts on the cost of capital approach.
- **Section 4** sets out the methodology and detailed results from our analysis to support our impact assessment;
- **Section 5** sets our areas for further consultation;

2 Background on sludge services

2.1 Sludge and wider waste markets

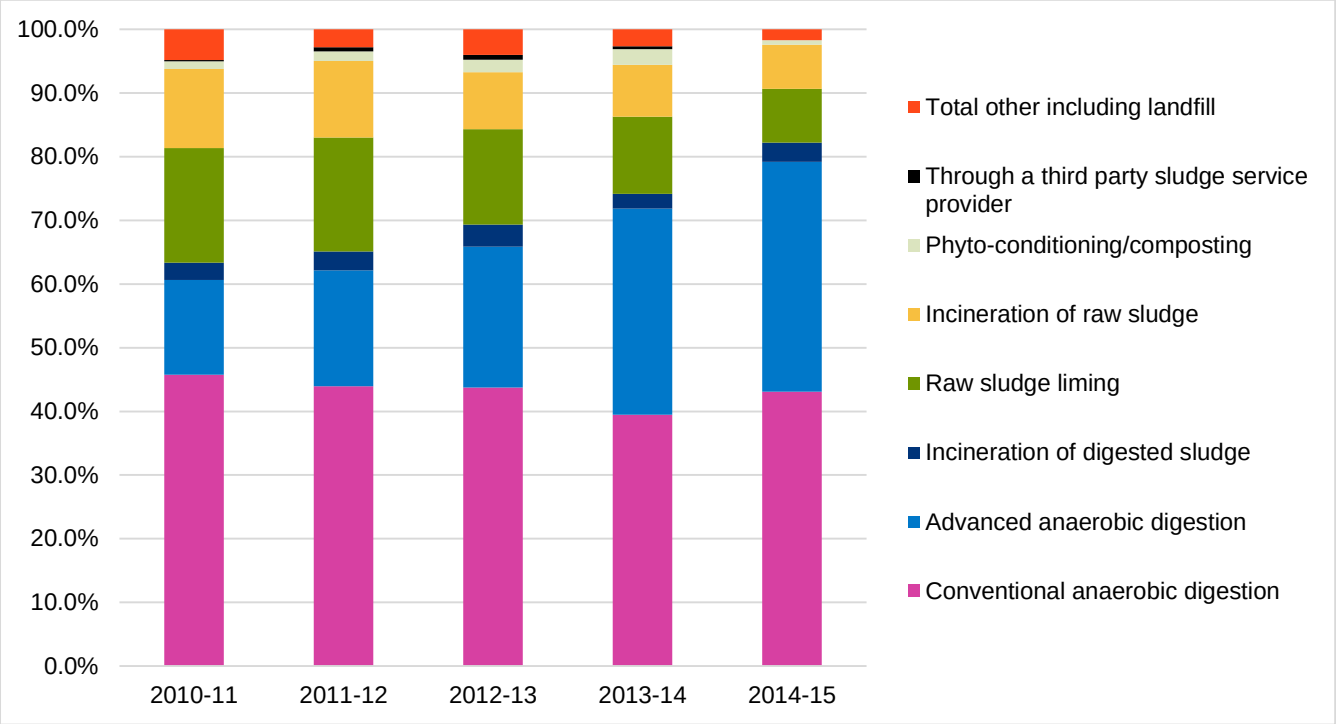
The wider waste and recycling sector in the UK generates a total turnover of some £18.3 billion, with a gross value added (GVA) of £5.5 billion[1]. In 2012, the UK generated a total of 200 million tonnes of waste, 117 million tonnes of which was organic waste[2]. There are a range of firms that provide services in relation to the treatment and disposal of other forms of organic waste (OOW) such as manure and food waste. OOW can be treated using techniques similar to those for 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).

The wastewater sector has a history of recycling sludge to agricultural land, successfully increasing proportion recycled to land from around 44% in 1992 to around 80% in 2010.

There has also been a recent focus on innovation in sludge treatment technology to increase renewable energy production, in particular through the use of advanced anaerobic digestion processes. The industry has been making increasing use of anaerobic digestion (AD) and advanced anaerobic digestion (AAD) with a change from around 60% of all sludge treated using these processes in 2010-11 to around 80% in 2014-15. But this also demonstrates the opportunity to increase the use of anaerobic digestion processes even further. The recent changes to how sludge is treated in England and Wales are illustrated in Figure 1 below (based upon information provided to Ofwat by companies).

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

Figure 1 sludge technology use over time



Much of the investment companies have made in sludge treatment processes in the last 10 years has consolidated treatment into large scale processes on a small number of sites, with the associated benefits of economies of scale. These economies of scale are particularly significant when companies use AD processes to treat their sludge. AD is a process by which environmentally hazardous organic waste such as sewage sludge or food waste may be stabilised, its volume for further processing reduced and a methane-rich biogas produced. The biogas which can be used to generate electricity and heat, or conversion into bio-methane for injection into the gas grid. This biogas is a renewable energy source and currently attracts UK Government renewable energy incentives. Companies have increasingly focused on maximising revenue from sludge processing in parallel to producing products suitable for safe and recycling.

Northumbrian Water has seen marked benefits from moving to AAD and changes to its sludge transport operations. These are illustrated in the case study below.

Case study: Dynamic efficiency from innovation - Northumbrian Water's sludge strategy

Northumbrian Water changed its sludge strategy since 2005 from liming and thermal drying to AAD with renewable energy recovery. The change was driven by a number of factors: the increasing cost of thermal drying due to the rise in energy cost; higher than expected maintenance costs of the drying plant; and advances in digestion technology with the application of thermal hydrolysis transforming cost effectiveness of anaerobic digestion.

The change to AAD has resulted in significant cost savings and environmental benefits. For example, Northumbrian Water now produces 50% less biosolids for recycling to agricultural land. It also directly injects biomethane produced from AAD into the natural gas grid which supports the UK Government's renewable energy policy and results in the company receiving renewable energy incentives.

Northumbrian Water now operates five sludge handling plants which thicken sludge from satellite wastewater treatment works for onward transport to its two treatment centres, located at its two largest wastewater treatment works.

The 24 year NPV of one of the treatment plants is a whole life cost saving of £35 million. It has reduced Northumbrian Water's unit cost of sludge treatment and disposal and increased renewable energy production from 39 GWh per year to 110 GWh per year during AMP5.

Consolidating sludge treatment on to a smaller number of sites and the opportunities to earn revenue from production of renewable energy raise questions about how to best regulate so that companies optimise across company boundaries (the closest site may belong to nearby WaSC), undertake investments to maximise revenue from energy production and collaboration with other organic waste processing. Until now, driven by regulatory incentives, each wastewater company has had independent sludge strategies which have looked to internal solutions for providing sludge treatment and recycling services. A fragmented approach is not likely to be optimal as companies have not collaborated with each other at their boundaries, nor looked to other service providers within their regions. The current price control framework may distort incentives to optimise third party revenues as the revenue control claws back additional revenue or negative costs. The lack of transparency around treatment of capital costs for purpose of transfer pricing also means that it is unclear whether customers' interests are protected when appointees provide sludge processing services to third parties.

How the wider organic waste markets operate

The organic waste market may provide guidance to the future evolution of the sludge market as it illustrates how commercial market for AD processing works and when compared with current sludge market illustrates how service definition and product measurement may need to evolve. Gate fees for organic waste can be positive or negative and vary on the basis of: economies of scale; nature/duration of contracts (risk sharing); financing arrangements; age of technology; revenue generated from the sale of recovered outputs (eg energy, compost sales etc); and price for managing residues.

The organic waste market typically measures quantities in wet tonnes rather than the dry tonnes used to characterise sludge quantities. The organic waste sector distinguishes between different types of waste and any pre-treatment requirements when comparing treatment gate fees. For example, in WRAP's 2015 summary gate fee report[3] higher gate fees are reported for packaged as compared to unpackaged commercial and industrial food waste, reflecting the additional cost to treatment providers of de-packaging waste prior to its treatment. Also, in the same report, composting gate fees vary according to the source of the waste. For example mixed food and green waste attracts a higher gate fee than green waste on its own.

The WRAP survey evidence shows that gate fees for Anaerobic Digestion (AD) using organic waste feedstock vary both within and across regions reflecting the factors listed above. Also, gate fees change from year to year reflecting the evolving organic waste AD market. The majority of AD operators surveyed for the 2015 WRAP report expected gate fees to reduce in the coming period based on the increasing level of competition in the sector. Contract duration in the organic waste sector is generally between 2 and 5 years which, combined with market prices being revealed, drives competition among providers.

As commercial relationships between wastewater treatment providers and sludge processors develop, we might expect gate prices to be used in the sludge sector. Similar to the OOW sector it is likely that a range of gate fees will develop reflecting different products, for example, a low dry solids content requiring thickening before treatment may have a higher gate fee. Similar to the organic waste sector we would expect gate fees to be developed and made transparent across the range of sludge

[3] http://www.wrap.org.uk/content/comparing-cost-alternative-waste-treatment-options-gate-fees-report-2015

services to enable comparison within the market and across the organic waste market.

2.2 Environmental regulations and potential barriers to markets

Some companies have highlighted that the environmental regulatory framework could be a barrier to the development of markets within sludge. Since December, we have been working with Defra, the Environment Agency and Natural Resources Wales to understand the relevant regulations and the potential barriers that might affect sludge markets. We understand that the design and operation of the environmental regulations is very similar in both Wales and England with only small differences.

In its response to our December consultation, the Welsh Government expressed support for an approach that could lead to a reduction, or where appropriate the recovery or recycling of sludge. It asked that we ensure our approach has no adverse impact on the environment or human health, and pointed out that there could be changes to classification of some wastes through possible new eco-toxicity definitions.

The relevant European directives and the associated regulations include those relating to the management of waste, the treatment of urban wastewater, and protection of human, animal and plant health from the recycling of waste derived products.

Companies involved in sludge or waste services and wastewater treatment must meet their environmental regulatory obligations. We understand that the type of regulation and permit that is required by companies depends on many factors, such as how the waste enters the wastewater treatment works, the type of processing equipment and the quantity and types of wastes that are processed, among other things. In addition, there is some uncertainty over some of the waste regulations.

Since December, we have sought to further understand what barriers currently exist that could impact on the effectiveness of sludge markets going forward. We have sought to further understand the opportunities and current barriers related to:

- co-digesting organic waste with sludge; and
- third parties treating, recycling and disposing of sludge on behalf of incumbents.

Co-digestion of organic waste with sludge

We are not aware of WaSCs currently carrying out co-digestion of organic waste with sludge. Although some companies currently process both sludge and food waste on the same site, the sludge part of their operations are carried out by their regulated companies, whereas the food waste is processed under commercial enterprises and is subject to different environmental regulations and associated costs.

We are not aware of any regulations that currently prevent an incumbent company or OOW from carrying out co-digestion. However, co-digestion would result in WaSCs moving towards a permitting regime. Currently, they may be exempted under the Urban Wastewater Treatment Directive and the Sludge (Use in Agriculture) Regulations. Co-digestion with any relevant material would also require companies to comply with regulations specific to the treatment of animal by-products.

If WaSCs move to operating under the environmental permitting framework it could result in WaSCs incurring new permit costs. One of the largest increases in cost is from the mobile plant permits under the Environmental Permitting Regulations framework. These permits incur a cost per deployment for every 50 hectares of land used for recycling waste materials. In England, “medium risk” waste costs £780 per deployment of 50 hectares. We understand that there is also a similar cost in Wales. In 2010, companies reported applying sludge to approximately 152,000 hectares of land. Therefore, if we assume in the future that 25% of the land was regulated under medium-risk mobile plant permits as a result of co-digestion, this would result in a deployment cost of £0.6 million per annum (excluding the permit application fees).

Despite this barrier we undertand that some WaSCs currently co-treat and recycle waste using the mobile plant permits, suggesting that this can still bring benefits.

We will work further on the implications of the environmental regulatory regime and perceived barriers to sludge market development with stakeholders through the sludge working group.

Third parties treating, recycling and diposing of sludge on behalf of incumbents

- We also considered whether it was possible for entrants to treat and dispose of waste on behalf of an incumbent sludge under current environmental regulations. The Environment Agency has already issued permits to commercial enterprises that are not WaSCs to carry out elements of the sludge treatment process, for example lime stabilisation. “Residual sludge” that has had some treatment can

then be treated by third parties. We are currently not aware of any reason why the Environment Agency might not be able to permit any company to take and treat sewage sludge.

2.3 Market interactions in our market design for sludge activities

In our December consultation, we set out the main interactions between potential entrants (WaSCs and third parties) in sludge services. In this section we further consider the market interactions of participants, specifically looking at:

- the licence provisions made under the Water Act 2014 and which licences are required to enable the market to develop for sludge services; and
- the type of trades that could arise between entrants and incumbents as well as the main interactions between the incumbent and entrant through the sludge transport,treatment, recycling and disposal process.

Although the next section sets out the sewerage licences that have been introduced into the Water Industry Act 1991 pursuant to the Water Act 2014, the responsibility for bringing these provisions into force lies with Secretary of State. We will continue to work with Defra to assist their work on bringing into force relevant parts of the Act, in accordance with priorities of the Government.

Licence provisions under the Water Act 2014

Although companies are already able to outsource some of the sludge transport, treatment, recycling and disposal services to third parties (e.g. liming of sludge, or recycling sludge to land), the introduction of sewerage licences could open-up markets further.

A new power for us to grant sewerage licences was introduced in the Water Act 2014 in respect of use of the sewerage system of a sewerage undertaker whose areas are wholly or mainly in England (a sewerage licence).

A sewerage licence may include one or more of the following authorisations (although we can currently only grant licences with retail authorisations until Defra bring the other authorisations into force):

- **A retail authorisation:** This is an authorisation to the sewerage licensee to provide retail services to business, charity and public sector organisation premises using the sewerage system of a sewerage undertaker.

- **A wholesale authorisation:** This is an authorisation to a sewerage licensee to remove (and treat) matter from the sewerage system of a sewerage undertaker where:

    - the sewerage system is being used to provide retail services to business, charity and public sector organisation premises in accordance with a retail authorisation; and
    - the removal of matter from the sewerage system is linked to the provision of retail services.

- **A disposal authorisation:** This is an authorisation to a sewerage licensee to remove (and treat) matter from the sewerage system of a sewerage undertaker where they (or an associated person) will not be providing retail services.

The use of licences can bring about benefits through regulating how participants should operate in the market. This can be done through requiring market particpants to adhere to certain market codes. Entrants are required to apply for a licence through us. We must also consult with the Secretary of State, the Environment Agency and Natural Resources Wales before granting sewerage licences with wholesale or disposal authorisations. In addition, only limited companies may be granted sewerage licences with wholesale or disposal authorisations.

We shall continue to engage with Defra to understand the role of sewerage licences within sludge markets, what services will require such licences to operate in sludge markets and the detail of appropriate exemptions.

Third parties and sludge service provision

Figure 2 below shows the main elements of the sludge transport, treatment, recycling and disposal activities. We envisage that third parties could provide a range of sludge services. For instance, a third party may only specialise in ‘dewatering’ and not in the treatment of sludge, or offer specialist sludge recycling to land services. Incumbents already use third parties to provide a sub-set of activities that make up the wider transport, treatment, recycling and disposal of sludge.

Sludge is produced at the incumbent’s WwTW. The sludge can either be treated directly on site, where the STC is co-located with the WwTW, or transported to a STC located elsewhere. To reduce the cost of transporting, the sludge is sometimes thickened either at the WwTW or via a remote thickening station. Thickening of raw sludge and dewatering of treated sludge will create a liquor which is likely to require treatment. In most instances this will be done by returning the liquor to the WwTW.

Some sludge treatment processes, such as anaerobic digestion, can produce energy which can be used to fuel the STC, sold to the co-located WwTW, sold to local businesses or sold to the grid. Treated sludge is then disposed of, recycled to agricultural land or put to other uses such as producing top-soil for land reclamation.

Figure 2: Main interactions between incumbent and third parties in sludge

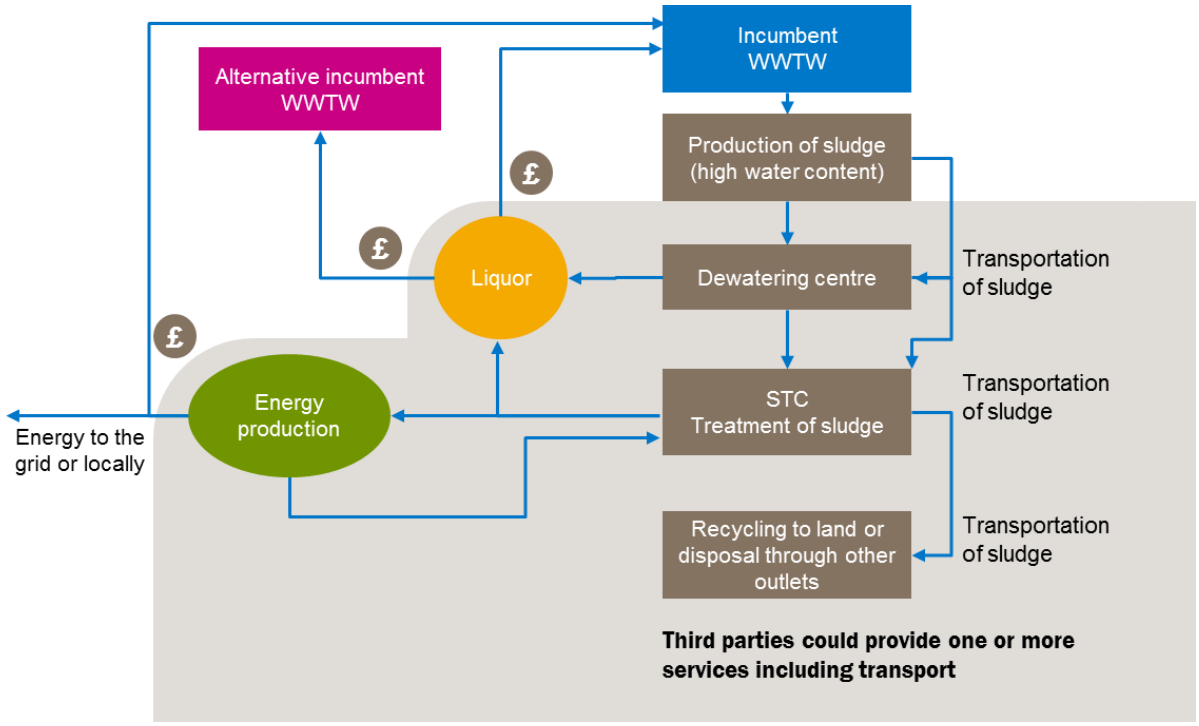


Figure 2 also illustrates that there will be an exchange of products (and associated charges) between the sludge producer and the third party sludge service provider during the sludge treatment and dewatering stages. These exchanges are likely to include:

- **Incumbent pays or receives payment from the third party for (one or more) sludge services[4].** Where the value of sludge is considered to be negative we would expect the incumbent to pay the third party to provide sludge services. However, where sludge has a material and positive value, the entrant could pay the incumbent to provide its services.
- **Third party pays the incumbent to treat liquor.** If the entrant provides treatment or dewatering services, it may produce a liquor, which could need

[4] A sludge service can be considered to be any of the activities that fall within the sludge boundary. This could include one or more part of the treatment, transport, recycling or disposal of sludge.

treating. It is likely that it will pay the incumbent for treatment, based on a trade effluent charges system if the liquor is sent to the incumbent's WwTW. The cost of treatment could be reduced if the entrant is able to pre-treat any of its liquor prior to discharging it to the wastewater treatment works.

- **Incumbent pays the entrant for its energy.** Energy that is produced from treating sludge could be sold back to the incumbent for use in its wastewater treatment.

3 Further detail to support our decisions

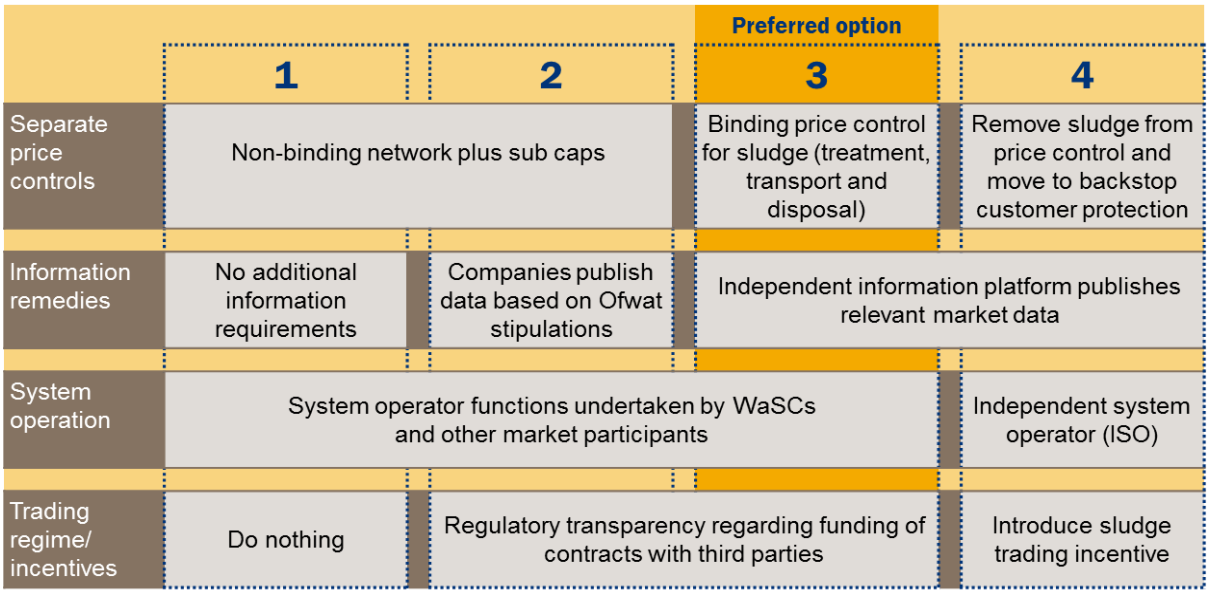
In this section we set out further detail about elements of our sludge design proposals described in Chapter 4 of our decision document . In particular, we explain the background to and further detail of:

- our proposed market design;
- informational remedies;
- the separate price control for sludge;
- our approach to the RCV and new investment; and
- the impacts of our decisions.

3.1 Our proposed market design for sludge

Figure 3 illustrates the four design options we considered in our December consultation. Our decision that we explain in Chapter 4 of our decision document is to retain our preferred option with some changes to simplify the information remedy, and transparency over market activity. We have come to this conclusion having listened to responses to our consultation and engaging with stakeholders through the sludge working group.

Figure 3 Four market design options for sludge



3.2 Improving market information

In this section we provide further detail on our proposals for information remedies.

3.2.1 Information specification

Chapter 4 , sets out the decision to develop sludge information requirements on an evolutionary and timely basis through first requiring companies to produce standardised information in a common format and for the outputs to be made available by 2017. This enables us to take steps to adapt the approach before 2020.

Indicative data items and the data format for the sludge information is shown in Table 1 below.

To ensure information is consistent across companies, we intend to continue to work with the sector to develop information requirements based on standard definitions, data confidence and categories.

Table 1: Indicative sludge market information data categories

Water company name **Contact details**				**Water company name** **Contact details**		
WwTW site name	Aaaa	Bbbb etc.		Sludge Treatment Centre name	Xxxx	Yyyy etc.
WwTW location (grid ref)				STC location (grid ref)		
Sludge quality or wastewater treatment Type				Sludge treatment process type		
Measured volume (m^3/year)				Onward sludge reuse, recycling or disposal route		
Average dry solids (%)				Further information (planning constraints, etc.)		
Sludge production measured mass tds/year						
Max tanker size (m^3)						
Storage constraints (frequency of tanker visits or total m3 storage)						
Further information (unusual sludge constituents, planning constraints, freshness etc.)						

Chapter 4 also outlined the decision to require publishing limited information on successful bids. Table 2 provides indicative data which companies will be required to publish in relation to successful bids.

Table 2: Indicative data to illustrate successful sludge market bids

Water company name **Contact details**		
WwTW site name (if appropriate)	Aaaa	Bbbb etc.
WwTW location (grid ref)		
Bid product or service (standard product or non-standard)		
Contract Volume (tds/year) or (m^3/year)		
Contract Type (e.g. regular, call-off, emergency etc.)		
Contract Duration		
Contract Award Date		

3.3 Price control for sludge

We set out in Chapter 4 of our decision document our decision to set a separate price control for sludge services. Our definition of sludge services includes transport, treatment, recycling and disposal activities. In this section we discuss in more detail the boundary between wholesale network plus activities and sludge activities.

The form of control we have decided to apply is an average revenue control. We would determine the allowed average revenue per unit of sludge by dividing the efficient revenue at a company level by tonnes of dry solids. Allowed revenues for each year of the control period would be set with reference to this average revenue, and an indicative level of total revenue arrived at by multiplying the average revenue allowed in each year by forecast volumes measured in tonnes of dry solids.

In this section we provide a description of how such an average revenue control could work in practice. We also set out here a limited number of specific questions related to the sludge price control on which we are consulting.

3.3.1 Definition of sludge activities

The decision to set a separate binding price control makes it necessary to consider an appropriate boundary between the wholesale activities associated with network plus and sludge. We discussed some of the options with the sludge working group. These options considered moving transport inside or outside the sludge boundary, and also considered if it was appropriate to include within the sludge boundary any wastewater treatment works co-located with sludge treatment centres.

We will work with companies to develop further the detailed specification of the activities and assets to be included within the definition of sludge for the purposes of the binding price control. We welcome responses from stakeholders through the consultation questions in this document. Companies may want to consider the impact any boundary change may have in conjunction with the regulatory accounting guidelines (RAGs) consultation for 2016-17 reporting (this closes on 22 June 2016). We will incorporate the final boundary definitions in the RAGs.

Current definition

As part of the accounting separation process, we previously defined the sludge business unit and identified the activities and assets which sat within it. The starting point of the sludge business unit is “the discharge of sewage sludge from sewage treatment process into pipework leading to sludge treatment processes; or to holding tanks for tankering to a sludge treatment site” [5].

Activities within the current definition of the sludge business unit are:

- **Transport:** This service includes the transport of sludge from the wastewater to the sludge treatment plant. All types of transport, and associated fuel costs, are included within this service.
- **Treatment**: This service includes all the activities related to sludge treatment, whatever process or technology is used.
- **Recycling and disposal:** The onward transport, recycling and disposal of sludge products to landfill, agricultural land, land reclamation sites and to other end users in various forms including treated sludge (biosolids) in liquid or cake form, incinerated sewage sludge ash, and composted sludge.

[5] http://www.ofwat.gov.uk/wp-content/uploads/2015/10/gud_reg405.pdf

- **Liquor treatment:** Where sludge treatment centres have distinct liquor treatment facilities, rather than returning the liquors directly to the wastewater treatment works, the liquor treatment plant assets are sludge assets. However, the activity of treating sludge liquors when they are returned to the wastewater treatment works is a network plus activity, but an appropriate charge for treating the liquors is paid by the sludge business unit to the wastewater business unit. We expect that a reduced cost reflective charge would be paid by the sludge business unit for returning any sludge liquors that had been through pre-treatment to the wastewater treatment works for final treatment prior to discharge to the environment in the site's final effluent. As the liquor treatment would be carried out by the network plus part of the business as a regulated activity, we would expect the charging for this to be done on a similar basis to trade effluent charging.

Future definition for price control purposes

The boundary between wastewater and sludge assets and activities may change as markets develop and we may need flexibility to modify that definition as markets develop. We discuss boundary definition impacts on company licences in Chapter 8 of our decision document .

In principle, we consider that the clearest definition is for sludge activities to start at the point that transport begins. This would mean that a sludge storage tank on a wastewater treatment works would be a wastewater treatment asset. This is a change from the existing boundary position of "discharge of sewage sludge from sewage treatment process into … holding tanks for tankering to a sludge treatment site". It removes from the inventory of sludge assets all basic sludge holding tanks on wastewater treatment works. It is unlikely that a third party would provide such storage facilities and therefore would detract from the sludge price cap to include something which would not be contracted out. Our view is that holding tanks which may have the ability to remove top water as sludge consolidates are included in this definition of sludge holding tanks that would remain as wastewater treatment assets. Any liquids taken off such tanks would remain a wastewater activity and costs for treating these liquors would sit within network plus. Tankering the consolidated sludge away from that site would be the start of the sludge activities.

It is our view that any assets which have moving mechanical parts that thicken sludge prior to it being transported or treated should be sludge assets. At wastewater treatment sites without sludge treatment centres these assets can be used as part of a sludge logistics optimisation activity, reducing transport costs at the expense of additional processing costs. We, therefore, consider that these activities are best included in the sludge business.

Liquor treatment

Liquors produced by any sludge thickening or dewatering assets would be the responsibility of – and the costs to treat them would sit with – the sludge service provider. However, it is often the case that the liquor treatment is undertaken by network plus on behalf of the sludge service provider. In this case, the treatment of liquors is a regulated network plus activity, in a similar way to the treatment of trade effluent.

We are not proposing any change to the current accounting separation boundary affecting liquor treatment. However, it is our view that charges for liquor treatment should be cost reflective, transparent and applied consistently to third-party and incumbent liquors. Charging rules may need to change to accommodate a clear approach to liquor treatment costs. This approach would aid the level playing field in sludge services, and would enable informed decisions on whether separate liquor treatment facilities are a cost effective way dealing with sludge liquors. We are proposing that companies develop an appropriate method of calculating liquor treatment charges, using characteristics of the liquor in their calculations. Our initial view is that this should be a 'modified Mogden' formula, which would consider volumetric flow rate, suspended solids, chemical oxygen demand (COD) and also ammonia concentration. Digested sludge dewatering liquors can be very high in ammonia compared to many trade effluent streams. The cost of treating liquors strongly correlates with ammonia concentration, particularly if the wastewater treatment works receiving the liquors has a tight ammonia consent.

The Mogden formula

The Mogden formula is used to calculate trade effluent charges by comparing the strength of a trade effluent to average sewage strength.

The unit charge is calculated as follows:

Charge per m3 trade effluent = [R + V + (Ot/B x Os) + (St/S x Ss)]

Where:

- R is a fixed charge per cubic metre for reception and conveyance;
- V is a fixed charge per cubic metre for volumetric and primary or preliminary costs, according to treatment;
- Ot is the strength of the trade effluent measured by settled chemical oxygen demand (COD) in milligrams per litre;

- B is the biological treatment cost per cubic metre of average settled sewage strength;
- Os is the average strength of settled sewage by COD at the wastewater treatment works;
- St is the strength of the trade effluent measured by suspended solids in milligrams per litre;
- S is the cost of the treatment and recycling/disposal of sludge (in pence per cubic metre); and
- Ss is the average strength of crude sewage measured by suspended solids (in milligrams per litre) at the wastewater treatment work.

Modifying the Mogden formula

For treating sludge liquors containing high levels of ammonia, companies could introduce an additional term to the Mogden formula. This additional term could appear similar to the biological treatment cost term, for example by comparing the concentration of the liquors with average settled sewage ammonia of say 35 milligrams per litre and multiplying by a treatment cost for ammonia per cubic metre of average settled sewage. There may need to be a subsequent reduction in the "B" term to account for the more segregated way of calculating treatment charges separately for the COD and ammonia concentrations.

Currently, trade effluent charges are calculated by each company and published on their websites annually. They are not site specific charges, although whether particular Mogden terms apply is a site-specific decision based on the wastewater treatment processes employed. It is our view that sludge liquor treatment costs should be calculated on the same company average basis.

3.3.2 How the average revenue control could be set in practice

We have decided to set an average revenue control for sludge and are now consulting on the unit measure for this control. We have considered two options for the units used to set the average revenue control:

- tonnes of dry solids in sludge; or
- population equivalent served.

Tonnes of dry solids is a direct measure of how much sludge is treated excluding all water content. Population equivalent is a standard measure of the number of customers that converts industrial customers' wastewater into the equivalent

number of people and adds that to the number of people served. There is some merit in both of these options.

Tonnes of dry solids is more of a 'commodity'-type measure because companies would be paid for what they actually treat, and so this measure seems more likely to promote effective markets. Given our long-term vision for sludge, at face value tonnes of dry solids is a measure that moves us closer towards that vision. In section 2 above we explain how sludge markets could work in a similar way to other organic waste market structures with gate fees that vary according to a number of factors, but the primary measure appears to be the tonnes of dry solids requiring treatment.

However, there are issues with measurement of tonnes of dry solids. Currently tonnes of dry solids are not measured in all locations and are often estimated. Even if tonnes of dry solids were to become the standard measure, it may still be difficult to measure it in all circumstances, such as where pipes rather than trucks used to transport sludge to processing sites. This is not necessarily an issue for small sites – in fact, tankered sludge from small sites may be measured more commonly at the point where tankers discharge to the STC than sludge produced at a sewage treatment works collocated with a sludge treatment centre.

Setting the revenue control on tonnes of dry solids may therefore have to be set using imperfect data initially. However, it would encourage the development of better measurement, which could ultimately provide useful information for markets. Although estimation would be required in setting a control based on a population equivalent basis, the degree of variance in the estimation would be lower.

Choosing to use tonnes of dry solids would also subject WaSCs to volume risk caused by the weather, or a change in trade effluent loads arriving at the wastewater treatment works, which would not be the case if we used population equivalent.

In addition, there is the potential to introduce perverse incentives for companies to change the way that they operate their wastewater businesses under a tonnes of dry solids measure, rather than population equivalent. Tonnes of dry solids does not differentiate between organic solids with calorific value, and inorganic material which potentially has no value. (Some inorganic solids may have a value as a fertiliser, such as those resulting from phosphate removal.) So applying a tonnes of dry solids average revenue control could diminish incentives to manage the volume of inorganic material in the sludge for example through poor grit removal or excessive chemical addition.

Population equivalent is usually calculated by measuring the strength and flowrate (load) of wastewater at a treatment works and relating them to the average load from one person. However, the load per person will produce slightly different quantities of sludge depending on the wastewater treatment processes employed. It is therefore a less direct measure of sludge production and would not reflect any increase in sludge production as a result of meeting tighter environmental standards.

Population equivalent would not be affected by any perverse incentives to increase the amount of sludge produced. Although the incentive would still exist to increase the population equivalent number, the calculation of population equivalence is independent from the sludge production process, and so could less easily be manipulated.

On balance, given the relative advantages and disadvantages of each approach, we are proposing that the average revenue control should be set on a £ per tonnes of dry solids basis. However, we are also proposing to collect information on population equivalents to use as a cross-check. We are keen to understand stakeholders' views of using tonnes of dry solids as the units of sludge for the price control.

We propose to set the average revenue control by assessing the efficient costs of providing the sludge service using a building-block approach based on totex with RCV run-off plus a return on RCV. Further work will be undertaken to develop our cost assessment methodology to estimate efficient levels of costs. We will consider further the level of efficiency challenge we wish to set, considering the balance between driving down costs using the regulatory tool of an efficiency challenge and the benefits of allowing market based price signals to emerge and reveal efficient costs.

We would determine the allowed average revenue per unit of sludge by dividing the efficient revenue at a company level by tonnes of dry solids. The average revenue control will be set at the price review, but outturn volumes of sludge produced through wastewater treatment may differ from the forecast volumes, so some volume risk will remain with the WaSC.

There are a number of further issues to be considered. These include:

- how over and under recovery of revenue is dealt with in the average revenue control;
- how we would assess efficient costs for sludge services; and
- how income from trading with WaSCs and other parties, transfer charging for non-appointed services, energy generation, sales of biosolids or from using

appointee assets for non-appointed businesses are accounted for in setting the average revenue control.

These will be discussed with the sludge working group and in our methodology consultation in July 2017.

3.3.3 Price control consultation questions

Consultation questions: price control for sludge

Q1 Do you agree that sludge holding tanks with only passive thickening should be network plus assets?

Q2 a) Do you agree that sludge liquor treatment costs should be charged on the basis of a modified Mogden formula which includes a factor for ammonia concentration?

Q2 b) Do you agree that these liquor treatment charges should be calculated on a company average basis, as they are currently for trade effluent charges?

Q3 Do you agree that tonnes of dry solids should be used as the units on which to set the average revenue control for sludge?

3.4 Our approach to historical RCV and new investment in sludge

As set out in Chapter 4] of our decision document , we have decided to set a separate average revenue control for sludge to facilitate the development of sludge markets which will generate benefits for customers. We will use a building-block approach in PR19 to determine the costs of providing sludge transport, treatment, recycling and disposal services.

The RCV is not directly linked to the assets of the water company's business and so an allocation of the RCV is required to set a separate price control for sludge services. Due to the characteristics of sludge (relatively short asset lives compared to rest of wastewater business and recent technological advances in sludge treatment), we will use a focused approach to allocating the RCV for sludge.

A focused allocation of RCV in sludge will foster efficient trading in sludge treatment services by providing an efficient asset cost base to set cost-reflective prices, prevent cross-subsidy from monopoly network plus services and ensure that the privatisation discount associated with the RCV benefits wastewater customers.

However, these outcomes are dependent on the focused valuation reflecting the value these assets would have in a competitive market.

Accounting separation information does not include the capital employed to provide sludge services, although the sector has previously valued assets used to provide services for the purpose of providing current cost accounting data. We are proposing a revaluation of sludge assets to establish a value, possibly a Modern Equivalent Asset Value (MEAV), for these assets and then to use this valuation to allocate the wastewater RCV to sludge services (via a focused allocation), with the remaining RCV allocated to network plus.

As set out in section 4.7 of Chapter 4 of our decision document , we commissioned CEPA to conduct a targeted review of sludge and water resources. We published their report on 31st March 2016 and, as indicated, we will be consulting on the findings and recommendations related to the asset valuations raised in their report. We are setting out an initial approach and intend to consult further with the sector (through the sludge working group) to develop and refine the approach and ensure consistency of the approach for the sludge asset valuation. We expect to publish asset valuation guidelines by 31 March 2017.

3.4.1 Approach to pre-2020 sludge RCV

In our December consultation we stated that we will protect the RCV allocated to sludge services at 31st March 2020, so that RCV allocated to sludge would have the same protection as the RCV of network plus. We also said that capital invested in sludge assets after 31st March 2020 would not be guaranteed a return from other parts of the wholesale business and potentially be exposed to volume risk.

We stated that we do not consider there is any prospect of stranded assets in the 2020-25 period, as allowed revenues are still determined through a regulated allowance for efficient costs. Companies will retain the choice to enter into trades only where it is efficient for them to do so, but need not engage in trading, should they choose.

We suggested there may be scope for stranding beyond 2025, if regulation evolves to market based pricing or regulated prices are adjusted on evidence from the market.

Our initial consideration of the guarantee confirms that it is both unnecessary in 2020-25 period and could create perverse incentives. It is unnecessary, as the

appointed company is the procurer of sludge services and so has the ability to decide whether or not to use its own assets or buy service from elsewhere.

Futher a guarantee may create perverse consequences for WaSCs to engage in trades to benefit from guarantee payments. This could lead to customers paying more for sludge treatment services.

A guarantee would encourage WaSCs to ignore the sunk costs in their exisiting sludge RCV when deciding whether to treat sludge or trade (outsource sludge treatment to another WaSC or new entrant sludge service provider). This would kick-start the sludge trading market, however, at a cost to customers who would also fund the return on the existing sludge RCV, that is, they would pay twice or pay for additional competition.

These issues apply in an environment where the incumbent does not have RCV at risk. The earliest the RCV guarantee is required is beyond 2025, by which time, some proportion of the RCV will be not be subject the RCV guarantee due to depreciation of both pre-2020 investment and new additions to the RCV in 2020-25 period. This means that companies will have direct interest in avoiding stranding and hence a mechanism will be easier to develop and align with customer interest.

As a guarantee mechanism is not required for 2020-25 and a mechanism is likely to have perverse consequences, we do not propose developing details of a mechanism at this time. The need and design of a mechanism will have to take account of our approach to setting any price controls for sludge after 2025 and therefore, we will consider whether a mechanism is necessary at PR24.

We address risk arising from the move to volume based revenue controls, in currently in section 3.3.2, noting the need for regulated allowed revenue to be based on reasonable volume estimates in setting the allowed cost of capital at PR19.

3.5 Summary of impacts of our decisions

In the December consultation we set out an initial assessment of the benefits and costs of our proposals for sludge in Appendix 6: Initial Draft Impact Assessment. Our overall view was that the net impact of our proposals would be positive and that the benefits available were significant, although our analysis was largely qualitative in nature reflecting the early stage in the policy development process.
As set out in Chapter 4 of our decision document , our impact assessment conclusion is that our final preferred policy package will generate the greatest net benefits taking account of the risks and uncertainties involved. We came to this

conclusion by considering in further detail our final policy package against the alternative ‘do nothing scenario’ across the following areas:

- a qualitative assessment against our Water 2020 objectives
- benefits (both quantified and non-quantified);
- costs (both quantified and non-quantified);
- risks and uncertainties; and
- distributional impact
- For each area in turn we provide an overview of our analysis below while further detail on the underlying methodology for our quantitative analysis of costs and beneftis can be found in Section 4 of this appendix.

3.5.1 How our sludge proposals relate to our Water 2020 objectives

In December we outlined how our sludge services policy options meet our Water 2020 objectives, address known problems and are practical to implement. This is set out in Table 3 below. This summaries the qualitative assessment that we carried out on the different options including are preferred option.

Table 3: Achievement of Water 2020 objectives

	1	2	3 Preferred option	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	Promote 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 Encourages ownership and innovation ✗
Addressing known problems	Information availability identified as market stimulant by potential entrants Company data less effective at reducing info asymmetry ✗	Information availability identified as market stimulant by potential entrants Build versus buy bias addressed through regulatory transparency ✓	Info that is consistent across companies is more effective Separate price control can solve 'negative costs' issue, is appropriate due to short asset lives and addresses related market cross subsidy concerns ✓	Removing price cap incentivises use of assets for alternative wastes More consistent info is more effective ISO removes any actual or perceived dispatch bias (but this not yet evident) ✓
Practicality	Avoid creating additional regulatory burden Quick and low cost of implementing Practical issue of legal ability to require info transparency ✓	Avoids cost and licence changes necessary for separate price controls Practical issue of legal ability to require info transparency ✓	Higher regulatory burden due to separate price control Licence change required for separate price control Practical issue of legal ability to require info transparency	Benefits of ISO limited relative to significant cost in context of sludge Not clear this fulfils our duties ✗

We have undertaken a high level assessment of our preferred sludge policy package (as well as the 'do nothing' alternative) against our wider objectives. This is summarised in Table 4 below.

Table 4: Achievement of Water 2020 objectives

	Do Nothing	Preferred Package
Achieves objectives	Not consistent with our pro-market objectives as it relies mainly on existing regulatory mechanisms. Does not expand existing regulatory tool set or sharpen incentives on outcomes and delivery. Delivers predictability by maintaining existing regulatory framework but not in line with the roadmap for reform we have set out.	Promotes markets in a proportionate and targeted way by focusing on a part of the value chain where potential gains from markets have been identified as high. Incentivises focus on maximising value from sludge, by revealing market opportunities for service providers. Delivers predictability to companies and investors in the transition to market-based arrangements by protecting historical RCV investment up to 2020.
Addresses known problems	Does not address identified problems within the current arrangements, which do not promote entry by new sludge service providers.	Proposals tailored to address identified barriers and problems with respect to greater use of markets in sludge, and to provide a level playing field with OOW companies.

	Do Nothing	Preferred Package
		Helps to address environmental challenges through a more efficient development and use of resources. Improves resilience by encouraging new service providers to provide alternatives to incumbent's own systems. Increased use of markets should deliver savings from more efficient investment decisions and better utilisation of assets and resources, which will flow through to lower customer bills. Price control separation should also allow more targeted and effective regulation, potentially generating further savings.
Is practical to implement	Low cost approach which avoids creating additional regulatory burden on incumbents, but new entrants will continue to face barriers to market entry. Revised access pricing regime required even under 'do nothing' scenario in light of Water Act 2014 changes.	Increased regulatory burden due to separate price controls and associated RCV allocation. Approach to RCV allocation avoids need to undertake full asset valuation exercise. Licence changes will be required. Some additional costs associated with market information platform but these have been kept to a minimum through a 'light touch' design.

Overall, our assessment is that the alternative policy options we considered do not meet our objectives as effectively as our final preferred policy package. Specifically:

- With respect to the **information platform**, we consider that our preferred option (under which companies provide information on sludge production locations and volumes) represents the best balance between achieving our objectives, addressing known problems, and practicality. The more complex alternative of a full market information database hosted by a third party provider would be considerably more resource-intensive, and in our view would not be proportionate given the early stage of market development. On the other hand, the 'do nothing' option would not address identified problems with information transparency and barriers to entry for third party sludge service providers.
-
- On **price control separation**, the alternative of a non-binding control on sludge would still incur many of the same practicality issues (for example, in terms of the costs of implementing and monitoring), but would not address our other objectives as effectively. For example, it would offer less protection to potential entrants against the possibility of cross-subsidy and would not promote the same degree of cost transparency or accountability. Conversely, although the 'do nothing' option of retaining the existing integrated wholesale price control would

be low-cost to implement (and hence practical), it does not provide an appropriate regulatory framework in the context of developing sludge markets.

- Our approach to **RCV protection**, under which historical RCV investment up to 2020 would be protected while investment beyond that point is incurred 'at risk', represents a practical approach that delivers predictability to companies and investors in the near term while ensuring that the benefits of markets flow through to efficient companies and customers in the longer term. The alternative of introducing an explicit RCV protection true-up mechanism would add significant complexity (and hence is less practical) as well as creating risks of distortions and unintended consequences.
- On the issue of **RCV allocation**, we note that some form of allocation is necessary in order to set a separate binding price control for sludge. Therefore a 'do nothing' approach to this issue is not appropriate. We consider that our preferred approach of an explicit allocation based on a focused methodology is proportionate and better meets the objectives of transparency and practicality than the alternatives we considered. An implicit or 'shadow' RCV allocation would lack transparency, while an unfocused methodology would not create a level playing field with OOW companies.
- Leaving responsibilities for **system operation** with incumbent companies, as we proposed in December, is a practical approach, proportionate and targeted given the current stage of market development. The alternative of an independent system operator (ISO) would add complexity and uncertainty to the arrangements as well as requiring considerable time and resources to implement.

3.5.2 The benefits of our preferred option

In Chapter 4 of our decision document we explain that our preferred policy option could deliver benefits of between **£372 million and £1386 million** in addition to non-quantified benefits. Our sludge approach is supported by a body of evidence outlined in the December consultation, the discussion in Chapter 4 of our decision document, and modelling which we explain in later in this appendix.

The benefits relate to both productive and dynamic efficiencies within sludge services include:

- Greater commercial focus: the separate price control and the information database will incentivise greater management focus and efficiency savings.
- Greater trading between WaSCs: potential efficiency gains could be achieved from trading as a result of large variances in opex costs between companies.
- Greater trading with OOWs: There is likely to be gains from trading with this sector due to the similar technologies used.

- Deferred expenditure in new investment: Increased trading with OOW industry and other WaSCS should lead to more optimised investment.
- Adopting new technology: particularly the conversion of sludge into energy products. The case study on Northumbrian Water in section 2.1 illustrates whole-life savings of £35 million as a result of moving to advanced anaerobic digestion (AAD) and optimising transport activities.

Promoting markets could also result in a substantial reduction in greenhouse gases and contribute to the UK Government's 2020 carbon reduction targets through conversion of sludge into renewable energy, and the European Commission's circular economy strategy.

Revealing more information on sludge markets could also support identifying alternative means of treatment during emergencies or routine maintenance, increasing the resilience of the sector.

We have assessed the level of benefits to Wales by considering the impact on companies wholly or mainly in Wales (Dŵr Cymru Welsh Water) and as indicated in Table 1 in chapter 4 we also estimate net benefits to Wales from our proposals.

We have carried out modelling to estimate a subset of the benefits, being the level of trades that may occur between WaSCs and between WaSCS and the OOW market, which we detail in section 4 below. We have also engaged with stakeholders to understand the distance over which companies tanker their sludge and have reflected this in our modelling assumptions. Taking into account the significant uncertainties over the costs and benefits of our preferred option, it is our judgement that the benefits will outweigh the costs.

Our approach has been to assess benefits from trading, using three approaches:

- Bottom up modelling of operating cost efficiency benefits using industry cost data. This is likely to understate benefits as the analysis is static and does not take account of incentives to improve efficiency from trading or the benefits of economies of scale from increasing throughput in a smaller number of plants. It does not take account of improvements from capital cost efficiency or increasing revenue from renewable energy generation.
- Bottom up calculation of the benefit from the WaSCs delaying investment in new assets. This delay would be possible because existing assets across the industry or OOW sector could be used to treat any additional sludge production that companies would currently build new assets to accommodate.
- A top down model of dynamic and productive efficiency gains based on regulatory precedent for introduction of markets in areas with monopoly economic

regulation. This estimates total expenditure benefits (totex) and wider dynamic benefits, but use industry aggregate rather than company area cost data.

The bottom up analysis indicates the potential for significant benefit from increasing in trading even within the existing asset configuration, while the top down approach shows significant wider benefits. There are limitations to the modelling we have done. There are factors that mean we could be either over-estimating or under-estimating benefits, such as our modelling assumption that there is no impact on transport costs. The data we have on transport costs is not granular enough to be able to calculate cost changes due to changing which site sludge is transported to.

3.5.3 The costs of our preferred option

We agree with respondents to our December consultation that there is uncertainty around the implementation costs of the design of the sludge market. To reduce this risk we have engaged with stakeholders to further understand, and take into account, the level of costs in relation to the design of our market mechanism.

Based on information we received from companies, together with internal analysis, the estimated costs of our preferred option range between £29 million and £58 million based on the following quantified costs:

- cost to companies of information provision to support sludge market information platform;
- cost to companies of separate price controls including ensuring accurate accounting separation;
- an estimate of the likely one-off costs of revaluing sludge assets; and
- an estimate of regulatory costs to Ofwat of running a separate price control for sludge.

We provide more details of the costs and how we calculated them in section 4 below.

Our impact assessment assumes there is no net cost to customers of the guarantee of the historical RCV (and so there is no net cost to customers[6]). We discuss this further in section 4.7.

3.5.4 The risks and uncertainties associated with our proposals

As with any market reform it may be that efficiencies and innovations do not occur at the pace expected or achieve the the level of benefits expected.

The expectation is that the sludge sector reforms proposed will lead to increased value generated from sludge through further innovation and integration with the OOW sector, benefiting both customers and the environment. At this stage we propose to facilitate market development through information remedies and a separate price control. We acknowledge that a gate price is a likely development necessary to achieve the full benefits expected and there are challenges to work through with the companies and other stakeholder to achieve this.

As outlined in the decision document the impact and outcomes associated with those decisions will be monitored so that we remain informed about what further changes are required to facilitate sludge market development.

Some stakeholders have identified environmental constraints on water companies moving to co-digestion and integration with the OOW sector but we consider these can be mitigated as follows:

- Regarding costs that could be associated with acquiring environmental permits under the Industrial Emissions Directive (IED) and associated Environmental Permitting Regulations (EPR) we will continue to engage with the relevant agencies to ensure that the impact of the regulations are achieving their intended objectives and are not a barrier to market development.

[6] We would not expect that any sludge trades will be entered into if these result in customers being worse off. This means that we expect that appointees will consider the benefits (cost reduction and savings) for customers as well as the costs to customers from any trade. The costs of a trade will include the returns on pre-2020 RCV which may become underutilised as a result of the trade.

- Further explore with companies how the duty of care to ensure the safe disposal of waste (under the waste regulations7) can be incorporated into contractual arrangements with third parties.
- Continue to engage with companies and environmental regulators to mitigate any risks to the long-term security of the agricultural land bank which could occur if parties fail to deliver sludge to the required standard that farmers expect from the wastewater sector.

We note that to some extent companies manage these risks now and we would expect that the industry can build on the record of success in environmental management in any contractual arrangements with third parties and through continued effective regulations.

The nexus between the water sector sector and the energy sector also creates opportunities and risks for further market development Under the Renewable Obligation (RO) scheme, AD (using organic waste) and sewage gas were banded for different levels of support from 2013 which differentiates funding levels between similar technologies. Water companies still face similar issues to install, operate and improve existing systems as in the other waste sectors yet receive lower RO support (from 2013). The different banding levels also constrains wider market development as organic waste AD would receive low support for processing sludge.

Further opportunities for value creation and innovation in the sludge sector are also provided by the Renewable Heat Incentive (RHI) which provides incentives for bio-methane injection to grid and current RHI reforms under consideration by DECC focus on promoting waste-based feedstocks including sludge. However, a risk going forward is that there will be differential RHI tariff rates for sludge and other waste-based feedstocks which could fragment the market.

There is a risk that the costs associated with sludge markets could increase if the design of markets becomes complex or due to costs that we did not foresee. We consider that we can minimise this risk by continuing to engage with stakeholders on the design on sludge markets.

[7] In the Waste Framework Directive, companies have a duty of care obligation under section 34 of the Environmental Protection Act 1990.

3.5.5 The distributional impacts of our proposals

Using a focused approach to allocating the RCV in sludge could have a potential impact on the balance of wastewater charges between different customer groups. For example, trade effluent charges for some could decrease, benefiting particular business users. In this example, there would be an associated increase for charges to other business and domestic customers.

The impact on customers' bills will be dependent on the actual RCV allocated to sludge (following the revaluations) and companies' charging methodologies. This makes it difficult to assess the actual impact on customers. However, we would not expect the impact to be significant as sludge makes up only a small proportion of the overall RCV. We will continue to assess this impact on customers' bills and work with companies to minimise the risk that any particular customer group is unduly disadvantaged by our proposals.

The wider OOW sector will benefit from participating in sludge markets. However, we would not expect this to put upward pressure on customers' bills.

4 Our analysis to support our decisions

In our December consultation, we set out an initial impact assessment of our sludge regulatory proposals. This included our initial views on the impacts of the different policy options that we were considering. The initial impact assessment was largely qualitative in nature reflecting the early stage in the policy development process.

Since December, we have sought to quantify more of the costs and benefits where appropriate by:

- modelling the beneftis of trading sludge services between Water and sewerage companies (WaSCs);
- modelling the benefits of trading sludge services between WaSCs and other organic waste (OOW) companies;
- modelling deferred capital expenditure savings; and
- analysing company views on the costs of our proposals.

Our decisions (both the separate price controls and sludge market information platform) should reveal information that drives efficiency within companies and, over time, should enable the development of markets involving existing WaSCs and firms in the wider waste market. We also expect that the proposals to introduce a market approach into sludge services will result in dynamic efficiencies over time. To understand these potential economic benefits, we have updated the analysis conducted for the Water Act Impact Assessment and applied the approach to the sludge sector. The efficiency gains from the reforms will, in part, be passed onto customers in the form of lower bills.

The results of our analysis have been integrated into the policy discussion in our decision document to reflect the fact that our assessment of impacts and policy analysis are fully aligned. In this section, for each piece of analysis, we:

- set out our methodology;
- provide an overview of the analysis; and
- set out and discuss our base case result and sensitivities (where appropriate).

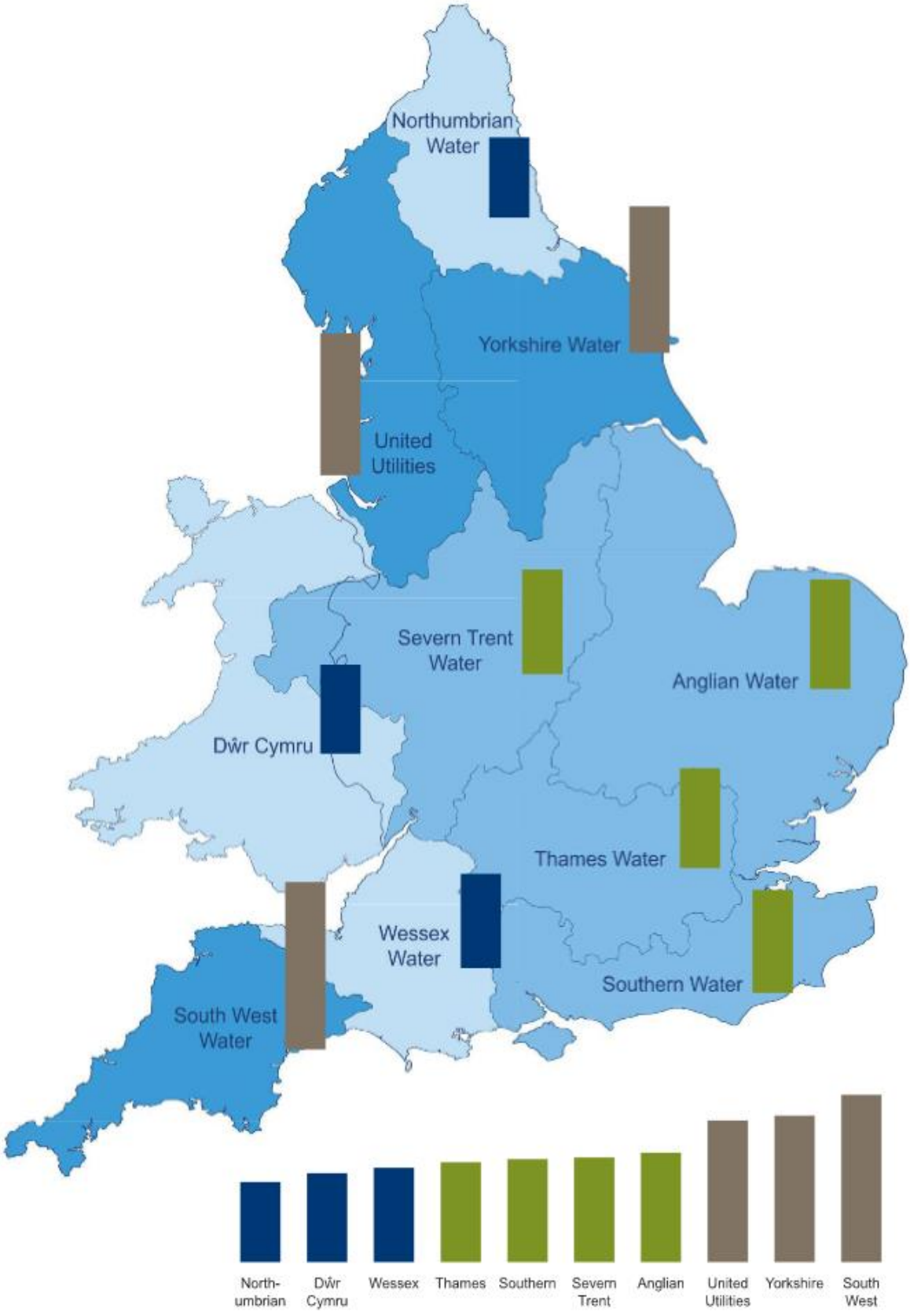
4.1 Benefits: trading sludge services between WaSCs

This analysis looks at the potential efficiencies resulting from increased trading among WaSCs for sludge services.

4.1.1 Our methodology

There are significant differences in unit operating expenditure for the treatment, recycling and disposal of sludge among companies, as shown in Figure 4 below. However, despite those differences, there is little trade occurring among companies. By introducing requirements for WaSCs to publish information, and by introducing a separate price control, these measures will increase management focus and transparency and will facilitate further trading of sludge services between companies.

Figure 4: Relative unit operating expenditure costs per tonne of dry solids across WaSCs

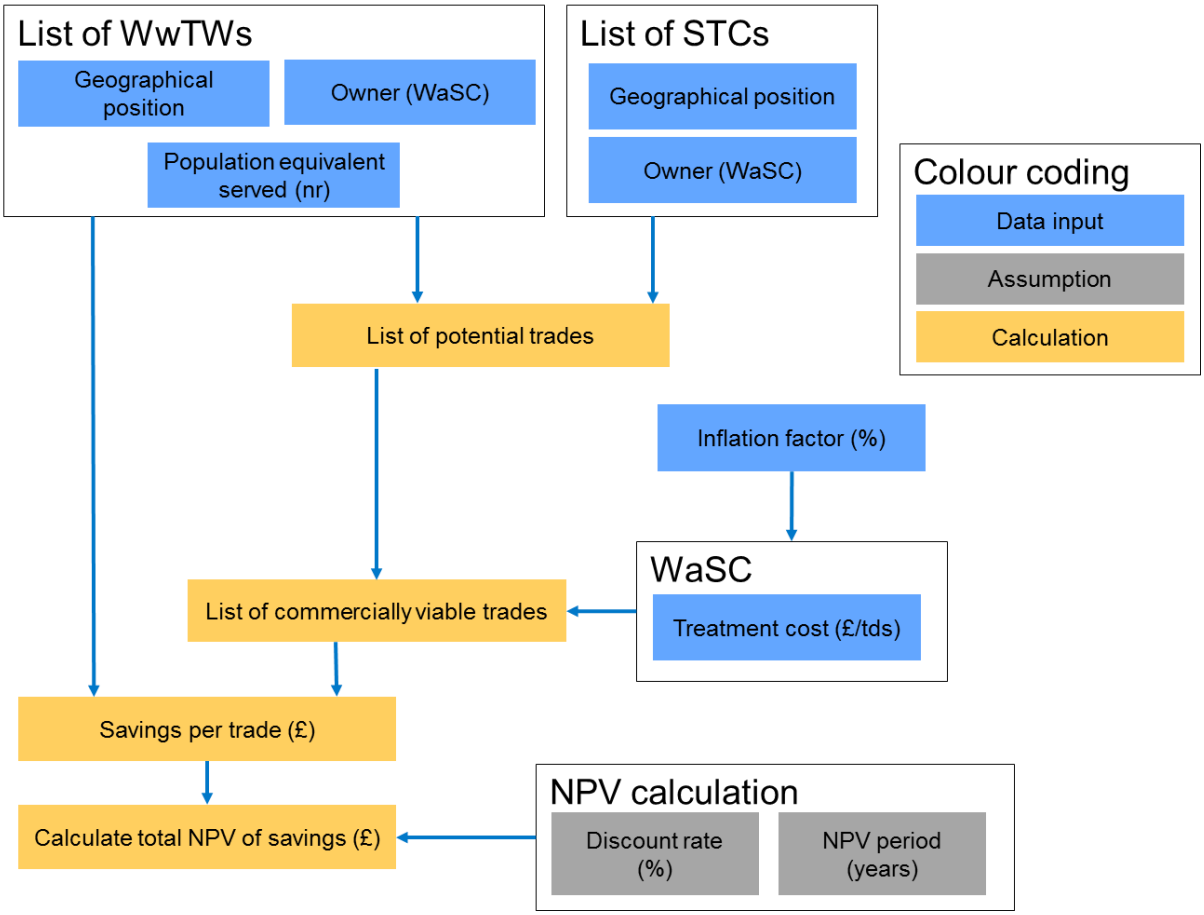


To understand the potential benefits, our approach involved comparing operating expenditure for the treatment (including liquor treatment) and disposal of sludge between WaSCs to estimate the potential operational cost savings if trading occurred between WaSCs within the current asset configuration.

4.1.2 Overview of analysis

The objective of the analysis is to provide an estimate of the potential benefits of trading between WaSCs in the sludge market. We explain how this is done with reference to the inputs, modelling assumptions and results. The structure is illustrated below.

Figure 5: Trading between WaSCs: model flow chart



Source: Ofwat analysis 2014

Inputs

The first input in this model is the list of Wastewater Treatment Works (WwTWs) serving more than 2,000 population equivalent[8]. For each of the WwTWs, the geographical location was identifed, the WaSC they belong to and the population equivalent they serve. A similar list for the Sludge Treatment Centres (STCs), their geographical position and the WaSC they belong to was also used.

The second input is operating expenditure for sludge treatment, recycling and disposal (but not transport) at the company level. We extracted the data from the Accounting Separation data companies reported to us from 2013-14 (adjusted to be expressed in 2015-16 prices).

The third input is the annual tonnes of sludge produced in 2013-14 to give a unit operating cost per tonne. This information was provided to us in the companies' annual return.

Assumptions

For the purpose of our analysis in the model we assumed that:

1. Sludge generated by WwTWs of less than 2,000 population equivalent is a small amount of the total tonnes of sludge a WaSC produces. Therefore, only WwTWs serving more than 2,000 population equivalent are considered in our analysis.
2. Sludge generated at a site with a co-located STC will not be traded.
3. Each person generates an average of 70 grams of waste per day. This estimate is based on the data extracted from a long panel of data of population equivalent served and tonnes of sludge produced at an industry level. By using 70g/person/day, we could calculate an assumed level of sludge production at each wastewater treatment works by multiplying the population equivalent by 70g/day and converting to tonnes/year.
4. There is no impact due to changes in transport costs from trading. We do not know the distance the sludge is being transported before the trading scenario is introduced. Trading has potential to both reduce or increase transporting of

[8] Location of sites greater than 2000 population equivalent were extracted from the Europa database of Urban wastewater sites: http://www.eea.europa.eu/data-and-maps/data/waterbase-uwwtd-urban-waste-water-treatment-directive-4

sludge.We have limited travelling distances to STCs within a 50km radius of a WwTW to ensure that only cost beneficial transactions take place.

5. All STC sites operate at the same, company average, unit cost operating expenditure. This is because data on operating expenditure at the WwTW and STC level is not available. We extracted the company average data from the Accounting Separation data from 2013-14 (adjusted to be expressed in 2015-16 prices) and divided by the annual tonnes of sludge produced to give a unit treatment and disposal operating cost per tonne.
6. STCs do not have any limit on their capacity (i.e. the amount of sludge they can treat). Although this is unrealistic at a site level, we know that at a company level, operators are able to reschedule their own sludge movements to release capacity at one site which is a process they currently use to manage outages.

Calculations

This model lists all the potential trades between WwTWs and STCs. For a potential trade to be considered, two criteria need to be met:

- the WwTW and the STC must not belong to the same WaSC (transport within a company is not considered trading); and
- the STC must be within a 50 km radius from the WwTW.

Once all potential trades have been identified, the average unit operating expenditure costs (£/tonne) of the company operating the WwTW (i.e. the sludge exporter) and the company operating the STC (i.e. the sludge importer) are compared. If the importer's unit cost is lower than the exporter's cost, then the trade is economically viable. If the importer's cost is higher than the exporter's cost, then the trade is not economically viable and is not taken into consideration in our analysis.

If the exporter has several potential trading partners (i.e. sludge importers), the importer with the lowest unit operating expenditure cost is selected so as to realise the maximum savings.

The difference in operating expenditure between the exporter and importer is then multiplied by the quantity of sludge traded. The savings for each trade are then summed to get the total savings at the industry level. Finally, we calculate the Net Present Value (NPV) of the savings for the next 30 years at the Social Time Preference Discount Rate of 3.5%.

Output

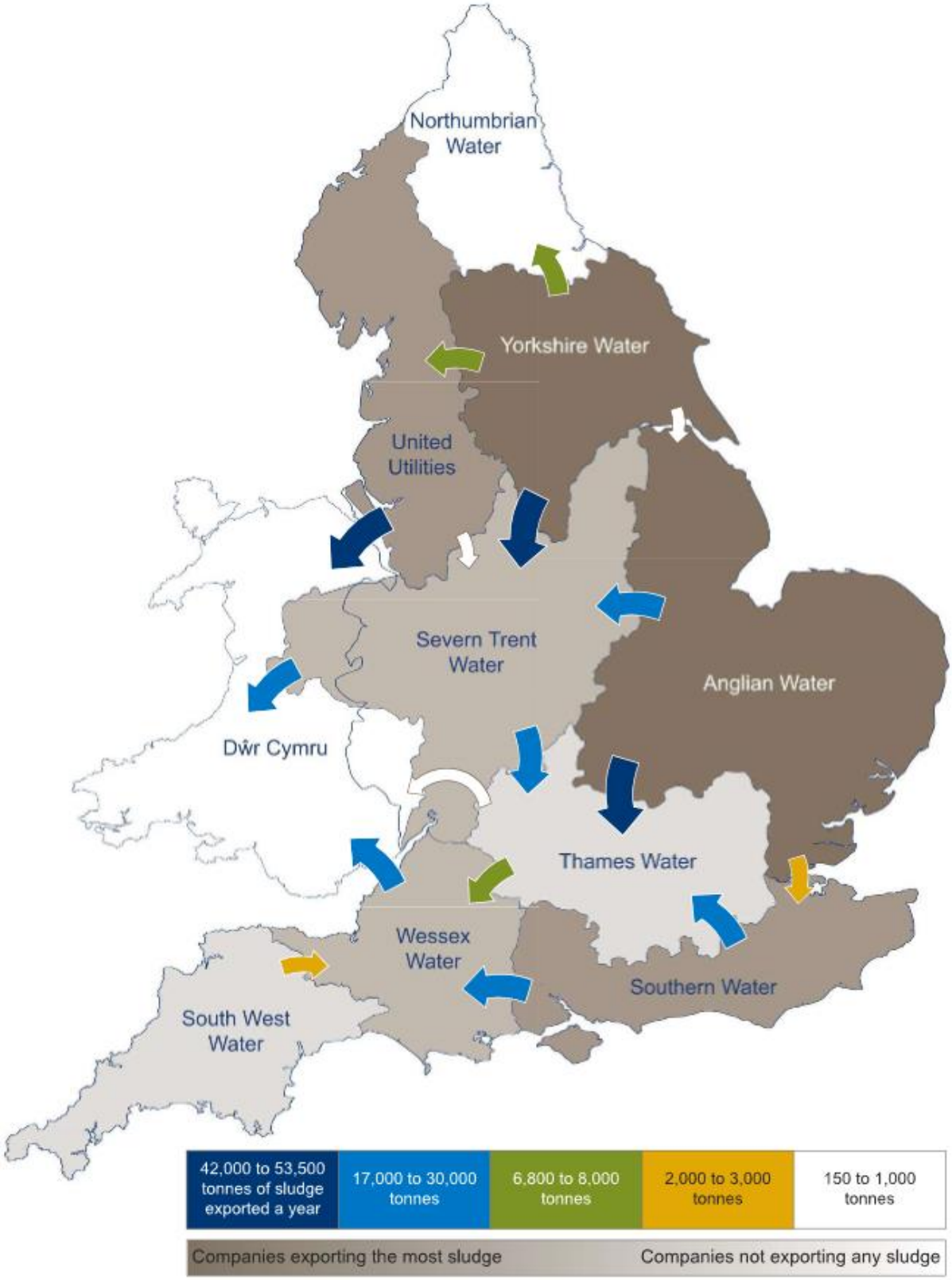
The output of the analysis is a NPV estimate of the potential savings from sludge trading between WaSCs.

4.1.3 Overview of results

The model estimates that about 214,000 tonnes of sludge could be traded annually. This is approximately 13.5% of the total industry sludge production. A total of 4,427 potential trades have been identified and 546 would be economically viable. Every incumbent would benefit from trading, some as exporters, and some as importers. Some companies might also benefit from importing sludge from some companies and exporting their sludge to other companies, as shown in Figure 6 below.

As explained this is a limited model because it is constrained by the existing asset configuration, does not include capital expenditure efficiencies, and does not account for changes in transport costs.

Figure 6: Map of sludge trading between WaSCs



The total NPV of potential savings for all companies over the next 30 years would amount to approximately £161 million. The savings are split between England (£124 million) and Wales (£37 million).

Sensitivity analysis around the maximum radius over which sludge can be traded was carried out and the results are presented in Table 5 below.

Table 5 Sensitivity of WaSC trading benefits to maximum trading distance

Radius	NPV of operational expenditure savings
30 km	£80m
50 km	£161m
70 km	£255m

This table shows that the NPV of operating cost savings could range from £80 million to £255 million depending on the radius applied. The lower value of 30km represents the lowest estimate of the distance stakeholders consider to be economic. The 50km value represents our best estimate and reflects what has been used in previous studies[9]. The high value of 70km represents the highest estimate based on discussions with stakeholders and the emerging evidence that technical changes such as sludge to energy are increasing the economies of scale and the economic travel distances in the sector. The estimated savings are likely to be conservative as they do not account for capital cost savings, which may well be as significant as operating cost savings.

4.2 Benefits: trading between WaSCs and other organic waste companies

This analysis looks at the potential trading that could occur between WaSCs and OOW companies for sludge transport and treatment.

[9] Office of Fair Trading, “Organic waste, An OFT market study”, September 2011, OFT1372.

4.2.1 Our methodology

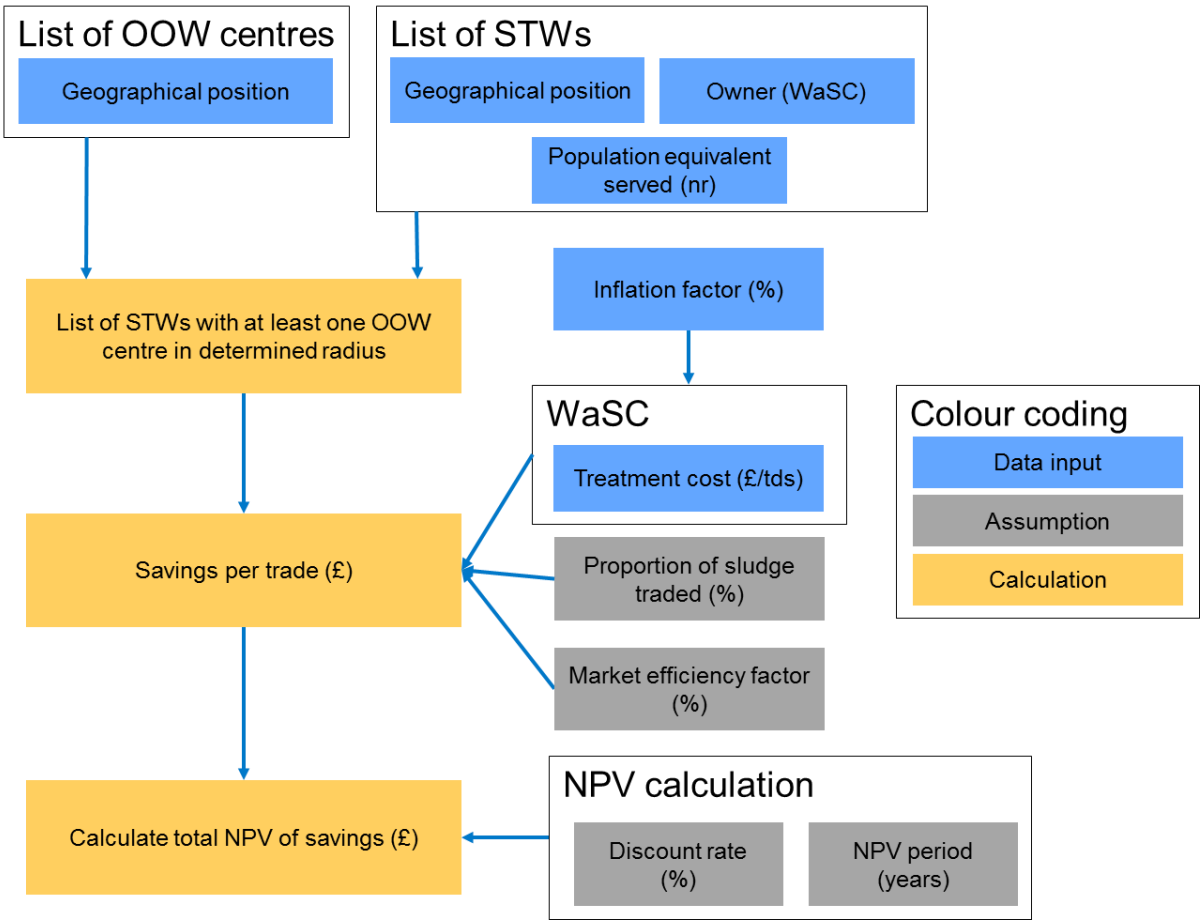
WaSCs and OOW companies have the possibility to treat both sludge and OOW. They can do so by either using clearly separated processes to treat the two types of waste separately or they can use co-digestion (i.e. the process of treating mixed sludge and OOW). The relevant environmental regulations, as described in currently section 1.1.2 but think should be section 2.2, will need to be considered when deciding whether to treat two wastes separately or combined.

WaSCs and OOW companies could benefit from these processes by using spare capacity and improving the composition of the waste they feed to their anaerobic digesters. However, despite those potential benefits, there is little trading occurring between WaSCs and OOW companies. By introducing markets and increasing transparency it will become easier for WaSCs and OOW companies to trade sludge and waste.

4.2.2 Overview of analysis

The objective of the analysis is to provide an estimate of the potential benefits of trading between WaSCs and OOW companies in the sludge market. We explain how this is done with reference to the inputs, modelling assumptions and results. The model structure is illustrated below.

Figure 7: Trading between WaSCs and OOW companies: model flow chart



Source: Ofwat analysis 2014

Inputs

The first input in this model is the list of WwTWs serving more than 2,000 population equivalent[10]. For each of those WwTWs, we have data on their geographical location, the WaSC they belong to and the population equivalent they serve. A list of the geographical positions of the OOW centres which use anaerobic digestion was also used. We extracted this information from the WRAP website.[11]

[10] Location of sites greater than 2000 population equivalent were extracted from the Europa database of Urban wastewater sites: http://www.eea.europa.eu/data-and-maps/data/waterbase-uwwtd-urban-waste-water-treatment-directive-4
[11] http://www.wrap.org.uk/content/operational-ad-sites

Data on operating expenditure at the company level is used in this model to calculate the cost savings. This data is extracted from the Accounting Separation data from 2013-14 (adjusted to be expressed in 2015-16 prices) and divided by the annual tonnes of sludge produced to give a unit operating cost per tonne.

Assumptions

In the model we assumed that:

1. Sludge generated by WwTWs of less than 2,000 population equivalent is a small amount of the total tonnes of sludge a WaSC produces. Therefore, only WwTWs serving more than 2,000 population equivalent are considered in our analysis.
2. Sludge generated at a site with a co-located STC will not be traded as this is assumed to be less economically viable.
3. As in the WaSC trading model, each person generates an average of 70 grams of sludge per day.
4. There is no impact due to changes in transport costs from trading. We do not have information on the distance the sludge is being transported before the export scenario is introduced so difficult to consider impact of trading, which has potential to both reduce and increase transport costs. However, in order to consider realistic travelling distances we assumed only OOW centres within a 50km radius of a WwTW are viable trading options.
5. All STC sites operate at the same, company average, unit cost operating expenditure. This is because data on operating expenditure at the STC level is not available. We extracted the company average data from the Accounting Separation data from 2013-14 (adjusted to be expressed in 2015-16 prices) and divided by the annual tonnes of sludge produced to give a unit treatment, recycling and disposal operating cost per tonne.
6. We could calculate savings by applying a market mechanism efficiency factor to the WaSCs' treatment costs. Because data on OOW centres' treatment costs or prices for sludge is not available, we could not calculate the difference in treatment costs from known information. For example, a 10% market mechanism efficiency factor implies that OOW companies can treat sludge 10% cheaper than WaSCs.
7. Only some of the possible exports from WwTWs to OOW centres will occur. This is because we expect a localised market and that not all OOW centres are likely to have lower operational expenditure costs than the WaSCs.

Calculations

This model lists all WwTWs which have at least one OOW AD treatment site within a 50km radius. The model calculates the total tonnes of dry solids that is within the

50km radius. We then assumed that 10% of that company's total sludge within 50km would be sent to one of the OOW centres. This reflects the fact that not all OOW centres are likely to have cheaper operating costs than the WaSCs. Savings are estimated based on 10% saving on the WaSC's own operating expenditure for any sludge taken to an OOW facility, as explained above proxy market efficiencies .

Therefore, to obtain the potential savings for a company, 10% of the amount of sludge within the trading radius of an OOW company is multiplied by the WaSC's operating expenditure multiplied by the cost efficiency factor.

The savings for each company are then summed to get the total savings at the industry level. Finally, we calculate the Net Present Value (NPV) of the savings for the next 30 years at the Social Time Preference Discount Rate of 3.5%.

Output

The output of the analysis is an NPV estimate of the potential savings from sludge trading between WaSCs and OOW companies.

4.2.3 Overview of results

The models lists 1,353 potential trades between WwTWs and OOW treatment centres. The model estimates that about 52,800 tonnes of sludge could be traded annually. This is approximately 3.4% of the total industry sludge production. Every WaSC would potentially benefit from trading sludge with OOW companies. There are four types of OOW treatment centres: commercial (38% of potential savings), on-farm (34%), industrial (20%) and part of an integrated waste management facility (9%).

The total NPV of potential savings for all companies over the next 30 years would amount to approximately £22 million. The savings are split between the English market (£20 million) and the Welsh market (£1 million).

Sensitivity analyses around the maximum radius over which sludge can be traded and the OOW treatment centre cost efficiency factor was carried out. The results are presented in Table 6 below.

Table 6 Sensitivity of benefits to transport distance

Radius	NPV of operational cost savings

30km	£19m
50km	£22m

Table 6 shows that the NPV of savings could range from £19 million to £22 million depending on the radius applied. The lower value of 30km represents the lowest estimate of economic transport distances from discussions with stakeholders. The 50km value represents our best estimate and reflects what has been used in previous studies[12]. A 70km radius would produce the same saving as the 50km scenario because all sludge produced at WwTWs not co-located with a STC is within 50km of an OOW site.

Table 7 Sensitivity of benefits to the difference between OOW and WaSC treatment costs

OOW treatment centre efficiency factor	NPV of operational cost savings
5%	£11m
10%	£22m
15%	£32m

Table 7 shows that the NPV of savings could range from £11 million to £32 million depending on the efficiency factor applied.

We have potentially underestimated the NPV of savings because only OOW centres using AD are taken into account in our analysis. If OOW centres using other treatment methods, such as co-composting, were included in our analysis the NPV of savings could be larger.

4.3 Productive and dynamic benefits assessment methodology

In addition to modelling the expected trading operational cost benefits, we also looked at the expected increase in productive efficiency and the gains from innovation arising from our proposed regulatory approach. This provides a “top down” view of expected benefits and therefore may not be additive with the results of

[12] Office of Fair Trading, “Organic waste, An OFT market study”, September 2011, OFT1372.

the modelling from increased trading between WaSCs and between WaSCs and OOWs.

We are aware of additional potential benefits that we have not been able to quantify through bottom-up modelling approaches such as the benefits from addressing issues of information asymmetry and the potential increase in the market opportunities for WaSCs through treating organic waste. So it is appropriate to consider top-down estimates as well as partial modelling to provide a range of benefits estimates.

4.3.1 Our methodology

The methodology for calculating the productive benefits is based on that used in the Water Act IA to estimate productive and dynamic efficiency gains. This involves monetising the benefits from one-off productive gains and on-going dynamic efficiencies against the likely future investment in sludge services investments. We expect these savings to accrue to WaSCs, who avoid incurring costs in the sludge business compared to what would have been incurred under the no change scenario, and are then shared with customers via lower bills.

Productive efficiency will occur as WaSCs become more efficient. Dynamic efficiency will occur, for example, as new technologies are applied which achieve higher returns from input sludge.

4.3.2 Overview of analysis

Inputs

The analysis initially involved identifying the cost base for the current sludge services sector. We used the annual average forecast of industry wholesale total expenditure (totex) expenditure for sludge transport, treatment, recycling and disposal for the period 2016 to 2020. This represents the annual average spend on sludge transport, treatment, recycling and disposal over the period based upon the PR14 business plans and is the most up-to-date information on the expected cost base.

Sludge services sector productive and dynamic efficiency gains were estimated by applying an assumed rate of efficiency gain to this cost base.

Productive efficiency is a one-off gain from changes to the sludge sector resulting in less efficient WaSCs catching up with more efficient WaSCs leading to more efficient totex expenditure than would be achieved under the current regulatory approach. The catch up is expected to be sustained over time as the changes in the sludge sector encourage a greater management focus.

Assumptions

The assumed rate of efficiency gain from changes to the sludge sector was based on our estimate of the difference in totex efficiency between the upper quartile incumbent and the frontier company, estimated to be 14.8% as part of PR14. This is our estimate of the comparative efficiency of incumbent WaSCs.

We assumed that all WaSCs would be at the upper quartile of totex efficiency by 2020. To estimate productive efficiency gains we assumed that the gap would reduce by 20% as a result of the proposed sludge sector changes representing a one-off 2.96% reduction in totex. The assumption of a 20% gain is based on the assumption in the Water Act impact assessment and represents a best estimate in the absence of any further evidence.

In addition to one-off gains from the proposed changes to the sludge sector we also expect new ways of sludge treatment and disposal to emerge based on innovation and applying new technologies. In line with the Water Act impact assessment we estimated dynamic gains by assuming there would be an uplift on the historical observed productivity improvements in the upstream sector (based on the PR04 price review) which range from 0.8% to 1.6%. These improvements can be considered as indicative of what could be achieved under a ‘do nothing’ scenario. To estimate potential dynamic efficiency gains, we assumed that there could be an additional 30% improvement on productivity gains under the sludge market reforms compared to a ‘do nothing’ scenario. We assumed these gains are made on an annual basis.

Calculations

We calculated productive efficiency as the NPV of a 2.96% one-off reduction in total sludge totex applied over the next 30 years in 2015-16 prices using the Social Time Preference Discount Rate of 3.5% equivalent.

We calculated dynamic efficiency as the NPV of a 0.42% reduction applied each year to 50% of the total sludge totex over the next 30 years in 2015-16 prices using the Social Time Preference Discount Rate of 3.5% equivalent.

Output

The outputs provide an indication of the productive and dynamic efficiency benefits (in £ millions) of the proposed reforms.

4.3.3 Overview of results

We estimated the NPV of productive efficiency benefits of our proposed regulatory approach in the sludge sector to be between £230 million and £690 million. We estimated the NPV of dynamic efficiency benefits to be between £142 million and £697 million. In table 8 below we look at sensitivities based on lesser and greater efficiency improvements.

Table 8: Estimated productive and dynamic benefits (NPV)

	Low (£m)	Mid (£m)	High (£m)
Total benefits	372	822	1386
Productive gains	230	460	690
Dynamic gains	142	363	697

4.4 Analysis of WaSC information on costs – sludge market information provision and separate price control

4.4.1 Our methodology

To understand the impact of setting-up a sludge market information platform and setting a separate price control for sludge, we considered in our impact assessment the additional cost to companies of doing so.

In February 2016, we sent an information request to the 10 WaSCs that would be affected by the December consultation proposals, asking them about the expected costs of implementing the sludge market information platform and the separate price control. Responses were received from the 10 WaSCs on a confidential basis. We have not independently verified the costs they provided.

We asked companies to provide cost estimates on implementing systems:

- to publish proposed sludge market information to defined standards and publish on company websites;
- to provide assured data to industry agreed standards to an independent information platform provider;
- if the information was provided only for sewage treatment works above 2000 population equivalent rather than all sewage treatment work; and
- to support carrying-out an additional price control.

In line with our approach for the impact assessment, we have used the costs companies provided to estimate the NPV of the costs of our proposals over 30 years for:

- the sludge market information platform; and
- a separate price control for sludge services.

The results of our analysis are discussed below.

Sludge market information provision

Inputs

We received a response from each of the ten WaSCs for the set-up and on-going costs of providing the sludge market information platform with the ranges as follows:

- set-up costs of a sludge market information platform - £0.1m to £20m
- set-up costs if the scale was reduced to sites serving a population of more than 2000 - £50k to £10m
- on-going costs of maintaining the platform - £0.01m to £9.4m
- on-going costs if the scale was reduced to sites serving populations of over 2000 - £20k to £0.29m
- metering costs - £1.2m to £51m

At the time when we asked WaSCs to provide cost estimates, we were considering the option of an independent third party to govern the data platform. As outlined in the decision document, our thinking on the details of the design and governance of the sludge information platform has developed since the information request was made in February. The market platform to be developed has reduced in scope compared with the proposal in December therefore the costs to WaSCS are likely to be lower than those provided through company responses given:

- third party costs to set this up will be minimal.

- we are not proposing that data be collected on the supply side, including costs of sludge services, at this stage.

In light of this we have made a number of adjustments to the data:

- We separated out the costs of metering from other costs identified by companies, such as system updates and provided separate estimates of these as it is not clear that all WaSCs will require additional metering.
- We excluded the set-up costs provided by two WaSCs which included costs for extensive installation of instrumentation and reflected the upper end of potential data requirements. Based upon our proposals it is our view that data at the level of measurement and detail will not be required to initiate discussions with third-parties. There may be a range of benefits to WaSCs to measuring and understanding volumes and costs in order to manage their business efficiently and so these costs may not be incremental to trading with third parties.

We acknowledge that the company responses were initial estimates and would expect these to change in line with our adjustments to reflect the lower information requirements we have adopted.

Assumptions

In providing their cost estimates WaSCs indicated they had assumed:

- the set-up costs include estimated costs for system changes and audit and assurance processes; and
- costs were provided on a ‘best estimate’ basis.

In addition there were different views on the need to install meters with only four WaSCs providing costs estimates reflectling companies different assumptions about metering requirements.

Calculations

To calculate the set-up and on-going costs of a sludge information platform:

- We separated out metering costs from other set-up costs identified by companies.
- We calculated set-up and on-going costs (excluding metering costs) as an average of the estimates provided by each of the ten WaSCs except exclusions.

- We used the average of on-going costs as a estimate of the annual costs for information provision.
- We calculated the NPV of these costs over 30 years, per company and then multiply this by 10 (the number of large companies in the industry) to get an industry figure.
- High and low sensitivities were calculated as simply plus and minus 20 percent of the set-up and on-going costs.
- To calculate metering costs, we assumed four companies would need to install meters at a cost of £1.5 million per company, based on the information provided to us by companies.
- High and low sensitivitiy for metering costs were calculated as assuming seven companies and three companies install meters at £1.5 million per company.

4.4.2 Overview of results

We estimated the NPV of the costs for setting-up and maintaining a sludge market information platform. Table 9 shows the costs under each scenario.

For companies wholly or mainly in Wales (ie Dŵr Cymru Welsh Water) we assumed their costs would be one tenth of the total for all ten companies.

Table 9 Estimated Sludge Information Platform Set-Up and On-going Costs

Cost Category	Mid Estimate	Range
Information Platform – Set Up	£3.5m £350,000 per company on average	£2.8m - £4.2m £280,000 - £420,000 per company on average
Information Platform – metering	£6.0m 4 companies required to install meters	£3m - £10.5m 3 to 7 companies required to install meters
Information Platform – On-going Costs	£15m £1.5m per company on average	£12.3m - £18.4m £1.2m to £1.8m per company on average
Information Platform – Set Up and on-going WwTWs serving > 2000 population	Most companies reported a proportional cost reduction if the data requirements were limited to sites serving a population of above 2000.	

Separate Price Control – Sludge

Inputs and Assumptions

In relation to separate price controls, some WaSCs reported one-off costs associated with the design and embedding the process and others reporting on-going costs with the ranges as follows:

- New price control set up costs - £20k to £15m
- New price control on-going costs - £0.3m to £0.7m

We also made adjustments to the data for the purpose of including costs in the impact assessment as follows:

- We removed any costs associated with the revaluation of assets as these were considered separately.
- We also assumed that companies would not be required to carryout large system upgrades in order to report the data or extensive new instrumentation. This resulted removing associated costs identified by two companies.
- We further excluded cost associated with a company who identified large costs associated with a third company and had included the requirement for significant new metering.

Calculations

We calculated the cost of the separate price control as follows:

- Set-up costs are the average of one-off costs proposed by WaSCs for the new price control, excluding some cost categories and significant outliers. On-going costs are the average of the on-going costs provided by companies, excluding outliers.

- High and low sensitivities were calculated as plus and minus 20 percent of the average set-up and on-going costs.

Some companies estimate that there would be no additional costs, others considered additional costs would be required for cost separation, assurance and financial modelling. We have taken this into account in our estimates.

Overview of Results

We estimated the NPV of the set-up and on-going costs and an additional price control. Table 10 shows the costs under each scenario.

Table 10 Company estimates of set-up and on-going of costs of separate price control

Cost Category	Mid Estimate (£)	Range (£)
Separate price control – Set up costs	£1.4m £140,000 per company on average	£1.1m - £1.7m £110,000 to £170,000 per company on average
Separate price control – on-going	£6.1m £610,000 per company on average	£4.9m - £7.3m £490,000 to £730,000m per company on average

4.5 Revaluation costs

4.5.1 Our methodology

We used two approaches to estimate the costs of revaluing sludge assets to support the focused allocation of RCV to wholesale sludge activities:

- An top-down approach based on the costs of valuation of all water and wastewater assets for PR09. We adjusted this cost on a pro-rata basis for the portion of assets used to transport, treat and dispose of sludge and we converted the subsequent cost to 2015-16 prices; and
- a bottom-up approach based on estimating the likely costs of a single firm valuing the sludge assets of all the incumbent WaSCs.

4.5.2 Overview of analysis

Inputs

Inputs for the top-down approach were:

- costs of asset valuation for PR09;
- indexation values to convert the PR09 valuation costs to 2015-16 costs; and

- sludge asset as a percentage of all water assets to pro-rata the costs from PR09.

Inputs for the bottom-up approach were estimates of the following (assumed values in brackets):

- the number of sludge treatment centres in England and Wales (around 200 sites);
- time to visit each site and review its capital and maintenance planning data (two days per site);
- time to develop and agree a valuation methodology with WaSCs (40 person days);
- time to calculate replacement asset values (30 person days);
- time to agree and sign-off valuations with WaSCs (30 person days); and
- the daily cost of a sludge engineer/accountant (£1,000 per day) and VAT rate (20%).

Assumptions

For the top-down approach, we assumed that the time taken to value sludge assets could be calculated as a percentage of the MEAV of sludge assets from PR09 compared to the MEAV of all water and wastewater assets from PR09.

For the bottom-up approach, the assumptions for each input (above) are given in brackets.

Calculations

For the top-down approach, we multiplied the cost of the water sector asset valuation exercise for PR09 by the proportion of these assets pertaining to sludge and converted this value into 2015-16 costs.

For the bottom-up approach, we multiplied the number of sites by the time required to visit each site and review the capital and maintenance planning data of each. To this value we added the number of days required to develop and agree the valuation methodology, carry out the calculations and sign-off the results. We multiplied this value (total number of person days) by the average daily cost of a sludge engineer/accountant and increased the result by 20% to account for VAT.

For both the top-down and bottom-up results, we multiplied the results by the PR09 MEAV of sludge assets in Welsh Water as a percentage of the PR09 MEAV of all sludge assets in England and Wales. This provided us with the split of costs between Welsh companies and English companies.

Output

We obtained a range of cost estimates for revaluing all sludge assets across the sector. The results are set out in the following section.

4.5.3 Overview of results

The top-down approach produced an estimate of £2.0 million if we pro-rata the costs of the valuation exercise undertaken for PR09. Of this, the cost to Dŵr Cymru Welsh Water would be £0.2 million and the cost to English companies £1.8 million.

The bottom-up approach produced an estimate of £0.6 million. Of this, the cost to Dŵr Cymru Welsh Water would be less than £0.1 million and the cost to English companies around £0.5 million.

Neither the top-down nor the bottom-up costs include the costs of Ofwat staff or their agents that might be involved in validating the valuation results, for example through a targeted review, although this is not expected to introduce a material additional cost to customers or companies.

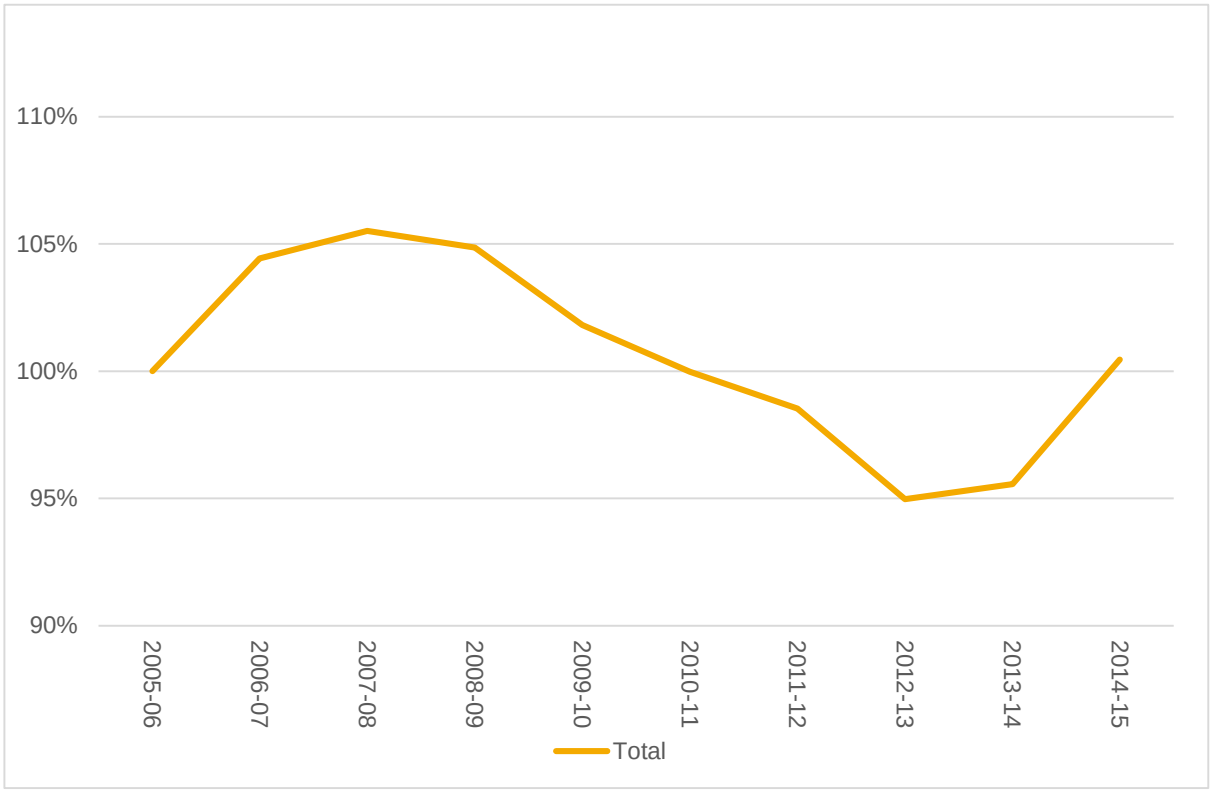
In summary, we apply a range of £0.6 million to £2.0 million overall, rounded to one decimal place as in the range £0.5 million to £1.8 million for England and from less than £0.1 million to £0.2 million for Wales.

4.6 Impacts on the cost of capital

As explained in section 4.5.4 of our separate decision document , the sludge control will be subject to volume risk from 1 April 2020 as a step towards developing markets for sludge. We explained that there is no risk of stranding of new assets in 2020-25, although this risk could increase in subsequent price control periods arising from investment in post 2020 assets.

The introduction of an average revenue control, companies will be exposed to variations in volumes produced int eh course of their sewage treatment activities in their area of appointment. Figure 8 below shows the variation in total industry sludge volumes reported by the companies over the ten years from 2005-06 to 2014-15.

Figure 8: Sludge volume variation over time



The sector appears to have gone through a full cycle, with volumes in 2014-15 at the same level as in 2005-06. In the intervening period, there was 10% volatility in volumes compared to the base year of 2005-06. Sludge volumes peaked 5% above and bottomed out 5% below their 2005-06 levels, although we are aware that some companies changed methods for measuring and reporting sludge production data during this period, which may mean that volatility is overstated.

This analysis emphasises the importance of setting the average revenue control by reference to an appropriate central assumption of volumes such that companies have an equal chance of over- or under-recovering against factors that drive the overall sludge market. We have said we will carry out further work on the approach to sludge volumes through the sludge working group. If a central view of sludge volumes is taken, based on a view of expected market conditions, there is an equal chance of over and under recovery against sludge volumes. The increase in risk may at least in part be non-diversifiable, as some of the variation may be associated with the wider economic cycle. In this case, the increase in risk will lead to an increase in the cost of capital. PwC estimate that the asset beta might increase and the cost of capital might increase by 0% to 0.4%. However, in its analysis, PwC concluded that the impact on beta associated with a shift from a revenue control to a volumetric price cap is broadly offset by an increase in the capital intensity as a consequence of a focussed RCV allocation.

PwC also suggested that reform of the price control could lead investors to perceive the introduction of assymetric risk for existing investment ie where investors expect that reform will introduce a downside risk to returns. Where investors perceive the introduction of assymetric risk, they may require a transitional risk premium unless they anticipate potential gains from market reform. For the sludge market each company will receive the same revenue under the price control irrespective of whether it chooses to treat or dispose of this sludge using its own assets and infrastructure or whether it arranges for sludge treatment to be carried out by another incumbent or new entrant. Companies will also have opportunity to gain from trading and will retain these benefits during the 2020-25 control. They are also protected from downside as trading is voluntary and companies only need to enter into trades where there is a benefit. Further, the pre 2020 RCV is protected, so existing investment is protected, which means that transitional risk is unlikely to be relevant. There does not therefore appear to be a case for a transitional premium on the cost of capital for sludge.

Based on the analysis and evidence, we do not consider there will be an increase in the cost of capital for sludge and so we have assumed an impact of zero for the impact assessment. This analysis is for purpose of the impact assessment and we will further consider the cost of capital for sludge when we make price determinations in PR19.

4.7 Costs of RCV guarantee

As stated in section 3.4, we have not proposed developing details of an RCV guarantee mechanism beyond 2025 at this time. To the extent a mechanism is needed beyond 2025, we will consider this as part of the PR24 methodology taking account of our approach to setting price controls for sludge at the time.

We would not expect that any sludge trades will be entered into if these result in customers being worse off. This means that we expect that appointees will consider the benefits (cost reduction and savings) for customers as well as the costs to customers from any trade. The costs of a trade will include the returns on pre-2020 RCV which may become underutilised as a result of the trade.

For the purposes of the impact assessment, we expect companies will retain the decision around sludge trading beyond 2025. We assume companies will be under no obligation to trade sludge and will have direct interest in avoiding stranding. As we cannot be certain of the exact approach to the regulation of sludge at PR24, we have assumed no costs associated with an RCV guarantee at this stage.

4.8 Ofwat Regulatory Costs

We assessed the potential Ofwat regulatory costs associated with the entire package of Water 2020 policies set out in the decision document. Full details of the methodology and results can be found in Appendix 6. For the purposes of the sludge impact assessment, a proportion of these costs can be allocated to costs associated with the sludge market reforms as follows:

- 50% of the price control-related regulatory costs have been allocated to the separate sludge control (with the remaining 50% allocated to the separate water resources control).
- 15% of the market-related regulatory costs have been allocated to the sludge sector.

The remaining costs have been allocated to the water resources impact assessment. We have also assumed that the costs are associated with both England and Wales.

5 Areas for further consultation

To support the development of our regulatory approach for sludge transport, treatment, recycling and disposal, we are consulting further on a small number of specific questions related to a separate price control for sludge, which we explain in section x above and summarise in the box below.

Consultation questions: price control for sludge

Q1 Do you agree that sludge holding tanks with only passive thickening should be network plus assets?

Q2 a) Do you agree that sludge liquor treatment costs should be charged on the basis of a modified Mogden formula which includes a factor for ammonia concentration?

Q2 b) Do you agree that these liquor treatment charges should be calculated on a company average basis, as they are currently for trade effluent charges?

Q3 Do you agree that tonnes of dry solids should be used as the units on which to set the average revenue control for sludge?

We will use existing fora, such as the sludge working group, for discussions with stakeholders as we develop the next level of detail on our regulatory design. We will consult on the detail of all our proposals through our price review metholodogy consultation in summer 2017.