PwC Economics & Policy

Balance of risk
Risk and reward across the water and sewerage value chain

December 2015

pwc

Notice of change

A correction has been made in this version of the report (February 2016) relating to footnote 191 in Appendix A. This is the only change from the version originally published in December 2015.

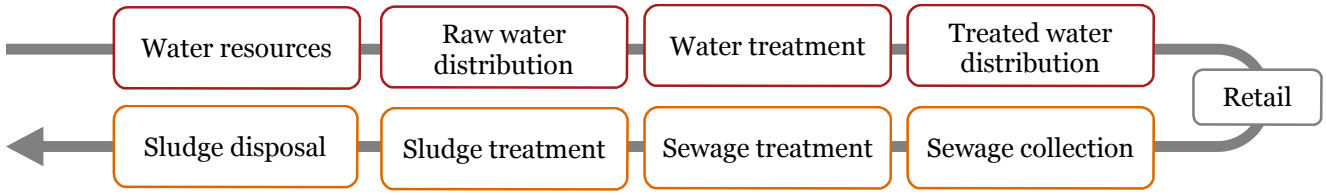
Date: 8 February 2016

Executive summary

Context

Ofwat is currently consulting on its *Water 2020* programme, which aims to change the regulatory framework and facilitate the introduction of new market structures in wholesale water and sewerage services in England. As part of this process, Ofwat seeks to understand how risk varies across the water and sewerage value chain (see figure below) and how the balance of risk may change as a consequence of a range of reforms it has proposed.

Water and sewerage value chain



Source: Based on Ofwat's value chain definition

A key feature of the UK water and broader utility regulatory regime since privatisation has been the sharing of risk, where water companies manage risks within their control, but investors' capital is highly protected. Risk is borne by either customers, companies or specific investor groups and the balance of risk between these stakeholders has varied over time in line with changes to the regulatory regime. One of Ofwat's key tools for managing risk is the inclusion of an allowed return in water companies' revenue allowance. This allowed return is based on the level of invested capital (the "RCV") and the weighted average cost of capital ("WACC"), which in turn reflects the level of risk to which an efficient company is exposed and represents the rate of return required by investors to compensate them for this risk. Due to its inclusion in companies' revenue allowance, the WACC, and therefore the level of risk, is an important determinant of customer bills. Reducing risks for water companies therefore has the benefit of reducing the cost of capital and can thereby reduce customer bills. However, risks that the company is best placed to manage, such as those in relation to investment decisions and operational performance, should remain with the company. This requires a regulatory regime that incentivises efficient risk management and remunerates companies for bearing risk but does not pass risk to customers, such as inefficient expenditure being incorporated into the RCV.

Any change to the profile of risk across the value chain may alter investors' required returns and therefore affect customer bills. Ofwat seeks to understand the potential for changes to the cost of capital as a result of different market reform options. Potential market reform options are focussed on water resources and sludge.

How we consider risk

The analysis in this report focuses on how risks drive investors' required returns, as measured through the WACC. The WACC is made up of a return to equity investors and a return to providers of debt financing ("debt investors"):

- Equity investors require a return for bearing *systematic, or non-specific, risks*, which an investor cannot avoid by holding a diversified portfolio. If an investor holds a diversified portfolio of equity investments, on average those investments which perform poorly due to specific factors will be balanced out by those which perform above expectations. Therefore, as long as an investor holds a diversified portfolio, the investor does not need to earn a higher return to compensate for bearing these risks. Using a Capital Asset Pricing Model framework, systematic risks are reflected in a company's asset beta, which is an input to the calculation of the cost of equity.

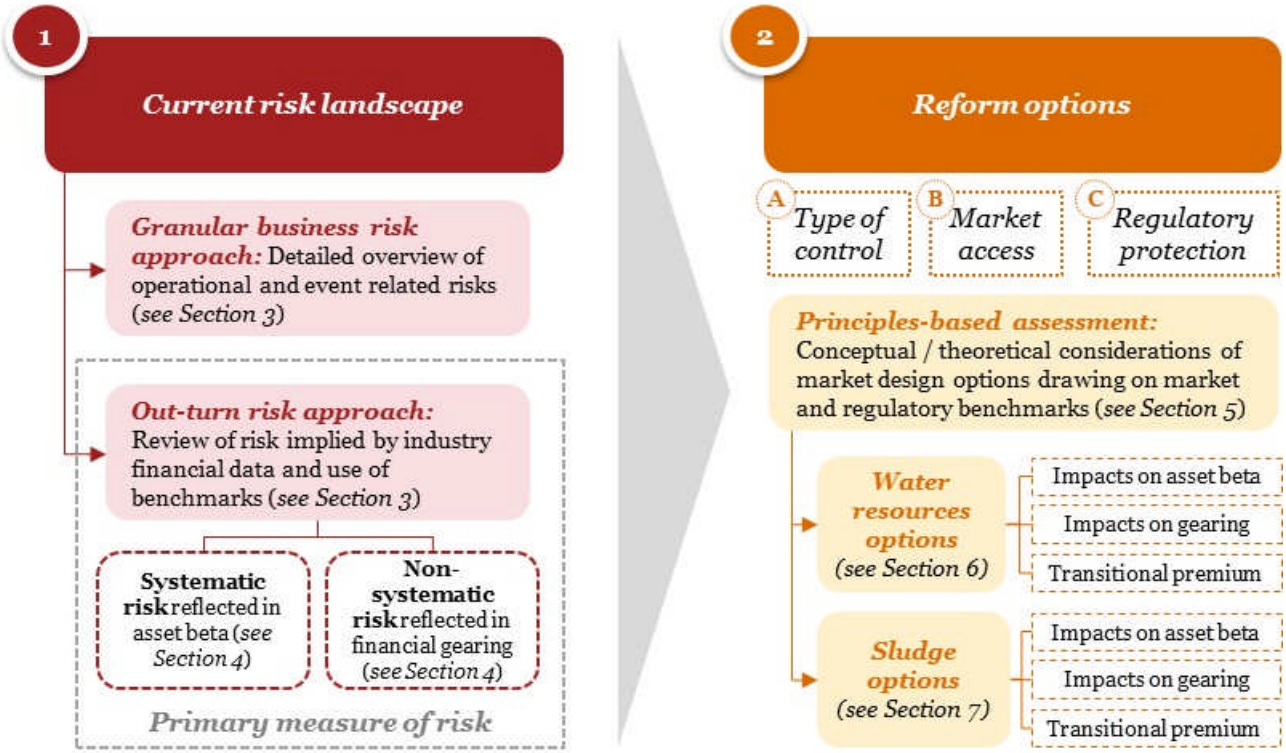
- In contrast, debt investors require a return for bearing default risk which can be influenced by all company risks, *i.e. systematic and non-systematic, risks*. In the event that the company defaults the return on debt will be less than promised. Following this, in a portfolio of debt investments if one investment fails to pay adequate returns due to specific factors there are no offsetting higher returns from other investments. This asymmetrical risk profile means that debt providers also require a return on their investment to reflect company specific risks. Specific risks will be reflected through a company's cost of debt and the level of financial gearing it can sustain.

Risk also has cash flow impacts. Exposure to downside risks increases the likelihood of reduced future cash flows and business value, whereas increased potential for upside risks increases the likelihood of increased cash flows and business value. Ordinarily cash flow risk is incorporated into cash flow projections which are prepared on an expected, or probability weighted basis. Where market reforms introduce new risks which impact both expected cash flows and business values, this impact can be calculated in relation to cash flows or can be estimated as the increase in investors' required returns to compensate for such risks. We therefore also consider risk from a cash flow and value perspective, as expressed in higher or lower return requirements.

Overview of our assessment

We first consider the total risks to which different business segments are exposed to and then consider how the differing characteristics of the value chain segments may impact the cost of capital, primarily through the asset beta and through the level of financial gearing which can be sustained. In most instances, small gearing changes are unlikely to impact the overall cost of capital. This is because lower gearing is, in part, offset by a lower cost of equity due to the financial leverage effect on the equity beta. Further, the incorporation of allowance for the actual tax paid in the regulatory regime limits the benefit of interest tax shields associated with higher gearing. We then review reform options, firstly through a principles based approach and then applied to water resources and sludge, the two areas chosen for reform by Ofwat. Our assessment captures the impact on the asset beta, gearing and we also consider other cash flow risks not captured (termed a transitional premium).

Structure of report



Throughout our analysis we have aimed to quantify potential risk impacts on the cost of capital, both in terms of current levels and potential changes resulting from different reform options. While we acknowledge that

there are limitations, particularly in terms of data availability, we consider that the analysis in this report provides an indication of the potential directional impacts to key risk metrics to promote discussion and further thinking in this area. As more data on the activities, costs and revenues of different segments of the value chain become available, and there are more details on reform options, the accuracy of these impacts could become more refined.

As a consequence, we do not suggest that the numbers in this report should be used for the purposes of Ofwat's price regulation, but rather can be used to begin debate and discussion on how risk in the value chain differs, both now and potentially in the future. If Ofwat decides to regulate specific segments of the value chain separately from the current wholesale price controls, Ofwat can use the approach and data in the report as a starting point for assessing the cost of capital across the value chain and then any additional impacts from the proposed reforms.

Current risk landscape

We have assessed the current risks across the water value chain using two approaches: (i) a "granular view of business risks" (a bottom-up approach) and (ii) an "out-turn" based (top-down) approach. We also consider company and regulatory risk mitigation tools and the effectiveness of these in reducing overall risk exposure. Both approaches provide us with a series of measures. These measures are not intended to be directly comparable.

Granular risk approach

Our granular business risk approach covers risks that are generally related to particular events that have been identified by companies and industry stakeholders. It provides a forward looking view of risks (as it is not constrained by risks which have materialised historically), but is inherently judgemental. We then assess the frequency and impact of these risks to determine which are the most significant. Based on this approach, we find that the water resources and sludge segments of the value chain are neither the most nor least risky segments, but are ranked in the middle of the value chain.

Out-turn approach

The out-turn approach to assessing risk is based on an analysis of the volatility in company cost and revenue segmented financial data. This approach also considers the varying level of capital intensity across the value chain and how this affects risk. This approach is based upon data over a relatively short period (where not all risks are likely to have materialised), and is susceptible to data categorisation challenges. It is therefore indicative and cannot be considered a perfectly reliable indication of future risks.

Of the two approaches, the out-turn approach is our preferred risk measure as it relates more directly to risks in relation to investors' capital. Using this measure we find that sludge has the highest level of risk compared to the rest of the sector, while the water resources segment is considerably less risky. The network infrastructure assets (treated water distribution and sewage collection) are the lowest risk segments of the value chain using the out-turn approach.

Exposure to systematic risk

We then consider how exposure to systematic risk varies across the value chain. We consider how different costs can drive differences in systematic risk as well as how differences in capital intensity can result in variation in asset betas across the value chain. In addition, we also carry out benchmarking of the asset betas for publicly-listed companies that are broadly similar, in terms of activities and/or the nature of risk exposures, to specific segments of the value chain. The table below sets out the directional variation in both asset beta and gearing across the value chain relative to the wholesale level values (based upon the PR14 determination, the wholesale level asset beta is 0.28 and gearing is 62.5%).

Directional differences from company level asset beta and gearing across the value chain

Value chain segment	Size of value (% 2015 MEAV)*	Asset beta differences	Gearing differences
Water resources	3.6%	↑	–
Raw water distribution	1.5%	↑	–
Water treatment	1.8%	↑	↓
Treated water distribution	20.4%	–	↑
Sewage collection	68.4%	↓	↑
Sewage treatment	3.7%	–	–
Sludge	0.7%	↑	↓

Source: PwC analysis, Company data

Note: Arrows indicate whether the value is higher or lower than the company level.

* The MEAV is the modern equivalent asset value and provides an indication of the size, by assets, of each segment of the value chain.

The table above shows that both sludge and water resources are likely to have slightly higher systematic risk (i.e. a slightly higher asset beta) than the company wholesale level asset beta of 0.28. This is due to differences in capital intensity/operational gearing and, in the case of sludge, greater exposure to power costs. Sludge is also expected to have lower gearing than the company level due to its higher level of total risk.

As the largest segment of the value chain, it is arithmetically difficult for the asset beta for sewage collection to differ significantly from the current wholesale beta. Relevant benchmarks and analysis of systematic risk exposures suggest that the beta for sewage collection is unlikely to be lower than 0.25. At the top end of the value chain beta range, relevant benchmarks and the directional impacts of cost exposures and operating leverage suggest that the asset beta for any single segment is unlikely to be higher than 0.4. The decision as to whether to apply differential betas in the context of segmental controls will need to consider further analysis as well as the variation in the estimation of beta across companies and over time.[1]

Assessment of reform options

Overview of approach

For the water resources and sludge segments of the value chain where Ofwat is considering introducing market reforms, we consider a broad range of reforms. This allows us to understand the implications of a broad range of reform designs and allows comparisons with previous work undertaken in the Cave review. These reforms do not reflect the specific reform options considered by Ofwat.

We assess the potential cost of capital impacts which may result from different market reforms. Specifically, we consider how systematic (non-diversifiable) risks and total risks (specific and non-diversifiable) may change across the value chain. For each reform option, we provide a view of the impacts on both asset beta (reflecting systematic risk) and gearing, two components of the traditional regulatory formulation of the WACC.

In addition, we consider the potential for the impact on asset beta and gearing to omit any (net) downside risks as a consequence of new market mechanisms. If reforms introduce asymmetric risks for investors, and expected cash-flows (i.e. the probability weighted central estimate) are altered as a result, the value of the business to investors will change. Such an effect is more likely when moving from one regulatory regime to another (rather than the natural positive and negative variation with a stable regulatory regime). Ofwat's regulatory regime

[1] We note that between 2001 and 2015 the asset betas for the three listed WaSCs (Pennon Group, Severn Trent, and United Utilities) have ranged between c. 0.1 and 0.4. This is a wider range than the potential range we have identified across the different segments of the value chain.

seeks to compensate investors for the risks they bear, so we also calculate the uplift to the required return to compensate for this new risk.

The standard CAPM model is not well suited to capturing asymmetric risks, as the model is required to be applied to symmetric, mean cash flow values. Therefore, this impact on investors needs to be captured through other means. One approach is to estimate the loss of value to investors under different outturn scenarios, and estimate the change in return required to offset fluctuations in value. Judgement is then required regarding the likelihood of each scenario in assessing the magnitude of the premium to the WACC.

Where downside risks are greater the value of the business will fall, and a higher return requirement above the WACC may be required to compensate for such risks (and preserve value). We term this a "premium to the WACC". Where upside potential is greater as a result of the market reforms, then a lower return requirement below the WACC could be justified, leaving investors in a neutral position.[2] Where risks arising from market reforms are symmetric, a premium to the WACC is not required. If these risks are ignored by Ofwat, then this could add to regulatory uncertainty for investors and could result in a regulatory risk premium in the future (for both equity and debt investors). If this risk is dealt with appropriately, then there could be a cost to consumers associated with this risk introduced, but no impact on regulatory risk.

Furthermore, we consider that any premium to adjust for asymmetric risks would only be transitional in nature, and would not be required in the long-run. Asymmetric risks arise as expected cash-flows may change as a result of market reforms, and the change in expected cash flows is measured relative to a baseline scenario of the existing regulatory regime. Over time as new investments are required to replace existing assets, the central estimate for expected cash flows will be calibrated to post-reform expectations regarding market share and asset utilisation. Once the market has settled in a post-reform state, risks around expected cash-flows will become more symmetric once again. It is the transition from full monopoly market share, and the associated predictability of existing asset utilisation to a more uncertain market state which could create asymmetric risks.

Principles based assessment

In assessing the potential cost of capital impacts arising from the reforms we first conduct a principles based assessment, this assessment is structured into three parts:

1. Control reforms - which covers changes to price control structure and approach;
2. Market access - which incorporates access pricing regimes; and
3. RCV based regulatory protections - which covers RCV allocation and the treatment of the RCV.

The relationship between these overarching categories and the more specific reform features considered is set out in the table below.

[2] The current ring-fencing of regulated activities is a factor that restricts the ability of companies to earn income from outside the sector, utilising regulated assets. Market reforms may therefore provide opportunities (or upsides) for companies to earn revenue from wider activities which were previously unavailable. These upsides should be considered alongside downside risks.

Reform features and descriptions

	Reform feature	Options	Description
Control reform	**1. Price controls**	Integrated wholesale v. separate binding control	A separate binding control would mean that the water and wastewater controls would be further split – with controls for the contestable activities, and controls for the non-contestable activities.
		Revenue control vs price control	A change from a revenue control to a price control means the regulated entity bears volume risk.
Market access	**2. Access pricing**	MEAV based v. wholesale minus v. LRIC	A LRIC (long-run incremental costs) approach directly estimates the costs to the incumbent of providing a sustained increment of demand for 'network' activities. A "wholesale minus" approach expresses the access price as the total wholesale price minus the costs the incumbent avoided in the contestable area i.e. through an entrant providing those services instead.
RCV based regulatory protections	**3. RCV allocation**	None v. focused MEAVs v. unfocused MEAVs	Whether to split the existing RCV, and if so, how to split, there are two options to focus on: either the £m MEAV ("focussed") or the % of total MEAV ("unfocussed") for the contestable area can be used.
	4. Treatment of RCV	Exposed to competition v. protected	Where the RCV is protected, it would be fully recoverable through allowed revenue. The options under consideration are: • Only new investment from 2020 onwards is exposed to markets • New investment and 2015-2020 RCV is exposed to markets • Full RCV is exposed to markets (including pre-2015 RCV).

Our findings from this assessment are set out below:

- **Control reforms** – we find that the form of the control can have an impact upon both beta and gearing as a change to a price-cap results in the introduction of volume risk. Drawing upon evidence from past determinations, and empirical beta evidence we find that a change in the form of control to a price-cap could increase asset beta by as much as +0.04. On the other hand, we do not find any evidence that splitting the value chain and introducing separate controls changes risks. Dividing a company into parts which are retained under the same ownership, should not impact its ability to generate returns, but does introduce the potential to subsequently alter risks, if new incentive regimes are introduced at the segmental control level.

- **Market access** – we find that the introducing new market mechanisms is likely to increase risk – particularly associated with market share and asset utilisation - but the degree to which this impacts the cost of equity rather than the cost of debt or gearing depends on whether this risk is systematic. Our review of academic evidence and past regulatory discussions concludes that the relationship between competition risk and beta is weak at best. This can be explained because market share loss is a diversifiable risk for a sufficiently diversified equity investor – i.e. market share losses by one company can be offset by market share gains by another. Therefore, we do not consider that exposure to markets should affect asset beta. An increase in overall risk is likely to move contestable market areas to a lower gearing level, more in line with benchmarks from other similar, but competitive sectors. There is potential for investors to expect market reforms to have a net negative impact on cash flows, either at the company level or as the sector as a whole. The latter would be possible where companies from outside the sector enter new water markets. Conversely, there is potential for the removal of regulatory restrictions to open up opportunities for water companies to grow new revenue streams, so the net effect is not necessarily negative. In order to provide an estimate of this potential effect we have created stylised models which calculate the premium to the cost

of capital for given expected market share loss scenarios and degree of fixed costs. We find the premium to the cost of capital would need to be 2% to compensate for a 20% expected loss in market share with a 75% fixed cost ratio for average, or representative water activities. This figure sits within the impact range provided by the Cave Review, albeit using a different approach.[3]

- **RCV based regulatory protections** – we find that different RCV allocation methods can result in significantly different impacts for both beta and gearing. A focussed allocation to the contestable areas has the potential to change the relative capital intensity across the value chain (but not in overall terms), furthermore a focussed allocation can lead to greater competition risks, placing downward pressure on gearing. On the other hand, we find that an unfocussed allocation of the RCV may not lead to significant risk changes compared to the current landscape as very little of the RCV is exposed to competition risk. One area of potential impact is debt financing arrangements which may be impacted through a reduction in the RCV contained in the monopoly part of the value chain. Lastly, we find that RCV protections, such as guaranteeing the recovery of the existing value of the RCV, have the potential to significantly lower the scale of transitional risk premia to the cost of capital and also investor perceptions of regulatory risk. With a substantially diminished transitional risk premium, no impact on the asset beta from exposure to markets, and limited impact from gearing changes, we consider movements to the cost of capital as a consequence of reforms are likely to be minimal.

We next apply this assessment to the specific reforms for the water resources and sludge segments of the value chain.

Application to water resources

For **water resources** the scope for contestable markets in existing water resource capacity is very limited. Water resource scarcity, coupled with large sunk costs, create significant barriers to entry and market entry is therefore likely to be slow and focussed on new investment. The four market reforms we consider are set out in the table below, and a brief description of each reform follows.

[3] Cave (2009) *Independent review of competition and innovation in water markets: final report*. This referred to analysis by NERA, which suggested the impact on the cost of capital for providers in contestable markets could be between 150 basis points and 400 basis points higher, although we note the reform options considered and approach was different. A full discussion of the findings in the Cave review is set out in Box 1 in Section 5 of this report.

Water resources reforms

Reform features	Reform 1	Reform 2	Reform 3	Reform 4
Price controls	Integrated wholesale control	Integrated wholesale control	Separate binding control	Separate binding control
Enabling mechanisms	None	None	CFD / split contracts	CFD / split contracts
RCV allocation	None	Unfocused MEAVs or unfocused capex	Unfocused MEAVs or unfocused capex	Unfocused MEAVs or unfocused capex
Access pricing	Wholesale minus	Wholesale minus	Wholesale minus	LRIC
Treatment of pre-2015 RCV	Not at risk	Not at risk	Not at risk	Exposed to markets
Treatment of 2015-2020 RCV	Not at risk	Not at risk	Exposed to markets	Exposed to markets
Treatment of new investment	Exposed to markets	Exposed to markets	Exposed to markets	Exposed to markets

Key aspects for each of these reforms include:

- For Reform 1, there is little departure from the current market design under which the NAV (New Appointment or Variation) regime operates. The most significant change is that markets will be introduced for new investment. Under this reform, new water resource providers can sell new capacity to retailers through paying a charge to access the incumbent companies "network plus" value chain segments.
- Reform 2 introduces RCV allocation on an unfocussed basis. Allocation of RCV on this basis allows the monopoly network elements of the wholesale water value chain to retain the substantial amount of the RCV. Consistent with option 1, new investment being exposed to markets takes the form of direct procurement.
- Reform 3 creates a separate binding control for water resources along with enabling mechanisms (such as contracts for difference). Additionally, less RCV protection is offered, as not only is new investment into the RCV exposed to competition, but any RCV from the 2015-20 period is also exposed.
- Reform 4 has access prices paid for accessing the "network plus" elements of the water value chain which are set by applying a long-run incremental cost ("LRIC") rather than a wholesale minus approach. Furthermore, RCV protections are removed entirely, and the full RCV (both existing and new) which has been allocated on an unfocussed basis to water resources is exposed to competition. As existing assets are exposed to competition we assume that markets are introduced for existing capacity, exposing some existing assets in the contestable segment to cost recovery risk.

Impact of water resources reforms on the cost of capital

For **water resources** reform, we find that there is unlikely to be any change to beta across the value chain. This finding holds across all reforms we considered. For most reforms, we also expect there to be very limited changes to gearing (particularly in the short-term). This is due to no exposure to asset stranding risk in both monopoly and contestable segments. Lastly, we find no requirement for a transitional premium to the WACC unless the existing RCV is exposed to new markets.

The impacts on beta, gearing and transitional premium to the WACC for each water resource reform option is set out in table below.

Summary of impacts of water resources reforms

Cost of capital component	Reform 1	Reform 2	Reform 3	Reform 4
Beta	No change to current risk assessment betas across the value chain.			
Gearing	No change to gearing in the contestable area. No change to gearing in "network plus" value chain.			Potential gearing reductions of 10% to 20% for contestable segment. However, in practice barriers to entry in the water resources market may mean that potential market share losses for incumbent's existing capacity is very limited.
Transitional premium above WACC	Where there are markets for new investment, existing investors are not exposed to new cash flow uncertainties. Market design also restricts cost recovery risk on new investments once sunk. No premium required.			Up to 1% premium to WACC where water investors do not view material potential upsides from reform.

Source: PwC analysis

Application to sludge

For **sludge** the proposed new market mechanisms are likely to take a different form to that of water resources, through the application of a "gate price" rather than an access price. For entrants providing sludge services, the price paid/received[4] is a gate price paid by the incumbent wastewater business to the entrant to undertake the sludge activity. The four market reforms we consider are set out in the table below, and a brief description of each reform follows.

[4] If sludge has a negative value, then there is a market for its disposal rather than purchasing a good per se.

Sludge reforms

Reform features	Reform 1	Reform 2	Reform 3	Reform 4
Price controls	Integrated wholesale control	Separate binding control	Separate binding control	Separate binding control
RCV allocation	None	Focused MEAVs	Focused MEAVs	Focused MEAVs
Access pricing	Wholesale minus	NA (reflects MEAV allocation)	NA (reflects MEAV allocation)	NA (reflects MEAV allocation)
Treatment of pre-2015 RCV	Not at risk	Not at risk	Not at risk	Exposed to markets
Treatment of 2015-2020 RCV	Not at risk	Not at risk	Exposed to markets	Exposed to markets
Treatment of new investment	Exposed to markets	Exposed to markets	Exposed to markets	Exposed to markets

Key aspects for each of these reforms include:

- For Reform 1, there is little departure from the current market design.
- In contrast to Reform 1, Reform 2 introduces a series of changes. These changes include a separate binding control for sludge – which would most likely take the form of a price-cap; RCV allocation and access price setting is done on a focussed basis (where RCV allocation to sludge is close to its modern equivalent asset value). This raises the capital intensity of the sludge segment of the value chain.
- Reform 3 and Reform 4 are then identical to option 2 in all aspects except for the level of RCV protection. Reform 3 exposes the 2015-20 RCV to competition and Reform 4 exposes the full sludge RCV to competition.

Impact of sludge reforms on the cost of capital

For the **sludge** segment of the value chain, we find that there is greater scope for market share gains and losses, although co-location of assets and transport costs limit the extent to which incumbent WaSCs could lose market share. Additionally, a price-cap is the form of control being considered for sludge.

We find for the sludge market reforms that there are no material changes to beta. This is because beta increases resulting from the introduction of volume risk are broadly offset by the relative increase in the capital intensity of sludge, which rises as a result of a focussed RCV allocation. We find a focussed RCV allocation can raise total risks though, as access prices should then reflect full economic costs, thereby encouraging new entrants and adding to competition risks. Most sludge reforms, if there are downside risks, have the potential for a transitional premium to the WACC, however, the magnitude of this can be substantially reduced through RCV protections, and may fully dissipate, and could be more than offset, if investors also view upside potential to market reforms.

The impacts on beta, gearing and transitional premium to the WACC (where downside risks exist) for each sludge reform is set out in the table below.

Summary of impact of sludge reforms

Cost of capital component	Reform 1	Reform 2	Reform 3	Reform 4
Beta	No change in beta.	Overall impact on beta is close to zero as increase due to the shift to a price-cap is broadly offset by increase in capital intensity as a consequence of a focussed RCV allocation. No change to beta in "network plus" segment.		
Gearing	No change in gearing.	Gearing reduced by around 2.5%. in sludge No change in gearing in "network plus" segment provided debt covenant thresholds can be updated for new regulatory regime.	Gearing impacts likely to fall between option 2 and option 4, – but weighed towards the premium set out in option 2.	Gearing benchmark for sludge business with competition and volume risk ~40%. Reductions may apply to "network plus" due to regulatory risk from RCV commitments.
Transitional premium above WACC	Very limited expected market-share loss, no premium.	Up to 0.4% premium above WACC where water investors do not view material potential upsides from reform, but this could be substantially negated where investors anticipate potential gains from market reform.	Up to 0.8% premium above WACC where water investors do not view material potential upsides from reform, but this could be substantially negated where investors anticipate potential gains from market reform.[5]	Up to 3% premium above WACC where water investors do not view material potential upsides from reform, but this could be substantially negated where investors anticipate potential gains from market reform.

Source: PwC analysis

Conclusion

Our review of different reforms indicates that, if investors perceive downside risks, there are some potentially significant impacts on the cost of capital and investor required returns *without regulatory protections*. However, with appropriate protections and transition mechanisms then these impacts could be minimised and could be more than offset if investors perceive potential upside.

Future work in this area could seek to refine the outputs in this report. Specific areas of work could include:

- the use of more, higher quality, data disaggregated across the value chain;
- a more detailed analysis of both opportunities and the likely provider changes resulting from proposed reforms, which will inform the degree of asset utilisation, market share risk and exposure to net upside / downside risks; and
- more work on the nature of cost structures, in particular the analysis of fixed and variable costs, in each segment of the value chain to inform the quantification of any premium to the WACC.

[5] With an assumption of constant RCV and a sludge asset life of 30 years, the proportion of RCV attributable to the 5 year period 2015-20 is one sixth of the total sludge RCV. We therefore add to the premium for new investment "exposed to competition", one sixth of the premium where the full RCV is exposed to competition.

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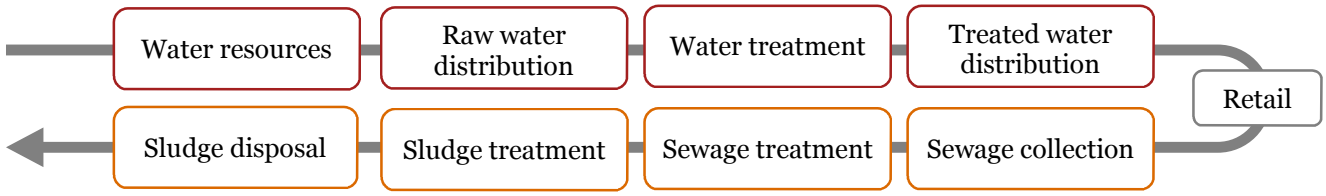
1. Introduction

1.1. Ofwat is currently in the process of consulting on its *Water 2020* programme, which aims to facilitate the introduction of markets in wholesale water and sewerage services in England. The greater use of markets and potential introduction of competition is specifically mandated by the Water Act 2014, which encourages '*greater use of markets for upstream (wholesale) water and wastewater services provided by companies under the jurisdiction of the UK government*'.[6] Upstream wholesale services are split between a number of segments, which are set out in the figure of the water and sewerage value chain below.

Figure 1: Water and sewerage value chain



Source: Based on Ofwat's value chain definition

1.2. PwC has been appointed by Ofwat to advise on the balance of risk across the water and sewerage value chain. This report provides an overview of the current risk profile of each segment of the value chain and assesses how these risks may change as a consequence of a range of reform options. In order to assess the implications of the potential separation of the value chain and promotion of competition and, this report seeks to understand the nature of risk in each segment of the water and sewerage value chain, with a particular focus on the two areas Ofwat is seeking to introduce new market mechanisms: water resources and sludge. Differing risk profiles across the value chain may have implications for the required return for different parts of the business (represented by the cost of capital for the wholesale business and the net retail margin for the retail business). As a result, disaggregation of the value chain could require commensurate adjustments to Ofwat's risk and reward framework.

1.3. A key feature of the water regulatory regime since privatisation has been a cost effective sharing of risk, where water companies manage risks within their control, but investors' capital is highly protected. One of Ofwat's key tools for managing risk is the inclusion of an allowed return in water companies' revenue allowance. This allowed return is based on the level of invested capital (the "RCV") and weighted average cost of capital ("WACC"), which in turn reflects the level of risk to which an efficient company is exposed and represents the rate of return required by investors to compensate them for this risk. Due to its inclusion in companies' revenue allowance, the WACC, and therefore the level of risk, is an important determinant of customer bills. Reducing risks for water companies therefore has the benefit of reducing the cost of capital and can thereby reduce customer bills.[7]

1.4. Any change to the profile of risk in the value chain may alter investors' required returns and therefore affect customer bills. In order to maximise the benefits of reforms, Ofwat seeks to understand the potential impact on the cost of capital as a result of its reform options.

[6] The Water Act 2014 leaves the introduction of competition to wholesale services in Wales open to possibility, but, the Welsh Government has not indicated any plans to bring this into force.

[7] Based on Ofwat's PR14 final determination, the weighted average cost of capital accounts for 21% of allowed company revenue.

1.5. Given the Water Act's emphasis on the "upstream (wholesale)" part of the value chain, the analysis in this document focuses on these parts of the value chain and does not cover the risks in the retail segment of the business in detail. Retail has already been separated from the rest of the water and sewerage value chain and has a unique risk and reward regime.

1.6. The remainder of this report is structured as follows:

- Section 2 explains the context and background of this work.
- Sections 3 and 4 set out our findings on the current risk landscape in the water sector; and assessing which risks are specific (non-systematic) and which are systematic.
- Section 5 sets out our principles based assessment of reform options.
- Section 6 specifically applies our assessment of reform options to the water resources segment of the value chain.
- Section 7 specifically applies our assessment of reform options to the sludge segment of the value chain.
- This is followed by a set of appendices, which includes supporting evidence and exhibits.

2. Context

2.1 The 2009 *Independent review of competition and innovation in water markets* (the "Cave review") undertaken by Professor Martin Cave established a number of recommendations for introducing the greater use of markets in the short, medium and longer term.[8] The trend towards a greater use of markets and competition in the water and sewerage sector was also included in the 2014 Water Act.

2.2 The regulatory package resulting from Ofwat's 2014 price review ("PR14") has delivered a number of the recommendations included in the Cave review. This includes: (1) a greater use of cost incentive menus and removal of the capital expenditure ("capex") bias that resulted from the Capital Incentive Scheme (CIS) menus; (2) the introduction of non-household retail competition; (3) separation of the retail and wholesale elements of the price control; and (4) an increase in transparency in changes in legislation and policy.

2.3 The completion of the recommendations above is consistent with the Cave Review's recommendation for '*a step-by-step approach*' to the introduction of competition, '*starting where the risk-return ratio is most favourable*'.[9] Ofwat's current proposals in its *Toward Water 2020* discussion paper, represent a next step for the implementation of the Cave Review's recommendations. However, these proposals, particularly those targeted at introducing greater competition and (partial) disaggregation of the water and sewerage value chain, represent more substantial changes to the structure of the current regulatory regime and the sector more generally.

2.4 These changes could have important consequences for the risk profile of water companies and therefore the required return to attract investment. Due to this, it is important to understand the variation (if any exists) in the risks across the water and sewerage value chain. Ultimately, this understanding of risk will be used to gain insight into any differences in the cost of capital. This exercise will apply to both the current market structure as well as a range of potential market design options aimed at introducing greater competition to upstream wholesale markets.

2.5 With respect to the cost of capital, the Cave review estimated that the introduction of competition into the sector could increase the cost of capital for water companies by 100 to 400 basis points. This would be driven by (a) investors requiring a '*higher cost of capital to compensate them for the increased risk of operating in a competitive environment*' and (b) companies having to reduce their gearing levels to maintain credit ratings, thereby placing greater weight on the higher cost of equity financing.[10] In addition, the Cave review also noted that there are a number of '*asymmetric risks from competition not considered by the capital asset pricing model which could also impact on the cost of capital*'.[11] We consider these asymmetric risks in more detail in this report (see *Appendix I*).

2.6 Both the cost of capital and the prevailing regulatory regime are key considerations to investors in the water sector. Investors are following developments in the industry closely and will be mindful of any changes in risk that could arise due to Ofwat's market design options. The approach to risk analysis in this project is therefore from an investor perspective of risk. Given this, it is first useful to set out who the investors in the water sector are and what they consider to be important.

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[8] Professor Martin Cave (April 2009) *Independent review of competition and innovation in water markets.*

[9] Professor Martin Cave (April 2009) page 10.

[10] Professor Martin Cave (April 2009) page. 65.

[11] Professor Martin Cave (April 2009) page 66.

Who are the investors in the UK water sector?

2.7 There are a range of investors in the water sector in England and Wales. These investors can be categorised into four groups, with the members of each group having broadly aligned interests[12]:

- Equity holders in listed companies – the listed companies are Dee Valley, Severn Trent, South West Water (Pennon Group), and United Utilities.
- Equity holders in unlisted companies – this is the majority of equity investors and consists mainly large institutional investors such as pension funds, sovereign wealth funds (SWFs) and infrastructure funds.
- Bond holders – bonds will be held by investors who are seeking yields above government bonds yields. The identity of these investors is generally unknown.
- Providers of short and medium term bank debt – this will include commercial banks as well as non-profit international lenders such as the European Investment Bank (EIB).

2.8 In summary, it is important to note that there are a range of different investor types that will have varying concerns, return requirements and risk appetites (e.g. capital growth, capital preservation and yield).

What are investors' concerns and priorities?

2.9 Investors will consider all risks when selecting an investment. When considering the expected return on invested capital, investors will primarily focus on the cash-flows earned by the company, which are in turn driven by the level of costs and revenues. Due to this, the primary risks that we are interested in are those related to the volatility of costs and revenues of the business.

2.10 Investors in company debt (bond holders and providers of short and term bank debt) are concerned with the bond issuer's ability to service the interest payments on the bond and repay the principal amount at maturity. Returns on debt are generally more fixed in nature and have a higher priority of claim than equity returns. Due to this, debt investors will be more concerned with the financial stability of the bond issuer, which will determine its ability to fulfil the interest and principal commitments of the debt instrument.

2.11 Bondholders, in particular, will also be concerned with how industry reform may impact covenants embedded in the bonds that they hold. As identified in a recent Moody's report, water company debt, particularly water and sewerage company (WaSC) bond debt, is '*currently subject to highly-covenanted financing structures*'.[13] These covenants are included in bond structures to protect creditors from (a) abandonment of any part of the appointed business; and (b) material changes in company licences.

2.12 In contrast to creditors, equity investors' (both listed and unlisted) returns are contingent on the performance of the company. When considering returns, equity investors will be more concerned with systematic (beta) risk because this is the element of risk which cannot be diversified. A main driver of beta risk is the volatility of expected returns, which, as mentioned above, is driven by the volatility in costs and revenues of the business in relation to the volatility of equity markets in general.

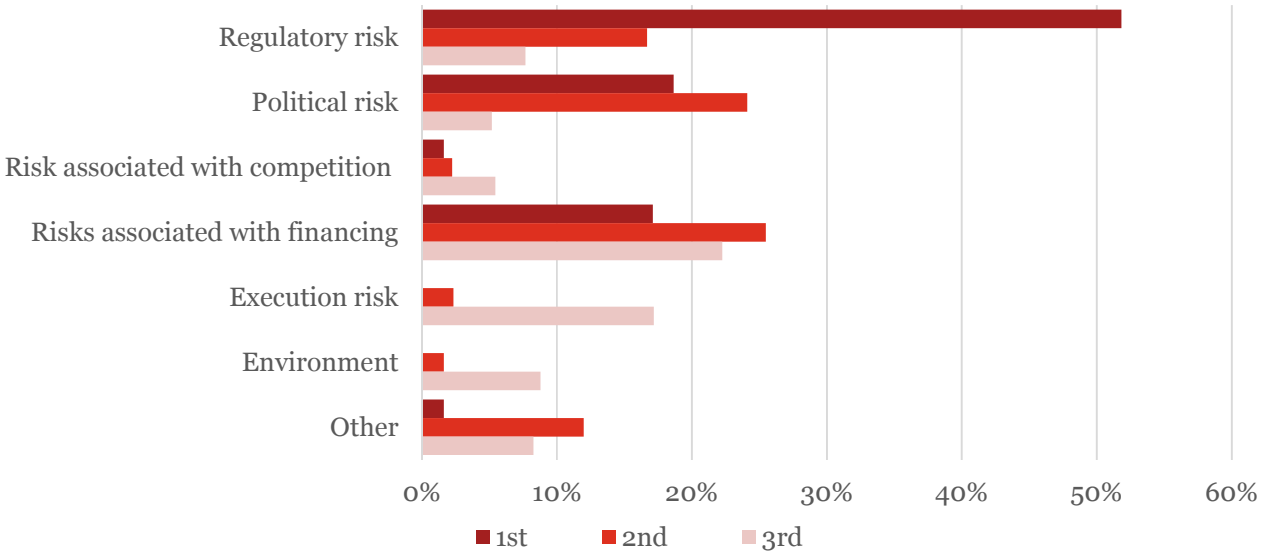
2.13 In a recent survey, water sector investors identified regulatory and political risks as the top risks in the sector (see figure below). However, it should be noted that this survey was carried out during PR14 as well as in the run-up to a national election, when regulatory and political risk would be expected to be at

[12] Categorisation of investors is from Indepen (2014) *2014 survey of investors in the water sector: A report by Indepen for Water UK*.

[13] Moody's Investors Service (14 October 2015) *Upstream reform could muddy UK waters*.

its highest. Other significant risks identified by investors include financing risk, execution risk and "other" risks. Environmental and competition risks were not ranked highly (this information is split by investor type in *Appendix H*).

Figure 2: Top 3 risks, all investor types



Source: Based on data from Indepen (2014) *2014 survey of investors in the water sector: A report by Indepen for Water UK*

2.14 The definitions of the risk categories in the figure above were not included in the survey report. Due to this, we interpret the meaning of these categories in their broadest sense as set out below:

- *Regulatory risk*: Risk of changes to the existing regulatory regime.
- *Political risk*: Risk of political intervention or legal changes to the regulation of the sector.
- *Risk associated with competition*: Uncertainty related to (retail) competition.
- *Risk associated with financing*: Uncertainty around cost of raising finance and/or the difference to the level of the regulatory weighted average cost of capital (WACC).
- *Execution risk*: Operational risks such as cost over-runs and management performance.
- *Environment*: Risk related to over-abstraction and pollution events.
- *Other*: Risks not reflected in the categories above.

2.15 We should not place undue weight on the assessment of regulatory and political risks in this survey, given its timing. This survey suggests that investors have relatively low concerns regarding the risk of competition and have higher concerns relating to execution and financing risks.[14]

[14] Given the timing of this survey, views expressed by investors relating to competition risk most likely relate to the introduction of non-household retail competition in 2017, rather than competition across the entire value chain.

3. The current risk landscape

3.1 In order to understand how reforms may alter risk across different segments of the value chain, we must first understand the current level of risk and how it varies across the water value chain.

3.2 This section seeks to understand risk exposures at both the company level and across the value chain, and both on an overall (total) risk basis and the degree to which this risk can be attributed to specific or systematic factors. The rest of this section is structured as follows:

- We identify and assess risks across the value chain from a **granular business risk approach**. This sets out the largely operational risks in each segment of the value chain and benefits from capturing a wide range of risks, from both a current and forward-looking perspective. However, the financial impact of these risks and effects on more general businesses risks categories is often difficult to identify and is necessarily judgemental.
- We then analyse risk using an **out-turn risk approach**, which considers risk through variation in company financial performance data (costs and revenues). This approach provides a direct measure of the financial risk that companies are exposed to. This approach is based on historic data, for a limited time period, and therefore the results will only reflect the risks which have materialised during this period and can't be considered a perfectly reliable indicator of future risks.
- We then discuss the importance of **capital intensity** across different segments of the value chain and how this affects risk. All else equal, higher capital intensity will dilute risks by spreading financial performance variation over a larger capital base.
- Based on the combination of financial performance variation and capital intensity we calculate a **value at risk** for each segment of the value chain. For the purpose of analysing risk from an investor perspective, we consider the value at risk measure to be most relevant, as it combines both risk and capital intensity. It therefore serves as our primary measure of risk across the value chain, but the other measures still provide helpful insights into the balance of risk.

Granular business risk approach

3.3 In our granular business risk approach (our "granular" approach), we seek to identify risks within each segment of the value chain. These risks are generally operational risks related to particular events that have been identified by companies and industry stakeholders. This approach is described below and involves several ways of gathering evidence to support choice of risk, frequency of occurrence and impact given that companies' risk registers are not generally published.

3.4 This approach benefits from capturing a wider range of risks unique to each value chain segment. In addition, it is a forward-looking approach and will therefore reflect both current and potential future risks. However, in order to reflect such a broad range of risks, an element of judgement is necessary. We have sought to reduce the impact of this by following a structured framework and drawing upon as wide an information pool as possible.

Risk identification

3.5 We identify the most significant granular risks in each segment of the value chain. In order to identify these risks, we follow a structured review of available documentation, using industry recognised risk assessment principles.[15]

3.6 This approach included the following steps:

i) *Identification of risks and grouping them together into significant risk factors for the business segment*. Some risks are considered too detailed for this study, e.g. microbial contamination from nearby grazing livestock. Where possible, we have grouped these with higher level risk, e.g. source contamination. However, we have distinguished between high impact events involving a critical asset, or critical period and low impact contamination events, as the cost implications for companies for these two types of event are different. Some risks apply across the value chain, or in multiple segments, although their expression may be greater in some segments than in others. We have included these risks in our long list of significant risks in each segment where they manifest.

ii) *Assessment of the frequency and impact of the mitigated risk, risk scoring and ranking, supported by review with Tony Conway (formerly Executive Director at United Utilities)*. Given the scarcity of quantitative data on many of these particular risks, these ratings are qualitative in nature – for both impact and frequency. We used the risk scores and the supporting evidence to identify the most significant five to six risks in each segment. Where they exist, we also identify any risk mitigation tools / processes that relate directly to granular risks. We use case studies to provide evidence for the frequency and impact scores of the granular risks.

iii) Recognising that steps 1 and 2 are a qualitative assessment based on expert judgement, further evidence to support the risk, includes a review of:

- General water sector publications that identify current risks and their consequences. One comprehensive example is the Techneau database of water hazards, which lists hazards in different segments of the water value chain for European water utilities. Other literature covers more general risks. The literature in other areas is less definitive, so we draw on other evidence to support our conclusions. This evidence is used to support the long list of risks generated in each value chain segment.

- Regulatory controls (e.g. legislation, mandatory customer or environmental protection standards). This aims to establish the importance attached by policy makers to mitigation, which both validates inclusion of the risk and helps us to understand the tolerable level of risk.

- Company business plans submitted for PR14 and water resources management plans to identify (1) the investment companies plan to make / customers are willing to pay for to mitigate the risk as a percentage of total planned spend. We recognise that this is mitigation expenditure to maintain or return the risk to a tolerable level, and could be considered business as usual; (2) how companies manage the risk (e.g. tolerate, treat, transfer, terminate); and (3) the "tolerated frequency of service failures" attached to the risk. Data from companies' annual performance reports as support for understanding frequency (e.g. how often companies experience sewer flooding).

- The evidence base with industry experts (including PwC sector experts and Tony Conway).

[15] Consistent with HM Treasury Orange Book, *UKWIR Tool for Risk Management of Water Utility assets*, 08/RG/05/25.

- Case studies showing where the risk has materialised, which we used to show how the risk might manifest in frequency and impact.

iv) We also consider how risks might change in the future (absent any regulatory and policy changes) through review of general water sector publications, e.g. companies' submissions to the "marketplace of ideas".[16]

3.7 Other relevant factors that we consider in identifying risks include:

i) Whether the risks apply to critical assets, where failures cannot be mitigated by use of alternative assets, and there are therefore costs associated with outage in the case of water or significant pollution events for sewerage.

ii) High impact low probability events relating to critical assets, where the damage and therefore costs associated with a failure would be large. These risks tend to be highly mitigated and heavily regulated, therefore the post-mitigation probability of failures is very small.

iii) Frequently occurring low impact events, where operational interventions are routinely used and performance is kept within a tolerable level of service based either on customer willingness to pay or on regulatory standards.

iv) Event costs will form part of companies' reactive maintenance programmes. The costs that are reported (e.g. through annual returns or in the media) are likely to refer to more extreme events and therefore may reflect upper end costs. The risk scores need to reflect this potential bias.

v) There could be bias towards reporting of more extreme or unusual events. We have tried to correct for this in our risk frequency scoring.

vi) Mitigated risk levels are likely to involve a small proportion of the customer base actually experiencing risks, although the risk may manifest on a daily basis in some cases. A subset of customers are likely to be exposed frequently, while others may never experience the effects of the risk itself.

3.8 Some risks will manifest in several parts of the value chain, but at different levels in different segments. For example, contamination manifests at all parts of the water value chain (DWI quality standards reflect quality from source to tap with sampling at customers' taps). However, our assessment is that the risk levels are greatest at treatment works (where treatment processes may or may not be able to mitigate for contamination upstream) and at specific points in the distribution system (e.g. service reservoirs).

3.9 Our identification of the top granular business risks in each element of the value chain is set out in the table below. Further detail is provided in *Appendix A*, including the full list of risks we consider for each segment and the evidence underpinning the frequency and impact scores assigned to risks.

[16] In keeping with its collaborative approach, Ofwat has asked for input from companies as to whether it is correct in its assessment of the challenges facing the sector by setting up a "marketplace of ideas".

Table 1: Granular business risks

Water resources	• Shortage of water during a drought • Catchment management measures are ineffective • Dam failure	• Over-abstraction • Source contamination
Raw water distribution	• Aqueduct failure • Other distribution asset failure • Contamination/infiltration	
Water treatment	• Critical asset contamination • Core component failure • Security breach including theft of materials	• Flood damage • Non-critical asset contamination
Treated water distribution	• Ground movements/freeze-thaw cause leakage • Bursts cause flooding • Supply interruptions and low pressure	• Contamination • Street works cause disruptions, e.g. to traffic • Water theft
Sewage collection	• Private sewer transfer and private pumping station transfer • Sewer flooding • Hydraulic flooding/CSOs	• Misuse of sewers • Street works cause disruptions, e.g. to traffic
Sewage treatment	• Major compliance breaches • Flooding of treatment works • Grit build-up	• Health and safety • Failure of key assets • Poisoning of microbes
Sludge (treatment & disposal)	• Loss of sludge processing capability • Suboptimal sludge throughput • Poor quality feedstock	• Inadequate sludge treatment • Methane storage

Source: PwC analysis

3.10 The risks identified in the table above will manifest differently depending on their nature (e.g. low probability high impact or high probability low impact), and how they impact companies' costs and revenues. For example "shortage of water during a drought" (under water resources) could manifest in a potentially complex way on companies' costs and revenues:

i) Companies will incur costs to mitigate the water shortage. For example, taking temporary bulk supplies, applying for drought permits to abstract more water from existing sources, bringing forward water resources schemes from future periods to generate additional supply, active leakage control, water efficiency measures, media campaigns, putting in place and enforcing demand restrictions (sprinkler bans, hosepipe bans, non-essential use bans).

ii) At the same time, there will be a potentially complex impact on revenue collected from customers on measured supply. Customers will naturally want to use more water during hot and dry weather, hence unmitigated demands will potentially rise. However, demand may be capped or may even reduce as a result of a successful "use water wisely" media campaign, or a demand restriction such as a hosepipe ban.

iii) The mitigated cost and revenue impacts, are further mitigated by regulatory arrangements. Hence, for example, while revenues vary in the short-term, they are likely to be trued up as part of the revenue control and through the WRFIM at a later date.

Rating risk across the value chain

3.11 We identify the primary granular risks in each element of the value chain using the risk rating matrix set out in the table below. The complete granular mitigated risk assessment is included in *Appendix A* for each element of the value chain. The impacts set out below are indicative, and should be considered to relate to the impact for a medium sized WaSC. A smaller or larger company might define different financial impacts and frequencies depending on the scale of its business and regional characteristics.

Table 2: Granular business risk rating approach

Impact	Catastrophic (>£10m)	**5**	5	10	15	20	25
	Hazardous (£1-10m)	**4**	4	8	12	16	20
	Major (£0.5-1m)	**3**	3	6	9	12	15
	Minor (£100-500k)	**2**	2	4	6	8	10
	Negligible (<£100k)	**1**	1	2	3	4	5
Overall risk score = frequency * impact			**1**	**2**	**3**	**4**	**5**
			Extremely Improbable	Remote	Moderate	Occasional	Frequent
			Frequency				

Source: PwC analysis

3.12 Our assessment of frequency, post-mitigation is based on the following assumptions[17]:

i) Frequent: occurs at least once per week for most companies. A proportion of the company's customer base will recognise the risk as a significant hazard based on their experience, or EA/DWI will see the risk as a significant day to day hazard.

ii) Occasional: occurs at least once per month for most companies, and may occur more frequently for some companies, groups of customers or water bodies.

iii) Moderate: Occurs at least once per year for most companies, and may occur more frequently for some companies, groups of customers or water bodies.

iv) Remote: Occurs less than once per year but more than once in ten years.

v) Extremely improbable: occurs once in ten years or less.

3.13 There may be factors that could impact companies. Hence, where appropriate, we have also considered the reputational damage a company might suffer as a result of a risk manifesting, and regulatory / political factors such as increased scrutiny and reporting costs. In Table 3, we summarise our findings of the granular business risk rating results.

[17] An extremely improbable event with a one-time catastrophic impact can have a similar risk score (i.e. is broadly equivalent) to frequent events with negligible impacts. For example, a risk that has a £99k ("negligible") impact, but occurs 100 times, will be broadly equivalent in financial terms, to a £10m (catastrophic) event that occurs once. As a result, both received a risk rating of 5.

Table 3: Granular business risk rating results

Value chain segment	Granular mitigated risks		
	Max. score	No. of risks (score > 4)	**Average score of most significant risks**
Water resources	8	4	**6.3**
Raw water distribution	8	2	**6**
Water treatment	8	3	**5.6**
Treated water distribution	10	8	**7.5**
Sewage collection	12	5	**8.5**
Sewage treatment	9	5	**6.7**
Sludge (treatment & disposal)	9	4	**6.2**

Source: PwC analysis

3.14 The ratings from our granular business risk analysis allow us to rank the different segments of the value chain in two ways. These are set out in the table below and include:

i) Our main "granular" risk rating (the "average score of most significant risks")

ii) The number of risks with a risk score greater than four (">4")

Figure 3: Value chain rankings – granular business risk approach

Rank	Main "granular" risk rating	No. of risks with score >4
1	Sewage collection	Treated water distribution
2	Treated water distribution	Sewage collection
3	Sewage treatment	Sewage treatment
4	**Water Resources**	**Water Resources**
5	**Sludge**	**Sludge**
6	Raw water distribution	Water treatment
7	Water treatment	Raw water distribution

Source: PwC analysis

3.15 Our granular business risk analysis shows that there is risk in every segment of the value chain. The nature of risk differs, where some segments of the value chain have more frequent lower impact risks and other segments have less frequent but high impact risks. The two measures of risk shown in Figure 3 above result in a broadly similar output, with both water resources and sludge positioned in the middle of the value chain in terms of risk ranking.

Out-turn risk approach

3.16 While the granular risk approach set out above considers operational / event risks across the value chain, the out-turn risk approach ("out-turn" approach) assesses how risk has impacted company historical financial performance. The out-turn risk approach is based on analysis of the volatility in company cost and revenue financial data. Given that investors currently invest in water companies on an aggregate level, i.e. they do not invest in individual segments of the value chain, we first consider risk at the company level. We then analyse total risk from an out-turn risk approach for each segment of the value chain.

3.17 Currently, there are some risks that are company level risk exposures. For these risks, it is more difficult to infer the differing level of exposure across the value chain. This includes (1) revenue risk; and (2) financing risk. We address revenue and financing risk in more detail below.

3.18 Another company level risk, bad debt risk, is closely related to revenue risk. However, this risk typically resides in the retail segment of the business, and because our report is not focused on the retail segment of the value chain, we do not assess bad debt risk.

3.19 This approach benefits from a more direct quantification approach that draws directly on historic data from company financial accounts and company data provided by Ofwat. However, due to changes in accounting separation and regulatory accounting guidelines over time, this data is not always available on a consistent basis. Furthermore, the data that is used assumes that companies have employed broadly similar cost allocation and reporting methodologies, which may not necessarily be the case (See *Appendix J* for more detail on accounting separation and accounting guidelines).

Risk identification

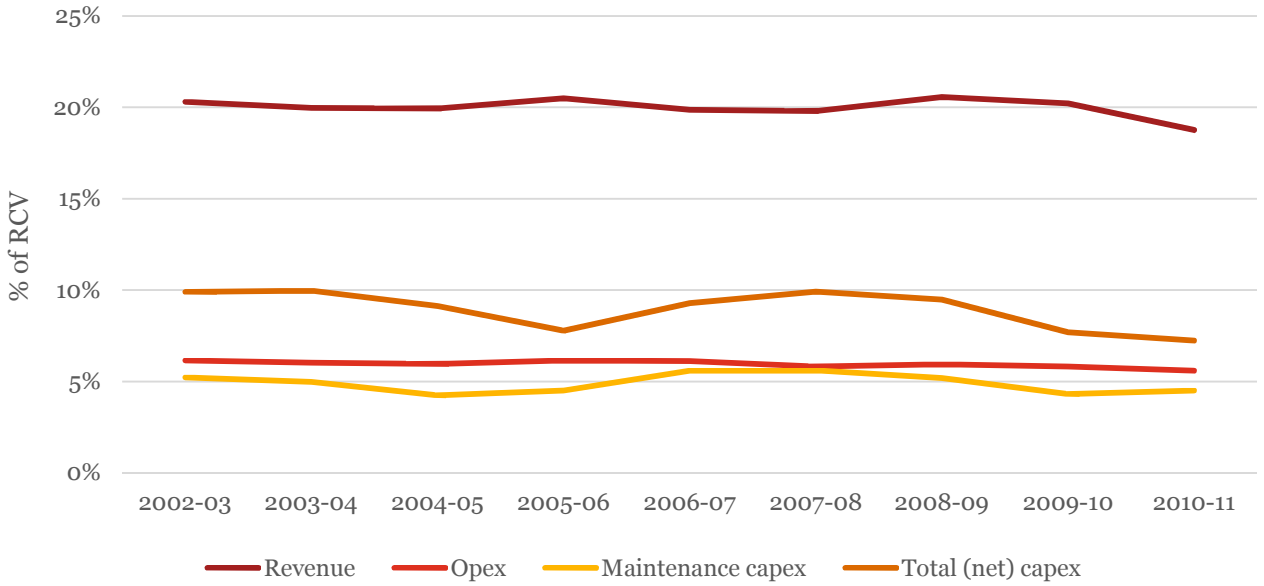
3.20 Water company returns are driven by the level and volatility of revenues and expenditures. Regulatory accounting data and company data submissions to Ofwat allow for the disaggregation of expenditures into a number of categories, which allows for a more detailed analysis of costs.

3.21 We review risk across the following areas:

- Revenue risk
- Operating expenditure ("opex") risk
- Capital expenditure ("capex") risk
- Financing risk
- Regulatory risk

3.22 The industry wide magnitude of these areas, as a percentage of RCV, is set out in the figure below. Financing risk is different in nature than the other risks identified (see discussion in paragraphs 3.44 to 3.46) and is therefore not included in this figure. The figure illustrates that revenue has the largest magnitude, followed by total (net) capex and opex.

Figure 4: Magnitude of industry revenue and cost data



Source: PwC analysis

3.23 In order to analyse revenue, opex and capex risks, we follow the steps below:

i) Analyse the risk (volatility) in the relevant metric. This is based on annual company data provided by Ofwat and sourced from regulatory accounts

ii) Overlay relevant regulatory mitigation tools to assess the net risk exposure. Risk mitigation, particularly regulatory mitigation tools, are generally applied at the company or wholesale (i.e. water and sewerage) level.

iii) Rank the value chain elements according to their level of risk.

3.24 We consider financing risk using a different approach to that described above. This is discussed in detail in paragraphs 3.44 to 3.46. We also consider regulatory / political risk. These are discussed below.

Risk mitigation

3.25 The regulatory risk mitigation tools available to companies are generally applicable across all elements of the value chain. We identify these in the table below as well as company risk mitigation processes that are applied at the level of the entire company.

Table 4: Company and regulatory risk mitigation tools

Risk	Company	Regulatory tools
Revenue risk	-	RPI indexation Revenue control (with wholesale revenue forecasting incentive mechanism (WRFIM) – 2015/16 onwards Interim determination of K (IDoK)
Operating expenditure (opex) risk	Use of contracts can transfer risk to suppliers. Uncertainty around some operating costs (e.g. power costs) can be can be hedged through the use of derivative instruments (forwards and futures contracts)	RPI indexation Totex cost sharing menus Uncertainty mechanisms (e.g. business rates)
Capital expenditure (capex) risk	Risk based maintenance Mains replacement	RPI indexation Totex cost sharing menus – 2015/16 onwards
Financing risk	Uncertainty around debt financing costs can be hedged through the use of derivative instruments (interest rate swaps, forward and futures contracts)	Allowed revenue remunerates efficiently incurred debt financing costs (assessed every 5 years) IDoK Substantial effect determinations
Regulatory / political risk	Companies can seek to influence regulatory or political change via regulatory consultation processes and engagement with relevant political stakeholders.	Ofwat aims to provide sufficient regulatory "forward guidance" on potential changes to the regulatory framework Consultation process with industry and relevant stakeholders on planned changes

Source: PwC summary from Ofwat documents

3.26 All analysis of cost and revenue risks is based on real (2014-15) prices to reflect risk mitigation via the indexation of prices and RCV to RPI. Due to this, volatility will reflect actual variations that companies are not protected for. In addition, given that our out-turn risk approach is based on out-turn company data, these data should reflect mitigated risks, except for true-up mechanisms which are typically applied in the next periodic control.

3.27 Greater detail on the primary risk mitigation mechanisms is provided in the context of these risks in the sections below.

Revenue risk

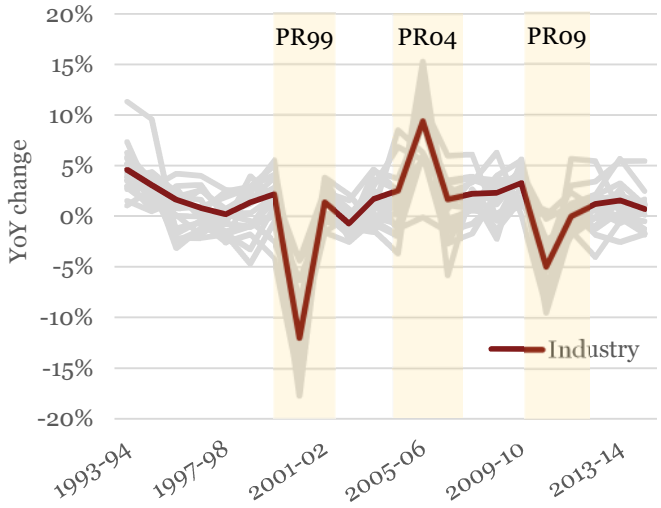
3.28 Revenue (demand) risk in the water and sewerage sector is low.[18] As shown in Figure 5 below, revenue data is only available at the appointee level and is relatively stable except for certain peaks and troughs, which typically occur immediately following a periodic price control. These peaks and troughs occur following Ofwat's price controls because allowed revenues are "reset" during this period to ensure revenues for the next five year control period are cost reflective. As a result, the revenue change in the first year of a new price control will generally be larger than the more predictable revenue charges during the price control.

3.29 Any revenue risk that does exist will be shared by all segments of the value chain. There may be some exceptions to this; for example, the revenue / demand for by-products from the sludge treatment process (gas, fertiliser) may have different variability compared to revenues for the core water and sewerage operations of the sector.

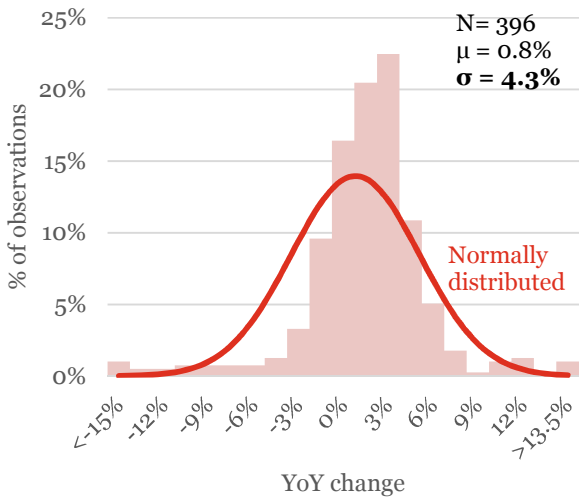
[18] Also see PwC (August 2014) *Company specific adjustments to the WACC*, page 28.

Figure 5: Company, revenue year-on-year change, 2014-15 prices

YoY changes: time-series, 1993-94 to 2014-15



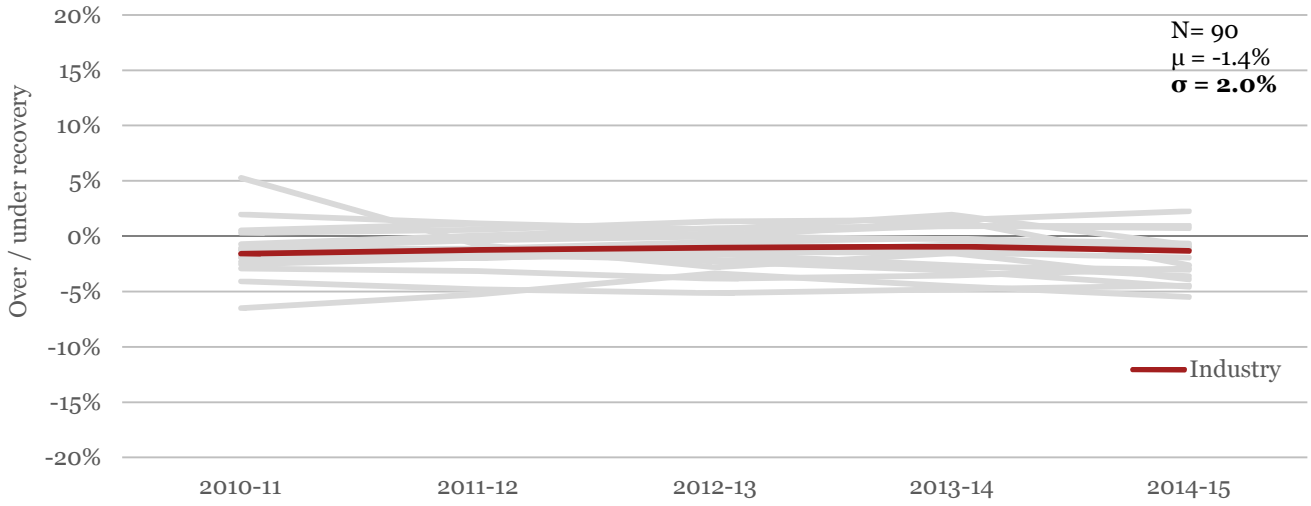
YoY changes: Actual distribution and normally distributed, 1993-94 to 2014-15



Source: PwC analysis, Ofwat

3.30 The year-on-year (YoY) changes in the figures above will reflect unexpected and expected variation in company revenues. In terms of analysing risk, only unexpected variation is strictly relevant, as expected variations will reflect company planning over the price control periods and are known in advance. At the company level, we review the difference between forecast and actual revenues, as measured by revenue over / under recovery as a proportion of turnover. This shows significantly less variation than the observed YoY changes, with a standard deviation of less than half of that contained in the YoY results.

Figure 6: Company, revenue over / under recovery as % of turnover, 2010-11 to 2014-15



Source: PwC analysis, Ofwat

3.31 Water companies also benefit from a range of regulatory mitigation tools that Ofwat has put in place. For revenue risks, these mitigation tools came in the form of a revenue control with the revenue correction mechanism (RCM) prior to PR14, and now with the wholesale revenue forecast incentive mechanism (WRFIM). Under the RCM, over / under recovery of revenue was adjusted at the end of the price control period and revenues in the following period were adjusted to account for this over / under recovery. For PR14, the WRFIM has introduced two main changes to the RCM:

i) An incentive structure has been added so that a penalty rate will apply to variations from forecast revenues that are in excess of 2% of the forecast revenue in each year.[19]

ii) Adjustments to account for over / under recovery of revenue can occur in-period (i.e. during the price control period in which the over / under recovery occurs) rather than being reconciled through a "true-up" mechanism at the end of the period.

3.32 The use of revenue controls reduces the revenue risk to which companies are exposed. Given that company revenues are adjusted to account for over / under recovery, the residual risk to companies is essentially the penalty component of the WRFIM. To illustrate this, we have set out a simplified example to show the likely magnitude of actual revenue at risk under the WRFIM.[20]

Table 5: Impact of WRFIM if applied to revenue over/under recovery from 2010-11 to 2014-15

Risk	2010-11	2011-12	2012-13	2013-14	2014-15
Industry total over/under recovery of revenue (£m)	**-160.9**	**-131.2**	**-114.4**	**-105.1**	**-156.4**
Industry turnover (£m)	10,079.76	10,560.62	11,023.75	11,516.57	11,826.98
Industry penalty (£m)	2.75	1.23	1.56	2.61	4.76
Industry penalty (% of turnover)	**0.03%**	**0.01%**	**0.01%**	**0.02%**	**0.04%**
Industry penalty (% of regulatory equity)	**0.01%**	**0.00%**	**0.01%**	**0.01%**	**0.02%**

Source: PwC analysis, Ofwat data

Note: We have assumed a penalty rate of 3% that is applied to revenue over/under recoveries in excess of 2% of forecast revenue. In practice, there is a linear increase in the penalty rate for over / under recovery between 2% and 3%, with the full 3% penalty rate only being applied to over / under recoveries in excess of 3%. The penalty is calculated on an individual company basis and then aggregated to an industry level.

3.33 The table above indicates that on a post-mitigation basis the revenue risk currently faced by companies is virtually immaterial. In addition, if companies experience variances between allowed and reported revenue, they can seek a waiver from WRFIM penalties if sufficient and acceptable evidence and representations are provided to explain this variance. Due to this, and the fact that any small residual revenue risk that does exist will be distributed uniformly across the value chain, revenue risk does not appear to pose a significant exposure for water companies or the constituent parts of the value chain.

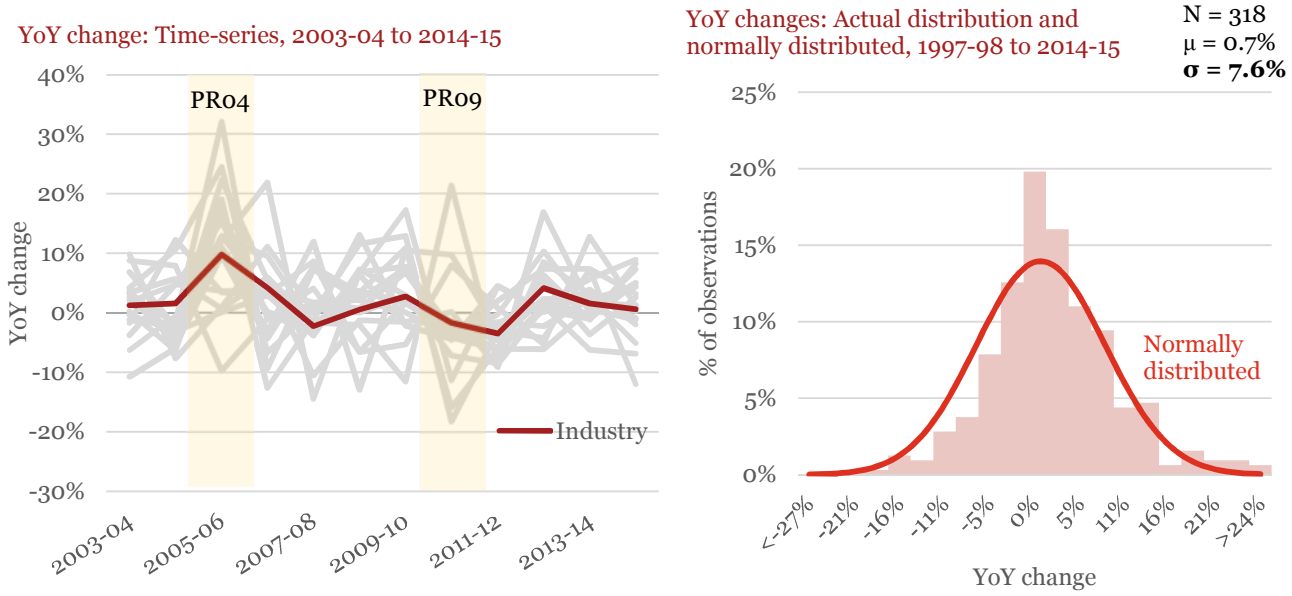
Operating expenditure (opex)

3.34 Opex is one of the main areas of company risk. Opex volatility will affect company profits directly. For the purposes of our analysis, we use opex excluding third-party services and capital charges. Total opex volatility (year-on-year changes) is shown in the figure below and is clearly more variable than year-on-year changes in revenue, both in the level of change as well as the difference across companies.

[19] See April 2014 Ofwat consultation (http://webarchive.nationalarchives.gov.uk/20150624091829/http://ofwat.gov.uk/pricereview/pr14/pr14publications/pap_con20140430rfim.pdf?download=Download#) p.4, and Ofwat's reconciliation rulebook for further details on the WRFIM (http://www.ofwat.gov.uk/wp-content/uploads/2015/10/pap_tec201507pr14reconrule.pdf).), page 46-59.

[20] We ignore inflation and financing cost impacts for the purposes of this illustrative example. Assuming that the company is efficiently financed, then the difference in real terms should be neutral.

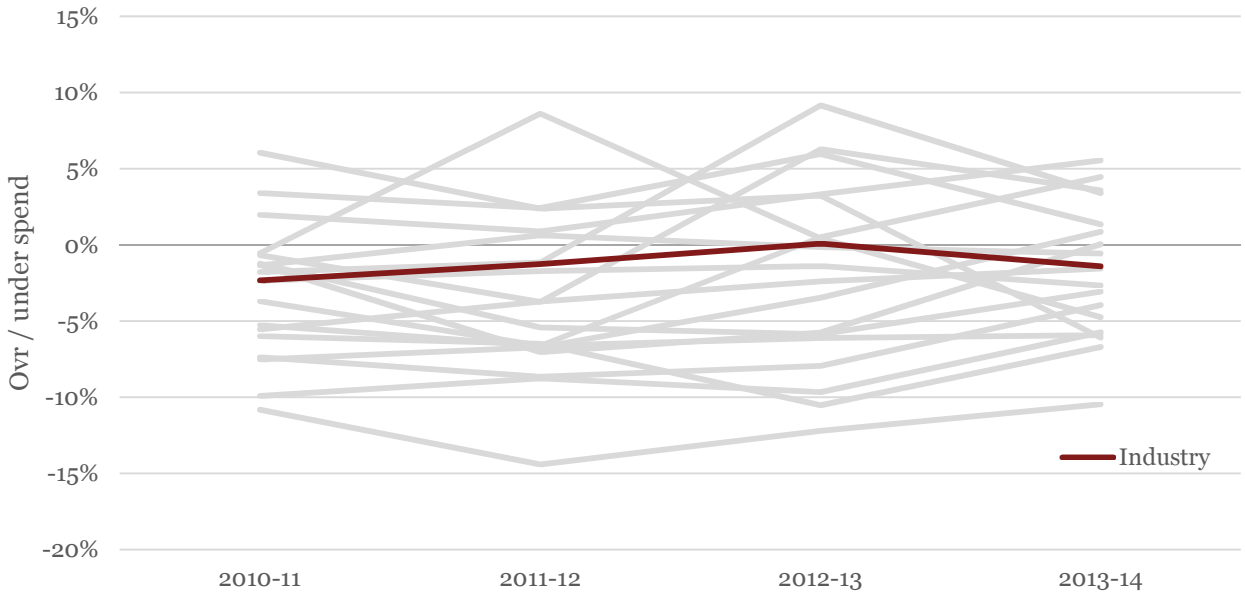
Figure 7: Company, total operating expenditure year-on-year change, 2014-15 prices



Source: PwC analysis, Ofwat

3.35 As with revenue risk, year-on-year changes in the figure above will reflect unexpected and expected variation in company opex. At the company level, we can compare the forecast v. actual opex for a limited period of time for which data is available. The figure below shows that the cost variation from forecast is significantly greater, ranging from -12.0% to 7.3% on average per year, compared to revenue variation from forecast, which ranges from -5.4% to 2.4% on average per year.

Figure 8: Company, opex over / underspend as % of baseline opex



Source: PwC analysis, Ofwat

3.36 Water companies benefit from a number of risk mitigation mechanisms relating to cost risks. For PR14, Ofwat has introduced cost performance menus, also referred to as total expenditure ("totex") menus, which seek to incentivise accurate forecasting of costs as well as provide company and customer protection for costs which vary from forecast. Specifically, a proportion of efficiently incurred cost over / underspend will be shared between the company and its customers. During its engagement with

companies during PR14, Ofwat assumed a cost sharing rate of 50%, i.e. cost over / under spend would be shared between the company and customers at a ratio of 50:50.[21]

3.37 Unlike the WRFIM, the totex menus leave companies with significant residual exposure to cost risk. This is set out in an illustrative example in below. As with the WRFIM example, this is a retrospective analysis that considers how the PR14 totex menus would have been applied to company cost over / under spend between 2010-11 and 2014-15.[22]

Table 6: Impact of totex menus applied to opex over/under spend from 2010-11 to 2014-15

	2010-11	2011-12	2012-13	2013-14	2014-15
Industry total opex over/under spend (£m)	-100.9	-55.0	3.8	-62.1	-44.6
Cost sharing rate	50%	50%	50%	50%	50%
Mitigated over/under spend (£m)	-50.46	-27.50	1.89	-31.05	-22.31
Unmitigated over/under spend (£m)	-50.46	-27.50	1.89	-31.05	-22.31
Unmitigated opex over/under spend (% of regulatory equity)	**-0.22%**	**-0.11%**	**0.01%**	**-0.11%**	**-0.08%**

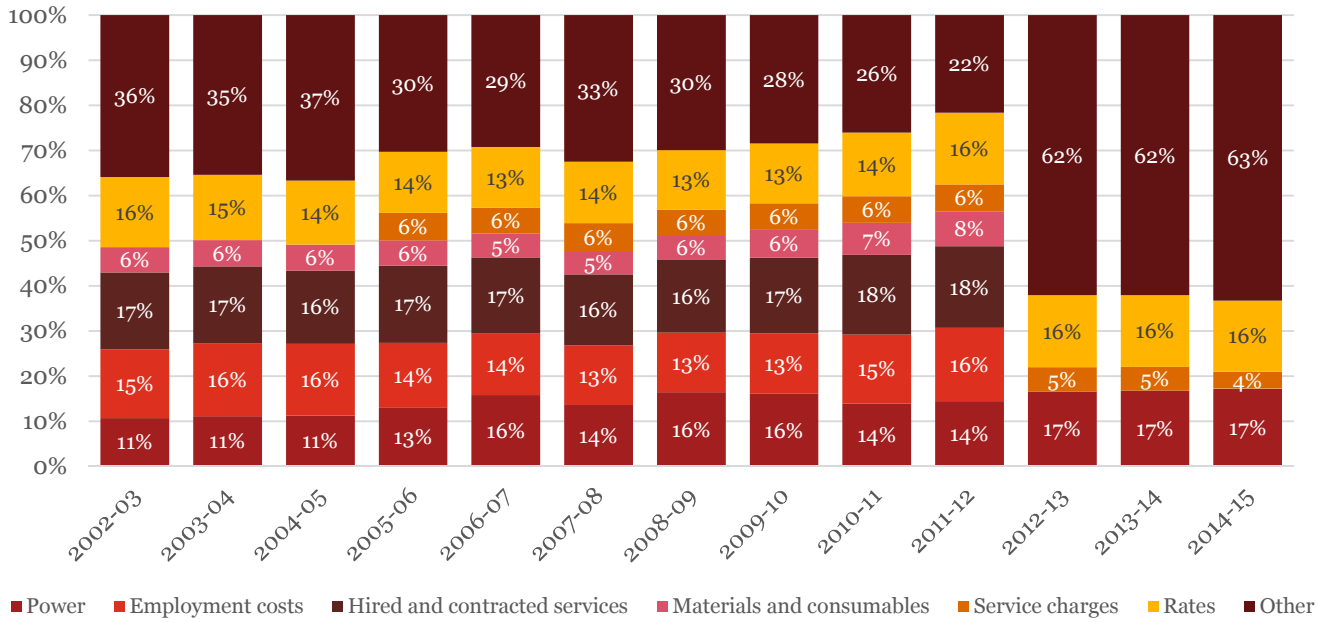
Source: PwC analysis, Ofwat data

3.38 Due to the more significant risk exposure, further analysis of company opex is worthwhile. Water company opex is made up of a variety of cost categories, which are shown in the figure below. After 2011-12, the regulatory accounting methodology used by water companies changed, resulting in a less disaggregated breakdown of opex cost lines, hence the fewer cost categories between 2012-13 and 2014-15 (further detail of the implications of these changes for this analysis is set out in *Appendix J*).

[21] In practice, this ratio will vary based on a company's baseline allowed expenditure, their menu "choice" and their actual outturn expenditure. In order to infer the potential risk mitigation effect of cost performance menus, we assume a cost sharing ratio of 50:50, consistent with Ofwat's PR14 assumption.

[22] This example is designed to illustrate the magnitude of risk exposure after risk mitigation mechanisms have been applied. In practice, the form of menu regulation may influence company cost decisions and therefore actual over / under spend could vary.

Figure 9: Company (ex. retail): Breakdown of total opex, 2002-03 to 2014-15

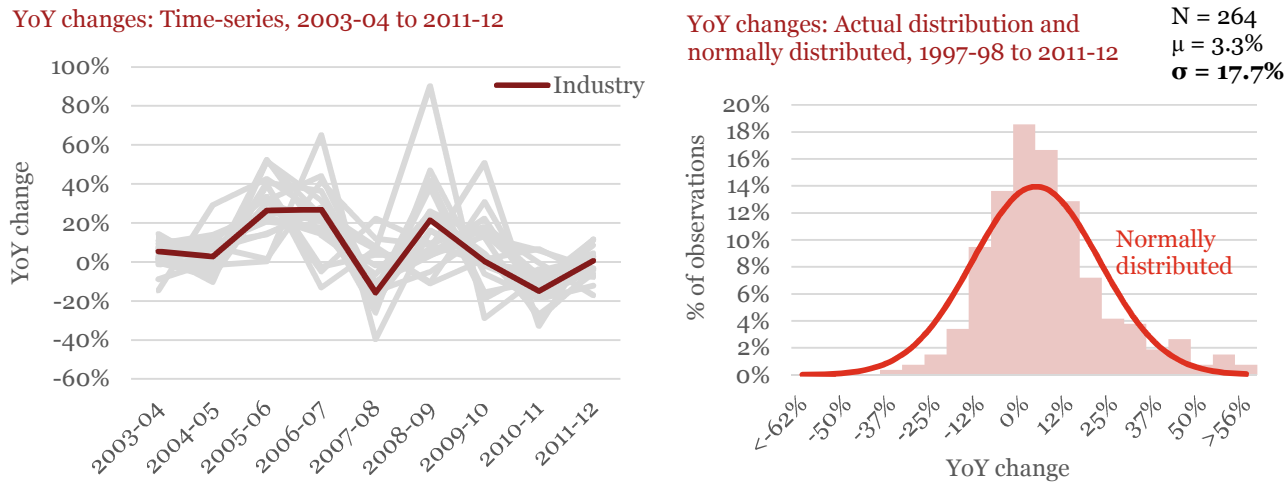


Source: PwC analysis, Ofwat

3.39 For the purposes of our analysis, we focus on three categories of opex to provide a more refined understanding of cost variability. These three categories are:

i) ***Power***: Between 2002-03 and 2014-15, power costs constituted 11% to 17% of industry opex.

Figure 10: Company, power costs year-on-year change, 2014-15 prices



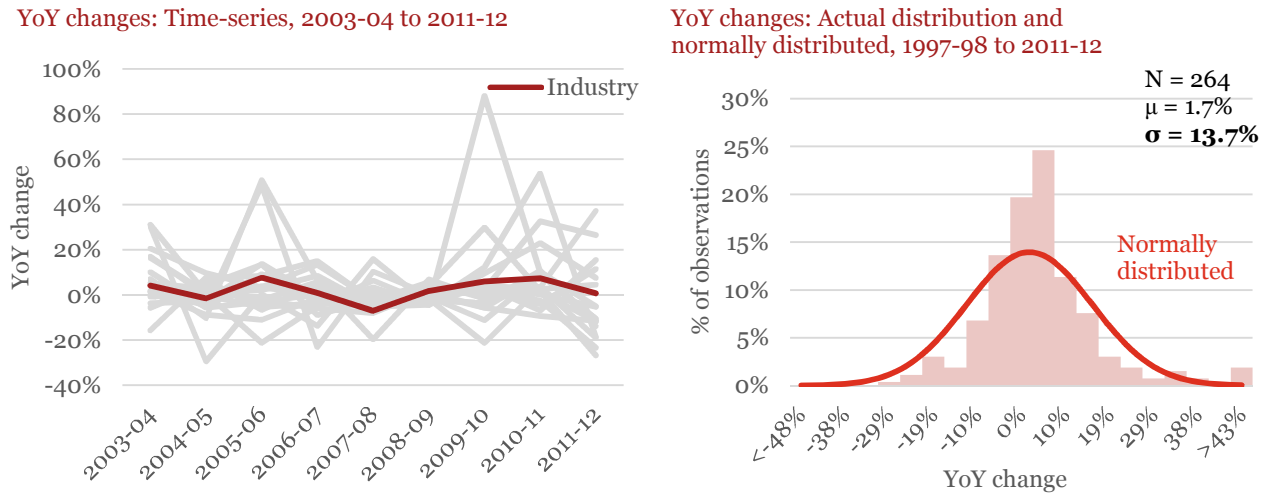
Source: PwC analysis, Ofwat

ii) ***Labour costs:*** We have included two separate cost lines as part of labour costs. These are "employment costs" and "hired and contracted services" costs.[23] Based on the cost item descriptions in Ofwat's regulatory accounting guidelines (RAGs), "hired and contracted services" consistent primarily of external, i.e. contracted, labour costs and therefore should be influenced by

[23] Detailed descriptions of these cost lines are set out in *Appendix J*.

similar economic forces as employment costs. Between 2002-03 and 2011-12 this constituted 29% to 32% of industry opex.[24]

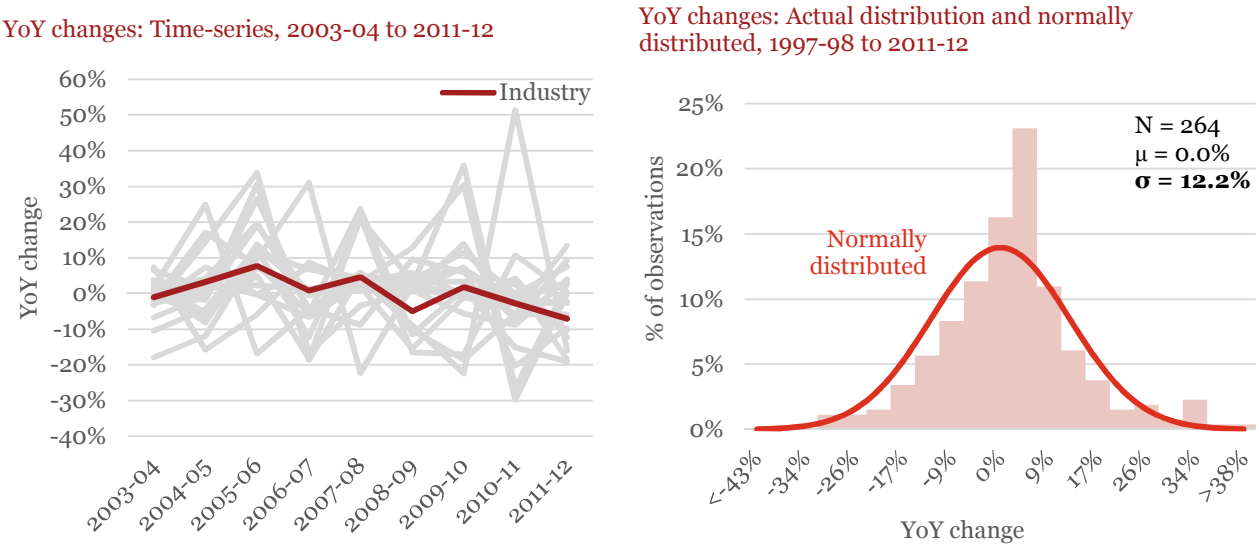
Figure 11: Company, labour costs year-on-year change, 2014-15 prices



Source: PwC analysis, Ofwat

iii) ***Other opex:*** This includes a range of cost types. The most significant costs in this category include (i) business rates, i.e. local authority rates; (ii) general and support expenditure such as general administrative, legal and maintenance costs; and (iii) materials and consumables including equipment (such as small tools and clothing), provisions, tarmac and backfill materials. Other costs have historically constituted approximately 55% of industry opex.

Figure 12: Company, "other" operating expenditure year-on-year change, 2014-15 prices



Source: PwC analysis, Ofwat

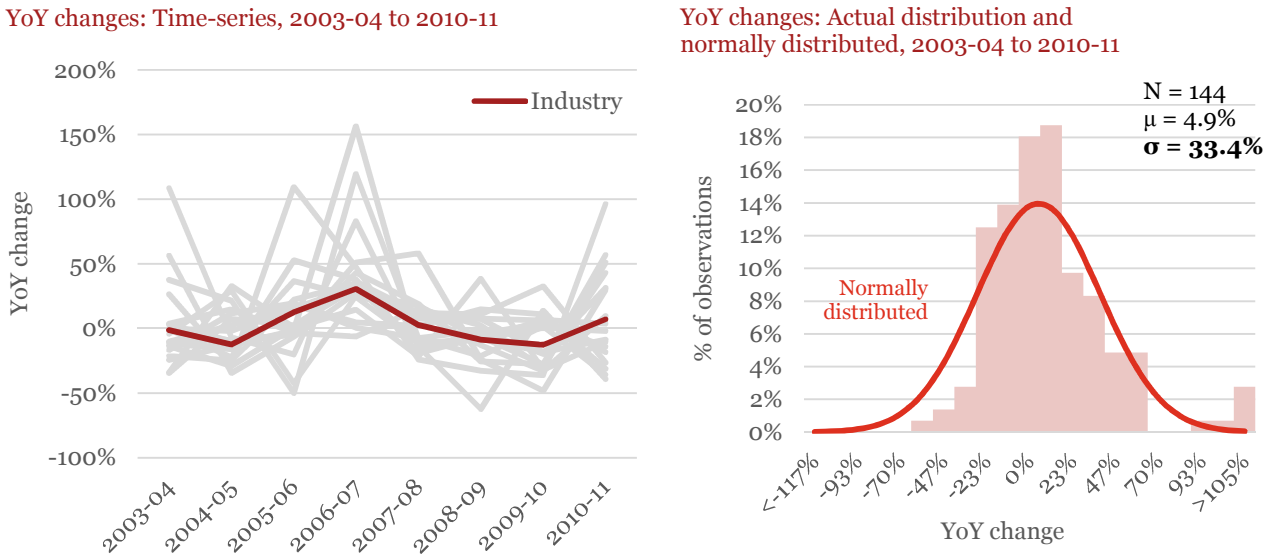
[24] After 2011-12, regulatory accounting guidelines changed and "employment costs" and "hired and contracted services" were no longer recorded as separate cost line items in company regulatory accounts. See *Appendix J* for more detail on the impacts of changes in regulatory accounting guidelines.

3.40 Of the three categories, power costs have the greatest variability and more so than labour costs. Other costs are likely to include some sub-categories with different variations, but as a broad category it has similar variation to labour costs.

Capital expenditure (capex)

3.41 We have reviewed movements in net capital expenditure. However, capital costs by their very nature are more variable and impacted by the planned timing of large-scale capital expenditure projects.[25] Due to this, we consider capital maintenance costs, which will be more to likely reflect unplanned variation in capex. Specifically, we look at the volatility in infrastructure renewals expenditure (IRE) and maintenance non-infrastructure (MNI) expenditure.

Figure 13: Company, capital maintenance costs, year-on-year change, 2014-15 prices

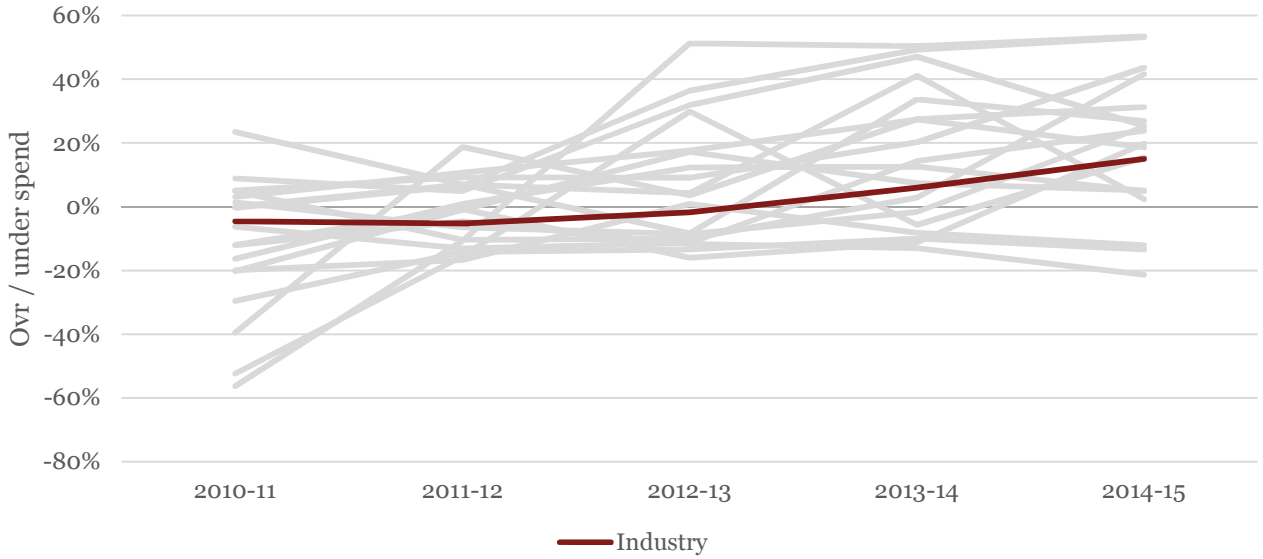


Source: PwC analysis, Ofwat

3.42 As with opex risk, year-on-year changes in the figures above will reflect unexpected and expected variation in company maintenance capex. At the company level, we can compare the forecast and actual capex (maintenance and enhancement) for a limited period of time where data is available. The figure below shows that the cost variation from forecast is significantly greater than both opex and revenue variation from forecast. This indicates that capital expenditure may pose a more significant risk than other risk factors.

[25] We have also considered five-year changes in net capital expenditure, i.e. changes in capex between asset management periods (AMPs). Naturally, this results in less variation in the dataset as year-on-year differences in capital expenditure are smoothed out over the control period. Based on five-yearly approach, the standard deviation of changes in net capital expenditure between AMPs at the wholesale company level is 20.4%. This is slightly lower than the standard deviation of year-on-year changes in maintenance capex (33.4%). For our primary out-turn analysis, we use the year-on-year changes in maintenance capex for the reasons mentioned in paragraph 3.41 and to maintain consistency with the assessment of other cost risk.

Figure 14: Company, capex (maintenance and enhancement) over / underspend as % of baseline



Source: PwC analysis, Ofwat

3.43 Similar to operating expenditure, any variation in capital expenditure from forecast expenditure will be mitigated through the new totex menus. Any efficiently incurred capex over / underspend will be shared between customers and the company at the same ratio (50:50) that opex over/ underspend is shared, thereby reducing the impact of capex volatility on companies by approximately half.

Financing risk

3.44 Financing risk stems from the uncertainty around the availability and cost of financing, both debt and equity. As equity earns the residual profits from the business after all other costs, financing risk is typically focussed on debt finance availability and cost and how this impacts equity returns. In regulatory terms, debt is normally categorised as embedded or new debt, where embedded debt costs are essentially fixed and therefore relatively low risk, i.e. they can be forecast with a high degree of accuracy. In contrast, the cost of new debt financing poses a risk to companies because the cost at which this debt can be raised is unknown prior to financing.

3.45 Financing risk is different from other business and operational risks we have identified above. Financing risk is driven by the amount of capital required across the water value chain and then specific financing decisions which can raise or lower exposure to financing risk. For example, higher gearing, lower embedded debt, and shorter-term debt can all raise financing risk.

3.46 For this *Balance of risk* study we are interested in the "inherent" risk across different parts of the water value chain and not the additional risk introduced through debt financing decisions, and which then impacts equity returns. The potential risk to company level equity returns is covered in further detail in *Appendix E.*

Regulatory / political risk

3.47 The water and sewerage sector in England and Wales is subject to the overview of multiple regulatory bodies including Ofwat, the Drinking Water Inspectorate (DWI), and the Environment Agency (EA) as well as UK and EU legislation.[26] For the purposes of this discussion of regulatory risk we primarily

[26] For example, the European Water Framework Directive, which requires the removal of controlled and dangerous substances from wastewater discharges, has potentially significant operating cost implications. Additionally, there is a risk that this legislation could result in the need for new treatment facilities and current treatment technologies becoming stranded.

focus on economic regulation, i.e. Ofwat's remit, as it is the economic regulation of the industry that has the most significant impact on company returns, e.g. through changes to WACC, introduction of competition, and use of incentive structures.

3.48 From an investor perspective, regulatory risk will be viewed in terms of the stability and predictability of the returns that are earned from their investments. In the absence of stability and predictability, investors will require higher returns in order to compensate for a higher level of uncertainty, i.e. risk. Due to this regulatory risk will increase where changes to the industry are either sudden or poorly communicated, or where a significant increase in risk to investment is not offset by corresponding protections by the regulator.

3.49 In the context of a changing market environment and evolving industry, it will also be necessary for water industry economic regulation to change in order to remain effective and fit-for-purpose. Thus it is not change which is an indicator or risk, rather the predictability in overall approach which is more important.

3.50 Beyond the risk around key regulatory determinations, such as price controls, regulatory and political risk ultimately relates to the potential ex post appropriation of sunk investment as the result of regulatory or political intervention. Due to this, any change in economic regulation should be clearly communicated, predictable and well-signposted. This process should also consider the appropriate pace of regulatory change.

3.51 Following the discussion above, regulatory risk will therefore be higher where:

i) there is significant sunk investment; and

ii) where the uncertainty of future regulation is greatest.

3.52 In the context of this study, which is analysing risk to provide evidence for Ofwat's programme of potential regulatory changes in PR19, regulatory risk in relation to point (ii) above, is essentially an endogenous feature. If part of regulatory risk is the uncertainty of future regulation, then it follows that Ofwat considering structural reforms and potential disaggregation of the value chain will increase regulatory risk in those areas that will be most affected by these changes. These risks will be higher for segments of the value chain that also have higher levels of sunk investment and long asset lives.

3.53 However, this study is not seeking to appraise uncertainty from Ofwat's own *Water 2020* reform programme, nor any future reform programmes which may review other parts of the value chain. Rather, decisions on economic regulation should be based on sound economic and commercial fundamentals, related to economic risk factors, rather than in the context of how regulation affects regulatory risk. This means we do not assess the balance of regulatory risk across the water value chain in this study.

Rating risks across the value chain

3.54 In order to assess the balance of risk across the water value chain we calculate an overall risk metric for each segment of the value chain. As a consequence of minimal exposure to revenue risks, this analysis focusses on the cost risks discussed above for each segment of the value chain. Specifically, in this section we calculate a combined cost risk metric that includes power, labour, "other" costs, and capex for each segment of the value chain.

3.55 While we overlay risk mitigation tools at the company level, we do not apply these at the value chain level as this would be inconsistent with the current regulatory framework. In practice, the different segments of the value chain and the different cost types within the value chain will be correlated to varying degrees and therefore variation in one cost type in a particular segment of the value chain may be offset (or enhanced) by cost variations in other parts of the cost structure and/or value chain.

Therefore, applying risk mitigation tools, such as the totex sharing rate, to historic variations may over / understate the actual effect these tools would potentially have.

3.56 A standard statistical measure of risk is the standard deviation, which measures the level of volatility in a dataset. To measure risk in the four cost categories we are analysing (power, labour, "other" costs, and capex) we calculate a standard deviation of the year-on-year changes observed in historical data for each cost type. The individual standard deviations for each cost risk are then combined to account for "portfolio" effects, i.e. offsetting / amplifying impacts caused by the correlations between different cost types. This provides an overall risk score for each segment of the value chain and is calculated as:

$$\sigma_{Total} = \sqrt{\sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_i \sigma_j \rho_{i,j}}$$

Where,

w_i, w_j = the weights for each cost type for costs i to n

σ_i, σ_j, = the standard deviation of historic year-on-year changes for costs i to n

$\rho_{i,j}$ = correlation between costs i and j

3.57 The weights applied to each cost type are calculated as the relevant cost (e.g. power) as a proportion of total cost within the relevant value chain segment.

3.58 Based on the approach described above, the overall risk score for each segment of the value chain (σ_{Total}) will reflect the cost's risk, its weight as a proportion of total cost, and the degree to which its variation is correlated to the variation of other costs. The results of this risk analysis are set out in the table below.

Table 7: Out-turn cost risk matrix

Value chain segment	Power	Labour	Other	Capex[27]	Overall risk score	Rank
Company (wholesale) level	21%	14%	15%	33%	17.5%	
Weighting	*9%*	*19%*	*21%*	*51%*	***100%***	
Water resources	19%	22%	13%	415%	51.5%	1
Weighting	*17%*	*19%*	*52%*	*12%*	***100%***	
Raw water distribution	58%	22%	13%	292%	25.8%	4
Weighting	*18%*	*20%*	*55%*	*8%*	***100%***	
Water treatment	54%	22%	13%	117%	41.0%	2
Weighting	*13%*	*14%*	*39%*	*35%*	***100%***	
Treated water distribution	30%	15%	30%	29%	16.3%	7
Weighting	*9%*	*21%*	*14%*	*56%*	***100%***	
Sewage collection	31%	20%	25%	27%	17.1%	6
Weighting	*5%*	*18%*	*12%*	*65%*	***100%***	
Sewage treatment	22%	24%	22%	40%	19.0%	5
Weighting	*13%*	*15%*	*19%*	*52%*	***100%***	
Sludge (treatment & disposal)	129%	38%	24%	71%	30.5%	3
Weighting	*5%*	*34%*	*26%*	*35%*	***100%***	

Source: PwC analysis

Note: The risk values in the table are standard deviations of year-year changes in each cost type.

3.59 On this measure, both water resources and sludge have higher risk than average for the sector. This is for different reasons. Power and labour costs are particularly volatile in sludge, whereas water resources risk is driven by its capex variability.

Capital intensity

3.60 Capital intensity is not a risk in itself, but can magnify the degree to which each unit of capital is exposed to other risks faced by a business. Therefore, the varying level of capital intensity across the water and sewerage value chain is an important consideration in assessing the balance of risk. In particular, capital intensity can reduce the degree to which each unit of capital is exposed to cost volatility. Capital intensity is, therefore, closely related to the financial concept of operational leverage[28], which links profit volatility to the degree of fixed costs in a company's cost structure.

3.61 Where a business is more capital intensive and has fixed revenue, i.e. through regulatory protections such as periodic revenue controls, a larger portion of this fixed revenue will be made up of remuneration for capital costs rather than operating expenditure (opex). As a result, the profits of a capital intensive business will be less sensitive to opex volatility than a less capital intensive business. A

[27] We have also considered assessing capex volatility on a 5-year basis, i.e. changes in net capex (enhancement and maintenance) between each asset management period (AMP). However, in order to maintain consistency between the other cost risks in our analysis, we use year-on-year changes in maintenance capex as our main measure of capex volatility. The use of 5-year capex volatility results in a slightly different ranking of the value chain segments on a cost risk basis, but the outputs of our primary "value at risk" metric are largely unchanged between the two measures.

[28] For a common corporate finance approach to operating leverage, see, for example, see Damodaran, *Estimating risk parameters,* http://www.stern.nyu.edu/~adamodar/pdfiles/papers/beta.pdf.

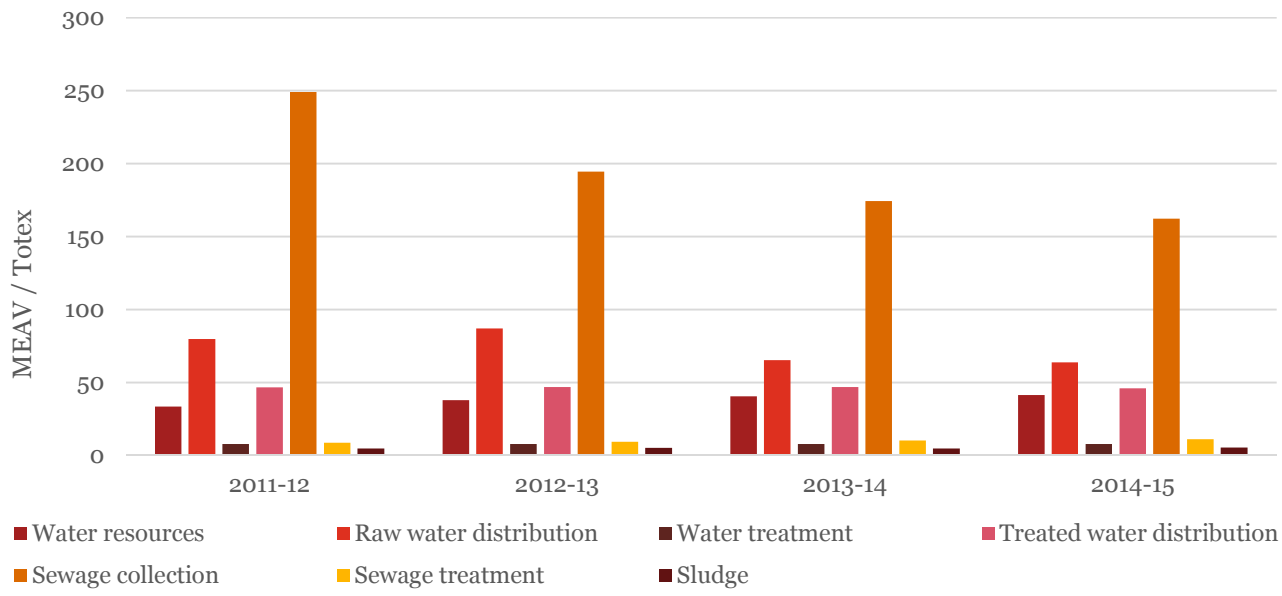
more capital intensive regulated business can, therefore, be characterised as having lower operational leverage. In this context, capital intensity and operational leverage can be viewed as "two sides of the same coin", where a highly capital intensive business can be said to have low operational leverage and vice versa. This relationship is relevant to our discussion of operational leverage later in paragraphs 4.61 to 4.69.

3.62 In addition, as discussed in paragraph 3.45 above, capital intensity also impacts the degree to which a business can bear financing risk. In particular, the more capital intensive a business is, i.e. one with a large capital base and high levels of capex, the more it will be able to bear financing risk. In practice, the effect of this relationship will be borne out in the degree of financial leverage (gearing) a business can maintain. Our view on the likely directional differences in gearing levels across the value chain are set out in Table 15.

3.63 To determine the varying levels of capital intensity across the value chain, we consider two measures of capital intensity.

3.64 The first measure calculates a ratio of the modern equivalent asset value (MEAV) to total expenditure ("totex")[29] on an annual basis.

Figure 15: Capital intensity – MEAV to totex ratios, 2011-12 to 2014-15



Source: PwC analysis, Company data

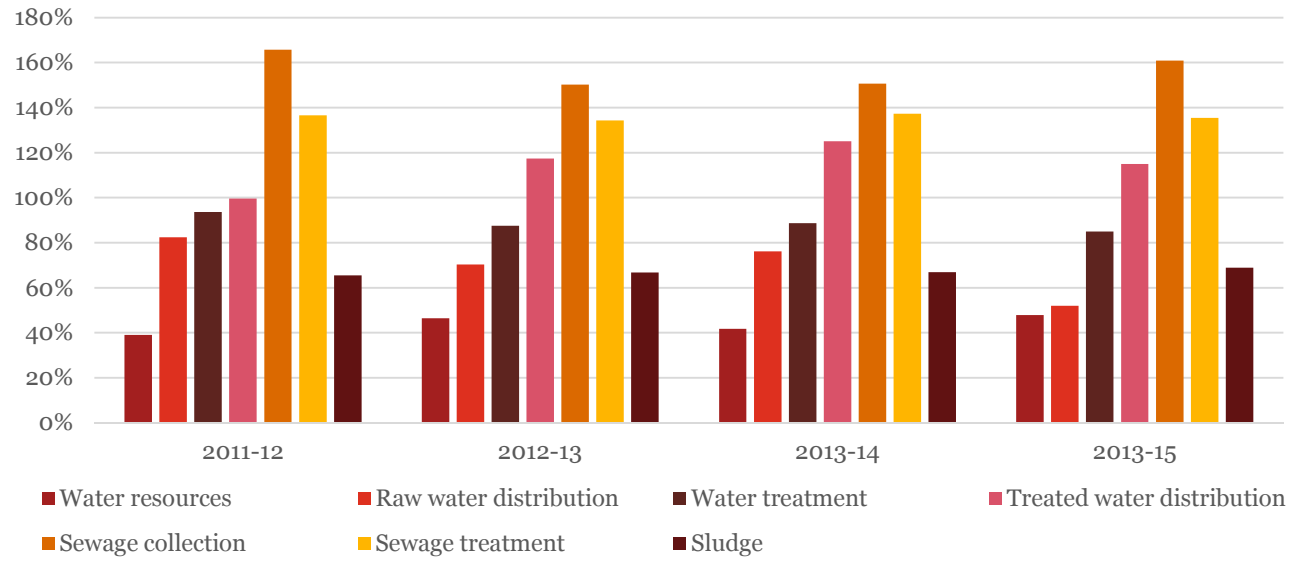
3.65 The figure above show that there is significant variation in the level of capital intensity across the value chain. Sewage collection is the most capital intensive segment with an average MEAV-to-totex ratio of 195x compared to sludge, the least capital intensive segment, which has an average MEAV-to-totex ratio of 5x.

3.66 A second measure of capital intensity considers the annual capital costs recorded in company income statements (i.e. depreciation charges) as a proportion of operating expenditure. This is shown in the figure below and shows broadly similar results. However, because this second approach uses regulatory accounting depreciation charges – current cost depreciation (CCD) and infrastructure renewals charge

[29] Totex is calculated as operating expenditure plus net capital expenditure for each segment of the value chain.

(IRC) –rather than total capex, this measure of capital intensity also reflects differing average asset lives across the value chain.[30]

Figure 16: Operational leverage – Depreciation:opex ratios, 2011-12 to 2013-14



Source: PwC analysis, Company data

3.67 The figure above shows that sewage collection is again the most capital intensive segment of the business, with an average depreciation:opex ratio of 157%. However, on this measure of capital intensity, water resources is the least capital intensive segment of the business with an average depreciation:opex ratio of 44%. We discuss this measure of capital intensity further in our discussion of operational leverage in paragraphs 4.61 to 4.69.

Value at risk and overall value chain risk rankings

3.68 By combining cost variability and capital intensity concepts, we can assess a value at risk measure. These value at risk figures are calculated by calculating an individual value at risk for power, labour, other direct costs, and MNI/IRE (capex) costs. We calculate the value at risk based on an 80% confidence interval of historic year-on-year variation across all companies. The monetary (£m) value is calculated as the percentage confidence interval multiplied by the latest value for the relevant cost category. For example, the 80% confidence interval for water resource power cost volatility is +/- 3.4%. This is multiplied by the latest (2014-15) power costs for water resources (£52.5 million) resulting in a +/- £1.8 million value at risk for water resource power costs. This value is then expressed as a proportion of the MEAV for each segment of the value chain in order to reflect the differing levels of capital intensity across the value chain.

3.69 The table below sets out our "value at risk" rankings, where 1 represents high risk and 7 represents low risk.

[30] For example, the average MEAV:totex ratio for sewage collection is greater than 150%, significantly higher than other segments of the value chain, but on a depreciation:opex ratio basis sewage collection, although higher, is a less obvious outlier. This is because sewage collection assets generally have very long useful lives, so the annual depreciation charges are calculated with reference to a longer time frame.

Table 8: Value at risk rating

Value chain segment	2015 MEAV weighting	Key drivers of risk	**Total value at risk**	**Overall risk ranking**
Water resources	3.6%	Capex	**+/- £ 56.1 m +/- 0.3% of MEAV**	**5**
Raw water distribution	1.5%	Capex, power costs	**+/- £ 31.7 m +/- 0.4% of MEAV**	**3**
Water treatment	1.8%	Capex, power costs,	**+/- £ 78.9 m +/- 0.9% of MEAV**	**2**
Treated water distribution	20.4%	Capex, other costs, labour costs	**+/- £ 63.0 m +/- 0.1% of MEAV**	**6**
Sewage collection	68.4%	Capex, labour costs, other costs	**+/- £ 44.8 m +/- 0.0% of MEAV**	**7**
Sewage treatment	3.7%	Capex, labour costs, other costs, power costs	**+/- £ 71.8 m +/- 0.4% of MEAV**	**4**
Sludge (treatment & disposal)	0.7%	Capex, labour costs, power costs, other costs	**+/- £ 60.9 m +/- 1.7% of MEAV**	**1**

Source: PwC analysis

Notes: Size of value based on the proportion of the 2015 net replacement cost MEAV, where net MEAV is equal to gross infrastructure assets + net non-infrastructure assets

3.70 The figure below illustrates how the cost risk and capital intensity measures combine to result in the overall "value at risk" measure. The cost risk measure gives an indication of the cost volatility across the value chain (as set out in Table 7). However, the cost volatility can, in most instances, be offset by a higher degree of capital intensity, when compared on a per unit of capital basis in the value at risk measure.

Figure 17: Risk rating summary

Rank	Cost risk	Capital intensity*	Value at risk**
1	**Water resources**	**Sludge**	**Sludge**
2	Water treatment	Water treatment	Water treatment
3	**Sludge**	Sewage treatment	Raw water distribution
4	Raw water distribution	**Water resources**	Sewage treatment
5	Sewage treatment	Treated water distribution	**Water resources**
6	Sewage collection	Raw water distribution	Treated water distribution
7	Treated water distribution	Sewage collection	Sewage collection

Source: PwC analysis

* Segments are ranked in terms of capital intensity in ascending order, i.e. the least capital intense segment is rank 1.

** Value at risk ranking is based on the value at risk, i.e. the £ value of cost risk, as a % of MEAV

3.71 In Figure 17, sludge activities are ranked in the middle of the value chain in relation to cost variability, but as a consequence of low capital intensity, the value at risk (per unit of capital) is higher than the rest of the value chain. Sewerage collection is at the other end of the spectrum. It has low cost risk and high capital intensity which means it is the segment with the lowest value at risk. While water resources has higher cost risk compared to the rest of the sector, its capital intensity is around the average for the sector and this brings its value at risk towards the middle ranking within the sector. For water resources this result is driven by the mix of capital intensive water sources (e.g. reservoirs) and operational cost intensive sources (e.g. boreholes). Raw water distribution is ranked in the middle of the value chain in terms of cost volatility and towards the lower end of the value chain in terms of capital intensity. However, on a value at risk measure, it moves up the rankings relative to other parts of the value chain because, in absolute terms, the MEAV is relatively small. As a result, the moderate level of cost risk in raw water distribution combines with a small asset base leads to a value at risk ranking that is slightly higher than the ranking inferred directly from the cost risk and capital intensity columns.

3.72 In this section, we have set out our view on the degree of total risk across the value chain. We have presented both a granular business risk approach as well as an out-turn risk approach. For the purpose of analysing risk from an investor perspective, we consider the "value at risk" measure to be most relevant, as it combines both cost risk and capital intensity. It is expressed as a value based measure and therefore establishes the relative riskiness of capital invested across the value chain. It therefore serves as our primary measure of risk across the value chain.

3.73 In the following section, we consider differences in systematic risk across each segment of the water value chain.

4. Separating systematic and non-systematic risk

4.1 Having identified the total risk exposures at the company and value chain level, we now assess which risks are specific (non-systematic) and which are likely to have systematic elements. Our approach aims to identify differences in systematic risk and, if so, the directional impact that his may have on the asset beta for each segment of the value chain. This is important for assessing differences in the required cost of equity across the water value chain.

4.2 This section of the report is split into three parts

i) We first consider the definition, identification and disaggregation of **systematic risk across the value chain** from a conceptual perspective.

ii) We then carry out a top-down **benchmarking approach** to inform how systematic risk, as measured in the asset beta, may differ across the value chain.

iii) We then consider the **incremental impacts from different drivers of beta** and the directional impacts these may have on different segments of the value chain.

Systematic risk across the value chain

4.3 In this section, we set out the following steps to our analysis. We

i) define what is meant by systematic and non-systematic risk;

ii) set out a framework for identifying systematic risks; and

iii) consider the best approach for reflecting systematic risk in the disaggregated segmental asset betas.

What are systematic and non-systematic risks?

4.4 If an investor holds a diversified portfolio of equity investments, on average those investments which perform poorly due to specific factors will be balanced out by ones which perform above expectations. Therefore, as long as an investor holds a diversified portfolio, the impact of specific risks will be diversified. These risks still matter to equity investors, but such investors do not require a higher return for bearing specific risks. The only remaining risks to which the equity investor is exposed are systematic risks – these affect all investments, albeit to varying degrees, and therefore cannot be "diversified away".

4.5 While systematic (beta) risks are more important for assessing return requirements for equity investments, all risks matter for debt investors. For debt investors, there is no upside potential on the promised yield on their investment. In the event that the company is unsuccessful there is the possibility that the return on debt will be less than promised. If one debt investment fails to pay adequate returns due to specific factors there are no offsetting higher return from other investments. This asymmetrical risk profile means that debt providers require a promised return on their investment to reflect company specific risks.

Identifying systematic risks

4.6 Within a cost of capital framework, systematic risks will be reflected by an investor/valuer in the asset beta used to calculate the cost of equity and non-systematic risk will be reflected in the cost of capital through (i) higher cost of debt; and (ii) lower financial gearing.

4.7 Systematic risks can also be understood using a formal definition of beta risks for a regulated utility as set out in the formula below[31]:

$$\beta_{equity} = f\,(Revenue\ risk\ ,\ operational\ leverage, financial\ leverage,\ bad\ debt)$$

4.8 Each of the *factors* in the equation above are discussed below:

i) *Revenue risk*: A combination of the fixed nature of revenues, via the price review process, and the highly inelastic demand for water and sewerage services means that revenue risk in the sector is minimal. Additionally, a number of regulatory mechanisms (previously the revenue control mechanism (RCM), now the wholesale revenue incentive forecasting mechanism (WRIFM)) provide protection for any residual revenue risk that may exist in the sector. Due to this, we consider the revenue risk in the sector to immaterial.

ii) *Operating leverage*: Operating leverage is not a risk in itself, rather it is a cost structure issue that can magnify risk. As discussed in paragraph 3.61 above,[32] operational leverage can be thought of in two related ways.

- Conventionally, operating leverage is a measure of the proportion of a firm's total costs that are fixed, where fixed costs are those costs that do not vary with the level of output. A higher proportion of fixed costs means that a firm has higher operating leverage and is therefore more exposed to cost / revenue volatility, which will affect the variability of company cash-flows and profits.

- In PR14, some water companies, building on the approach used by the Competition Commission (CC) in its consideration of the referral of Bristol Water's price determination following PR09,[33] also interpreted operating leverage for regulated utilities as the size of potential revenue or cost shocks relative to the capital invested in the business. In this interpretation, if a revenue or cost shock is large relative to invested capital, then the impact on returns will be more significant. In other words, a regulated utility which has a relatively small capital base will have more volatile returns for a given revenue or cost shock when compared to a similar firm with a larger capital base. The validity and applicability of this approach is discussed in further detail in paragraphs 4.61 to 4.74.

Assuming that revenue risk in the sector is relatively small, as discussed above, operational leverage risk for regulated utilities is therefore essentially related to (a) the **cost volatility**; and (b) the **capital intensity** of a business.

iii) *Financial leverage*: Given that our analysis is focused on variations in asset beta, financial leverage (gearing) is not relevant to the discussion of systematic risk here.

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[31] Morin (1994) *Regulatory finance: Utilities cost of capital*, page 78.

[32] Also see our report for PR14, PwC (August 2014) *Company specific adjustments to the WACC*, page 29.

[33] Competition Commission (2010) *Bristol Water plc - A reference under section 12(3)(a) of the Water Industry Act 1991*. A similar approach has also been used in Bristol Water's appeal to Ofwat's price determination for PR14, see CMA (2015) *Bristol Water plc: A reference under section 12(3)(a) of the Water Industry Act 1991*, 6 October 2015.

iv) *Bad debt*: Our analysis focuses on the disaggregation of risk in the wholesale part of the business (the retail part of the business was split out as part of PR14). As bad debt risk sits within the retail part of the business, we do not consider this beta risk in detail.

4.9 Having discussed the fundamental factors that affect beta above, we now discuss potential approaches to beta disaggregation and the applicability of these to the water and sewerage value chain.

Approaches to beta disaggregation

4.10 Conceptually, the constituent betas for each segment of the value chain should reconcile to the overall beta for the wholesale part of the business. Given this, we can express the asset beta for the wholesale part of the business as follows:

$$\beta_{Wholesale} = \omega_{WR}\beta_{WR} + \omega_{RWD}\beta_{RWD} + \omega_{WT}\beta_{WT} + \omega_{TWD}\beta_{TWD} + \omega_{SC}\beta_{SC} + \omega_{ST}\beta_{ST} + \omega_{SL}\beta_{SL}$$

Where,

ω = the weighting applied to each beta

β = the asset beta for each element of the value chain

WR = Water resources; RWD = Raw water distribution; WT = Water treatment; TWD = Treated water distribution; SC = Sewage collection; ST = Sewage treatment; and SL = Sludge

4.11 For PR14, Ofwat determined that an appointee level asset beta of 0.3 was appropriate. If the retail adjustment is taken into account, this implies a wholesale asset beta of 0.28.[34] Therefore, the constituent weights and betas in the formula above should reconcile to an overall beta for βWholesale of 0.28. In order to calculate inputs for the equation above, it is necessary to determine a value for the weights (ω) and the beta (β) for each segment in the value chain.

4.12 For the weights, we use the split of net modern equivalent asset value (MEAV) across the value chain.[35] This data is readily available and is reported by companies in their regulatory accounts. The MEAV is also a suitable proxy for the fundamental value of different parts of the business and therefore is a suitable weighting mechanism to use for the calculation of beta.[36]

4.13 Inferring appropriate estimates for the segmental asset betas is less straightforward. We have identified three regulatory precedents of beta disaggregation across the value chain, which we summarise below. Further details on the quantitative analysis of these examples are provided in *Appendix D*. We then discuss a number of empirical approaches to infer the different beta across the value chain.

Telecoms (Ofcom)

4.14 In January 2005 Ofcom issued a consultation document on risk and the cost of capital, which proposed that the equity beta should be lower for BT's copper access business than for the BT Group as a whole. Given the lack of existing evidence on this approach, Ofcom commissioned PricewaterhouseCoopers LLP, in consultation with Professor Julian Franks of the London Business School, to examine in more detail whether a disaggregation of BT Group's beta was appropriate, and if so, what evidence there was to enable the different beta figures to be calculated.

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[34] For PR14, the beta for water and wastewater was determined to be the same level. The analysis of the wholesale beta is provided in *Appendix K*.

[35] Net MEAV is equal to net non-infrastructure assets, i.e. gross assets less accumulated depreciation, plus gross infrastructure assets.

[36] As with other regulatory accounting data, the accuracy of MEAV data is dependent on the quality and consistency of companies' internal reporting processes.

4.15 In the paper *Disaggregating BT's betas*,[37] indicative quantitative evidence for a lower beta in BT's copper access business is found according the following approaches:

i) Quantitative analysis of the betas of a cross section of telecommunications businesses, which examined how overall group betas varied between telecommunications companies which differed in the proportions of their business. A sample of 56 companies across 29 countries in Europe, Asia-Pacific, the USA and Canada was created and used in the regression analysis.

ii) Quantitative analysis of BT's beta over time, which estimates the implied beta for BT's copper access by examining the statistical evidence for a correlation of historical movements in the group beta with changes in the share of the access business within the overall group.

4.16 The econometric analysis reinforced the evidence that BT's ICT business was likely to have a beta that was higher than that for the group as a whole, and it also suggests that core telecommunications activities, such as copper access, are likely to have a lower beta. However, due to issues regarding the availability and choice of data, further discussed in *Appendix D*, the reliability of the absolute figures was weak and the conclusion of the paper was only directional as a result.

Gas distribution and transmission (Ofgem)

4.17 In the *Gas Distribution Price Control Review, Final Proposal*, Ofgem suggested that '*GDNs are overall no less risky, and may be somewhat more risky, than the transmission companies under their current price controls. This supports the view that the allowed rate of return on equity for GDNs should be no lower, and could be somewhat higher, than the 7.0 per cent rate assumed in TPCR.*' [38]

4.18 In order to reach this conclusion, both a bottom-up and a top down analyses were carried out. In this section we give an overview of the top down analysis, but more details on both approaches are presented in *Appendix D*.

4.19 As far as the top-down analysis is concerned, Oxera, on behalf of Ofgem, performed a cross-sectional analysis based on ordinary least squares (OLS) so that each company's asset beta was determined by the share of its business in network and production activities for gas and electricity. The segment share was measured by one of the three measures: profit, revenues or asset size. Since there are no pure gas distribution or transmission network owners traded within the UK, this study was based on international data. 50 energy firms (38 US and 12 EU) were included in Oxera's final sample. For each firm in this sample the latest financial statements were analysed, and from this analysis, Oxera obtained the proportion of firms' activities attributable to the different business segments of the companies.

4.20 Despite Oxera's conclusion[39] on a relevant difference between gas transmission and distribution, once CEPA[40] ran statistical tests on the models, no significant statistical difference was identified. Moreover, once potentially omitted variables controlling for differences in regulatory regimes were included in the models, the results from Oxera on a relevant difference between the two segments were further weakened.

4.21 In response to the CEPA argument, the GDNs submitted an updated report from Oxera. This report argued that not only did the risk analysis support a higher cost of equity for the gas distribution networks, but that, even if the conclusion was that of no risk differential, then the higher gearing levels used in setting the cost of capital for the gas distribution networks necessitated a higher cost of equity, using fundamental corporate finance theory (Modigliani-Miller). With this argument, Ofgem accepted

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[37] PricewaterhouseCoopers LLP (2005) *Disaggregating BT's betas*.

[38] Ofgem (2007) *Gas Distribution Price Control Review, Final Proposals*.

[39] Oxera (2007) *Is there a risk differential for energy networks?*

[40] CEPA (2007) *Relative risk and the cost of equity*.

Oxera's view and concluded the presence of a risk differential between gas transmission and distribution.

Airports (CC/CAA)

4.22 In the context of recommending to the Civil Aviation Authority (the CAA) the maximum level of airport charges that Heathrow Airport Ltd (HAL) and Gatwick Airport Ltd (GAL) may levy during the period of five years beginning on 1 April 2008, the Competition Commission estimated the equity beta for the whole BAA group,[41] and disaggregated it into Heathrow, Gatwick and other services, in order to capture any relevant differences in the cost of capital.

4.23 In order to set different price limits for Heathrow and Gatwick, the Competition Commission suggested a formula on how to disaggregate the obtained asset beta into the different airports. More details on both how to obtain the asset beta for the whole group and the formula are presented in *Appendix D*. In summary, the formula imposes that the "asset weighted average" of the betas across the different parts of BAA plc group must equal the asset beta for the whole group. This makes intuitive sense, since splitting a certain business into parts for the purpose of the analysis, should not impact the risk of the business as a whole.

4.24 Following this, a qualitative assessments of the different levels of risk to which the two airports were exposed was presented. This concluded that, under the criteria of demand risk, riskiness of airline customers and operational leverage, Gatwick was be riskier than Heathrow. According to the CC, this conclusion justifies the formulation of two simplifying assumptions that make it possible to solve the suggested formula and assign a beta of 0.47 to Heathrow and a beta of 0.52 to Gatwick.

Beta disaggregation for the water value chain

4.25 For the purposes of disaggregating beta across the water and sewerage value chain, we considered the feasibility of running similar cross-sectional analysis to Ofgem and Ofcom. This approach would test whether any difference in betas between different parts of the value chain is statistically significant. While this type of econometric analysis represents a more technical and potentially more robust approach, it relies on sufficient availability and quality of data for relevant comparators. In the case of the water and sewerage value chain, the data was not sufficient to allow for this approach.

4.26 Our potential sample started with 22 companies and was composed of all the public companies involved in water and wastewater activities in Europe and US, with a total revenue higher than £12 m. The reason why we used 12 million as a threshold comes from the fact that Dee Valley, the smallest water company in England and Wales, has annual revenues of approximately £12m. In order to maintain the comparability of the potential dataset used for this analysis, we therefore excluded potential companies with less than £12m. For the same comparability reason, we excluded companies outside Europe and the US. Finally, given the fact that one of our inputs in the regression analysis would be the companies' asset betas, as in the discussed literature precedents, we focused our analysis on publicly listed companies.

4.27 Although 22 is already not an adequate sample size to run a statistically significant regression, we searched for a segmentation in revenues in the financial statements of the companies considered. Eleven companies did not show any segmentation in their revenues. Four companies presented a segmentation between the regulated and non-regulated water and wastewater activities. Two companies presented a geographical segmentation of revenues, and only five companies' financial statements provided a segmentation between water supply and sewerage services, or, more generally,

[41] Competition Commission (2007) *Competition Commission report on Heathrow and Gatwick price controls 2007*, Appendix F.

between water activities and services. No segmentation was thus granulated enough to carry out a statistically significant analysis that would serve our purpose.

4.28 For these reasons, our approach is more similar to that used by the Competition Commission in the Heathrow and Gatwick price review of 2007. In particular we used a similar formula to the one presented in their discussion, imposing that the "asset weighted average" of the betas across the different parts of the water businesses must equal the asset beta for the whole businesses.

4.29 We follow two approaches to assessing systematic risk impacts. These are:

i) A **benchmarking approach** in which we seek to identify direct comparators for different parts of the water and sewerage value chain

ii) Calculation of the **incremental impacts from different drivers of beta** based on analysis of companies with different levels of systematic risk exposures.

Benchmarking approach

4.30 The table below sets out the results from our benchmarking approach for the different segments of the value chain. See *Appendix C* for detailed beta benchmarks. The benchmark data in the table below is based on the most recent available market and regulatory evidence. However, it should be noted that any estimate of beta will contain an element of statistical uncertainty. In addition, given the unique nature of activities undertaken by the different segments of the value chain, the number of suitable mono-line comparators is limited. Despite these limitations, we consider the asset betas in Table 9 to reflect the best evidence available for this exercise.

Table 9: Value chain beta benchmarks

Value chain element	Relevant benchmarks and commentary	Beta
Company level (wholesale)	**Calculated from PR14 wholesale WACC, holding cost of debt constant.**[42]	**0.28**
Water resources	US water companies do not serve as direct comparators due to difference in regulation. However, relative benchmarking shows that the asset beta of a water resource company is **0.02 below** that of water companies.	≈0.26
Raw water distribution	Assumed equal to treated water distribution.	0.2 to 0.33
Water treatment	Water treatment benchmarks in *Appendix C* are primarily companies which are exposed to competition. There is a lack of suitable benchmarks due to the current regulatory protection water treatment receives. In the absence of suitable benchmarks, we assume beta for water treatment is equal to the overall wholesale level.	≈0.28
Treated water distribution	The range of asset beta from the RIIO transmission and distribution determinations is 0.32 to 0.38. We take 0.33 to be an upper bound as energy typically faces more demand risk than water.[43] For National Grid we estimate 5yr monthly betas and 2yr daily betas of 0.25 and 0.38 respectively. To determine a lower bound we subtract 0.05 from the lower of these values to account for lower demand risk in water – the CC/CAA made a similar reduction when adjusting for the difference in demand risk (as well as other factors) between Heathrow and Gatwick. The mid-point formed by this range is 0.265. Openreach provides another network benchmark, the latest Ofcom asset beta assumption was the business was 0.50. But Openreach faces a high-powered regulatory regime and also encounters greater demand risk. Therefore we consider it a less relevant benchmark.	0.2 to 0.33
Sewage collection	See Treated Water Distribution above for our benchmarking of "network" elements of the value chain. Based on the WACC for Thames Tideway we have inferred an asset beta of c. 0.23.	0.2 to 0.33
Sewage treatment	Lower end of competitive benchmarks for sewage treatment beta imply that current beta for sewage treatment (under regulatory protections) is unlikely to be higher than wholesale beta for whole value chain.	≈0.28
Sludge	The average of "sludge plus" and "solid waste plus" comparator groups in *Appendix C* gives an asset beta of 0.43. However, this average is skewed by the asset beta for Daiseki. Synagro is the closest to a pure-play comparator for sludge (no longer floated but old stock data available). The betas estimates for Synagro range from 0.23 to 0.29. We take the lower end of the Synagro range as a lower estimate for a Sludge beta, and take the average across the "sludge plus" and "solid waste plus" groups as an upper estimates (due to the protections current sludge activities receive through being part of a vertically integrated monopoly). The mid-point of the range 0.23 to 0.43 is 0.33.	0.23 to 0.43

Source: PwC analysis, Capital IQ, Datastream, regulatory documents

[42] The calculation of 0.28 is provided in *Appendix K*.

[43] Energy use is marginally more discretionary than water use, i.e. it is more feasible for consumers to reduce energy costs than it is for an essential good such as water. This is reflected in the standard deviation in YoY changes in electricity consumption (TWh) between 1996-97 and 2011-12, which was 2.8%. In comparison, the standard deviation for water consumption (Ml/d) during the same period was slightly lower at 2.0%. Based on data from Ofwat and the Department of Energy and Climate Change (DECC).

Incremental impacts from different drivers of beta

4.31 In addition to the direct benchmarking approach set out above, we also consider the incremental impacts of different drivers of beta. Based on company cost data and broader market evidence we consider whether the following factors are likely to be systematic or non-systematic and have an impact on the beta for the different segments of the value chain:

- Operating expenditure
  - Power costs
  - Employment costs
  - Hired and contracted services
  - Materials and consumables
  - Service charges
  - Rates
- Capital expenditure
- Operating leverage

Labour costs

Other operating expenditure

4.32 The six operating expenditure categories listed above represent approximately 78% of total operating expenditure (see Figure 9 above).[44]

4.33 It should be noted that this analysis seeks to indicate a directional impact on beta. The analysis is restricted, in particular, by the limited availability of segmental data. Due to this, the ability to carry out robust statistical analyses with relevant significance tests is, in general, not currently possible. However, as more disaggregated data becomes available in the future, then more detailed risk analysis may be possible. We have also noted, in *Appendix J* other potential limitations of segmental data provided in company regulatory accounts.

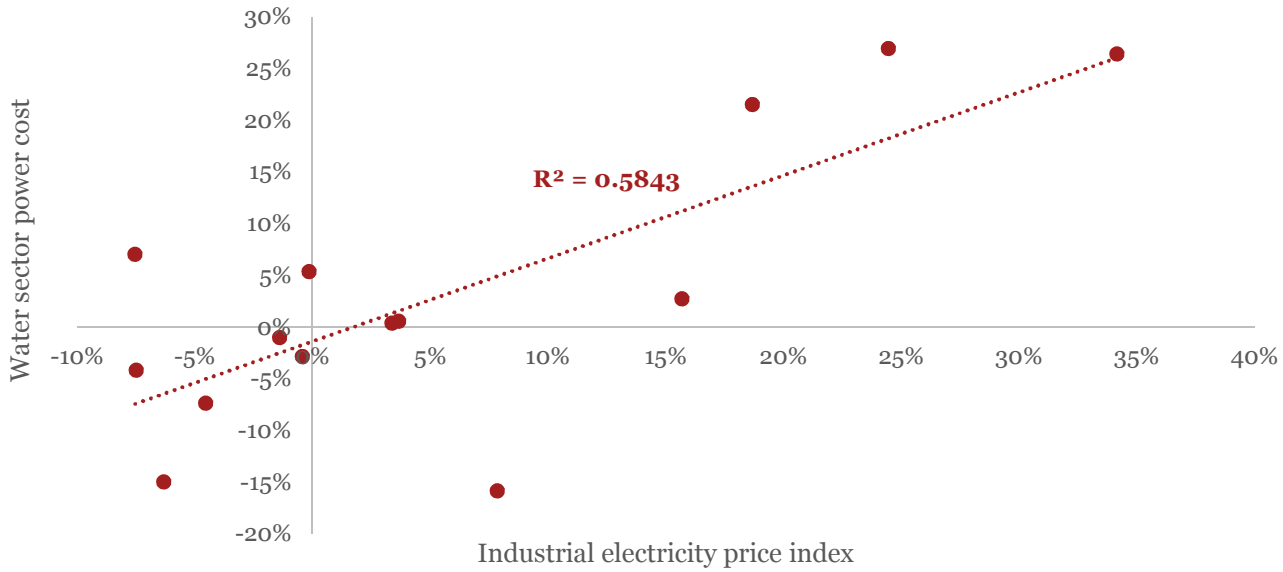
Power costs

4.34 Power costs will represent an input cost, to varying degrees, across all sectors, therefore changes in power prices should be expected to impact upon market-wide returns. On balance, we consider that power costs are most likely negatively correlated with overall market performance. While there will be some companies, e.g. power generators and oil/gas companies, that may benefit from higher power costs, the wider market is likely to be negatively impacted by higher power costs.

4.35 In order to gain some insight to the degree to which water company power costs are systematic, we consider the relationship between the volatility of company power costs and volatility in the UK industrial electricity price index. The scatter plot below shows this relationship for company-level power costs. This relationship provides an r-squared value of 0.58, which suggests that there is a positive relationship between volatility in power costs, at the water company-level, and volatility in power costs in the broader market. Therefore, at least a proportion of company power costs can be considered to contribute to water company systematic risks. However, because the relationship is not perfect there is also likely to be some variation in power costs that relates to company specific factors and could therefore be considered to be non-systematic.

[44] Based on 2011-12 cost data, the remaining 22% of operating expenditure is made up of a range of cost categories including "Associated companies", "Bulk supply imports", "Scientific services" and "Exceptional items" and "Other direct costs". A full breakdown and definition of cost types is set out in *Appendix J*.

Figure 18: Company: Power costs v. industry electricity price index, YoY change, 1997-98 to 2011-12 (ex. 2002-03)

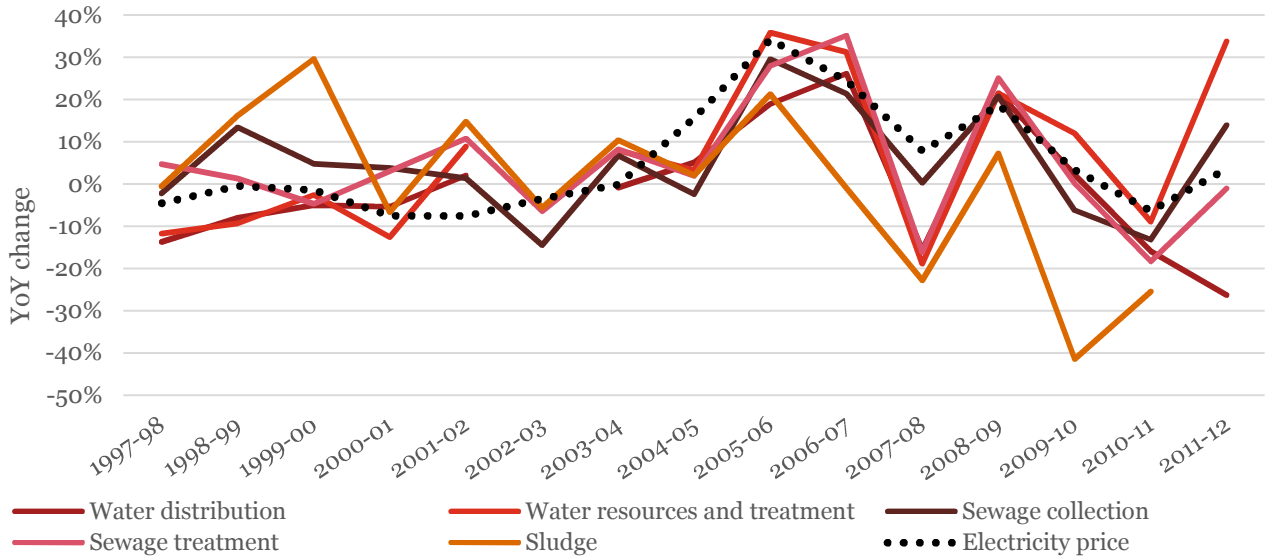


Source: PwC analysis, DECC, Company accounts

* Charts exclude 2002-03 data because South East Water enters dataset in 2002-03

4.36 This analysis can also be carried out at the value chain level to provide insight into which parts of the business are likely to have higher systematic risk. The figure below shows the variation in power costs across the value chain relative to the industrial power cost index. The sludge segments stands out as having higher peaks and lower troughs compared to other segments.

Figure 19: Value chain elements and industrial electricity price index, YoY change, 1997-98 to 2011-12



Source: PwC analysis, DECC, Company accounts

* Charts exclude 2002-03 data because South East Water enters dataset in 2002-03

4.37 In order to inform the direction of a potential beta adjustment for the level of systematic risk exposure to power costs, we look at whether companies that are more power intensive have a higher observed beta compared to companies that are less power intensive.

4.38 A publication by the UK Government sets out the top 20 power intensive sectors in the UK based on information collected by the ONS (see table below). It ranks sectors according the size of their electricity costs as a percentage of gross value added (GVA).

Table 10: Top 20 power intensive sectors in the UK

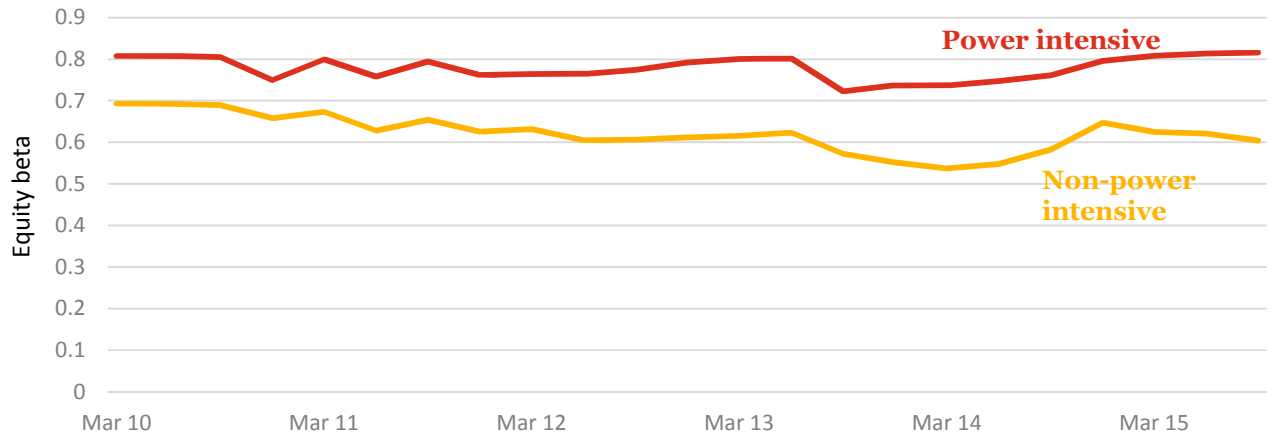
Top 20 power intensive sectors in the UK	
Aluminium	Clays and kaolin
Electric arc steel	Veneer sheets, plywood, fibreboard
Fertilisers and nitrogen compounds	Cement
Paper and paperboard	Hollow glass
Throwing and preparation of silk	Iron and steel
Industrial gases	Copper
Inorganic basic chemicals	Synthetic rubber in primary forms
Non-wovens and articles made from nonwovens	Refineries
Household and sanitary goods	Man-made fibres
Preparation and spinning of worsted-typefibres	Sewing threads

Source: ONS

4.39 Using the sector classification in the table above and sector classifications from S&P Capital IQ, we classify all companies on the FTSE All –Share Index as either power intensive or non-power intensive.[45] We then calculate equity betas for the companies in each group.

4.40 The average equity betas for power intensive and less power intensive companies are presented in the figure below. On average, power intensive companies have an equity beta that is approximately 0.2 higher than less power intensive companies. The listed water companies (Pennon Group plc, Severn Trent plc, United Utilities Group plc) are included in the power intensive group but have a lower average asset beta than that of the group as a whole (see *Appendix G* for a detailed list of the industries included in each comparator group).

Figure 20: Equity beta of power intensive v. power intensive companies



Source: PwC analysis, Capital IQ

[45] S&P Capital IQ is a subscription data service that provides market and company data. The industry classifications used by Capital IQ are slightly different to those referred to in the ONS classifications and therefore requires a mapping exercise between the two classification structures.

4.41 This analysis suggests that those segments of the water and sewerage value chain that have greater exposure to power costs,[46] than the company average, may have a higher asset beta. The indicative directional impacts on asset beta from this analysis are set out in the table below.

Table 11: Directional impact of exposure to power costs on asset beta

Value chain element	Proportion of power cost in cost base	Directional change to value chain beta
Water resources	17%	–
Raw water distribution	18%	↑
Water treatment	13%	↑
Treated water distribution	9%	–
Sewage collection	5%	↓
Sewage treatment	13%	–
Sludge (treatment & disposal)	5%	↑

Source: PwC analysis, Company data

Note: Arrows indicate whether the value is likely higher or lower than the company level figure

Labour costs

4.42 Similar to power costs, we would expect labour costs to be systematic because nearly all industries will have some exposure to variations in labour costs.[47] Conceptually, we expect labour costs to be positively correlated with the broader market because as the economy grows, demand for labour will also grow, and therefore the cost of labour will also increase as it becomes increasingly scarce.

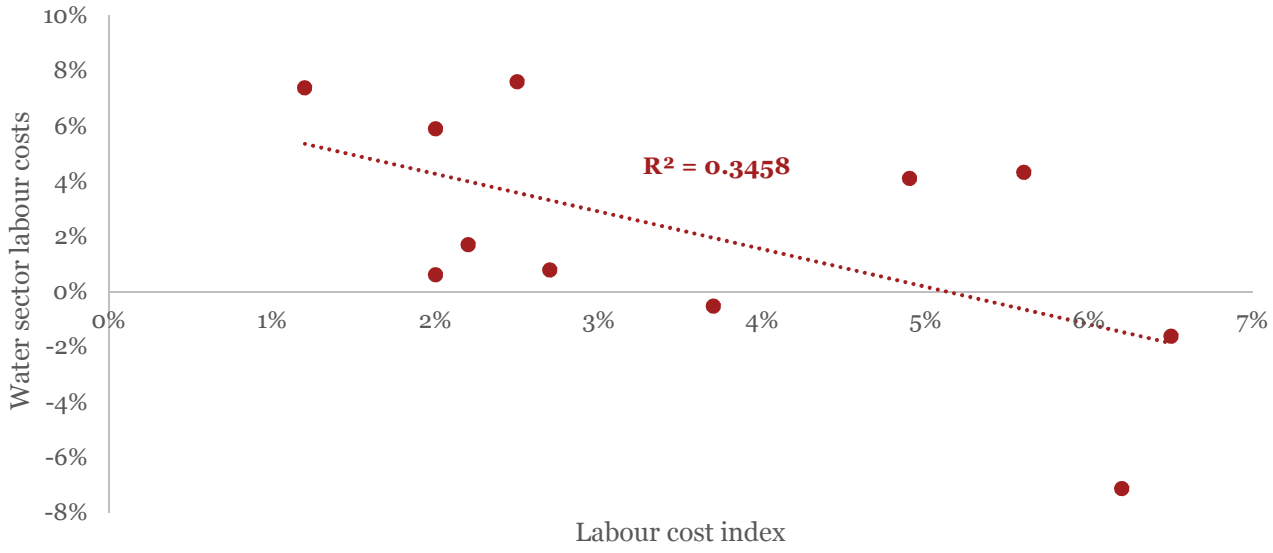
4.43 To examine the link between market wide labour costs and water company labour costs, we use the ONS's index of labour costs, which includes wages and salaries, national insurance contributions, employee pension contributions, sickness, maternity and paternity payments and benefits in kind. This is a broad measure of labour costs and is more likely to reflect the labour costs included in water company accounting data.

4.44 However, the relationship between economy-wide labour costs, as measured by the labour cost index, and company labour costs is not clear. At the company level, available data suggests that there is a negative relationship between company labour costs and labour costs in the wider economy (see Figure 21 below). This could be a spurious relationship as there is not a clear rationale for why water sector labour costs would be negatively related to the wider market labour. It is therefore difficult to determine whether water company labour costs are systematic.

[46] For each segment of the value chain, the level of exposure to power costs is a function of (a) the volatility of power costs; and (b) the weighting as a proportion of the segments total costs. These variables are set out in Table 7.

[47] For the purposes of this analysis, we have classified both "employment costs" and "hired and contracted services" as labour costs. Based on its cost line description (see *Appendix J*), "hired and contracted services" are primarily made up of contracted labour, e.g. lawyers and professional advisors, which will also be influenced by economy wide labour costs.

Figure 21: Company labour costs v. labour cost index, YoY change, 1997-98 to 2011-12

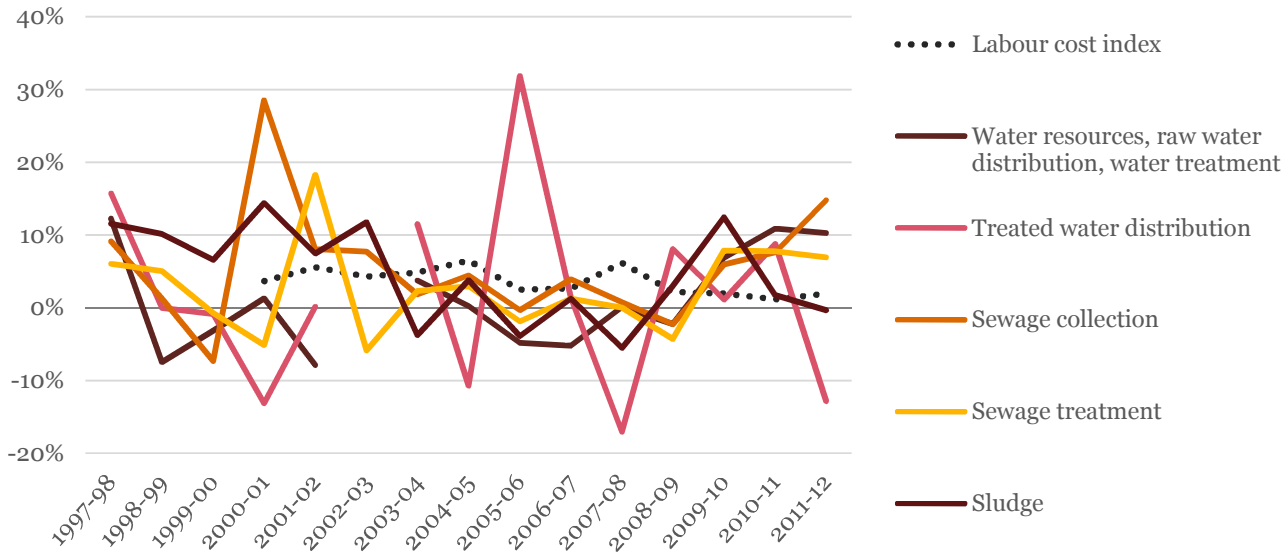


Source: PwC analysis, ONS, Company accounts

* Charts exclude 2002-03 data because South East Water enters dataset in 2002-03

4.45 At the value chain level, labour costs appear to have little relationship to movements in the labour market index. This is shown in the figure below.

Figure 22: Value chain elements and labour cost indices YoY change, 1997-98 to 2011-12



Source: PwC analysis, ONS, Company accounts

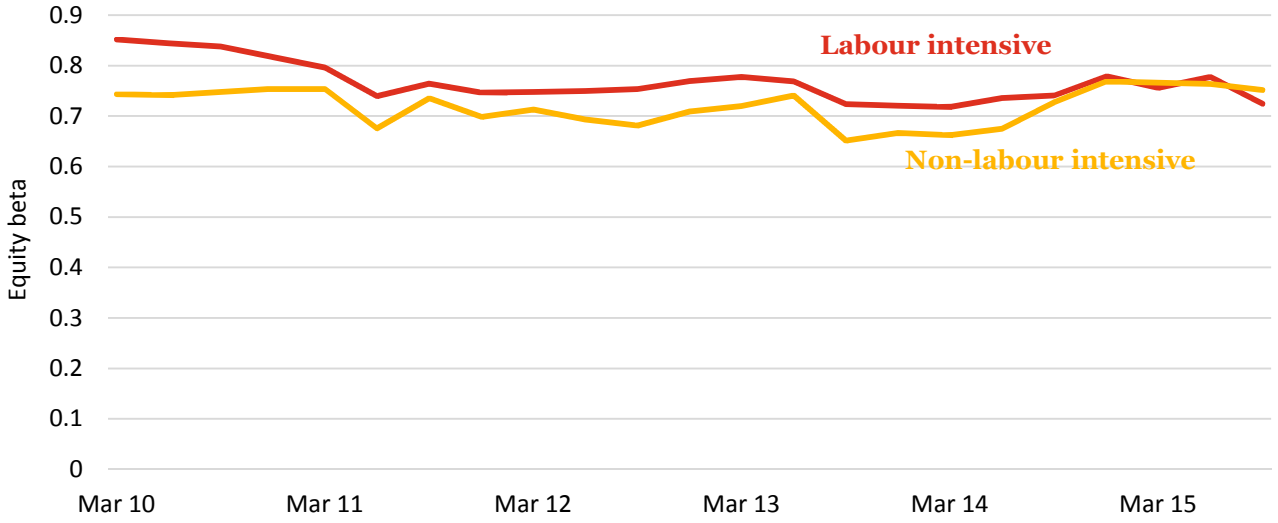
* Labour costs for water resources, raw water distribution and water treatment is not separated in company data. Chart excludes 2002-03 data because South East Water enters dataset in 2002-03

4.46 Similar to power-intensive companies, we can investigate the difference in beta of more labour intensive companies compared to those that are less labour intensive. We use the 2-year equity beta in our analysis. We use salary costs as a proportion of total revenue as an indication of the labour intensity of a company. We classify companies that fall in the upper quartile of the dataset qualify as labour intensive. Conversely, those companies that fall in the lower quartile are considered non-labour intensive.

4.47 We use all companies on the FTSE All-Share Index for this analysis. The upper quartile of this dataset is 5.2% and the lower quartile is 0.1%. Therefore, companies that have salary costs as a proportion of total revenue that are greater than, or equal to, 5.2% are classified as labour intensive. Companies that have salary costs as a proportion of total revenue less than, or equal to, 0.1% are classified as less labour intensive.

4.48 The resulting average equity betas for labour intensive and non-labour intensive companies are presented in the figure below.

Figure 23: Equity beta of labour intensive v. non-labour intensive companies



Source: PwC analysis, Capital IQ

4.49 On average, labour intensive companies have a higher equity beta compared to non-labour intensive companies by 0.04. The listed water companies (Pennon Group plc, Severn Trent plc, United Utilities Group plc) fall within the labour intensive group with average salary costs as a proportion of revenue of 13.8% (see *Appendix G* for a detailed list of the industries included in each comparator group).

4.50 As noted above, the difference in beta between labour and non-labour intensive companies is relatively small (0.04, on average). Given this relatively small difference in beta, and unclear relationship between water company labour costs and wider economy labour costs, we do not consider there is convincing evidence that more labour intensive segments of the water and sewerage value chain would have a higher or lower beta than less labour intensive segments.

Other operating expenditure

4.51 While the economic rationale for considering power and labour costs as potential sources of systematic is relatively clear, due to their linkage to wider power and labour markets, other operating expenditure categories are not as clearly linked to the wider economy. We discuss the more significant "other" operating expenditure categories for water companies – materials and consumables, service charges, and rates – below.

Materials and consumables

4.52 According to Ofwat's regulatory accounting guidelines as, materials and consumables '*includes equipment (such as small tools and clothing), provisions, tarmac and backfill materials, but excludes all items capitalised or included within infrastructure renewals expenditure*'.[48] Based on this

[48] Ofwat's regulatory accounting guidelines (RAGs), March 2010.

description, it is not clear whether any of these costs could be considered systematic. It is possible that this cost category includes some chemical costs, used in water and sewage treatment processes, which may fluctuate in line with broader commodity cycles. In this case, a portion of materials and consumables costs may have a systematic element.

4.53 However, given the broad nature of this cost category, and in the absence of further cost disaggregation, any conclusion on the impact of these costs on beta would be purely speculative. Due to this, we do not consider there to be sufficient data to suggest any potential impact on beta.

Service charges

4.54 Service charges are defined as the '*total cost of service charges by the Environment Agency or canal & river trust for discharge consents*'[49] We consider these to be a specific cost category that applies only to water and sewerage companies. Due to this, it is by definition a diversifiable cost and therefore should have no systematic element or impact on beta.

Rates

4.55 Rates, also referred to as "local authority rates", '*includes both the local authority rates, cumulo rates and sewerage site rates*'.[50] There may be a systematic component to these costs because all businesses will, to some extent, be exposed to the cost of business rates, which are conceptually similar to a tax expense. Rates are calculated with reference to the "rateable value" of a commercial property, which is a notional value for the annual rent that the property could be let for on the open market. In theory, commercial rents would be expected to be cyclical, i.e. when the economy is growing, we expect commercial rents to also increase. This would most likely act as a dampening effect on beta, as an increase in rates during a period of economic growth would dampen the profits of companies throughout the economy.

4.56 For water companies, rates costs are included in their allowed revenue. In conjunction with the fact that rates are set once every five years and are, therefore, relatively predictable, means that any exposure to these costs is likely to have minimal impact on beta. In addition, any uncertainty around changes in rates is mitigated through a specific uncertainty mechanism implemented by Ofwat during PR14, which provides protection against any unexpected increase in rates during the price control period.

4.57 Due to this, we consider that the company level beta of 0.28 will reflect the effect of the pass-through nature of rates' costs and therefore do not consider an adjustment to the beta to be justified.

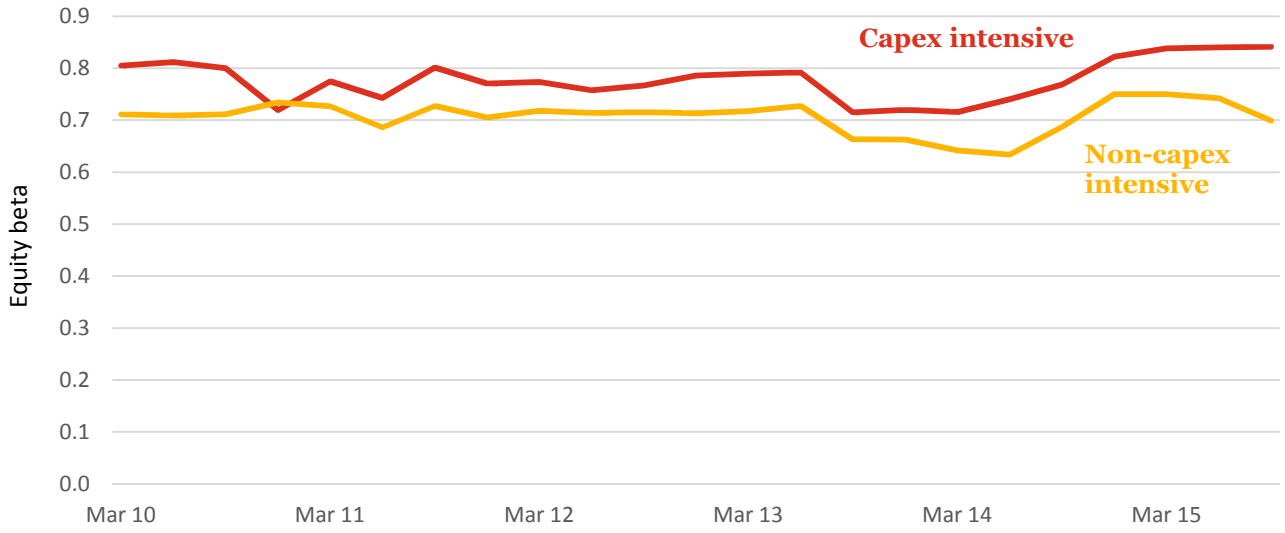
Capital expenditure

4.58 In addition to the operating expenditure categories discussed above, we also consider whether capital expenditure may be a source of systematic risk. Similar to power and labour costs, we look at whether the equity beta for companies with high levels of capex, relative to opex, differs from that of companies with low levels of capex. This analysis indicates that capital intensive companies (as measured by capex:opex ratios) of the FTSE-All Share have a beta that is, on average, around 0.07 higher than non-capex intensive companies (see figure below). The listed water companies (Pennon Group plc, Severn Trent plc, United Utilities Group plc) are included in the capex intensive group with an average capex:opex ratio of 40.3% (see *Appendix G* for a detailed list of the industries included in each comparator group).

[49] Ofwat's regulatory accounting guidelines (RAGs).

[50] Ofwat's regulatory accounting guidelines (RAGs).

Figure 24: Equity beta of capex intensive v. non-capex intensive companies



Source: PwC analysis, Capital IQ

4.59 However, these findings should be interpreted in the context of differences between water companies and other companies on the market index. In particular, capital intensity will have fundamentally different impacts for regulated companies with revenue protections and unregulated companies. For unregulated companies, capex represents a fixed cost on which a future return is uncertain. In contrast, for regulated companies, such as water companies, capex converts into the RCV with relatively certain future returns (in the form of depreciation and revenue allowances). This significantly reduces the risk associated with future cash flows.[51] To illustrate this effect, we can compare the asset beta of listed water companies (around 0.3 at the time of PR14) to the non-capex intensive and capex intensive companies in Figure 24. Despite water companies being highly capex intensive businesses, relative to other constituents on the FTSE All-Share, their observed asset beta is significantly lower than even the non-capex intensive comparator group.

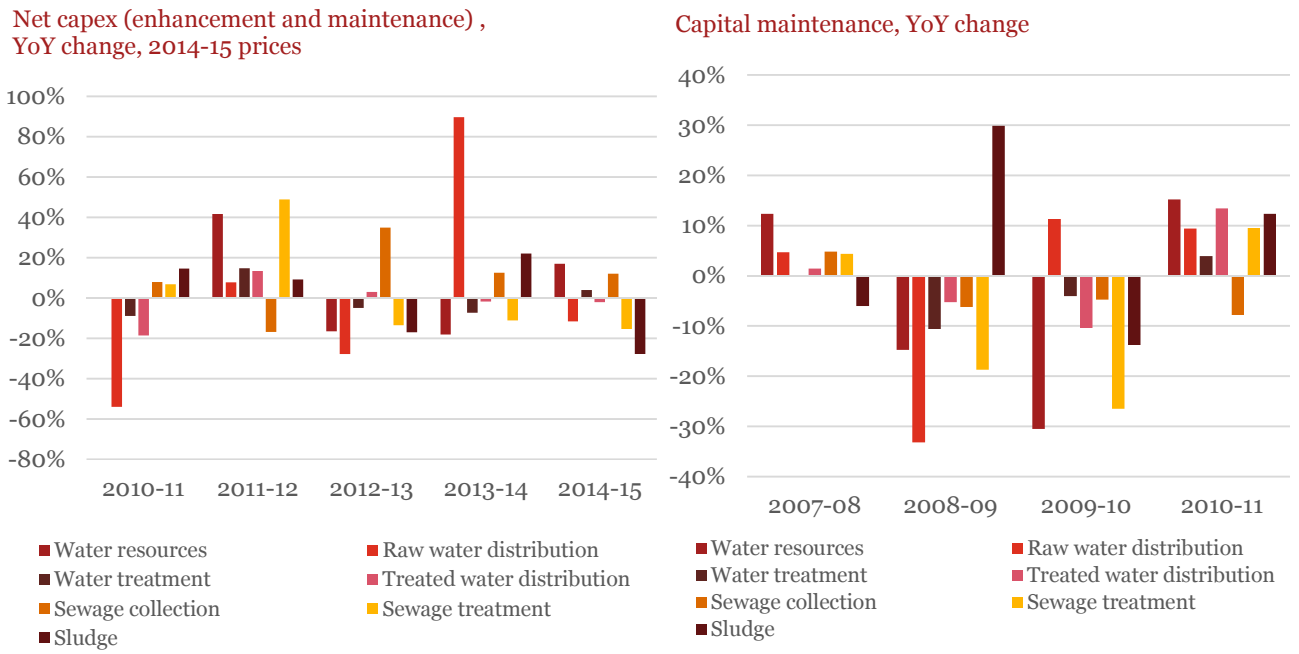
4.60 Due to this, we consider that the beta differential implied by this analysis should not be applied in the context of the segmental analysis of water companies. There are two further reasons that suggest a beta adjustment for capital expenditure may not be appropriate:

i) As explained above, water companies are highly capital intensive businesses. We note that all segments of the water and sewerage value chain have capex:opex ratios that are in the 90th percentile of capex:opex ratios of the entire FTSE-all share index and therefore can all be considered to have very high levels of capex relative to the wider market. This provides further rationale that the asset beta may not differ between the segments of the water and sewerage value chain.

ii) We also note that company, and segment level, capex is extremely variable both on a total net capex basis and a maintenance capex basis only (see figure below). In addition, capex will be largely driven by company and project-level decisions and therefore, it is difficult to determine from company financial data, whether there is any systematic risk exposure related to capex. Due to this, we treat capex volatility to be a non-systematic risk.

[51] For regulated businesses with revenue protections, there are arguments that the effect of capital intensity can have the opposite effect on asset beta, i.e. higher capital intensity reduces systematic risk. This is discussed in further detail in the section "Operational leverage" below.

Figure 25: Capital expenditure, YoY changes, 2014-15 prices



Source: PwC analysis, Ofwat analysis, Company data

Capital intensity and operating leverage

4.61 As described in paragraph 3.60, operating leverage is a form of cost structure that can magnify the exposure to systematic risk and can therefore affect the level of the asset beta. We also explain that operational leverage, in the context of a regulated industry with revenue protections, can also be thought of in terms of capital intensity. For the purposes of assessing operational leverage across the water and sewerage value chain, the availability of relevant data means that a capital intensity measure of operating leverage, as opposed to a fixed v. variable cost measure, is more readily accessible.[52] During PR14, all eight of the water-only companies (WoCs) submitted a case for an uplift to their cost of capital to account for operational leverage. As explained in our report for Ofwat:

> *'The WoCs' interpretation of operational leverage for regulated utilities is more about how either revenue or cost risks impact returns. In this interpretation, if a revenue or cost shock is large relative to the capital invested in the business, then the impact on returns will also be large. So a regulated utility which has a lower comparative level of capital employed will have more volatile returns for a given revenue or cost shock when compared to a similar firm with a high comparative level of capital employed. In other words, it is the 'low RCV' which drives the WoCs' interpretation of higher operating leverage, rather than the conventional definition which relates to a high degree of fixed costs.'*[53]

4.62 As part of our work, we reviewed a range of measures for estimating the differences in cost and revenue risks for WaSCs and WoCs. This included revenue/RCV and totex/RCV ratios, as well as operating and

[52] A fundamental fixed v. variable cost measure of operating leverage requires detailed information on company cost structures that goes beyond information provided in company statutory or regulatory accounts. Alternatively, the degree of operating leverage (DOL) can be calculated as the ratio of the percentage change in operating profit to the percentage change in sales (turnover). Given that turnover is not disaggregated to a business segment level in water company accounts, assessing operating leverage on this basis is also not feasible.

[53] PwC (August 2014) *Company specific adjustments to the WACC: A report prepared for Ofwat*, page 29.

capital expenditure risks. Based on this review, we found that the empirical evidence for WoCs having higher operational leverage was inconclusive as the evidence did not show '*a credible situation where WoCs are exposed to greater systematic risks as a consequence of their different cost structures compared to WaSCs*'.[54] This was supported by empirical evidence of water company transactions and betas estimates, both comparing WaSCs to WoCs.[55] In addition, the fact that water and sewerage companies (WaSCs) did not argue for differential costs of capital for their water and sewerage RCV supported this conclusion.

4.63 Our conclusion in PR14 was based on evidence which indicated that the differences in operational leverage, particularly the difference in water and sewerage activities, was relatively small. In contrast, our analysis of operational leverage across the different segments of the value chain indicate that there is a much wider variation in operational leverage than that observed between water and sewerage activities. The operational leverage across the value chain is set out in Table 12.

4.64 Following PR14, Bristol Water appealed its final determination, which was subsequently reviewed by the Competition and Markets Authority (CMA). We discuss the CMA's discussion and findings on operational leverage below.

Adaptation of CMA adjustment for operational leverage

4.65 In the recent work on Bristol Water's appeal to its PR14 final determination, the CMA included an uplift to the asset beta to account for higher operational leverage. This is based on a measure of operating leverage calculated as:

Operating leverage = (RCV run-off + return on capital) / Revenue

4.66 This formula is essentially calculating the capital intensity of a business with the underlying logic being that for a capital-intensive business, a larger proportion of revenue will be made up of return to and return on capital. Based on the CMA's operating leverage methodology, the asset beta adjustment for Bristol Water was 0.04. In their report on Bristol Water's appeal to Ofwat's PR14 determination, the CMA note that '*there is uncertainty over the scale of any [operational leverage] uplift, and we agree that calculating a single value is difficult*' and '*that there are limitations on using a particular measure [of operational gearing], in part because of the difficulty in demonstrating the scale of the relationship between any measure of operational gearing and asset beta*'.[56] While the CMA note that any operational gearing adjustment is difficult, they recognised the conceptually validity of the argument and ultimately made an adjustment for this.

4.67 Given that the differences in operating leverage across the value chain are larger than the differences between WaSCs and WoCs, this requires further consideration. In order to gain a view on business segment operational leverage, our analysis requires a more disaggregated approach. Because of limitations in the available data, we use a slightly different definition of operational leverage using cost data from regulatory accounts that is allocated to the different elements of the value chain. Specifically, we calculate operating leverage as:

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[54] PwC (August 2014) *Company specific adjustments to the WACC: A report prepared for Ofwat*, page 32.

[55] In 2008, the average asset beta across the listed WaSCs (0.28) was slightly lower than the one listed WoC (0.35). However, asset beta estimates, as of September 2013, suggested the opposite – with the listed WoC appearing to be less risky, with a beta of 0.17 and WaSCs with an average beta of 0.24. Similarly, when looking at transaction ratios, we found that there was no tendency for lower valuations for WoC businesses or share trades. In fact, the average price to RCV ratio for WoCs (1.27x) is higher than WaSCs (1.18x).

[56] CMA (2015) *Bristol Water plc: A reference under section 12(3)(a) of the Water Industry Act 1991*, 6 October 2015, paragraph 129 and 135.

Operational leverage = (CCD + IRC) / (Opex + CCD + IRC)

Where,

CCD = Current cost depreciation

IRC = Infrastructure renewal charge

4.68 This is conceptually similar to the CMA's calculation of operating leverage. Based on the data that is available at the business segment level, we use depreciation charges (CCD and IRC) as a proxy for the "RCV run-off" component of the CMA operating leverage calculation. We do not include a return on capital component, as this requires (a) an assumption about the split of the asset base, which is one of the key considerations of the market design options, rather than a current risk issue; and (b) a disaggregated rate of return (WACC), which in the context of this analysis is circular. However, we would not expect the inclusion of a return on capital component variable to significantly change the direction of the results of this analysis because the level of depreciation and return on capital are ultimately both driven by the size of the asset base and so the relative ordering of the value chain segments in terms of operational leverage would be unchanged.[57]

4.69 This analysis is set out in the in Table 12.

Calculating operational leverage adjustment to asset beta

4.70 In order to calculate the beta impact of difference in operating leverage across the value chain, we draw upon available benchmarks. This includes the following evidence:

i) *PR14 wholesale*: We assume that the level of operating leverage for the industry as a whole (52%) is consistent with the wholesale beta of 0.28. However, there is variation in the level of individual companies' operating leverage.

ii) *TTT based estimate*: As part of the allowed revenue calculation for Thames Tideway Tunnel (TTT), Cambridge Economic Policy Associates (CEPA) calculated a plausible range of cost of debt and cost of equity scenarios for TTT.[58] Using these scenarios we solve for the implied asset beta, which will be representative of a beta that reflects a capital intensive sewage collection asset. We therefore use this asset beta as representing the operating leverage of sewage collection (61%). The average asset beta from CEPA's scenarios is 0.23.

iii) *CMA based estimate*: As noted above, the CMA considered a maximum operational leverage adjustment of 0.04 to Bristol Water's asset beta. We include the resulting asset beta of 0.32 (wholesale asset beta of 0.28 plus uplift of 0.04) and corresponding operational leverage for Bristol Water as an additional point of reference in the figure below.[59]

iv) *Regulatory benchmarks*: To broaden our comparator set we also consider the level of operational leverage of regulatory benchmarks. Specifically, we calculate the operating leverage (using regulatory depreciation and opex measures from company regulatory accounts) for regulated businesses in electricity and gas transmission and distribution. We take the average operational

[57] If Ofwat decides to implement separate price / revenue controls for different segments of the value chain, then this analysis could be improved significantly as both revenue and allowed return data will be available on a more disaggregated basis.

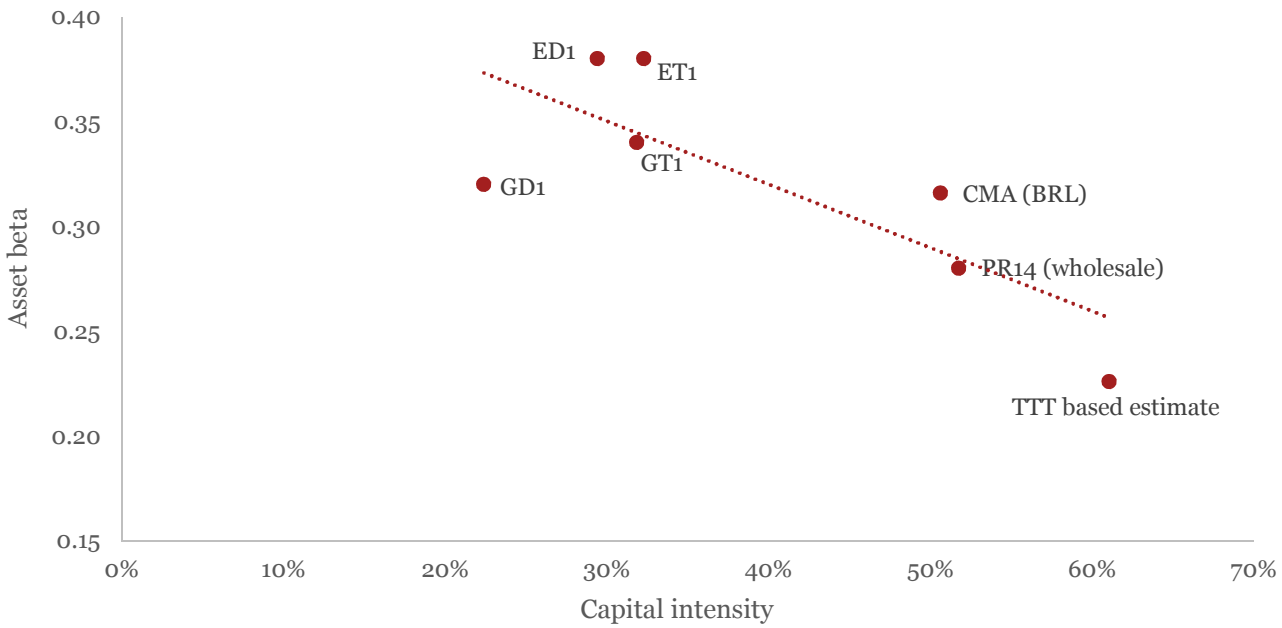
[58] Cambridge Economic Policy Associates (CEPA) *Thames Tideway Tunnel – Cost of capital*, CEPA briefing note, 25 August 2015.

[59] CMA (2015) *Bristol Water plc: A reference under section 12(3)(a) of the Water Industry Act 1991*, 6 October 2015.

leverage across companies and use the regulatory determined asset beta and include these data points in the figure below.

4.71 Based on the above data points, we can plot a relationship between asset beta and operational leverage as set out in the figure below.[60]

Figure 26: Asset beta adjusted for capital intensity



Source: PwC analysis, Company data

4.72 There are clear limitations to this benchmarking analysis. Firstly, the number of data points is low. Secondly the TTT estimate is likely to have been reduced by the considerable package of Government support provided to attract low cost financing[61]. Lastly the energy comparators generally operate in an industry with higher volume risks, which we have not sought to adjust. These last two observations increase the slope of the line.

4.73 However, if we do use this relationship, we can then interpolate the asset beta for the different segments of the value chain given their level of operational leverage. The directional impact of operational leverage on asset beta for each segment is set out in the table below.

[60] In the chart, the x-axis is labelled as capital intensity because the measure of "operational leverage" used is essentially a measure of capital intensity, i.e. (CCD + IRC) / (CCD + IRC + opex).

[61] The Government support package for TTT included six separate core contract documents, which seek to mitigate against low probability, high impact events. This includes: insurance corer of last resort, additional equity contributions in the event of significant construction cost overruns, and a short-term liquidity facility in the event of financial market disruption.

Table 12: Directional impact of operational leverage on asset beta

Value chain element	Operating leverage	Directional change to value chain beta
Company (wholesale) level	**52%**	
Water resources	30%	↑
Raw water distribution	41%	↑
Water treatment	47%	–
Treated water distribution	53%	–
Sewage collection	61%	↓
Sewage treatment	58%	–
Sludge (treatment & disposal)	40%	↑

Source: PwC analysis, Company data

Note: Arrows indicate whether the value is likely higher or lower than the company level figure

4.74 This analysis suggests that water resources has the highest potential operational leverage uplift and sewage collection is likely to have the biggest negative adjustment. Given the similarity between the operational leverage values at the company level and for treated water distribution, water treatment and sewage treatment, we do not consider that an operational leverage for these three segments is valid. This is consistent with our findings at PR14, that the difference between WaSCs and WoCs did not warrant adjustment due to the relatively small differences.[62]

Summary

4.75 In the table below, we set out the potential directional adjustments to the value chain betas from the starting wholesale beta of 0.28. As discussed in the preceding pages, we find that there is reasonable evidence to suggest that the segmental asset betas may differ due to different exposures to power costs and operational leverage.

4.76 Evidence on labour costs does not show any discernible relationship between water company labour costs and labour costs in the wider market. Furthermore, changes in labour costs do not appear to be correlated with changes in the wider market. We do not therefore recommend adjusting beta for labour costs. There is limited data with which to assess other operating costs (materials and consumables, service charges, and rates) and therefore we do not consider the evidence to support any differentiation in asset beta.

[62] The operational leverage ratios for and the water and sewerage wholesale services of 48% and 55%, respectively – a difference of 7 percentage points.

Table 13: Adjustment to asset beta for systematic cost and operating leverage risks

Value chain element	Directional change for:						
	Power costs	Labour costs	Materials & consumables	Service charges	Rates	Operational leverage	Value chain beta
Water resources	–	–	–	–	–	↑	↑
Raw water distribution	↑	–	–	–	–	↑	↑
Water treatment	↑	–	–	–	–	–	↑
Treated water distribution	–	–	–	–	–	–	–
Sewage collection	↓	–	–	–	–	↓	↓
Sewage treatment	–	–	–	–	–	–	–
Sludge (treatment & disposal)	↑	–	–	–	–	↑	↑

Source: PwC analysis, Capital IQ, Company data

Note: Arrows indicate whether the value is likely higher or lower than the company level figure

Cost of capital inputs across the value chain

4.77 Table 14 and Table 15 below set out our overall view of the asset beta and gearing for each segment of the value chain. Our asset beta figures combine the findings from our analysis of the benchmarking approach and the incremental impacts from differing exposure to cost drivers.

Table 14: Directional differences from company level asset beta across the value chain

Value chain segment	Value at risk ranking	Size of value (% 2015 MEAV)	Beta (based on incremental impacts)	Beta (based on benchmarks)	Overall beta estimate
Company level (wholesale)	-	**100%**	**0.28**	-	**0.28**
Water resources	**5**	3.6%	↑	≈0.26	↑
Raw water distribution	**3**	1.5%	↑	0.2 to 0.33	↑
Water treatment	**2**	1.8%	↑	≈0.28	↑
Treated water distribution	**6**	20.4%	–	0.2 to 0.33	–
Sewage collection	**7**	68.4%	↓	0.2 to 0.33	↓
Sewage treatment	**4**	3.7%	–	≈0.28	–
Sludge	**1**	0.7%	↑	0.23 to 0.43	↑

Source: PwC analysis, Company data

Note: Arrows indicate whether the value is likely higher or lower than the company level figure

4.78 As the largest segment of the value chain, we have found that the asset beta for sewage collection is unlikely to differ significantly from the current wholesale beta. Relevant benchmarks and analysis of differential systematic risk exposures suggest that the beta for sewage collection is unlikely to be lower than 0.25. At the top end of the value chain beta range, relevant benchmarks and the directional impacts of cost exposures and operating leverage suggest that the asset beta is unlikely to be higher than 0.4. The decision of whether to apply differential betas in the context of segmental controls will

need to consider further analysis as well as the variation in the calculation of beta across companies and over time.[63]

Table 15: Directional differences from company level gearing across the value chain

Value chain segment	Value at risk ranking	Size of value (% 2015 MEAV)	Gearing	Relevant benchmarks and commentary
Company level (wholesale)	**-**	**100%**	**62.5%**	We note that Ofcom makes no gearing distinction between different parts of BT's value chain, and differences between HAL, GAL and STAL in the CAA's Q5 price review where primarily driven by demand risk, which is not as relevant for the water sector.
Water resources	**5**	3.6%	–	Based on the value at risk rankings, we note that water resources was ranked towards the centre on the value at risk basis. We set gearing for this element of value chain equal to the notional wholesale level.
Raw water distribution	**3**	1.5%	–	Assumed equal to the notional wholesale level
Water treatment	**2**	1.8%	↓	Treatment benchmarks in *Appendix C* maintain gearing of approximately 40% despite being in a competitive environment. As water treatment is current part of a vertically integrated monopoly we would expect it to sustain higher gearing, but at less than the wholesale level due to its relatively high risk rating
Treated water distribution	**6**	20.4%	↑	Ofgem RIIO precedents lie in the range 60% to 65%. This element of the value chain has one of the lowest value at risk rankings. Gearing may be marginally below 65%.
Sewage collection	**7**	68.4%	↑	See "Treated Water Distribution" above.
Sewage treatment	**4**	3.7%	–	Benchmarks in *Appendix C* indicate that gearing, as part of the current vertically integrated value chain, is unlikely be significantly less than the wholesale gearing level. The "value at risk" ranking for is also towards the middle of the value chain rankings.
Sludge	**1**	0.7%	↓	We would expect the sludge business to maintain higher gearing levels than "Sludge plus" comparators due to regulatory protections, but as this element of the value chain received a high value at risk ranking, we would expect its gearing to be lower than the notional wholesale level.

Source: PwC analysis, Company data

Note: Arrows indicate whether the value is likely higher or lower than the company level figure

4.79 In most instances, small gearing changes are unlikely to impact the overall cost of capital. This is because lower gearing is, in part, offset by a lower cost of equity due to the financial leverage effect on the equity beta. Further, the incorporation of allowance for the actual tax paid in the regulatory regime limits the benefit of interest tax shields associated with higher gearing.

[63] We note that between 2001 and 2015 the asset betas for the three listed WaSCs (Pennon Group, Severn Trent, and United Utilities) have ranged between c. 0.1 and 0.4. Notably, this is a wider range than the potential range we have identified across the different segments of the value chain.

5. Reform options

5.1 In the previous sections we have set out available evidence to indicate how risk currently varies across the water value chain.

5.2 In the next three sections we assess potential cost of capital impacts which may stem from reform options. This includes assessing impacts to the segments of the value chain where markets are being introduced (the contestable areas), as well as segments which will remain regulated monopolies (the non-contestable areas). In assessing the potential cost of capital impacts arising from different reforms, we first conducted a principles based assessment. Following our principles based assessment, we go on consider market design options that are specific to the water resources and sludge segments (sections 6 and 7, respectively).

5.3 Following discussions with Ofwat, two sets of four reform options have been used for the purpose of our work. These allow review of a wider set of reforms than those being considered by Ofwat.

5.4 Our principles based assessment, which is covered in this section, is structured into three parts:

i) Control reforms - which covers changes to price control structure and approach;

ii) Market access – which incorporate access pricing regimes and introduction of competition; and

iii) RCV based regulatory protections – which covers RCV allocation and the treatment of RCV.

5.5 The remainder of this section is structured as follows:

i) Our approach – we first set out our approach to estimating cost of capital impacts; we then set out our approach to reviewing the market design options.

ii) Review of market design features – this section combines our approaches to estimating cost of capital impacts and reviewing the different market designs, setting out in turn the cost of capital impacts associated with the core design features.

Our approach

Approach to estimating cost of capital impacts

5.6 When assessing the impact of reform options on the cost of capital across the value chain, we consider how systematic (non-diversifiable) risks and total risks (specific and non-diversifiable) may change relative to the current risk landscape. Consistent with the outputs shown in the conclusion of section 4 above, for each of these three parts, we assess how different features of the reform options we consider impact on both beta and gearing.

5.7 Using the CAPM, the change in returns required by equity investors depend only the extent of changes in systematic risk. Changes to total risk can lead to changes in both gearing and the cost of debt, and disentangling which of these parameters adjusts in relation to changes in total risk can be difficult. For example, where business risks rise, if that business was to maintain the same level of gearing, debt investors may require a higher return. Equally, the same business may opt to lower its gearing as a consequence of increased risk so as to maintain a target credit rating, leaving the cost of debt unchanged. For the purpose of our analysis, we consider how gearing may adjust to changes in risk brought about by the different reforms, and leave debt investors bearing no more risk and therefore the cost of debt unchanged.

5.8 The main sources of evidence used in identifying the type and magnitude of risks introduced through reform options are:

i) academic evidence;

ii) benchmarks from other regulated UK sectors;

iii) benchmarks from other sectors in the UK and internationally;

iv) past studies on regulatory reform, competition and the cost of capital;

v) outputs from Ofwat's RCV/revenue allocation model; and

vi) our own empirical analysis.

5.9 In addition, we consider whether the one-off and potentially asymmetric risks associated with upstream market reforms can be fully accounted for through these core cost of capital parameters, or whether additional adjustments to the WACC are required. Specifically, we consider whether there is the need for a transitional premium above the cost of capital (we now discuss the rationale for this below)

Transitional premium to the WACC

5.10 Currently all value chain segments are part of companies that are vertically integrated regulated monopolies. Where new markets are introduced, competition risks will arise through exposure to market share changes and subsequent impact on asset utilisation.

5.11 If reforms introduce asymmetric risks for investors, and expected cash-flows (i.e. a probability weighted central estimate) are altered as a result, the value of the business to investors will change. Such an effect is more likely when moving from one regulatory regime to another (rather than the natural positive and negative variation with a stable regulatory regime). Ofwat's regulatory regime seeks to compensate investors for the risks they bear, so we also calculate the uplift to the require return to compensate for this new risk.

5.12 The standard CAPM model is not well suited to capturing asymmetric risks, as the model is required to be applied to symmetric, mean cash flow values. Therefore, this impact on investors needs to be captured through other means. One approach is to estimate the loss of value to investors under different outturn scenarios, and estimate the change in return required to offset fluctuations in value. Judgement is then required regarding the likelihood of each scenario in assessing the magnitude of the premium to the WACC.[64]

5.13 Where downside risks are greater the value of the business will fall, and a premium to the WACC would be required. Where upside potential is greater as a result of the market reforms, then a downward adjustment to the WACC could be required. Where risks arising from market reforms are symmetric, a premium to the WACC is not required.

5.14 Furthermore, we consider that any premium to adjust for asymmetric risks would only be transitional in nature, and would not be required in the long-run. Asymmetric risks arise as expected cash-flows may change as a result of market reforms, and the change in expected cash flows is measured relative to a baseline scenario of the existing regulatory regime. Over time as new investments are required to replace existing assets, the central estimate for expected cash flows will be calibrated to post-reform expectations regarding market share and asset utilisation. Once the market has settled in a post-reform state, risks around expected cash-flows will become more symmetric once again. It is the transition

[64] An alternative approach would be to extend the CAPM framework to a "third moment" model, where additional estimates regarding coskewness coefficients and a market coskewness risk premium are added to the standard framework. However, we find there to be considerable drawbacks to this approach. Firstly, it is less suited to cash flow asymmetries (and more suited to return asymmetries. Secondly, the estimate of a coskewness coefficient requires stock market information which is not directly available for wholesale value chain segments. Lastly, there is a lack of literature which can be utilised when assessing the appropriate magnitude of a coskewness risk premium.

from full monopoly market share, and the associated predictability of existing asset utilisation to a more uncertain market state which creates asymmetric risks.

5.15 The current ring-fencing of regulated activities is a factor that restricts the ability to earn income from outside the sector, using regulated assets. However, defining what constitutes a regulated service is not always straightforward, and different treatment can be afforded to different activities.[65] Market reforms may therefore provide opportunities (or upsides) for companies to earn revenue from wider activities which were previously unavailable and these upsides opportunities should be considered alongside downside risks.

5.16 We consider this approach of assessing a transitional premium to the WACC is a helpful during the early stages of market reforms. It is when uncertainty is arguably highest and is consistent with regulatory determinations which have not in the past adjusted for potential market share changes. Once the impact of reforms are better understood, then the impact of competition and market liberalisation can be incorporated into cash flow projections used in regulatory determinations. By way of example, projections on asset utilisation and additional sources revenue can consider likely competition effects, by company, in regulatory financial models, without any need to adjust the cost of capital.

Structure of our assessment

5.17 In the following review of market reforms, we therefore divide our assessment of cost of capital changes into three parts:

i) Impacts on beta – this component of the cost of capital captures changes in systematic (or non-diversifiable) risk;

ii) Impacts on gearing – this component captures the increase in risk to debt investors; and

iii) Impacts on transitional premium to the WACC – this component estimates the increased return to compensate investors for an asymmetric balance of downside risks (see *Appendix I* for a full description of methodology).

Review of the option features

5.18 Each of the reforms can be described along four dimensions (or "features"):

i) price control format;

ii) access pricing;

iii) RCV allocation; and

iv) treatment of the RCV.

5.19 Our review of these reform features is grouped into three overarching categories. Firstly we consider "control reforms" which covers changes to price control structure and approach. Secondly, we consider "market access" which incorporates access pricing regimes and facilitates competition. Lastly, we consider "RCV based regulatory protections", which covers RCV allocation and the treatment of the RCV. A brief description of each reforms is summarised in Table 16 below.

[65] For example, see Ofwat (2010) *The treatment of regulated and unregulated business in setting price controls for monopoly water and sewerage services in England and Wales – a discussion paper*.

Table 16: Reform features and descriptions

	Reform feature	Options	Description
Control reform	**1. Price controls**	Integrated wholesale v. separate binding control	A separate binding control would mean that the water and wastewater controls would be further split – with controls for the contestable activities, and controls for the non-contestable activities.
		Revenue control vs price control	A change from a revenue control to a price control means the regulated entity bears volume risk.
Market access	**2. Access pricing**	MEAV based v. wholesale minus v. LRIC	A LRIC (long-run incremental costs) approach directly estimates the costs to the incumbent of providing a sustained increment of demand for 'network' activities. A "wholesale minus" approach expresses the access price as the total wholesale price minus the costs the incumbent avoided in the contestable area i.e. through an entrant providing those services instead.
RCV based regulatory protections	**3. RCV allocation**	None v. focused MEAVs v. unfocused MEAVs	Whether to split the existing RCV, and if so, how to split, there are two options to focus on: either the £m MEAV ("focussed") or the % of total MEAV ("unfocussed") for the contestable area can be used.
	4. Treatment of RCV	Exposed to competition v. protected	Where the RCV is protected, it would be fully recoverable through allowed revenue. The options under consideration are: • Only new investment from 2020 onwards is exposed to markets • New investment and 2015-2020 RCV is exposed to markets • Full RCV is exposed to markets (including pre-2015 RCV).

5.20 In the review of reform features subsection below, we assess each feature for its potential impact on the cost of equity (via changes in beta), gearing, and in some instances model the magnitude of premia to the WACC required to offset any asymmetric effects of the reforms.

Review of features – control reform

Price control format

5.21 In relation to the control format there are two aspects we consider:

i) The first is the form of the control, in particular, whether the control removes volume risks (a revenue-cap) or whether the company bears volume risk (a price-cap). Under the current integrated wholesale revenue controls, companies face very little volume risk. Changing to a price-cap where companies do bear volume risk therefore has implications for the balance of risk and reward.

ii) The second is whether the contestable segment of the value chain is given its own separate binding control – separated from the current integrated wholesale control[66]. We consider whether there is an effect on risk from the splitting of the existing wholesale control in of itself, and additionally consider second order impacts which may arise from the setting of incentives across multiple controls.

[66] Binding means companies cannot recover more than allowed revenue under each control and cannot transfer costs between them.

Impact on Beta: form of control

5.22 The impact of a price control is set out by Alexander and Shugart, '*A pure price cap ensures a stable price path, but means that the revenue stream from the company's regulated businesses may vary as a result of demand being higher or lower than forecast. This volatility will be reflected in the profit stream. Thus under a pure price cap, the company bears the risk (both upside and downside) of unexpected changes in demand.*'[67] The transition to a price control, and subsequent exposure to market level demand risk may therefore increase beta where demand has linkages to the business and economic cycle. For example, in the case of sludge volumes, sewage volumes are the main driver – this may be linked to industrial output and population growth, and hence does have some relationship to the business and economic cycle.[68]

5.23 In terms of quantifying the impact of this change on beta, there are limited previous examples to draw upon. A starting point for assessing impact is the differences between Ofwat's PR04 and PR09 price reviews. The PR09 final determination stated that, '*The revenue correction mechanism introduced for this review removes any risk associated with household demand, limiting any difference in systematic risk to demand from large users. For most water only companies, the proportion of revenue from large users is comparable to the range for the water and sewerage companies.*'[69] As volume risk was largely mitigated through the revenue correction mechanism introduced at PR09, by comparing the asset beta set at the PR04 and PR09 determinations we can assess the impact of removing volume risk (although we acknowledge there were other changes to the regulatory approach in PR09). Consistent with the view that lower volume risk can reduce asset beta where volumes are systematic, the asset beta assumption fell by 0.05 between PR04 and PR09, from 0.45 to 0.4.

5.24 Another observation which can inform beta impacts is taken from water regulation in Australia. In SA Water's 2016 Price Determination, regulatory reforms meant SA Water faced less exposure to volume risk. The ESC report concluded that, *'a revenue cap guarantees that SA Water will recover the revenue set in the determination. It therefore provides longer-term stability of returns to SA Water and lower systematic risk of equity.'*[70] Based on this conclusion, the ESC considered a reduction in the asset beta of 0.04 to be an appropriate adjustment to reflect the transition from a price control to a revenue control.[71]

5.25 A price-cap also represents a more intensive form of regulation relative to a revenue-cap. Past analysis from PwC on study of rates of returns bid on PFI projects, and analysis by Alexander, Mayer and Weeds (1996) for the World Bank, found linkages between asset beta and the intensity/power of a regulatory regime.[72] These studies were done during a period of diversity across regulatory approaches. By comparing the asset beta for companies which operated under different intensities of regulatory regime, the impact of a transition from a less intense to a more intense regime was measured. Regimes were defined as follows.

- High powered regimes – RPI-X price controls

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[67] Alexander and Shugart (1999), *Risk, volatility and smoothing: regulatory options for controlling prices*, Discussion paper.

[68] In this context we are discussing fluctuations in market level demand, and not considering volume risk at the firm level through market share changes. We discuss the impact of competition risk on beta in *Appendix B*.

[69] Ofwat (2009) *Future water and sewerage charges 2010-15: Final determinations.*

[70] Essential Services Commission (2015), *SA Water Regulatory Rate of Return 2016 – 2020*, Final Report to the Treasurer.

[71] An equity beta change of 0.1, de-levered at the corresponding level of gearing. Analysis of SA Water's revenue volatility shows that revenue volatility is very similar to that of water companies in England and Wales before PR04, and hence a suitable benchmark.

[72] PwC (2002) *Study into rates of return bid on PFI projects*; Alexander, Mayer and Weeds (1996) *Regulatory Structure and Risk and Infrastructure Firms: An international comparison*, Policy Research Working Paper 1698.

- Intermediate powered regimes – Discretionary measures
- Low powered regimes – rate of return based measure

5.26 Between 1990 and 2001, we found that higher-powered regimes had an asset beta 0.04 higher than intermediate regimes. Therefore, where the design option proposes a transition towards a price-cap, this evidence also supports a view that the asset beta could rise by approximately 0.04.

5.27 **Conclusion:** combined evidence suggests that a change in the form of control to a price-cap could increase asset beta by as much as +0.04.

Impact on Beta: splitting existing controls

5.28 We note that previous splits in price controls in the water sector (separate wholesale controls and additional retail controls) did not lead to discernible cost of capital changes. In addition, the CMA recently stated in the Bristol Water PR14 appeal that, '*financial theory would indicate that dividing a company into parts (retained under the same ownership) should not affect either its profitability or the returns it generates. Therefore, we were not convinced that the implementation of separate controls should in itself require any increased returns*'.[73]

5.29 In addition to the direct effects of splitting existing controls, there could be an impact on asset beta where the intensity of regulation is raised as a result (see PwC/Oxera evidence discussed above). However, such an impact would depend on the asymmetry of efficiency incentives between different controls. For example, where the penalties/rewards associated with meeting cost targets are symmetric across different controls, a company would be unaffected by the inability to distribute costs across the value chain. However, where penalties/rewards are not symmetric across different controls, the intensity of regulation has scope to change the overall risk exposure.

5.30 **Conclusion:** the introduction of separate binding controls should not lead to a change in asset beta where there is no material divergence of incentives used in the separated controls.

Impact on Gearing: form of control

5.31 Regarding the form of the control, the volume risk which is associated with a price control could reduce the debt capacity of a firm. However, evidence regarding the magnitude of potential impact is mixed.

5.32 As a consequence of a change in demand risk (linked to a declining population) IPART in Australia lowered the gearing assumption for Essential Energy Broken Hill to 55% from 60% (60% is typically adopted in the Australian regulatory sector) – a reduction of 5 percentage points.[74]

5.33 However, other evidence from regulated UK airports suggests that an adjustment to gearing may not be necessary. Heathrow airport is regulated under a price control, and is perceived to have higher demand risk than the water sector, yet it manages to maintain gearing commensurate with highly leveraged water companies. Furthermore, the notional gearing selected by the CAA for Heathrow in the Q6 determination is just 2.5 percentage points lower than Ofwat's equivalent figure.[75]

5.34 Analysis of water companies' revenues and airports' revenues shows that the variability in revenue growth is significantly larger for airports (see Table 17 below). Over the period pre-PR14 the standard

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[73] Competition & Markets Authority (2015) *Bristol Water plc: A reference under section 12(3)(a) of the Water Industry Act 1991*, paragraph 10.218.

[74] Independent Pricing and Regulatory Tribunal (2014), *Essential Energy's water and sewerage services in Broken Hill: Review of prices from 1 July 2014 to 30 June 2018*.

[75] The notional gearing selected by the CAA for Gatwick in Q6 was 55%, 7.5% below Ofwat's PR14 point estimate.

deviation in annual water company revenue growth was 4.3%[76], for designated airports in the UK (Heathrow, Gatwick, and until 2014, Stansted) over the period 2004-05 to 2013-14, the equivalent figure was 8.3%. This is consistent with the view that airports face greater demand risk than water companies. This higher demand risk the aviation industry faces therefore may make it an inappropriate benchmark for the water industry. However, looking at the volatility in revenue growth for Heathrow specifically, the standard deviation in annual revenue change is 6.6%, and that this figure may have some upwards impact due to the opening of terminal five. This means that Heathrow may set a minimum gearing benchmarking the gearing of water companies under a price-cap, as it has variability in demand growth not dissimilar to that of water companies.

Table 17: Variability in revenue growth

Industry / company	Time period	Standard deviation in annual revenue growth
Water industry (England and Wales)	Pre-PR14	4.3%
Designated airports	FY2005 to FY2014	8.3%
Heathrow	FY2005 to FY2014	6.6%

Source: Regulatory accounts, Ofwat

Note: sample size very small for Heathrow, and small for designated airports

5.35 **Conclusion**: A reduction of approximately 2.5% in gearing assumption for a change to a price control would be consistent with available regulatory benchmarks.

Impact on Gearing: splitting existing controls

5.36 Regarding the effects of splitting existing controls, where we assume that the contestable areas are still financed as part of an integrated water group we would expect little impact on gearing. If, on the other hand, we consider a contestable segment that was financed on a standalone basis, the loss of business diversification could lead to increased risk to debtholders. Again, we note that previous splits in price controls in the water sector did not lead to discernible gearing changes.

5.37 **Conclusion:** We would expect there to be no material change to gearing assumptions from splitting existing controls.

Review of features – market access

Access pricing

5.38 Setting access prices is a key tool in facilitating market entry. There are many methodologies and cost concepts that can be applied when establishing an access price. Broadly speaking the methodologies can be divided into "cost-based" approaches and "retail-minus" based approaches (in the context of water, where the contestable segment is part of the wholesale control, it is more accurate to refer to this approach as "wholesale minus"). Within each methodology there is a further range of cost concepts that can be applied.

5.39 While the precise combination of methodology and cost concept chosen by Ofwat will lead to different levels of access prices, using the characteristics of each access price methodology, along with past experience in other regulatory sectors, we can form a view on how each methodology could impact on the balance of risk and reward.

[76] Ofwat introduced the revenue correction mechanism (RCM) for PR09, which was applied to revenue variation between 2010 and 2015. However, this is a true-up mechanism and, therefore, would not have affected the in-period revenue variation for water companies.

5.40 Given that the access price links the contestable value chain segment to the monopoly segments of the business, our discussion here considers the impact on the balance of risk and reward across the entire value chain.

5.41 Retail minus based access prices, which have been estimated on the basis of cost avoided, tend to be more protective to incumbents because all common costs can still be recovered by the monopoly segment of the business. The profit of the monopoly segment of the value chain is negligibly affected between different providers (including the wholesale activities of the integrated company).

5.42 Long-run incremental cost (LRIC) based access prices involve estimating the cost of providing monopoly activities. LRIC tends to be less favourable to the incumbent business. This is because under a LRIC approach, common costs are shared with the contestable segment, and so access prices tend to be lower. However, the economic value of assets included in LRIC could result in higher access prices in the water sector compared to wholesale minus approaches as a consequence of the difference between regulatory capital values and the MEAV. Depending on the precise cost and asset valuation concepts applied, this can create cost recovery issues for the monopoly element of the business. An additional consideration relating to LRIC is its relative instability as a measure of cost/price, for example, other regulators have found that resulting outputs from LRIC can vary considerably depending on relatively subjective inputs.

5.43 Past regulatory experience suggests that adopting a LRIC approach to access prices can be challenging to implement. For example, the CAA considered adopting this methodology as part of their Q6 determination for Gatwick, but found that, '*a long run incremental cost (LRIC) approach would have conceptual benefits from being linked to a notion of future competitive prices, however the input assumptions required significant judgement and could lead to starkly different pricing profiles*'.[77]

5.44 Ofgem (2012) also found that a key issue of the LRIC methodology was that it is based on assumptions that require a degree of subjective judgement. In addition to the degree of judgement involved, detailed bottom-up engineering models which may be required for LRIC estimates can be time-consuming and complicated to build and maintain, and have significant requirements for input data.

5.45 As access prices facilitate market entry, we also consider the impacts on a transitional premium to the WACC. As discussed at the beginning of the section when setting out our approach, the premium is estimated by considering how much higher (or lower) the WACC would need to be for investors to be NPV neutral between full monopoly and a downside scenario where market share has been lost (or gained). As we go onto assess the role of regulatory protections in the rest of this section, for the time being the analysis presented abstracts from any regulatory protections. This means that companies are fully exposed to market share losses through the introduction of markets for existing capacity and bear associated risks of lower asset utilisation and even stranded assets.

5.46 However, the risks associated with contestability are dependent on appropriate access prices. If access prices are set at a level which does not facilitate market entry (i.e. sub-economic for new entrants), then any impact on the transitional premium to the WACC would be substantially eliminated.

Impact on beta

5.47 Our review of academic literature revealed that there is not a conclusive relationship between competition and beta (see *Appendix B* for a full discussion). Some papers find there is a positive relationship between more competitive markets and beta. However, other studies find there to be competing forces which act on beta as markets become more competitive, and that conclude that beta may decrease as the intensity of competition is raised. Moreover, we find those papers which do find a positive relationship between lower market power and beta are not relevant in the context of utility regulation. The dynamic relationship between regulators and companies means that the assumptions

[77] Civil Aviation Authority (2013) *Economic regulation at Gatwick from April 2014: final proposals.*

made in these studies are inapplicable. For example, companies cannot exercise market power through choosing output levels, as these academic studies assume.

5.48 Opening up a segment of the value chain to contestability will put market share at risk. But our review of past regulatory discussions leads us to conclude that, regardless of the cause of market share loss, this may not necessarily increase beta. This is because in a CAPM framework equity investors hold diversified portfolios. Therefore, as one firm's market share loss is another firm's market share gain, sufficiently diversified investors could be neutral at the portfolio level. In other words, diversification means although one stock in their portfolio may fall, there are offsetting increases elsewhere in the portfolio. On this basis, we suggest that no access pricing/competition adjustment is made to beta.

5.49 **Conclusion:** No impact on beta through competition effects.

Impact on gearing

5.50 The ability for the contestable segment to maintain a given level of gearing will depend on the extent of competition. Entry incentives will in turn depend on the methodology used to estimate access price. For example, a LRIC based access price which does not include common costs will provide different entry incentives to "LRIC+".[78]

5.51 Where competition risk is introduced and no RCV protections are provided, the gearing of the contestable segment should align with that of competitive comparator companies. Our comparator analysis shows that this gearing level could be approximately 40%. Evidence used in the Cave Review also suggests gearing could be of a similar level in a highly competitive setting. Based on analysis of energy sector benchmarks, actual gearing levels were anticipated to fall to around 35% at an investment grade credit rating of BBB+ (see Box 1 below for further discussion).

5.52 As aforementioned, a wholesale minus access pricing regime can be more protective for the incumbent's monopoly network part of the value chain. Therefore, adopting this access price methodology is unlikely to lead to gearing changes for this particular segment of the value chain. Where a LRIC access price regime is implemented there is the possibility that there could be cost recovery challenges for the monopoly network part of the value chain.

5.53 Not all regulatory experience suggests that gearing would be lower with an access price regime. BT's gearing has not moved substantially with the transition from retail price controls to a wholesale access pricing regime.

5.54 **Conclusion:** in the contestable segments of the value chain, gearing may move towards competitive benchmarks. Competitive benchmarks provide evidence of gearing levels approximately 10% to 20% below current notional regulatory assumptions. The new gearing level in the non-contestable segment depends on the precise access pricing methodologies adopted. A wholesale minus access price is unlikely to have an impact on the gearing of the monopoly network element of the value chain, but a LRIC access price could lead to a gearing reduction. However, as long as LRIC allows the full recovery of economic costs, there may be limited impacts on gearing in the "network plus" element of the value chain.

Impact on transitional risk premium to the WACC

5.55 Opening value chain segments to contestability means that there is a risk of market share loss and an associated risk of reduced asset utilisation and potentially asset stranding. But it also presents companies with an opportunity to expand their business into new markets, and offers the scope to increase utilisation of existing assets. The balance between the opportunities and downside risks presents uncertainty for investors. It is also likely to vary on a company by company basis.

[78] LRIC+ is where additional allowances are made to the access price to account for common costs.

5.56 Investors are likely to be concerned about the uncertainty surrounding the potential introduction of downside risk. This may be true in the case of individual companies and when considering the sector as a whole and the potential of entry from outside the sector. This view is supported by statements from companies. For example in the Cave Review, South West Water was quoted as saying, '*investors are unlikely to see competition as resulting in a lower risk to the incumbent. This therefore inevitably results in a higher cost of capital.*'[79]

5.57 As a consequence, we present some illustrative analysis which shows the additional return on capital investors would need to be NPV neutral under different market share loss scenarios. The analysis presented shows impacts under realised market share losses rather than an expected outcome i.e. a probability weighted outcome for investors. Therefore the more extreme outputs should be viewed as "worst-case" outcomes for investors from contestability.

5.58 As discussed earlier in this section, the estimates inform the magnitude of a transitional premium above the long-term WACC for a particular contestable segment, and only apply where investors do not consider material potential upsides from reform. The size of any premium could be substantially or fully negated where investors anticipate potential gains from market reform. This could be market share gains from other water companies, or new growth opportunities from newly liberalised markets.

5.59 The full methodology underlying our calculations for the transitional risk premium to the WACC are set out in *Appendix I*.

5.60 The risk premium in Table 18 below, has been calibrated towards a contestable segment which has similar characteristics of the industry overall (i.e. similar revenue composition and capital intensity). Therefore, the results should only be interpreted as illustrative.[80] The table sets out premiums which would apply in the context of markets for existing capacity, and where all assets are at risk of being stranded, and a price-cap is in operation. The outputs should therefore be interpreted with caution. The columns in the table set out a wide range of fixed cost assumptions ranging from 10% to 75% - this is the proportion of opex which is assumed to be invariant to outputs levels. The rows in the table show different amounts of market share losses – extending all the way to 20%. In practice industry fundamentals could restrict net market share losses to significantly smaller sizes. We discuss this further in sections 6 and 7.

5.61 Different fixed costs and market share loss combinations result in very different outcomes. Where a relatively lower proportion of operating costs are invariant to output – which is likely be realistic over longer-term horizons – and market share losses are restricted, the transitional premium can be less than 1%. At the other extreme the premium could be as large as 2%.

[79] Professor Martin Cave (April 2009) *Independent review of competition and innovation in water markets*, paragraph 4.26.

[80] Risk premium calculations specifically calibrated to water resources and sludge are presented in subsequent sections. Calibrations to the "industry" level represents post-reform figures provided by Ofwat.

Table 18: Transitional risk premium to the WACC – full RCV exposed to competition

		Proportion of operating costs which are fixed			
		10%	25%	50%	75%
Market share loss	5%	0.3%	0.4%	0.4%	0.5%
	10%	0.6%	0.7%	0.9%	1.1%
	15%	0.9%	1.1%	1.3%	1.6%
	20%	1.3%	1.5%	1.8%	2.1%

Source: PwC analysis

Notes: risk premia shown abstract from RCV protections. Premia presented represent illustrative upper bound values.

5.62 Although we adopt a different approach, we note that the magnitude of the WACC premium presented in the table above overlaps with a WACC premium estimate of approximately 150bps to 400bps which was reached by NERA through benchmarking of electricity plants which operate in highly competitive environments with no regulatory protections (see box 1 below for a full discussion). An important note of distinction is that in NERA's analysis changes to the WACC were applied through increases to beta, rather than being transitional. In contrast, we do not find that market reforms under consideration by Ofwat lead to increases to beta as potential market share losses are a diversifiable risk (see *Appendix B* for discussion on competition risk and beta).

5.63 The analyses presented above demonstrates possible adjustments that may be required to where downside risk to investors is substantially heightened. However, as we go onto discuss in the following subsection, regulatory protections in the form of RCV allocation and RCV protections can materially mitigate risks to investors. A similar observation was made in the Cave review, where it was noted that reductions to the scope of market opening and extent of value chain exposed in addition to protections against asset stranding could '*reduce the estimated impacts on financing costs, potentially significantly*.'[81]

Box 1: Cave Review and market benchmarking of the impact on WACC

In 2008 on behalf of 15 water and sewerage companies NERA produced a study into the financial implications of competition models. We summarise NERA's analysis regarding the impact of competition models on the cost of capital below and then discuss how this evidence was employed in the Cave Review.

Summary of NERA's WACC premium analysis:

NERA found that, *'drawing on market evidence and analyst reports in other sectors… as well as our discussions with investors, we estimate that new resources and treatment business units operating in contestable markets will face increased cost of capital of between 100bps (in long-term contract single buyer situations) and 400 bps (in wholesale markets) relative to the regulated integrated business.'*[82]

NERA's assessment placed these value chain segments outside the scope of regulation, placing risks with investors. Introducing risks associated with a competitive environment which were not present pre-reform or which were passed back to customers through regulatory mechanisms. In other words, NERA assumed there was no regulatory protection in place for the water resources and water treatment segments of the value chain.

[81] Cave (2009) *Independent review of competition and innovation in water markets: final report*, paragraph 4.95.

[82] NERA (2008) *Financial implications of competition models Water UK*.

These cost of capital increases were focused on changes to beta (non-diversifiable risks),[83] and then expected maximum financial leverage was separately assessed. The WACC premiums of 100bps and 400bps were primarily based on evidence from energy sector benchmarks:

- The increased cost of capital estimate of 100bps for "single buyer situations" refers to a single-buyer signing a long-term "life-of-plant contact" – these contracts may be required because without them investors may be reluctant to sink fixed capital.
- The increased cost of capital estimate of 400bps for "wholesale markets" refers to a merchant plant operating in a wholesale competitive market – facing wholesale market price uncertainties without the security of a long-term contract of regulatory protections regarding capital cost recovery.

A key driver of systematic risk in NERA's framework is that a producer's financial performance depends on potentially volatile market prices and inputs prices – which they say are likely correlated with macro-economic factors. These risks are said not to be transferred or mitigated through contracts or regulation. Based on this logic, NERA form the expectation that '*market of beta risk for water producers in wholesale markets to be notably higher than that of an integrated regulated water business*.'

Acknowledging that the key sources of evidence for the magnitude of the WACC increase proposed by NERA were:[84]

- A Credit Suisse research note on International Power plc (who have a portfolio of contracted and merchant plants) comparing the WACC differences (driven by beta risk) between contracted and merchant electricity plants in the US, Australia and Europe – finding a premium of 370bps to 410bps.
- Morgan Stanley research suggesting a lower premium of 150bps for the worldwide set of International Power's contracted plants versus merchant plants, noting that this premium could be higher where plants face higher commodity or technology risks.
- Comparing contracted plants relative to a regulated integrated or network business, NERA cite the same Morgan Stanley research paper which estimates an asset for contracted plant of 0.6. NERA assume an asset beta of 0.4 for a network utility, and then show that this implied a WACC premium for a contracted plant of 100bps.

<u>Summary of NERA capital structure analysis:</u>

NERA separately assess the maximum efficient capital structure for each business element – based on actual company gearing rather than notional industry values. The main sources of evidence employed are a research note from S&P and interviews. Based on these sources, NERA used:

- A maximum gearing for a network business with structured financing of 85%.
- A maximum gearing for a network business with listed equity of 70%.
- A water production (water resources and water treatment) entity in a wholesale competitive market with a BB credit rating could have a gearing of 35% to 50%, and for a BBB+ rating a maximum gearing of 35%.
- A water resources and water treatment entity under a single buyer structure (i.e. long-term contract) a maximum gearing of 55% to 70%.

<u>Application in the Cave Review</u>[85]

The Cave review noted that evidence available on cost of capital impacts is limited, and will depend on the characteristics of the regulatory and legal framework in place. However, it did acknowledge that investors would expect a higher cost of

[83] Our assessment of the linkages between contestability and beta finds that there is not necessarily beta increases where market access is established. The application of this finding to water resources and sludge are discussed in Sections 6 and 7 respectively.

[84] Morgan Stanley (December 2007) *Higher for Longer Commodity Prices: Buy Generators Focus on Clean Energy*, page 11; Credit Suisse (May 2006) *International Power*, page 19.

[85] Cave (2009), *Independent review of competition and innovation in water markets: final report*.

capital to compensate for the risks associated with a competitive environment. Further adding that these impacts would be more pronounced where focussed RCV allocation was adopted.

The review cited the evidence presented by NERA (as discussed above) but highlighted that competitive models it was proposing differed from those examined by the water companies with respect to market opening, exposure to competition and regulatory protections. Going on to state that the differences in these factors could reduce the estimated impacts on financing costs significantly.

RCV and access prices which reflect full economic costs

5.64 In the absence of additional regulatory mechanisms, in order for access prices to reflect the full economic costs borne by new entrants, a focussed RCV allocation is required. This is because a focussed allocation creates return for the contestable area that is based on MEAV values, removing the distortions created by the RCV discount.[86] Where full economic costs are not reflected then the likelihood of entry is markedly reduced.

5.65 However, depending on the size of the contestable MEAV relative to the size of the wholesale RCV, a focussed approach may expose a considerable level of capital to competition risks. As we go onto discuss in the subsection below, such concerns may justify protections in the form of alternative RCV allocations.

Review of features – RCV based regulatory protections

RCV allocation

5.66 Possible reform options for RCV allocation are described as "focussed" or "unfocussed". We define each approach below:

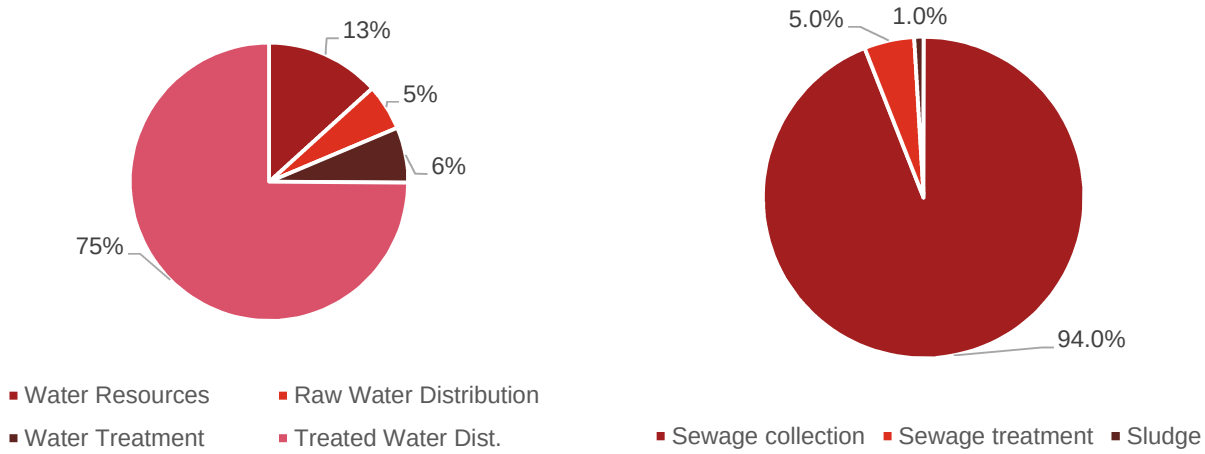
i) Focussed: this approach takes the MEAV (£m) of a particular business segment and truncates the relevant wholesale RCV by that monetary amount – as MEAVs are large relative to RCV this method results in a higher proportion of RCV in the contestable area.

ii) Unfocussed: this approach allocates RCV proportionally based on the relative size of MEAVs across segments. This method results in a relatively lower proportion of RCV in the contestable area.

5.67 To illustrate the differences between these two approaches, the figures below calculate how RCV would be split under an unfocussed MEAV allocation across the wholesale water and wastewater value chains, respectively (based on FY2015 data), and how the total RCV would be allocated to contestable segments under a focussed approach. Under an unfocussed approached, water resources would account for 13% of water RCV, and sludge would only account for 1% of wastewater RCV. Under a focussed approach the split of RCV would result in approximately 67% of water RCV being allocated to water resources, the equivalent figure for sludge and wastewater RCV would be approximately 10%.

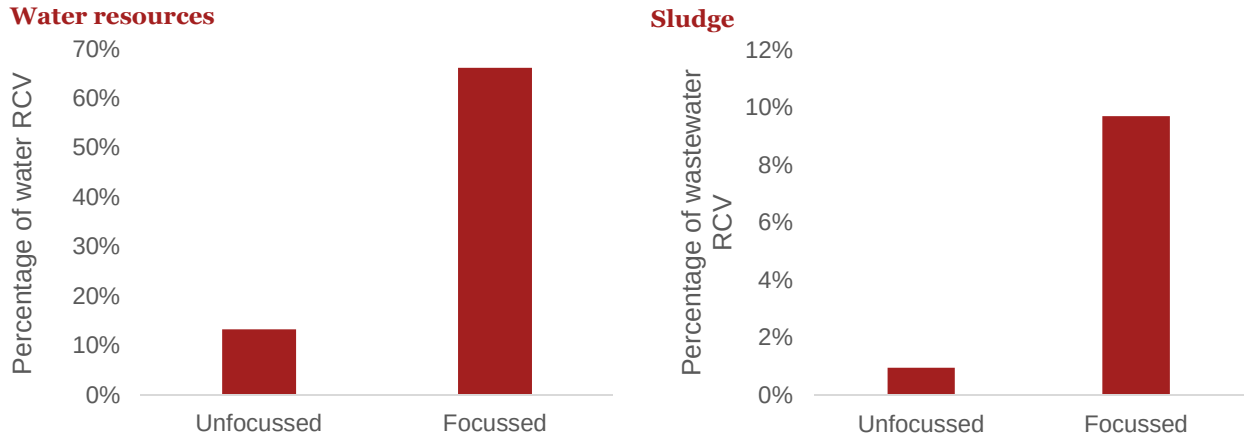
[86] At privatisation the RCV was set at a substantial discount to the MEAV of all water company assets.

Figure 27: value chain – unfocussed MEAV allocations



Source: PwC analysis

Figure 28: value chain – focussed MEAV allocations



Source: PwC analysis

Focussed RCV allocation

5.68 A focussed RCV allocation has implications for the cost of capital in both the monopoly network elements of the value chain as well as the contestable element. This occurs through the change to capital intensity due to the interaction of a focussed allocation and the existence of a large RCV discount to MEAV values. This change in capital intensity has the potential to change both asset beta and gearing.

Impact on beta: focussed

5.69 A focussed approach to allocating RCV to the contestable area results in a larger allocation of RCV. This can alter capital intensity figures compared to the capital intensities calculated in the assessment of the current risk landscape.

5.70 Using data from Ofwat, we find evidence to support an increase in capital intensity where RCV is allocated on this basis.[87] Comparing value chain segments who had lower capital intensities in the current risk landscape to their ranking post-focussed RCV allocation, showed that there could be movements in ranking relative to other segments.

[87] In this instance we measured capital intensity as operating cash flow as a proportion of revenue.

5.71 The capital intensity analysis set out in the current risk landscape section above showed that, those segments of the value chain which are more capital intensive may have lower asset betas, while less capital intensive segments may have higher asset betas. When we allocate RCV to a segment on a focussed basis, we may therefore expect an impact on the asset beta of that segment (and an offsetting adjustment elsewhere in the value chain). Namely, that a focussed allocation is likely to lead to a lower asset beta in the contestable a segment, but that in the non-contestable segments a countervailing decrease in capital intensity could raise asset beta.

5.72 The extent to which capital intensity if re-distributed will depend on the £m MEAV value of the contestable segment relative to the wholesale RCV. Where MEAV of the contestable segment is a material proportion of wholesale RCV we would expect an upward beta adjustment to the monopoly elements of the value chain due to capital intensity reduction – leaving no net impact on a capital weighted basis across the wholesale value chain.

5.73 **Conclusion:** The magnitude of beta adjustments will depend on the MEAV size of the contestable segment.

Impact on gearing: focussed

5.74 Where the RCV is allocated on a focussed basis, the contestable segment has an asset base commensurate with market benchmarks. This is because the "new RCV" in the contestable segment no longer reflects the RCV discount established at privatisation. Where access prices are aligned with RCV allocation, this allocation should help to create entry incentives, raising competition risks for the contestable segment. The Cave review noted that, in respect of changes to the cost of financing, '*these impacts would be more pronounced where a focused approach to the allocation of the regulatory capital value between business units was adopted or the whole regulatory capital base was at risk*.'[88]

5.75 Market benchmarks for some contestable segments suggest that gearing could be around 40%.

5.76 There will not be any significant impact on gearing levels for the monopoly segment, but absolute debt levels will fall, as RCV is allocated to contestable segments. This may lead to challenges in relation to existing financing. The debt covenants which are built into the financing structures of many water companies are designed to protect creditors from significant changes to industry structure.[89] In the absence of regulatory protections, more extreme market reforms could potentially create financing disruption in the sector should covenants be breached. While the economic gearing of non-contestable segments of the value chain may not change, and gearing of the contestable areas may, and the impact on debt covenants could be amplified if the ratings agencies and debt investors continue to focus on the RCV held in the non-contestable area of the business in relation to the overall net debt of the appointee water company. This could create a transitional financing challenge, or a requirement to amend either the debt or debt service figures to account for the contestable area with allocated RCV. We consider it is the economic gearing of different activities which is more important to how Ofwat sets allowed returns, and not such financing issues.[90]

5.77 **Conclusion:** There is a potential reduction in gearing to around 40% in contestable segments, but no change in monopoly segments.

Unfocussed RCV allocation

5.78 As demonstrated by Figure 28 above, the size of contestable RCV can vary considerably depending on the RCV allocation methodology adopted. An unfocussed allocation offers more protection to investors,

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[88] Cave (2009), *Independent review of competition and innovation in water markets: final report*, paragraph 4.93

[89] Moody's Investors Service (14 October 2015) *Upstream reform could muddy UK waters.*

[90] We note that the capital structure of Ofwat's notionally financed water company in PR14, geared at 62.5%, provides considerable headroom compared to gearing covenants used in water company financing.

as much larger element of the RCV remains in the monopoly network segments of the value chain. These elements are not exposed to competition risks, and therefore there is lower potential for capital cost under recovery.

5.79 As our current risk assessment allocates capital on the basis of unfocussed MEAV (for example our value at risk analysis), where an unfocussed allocation approach is used, we do not need to make any further adjustments to either beta. Despite some RCV being allocated to the contestable area, potentially putting the recovery of the associated capital costs at risk, we see the likelihood of this being negligible where access prices are reflective of an unfocussed RCV allocation.[91]

Treatment of RCV

5.80 Since privatisation of the water industry the RCV has been an essential part of providing stability for investors. It anchors investors' expectations regarding the likely returns they can receive and is employed in debt covenants across the industry. The regulatory commitment to the RCV has lowered risk to investors and historically has allowed the water industry to achieve low debt financing costs.

5.81 Any changes to the RCV are therefore very important to investors. This sentiment was captured in a CCRP paper, stating that, '*if UK regulators were seen by investors as violating that spirit [commitment to the RCV], then the RAB's credibility as a commitment device could disappear very quickly – and would probably be virtually impossible to retrieve. In this regard, investor perceptions are almost as important if not more important than observed developments… the key to RAB success is that it provides effective protection against asset stranding e.g. by regulatory arbitrarily changing the rules on depreciation or asset classification.*'[92] As allocation of RCV to contestable areas can increase its exposure to competition risk, Ofwat is considering protection to the RCV to ensure that historic commitments to the RCV are maintained through the process of introducing new market mechanisms.

5.82 Possible treatment of the RCV in our reform options is:

i) New investment being exposed to competition – this will hold across all options. This means that the capital costs associated with new investment into the RCV on an ongoing basis will be not be guaranteed recovery through allowed revenue (only applied to the contestable elements of the value chain).

ii) Pre 2015-2020 RCV being exposed to competition – this means that in addition to new investments, an additions to the RCV that were made during AMP6 will also be at risk.

iii) Pre 2015 RCV being exposed to competition – this means that the full existing RCV allocated to the contestable elements of the value chain will also at risk. This would contravene previous commitments Ofwat has made regarding the pre-2015 RCV.

Impact on beta

5.83 Allocating RCV to contestable segments of the value chain means that the capital costs associated with that RCV can be put at risk through potential market share losses. RCV protections have the potential to mitigate these impacts, but as set out in *Appendix B* we discuss the impact of competition and market share loss on beta, and conclude that for a sufficiently diversified investor, market share loss is a diversifiable risk.

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[91] This does not hold across all reform options, we discuss individual reform packages in Sections 6 and 7.

[92] Stern, J (2013) *The role of the regulatory asset base as an instrument of regulatory commitment*, CCRP discussion paper.

5.84 For all of the RCV options set out above, we conclude that there will be no impact on beta, this is because the risks here are specific to regulated water companies in England and Wales.

Impact on gearing

5.85 For new investments being exposed to competition, there will be no change to gearing in the short-term. This is because it will take time for the "new RCV" for the contestable areas to build-up, and the existing RCV will still benefit from regulatory protections.

5.86 Comparators which do not receive asset protections can inform our understanding of what gearing levels are sustainable should Ofwat change its treatment of the pre-2015 RCV. Drawing upon the comparators operating in competitive markets (set out in *Appendix C*) we find that broadly, the average gearing across the "sludge plus" and "solid waste plus" and "other waste plus" comparators is approximately 40%. The suitability of these competitive comparators will vary depending on the contestable segment of the value being analysed. However, gearing capacity could also decline further than this as a result of retrospective changes to RCV commitments, increasing regulatory risk from the viewpoint of investors.

Impact on transitional risk premium to the WACC

5.87 Although the degree of competition in contestable segments will depend on other design features, we update our analysis of the transitional premium to the WACC to the uplift where only new RCV investment is exposed to competition risks. This is set out below and contrasts to the results set out in Table 18 above where the full RCV is exposed to competition. The outputs in Table 19 below therefore incorporate some degree of RCV protection, however, the outputs still reflect downside market share loss scenarios rather than expected outcomes. Except for the degree of RCV protection, we use the same assumptions set out in paragraph 5.60.

5.88 Here the premium reflects the uncertainty investors face regarding the cash flow profile of new investments into the RCV. Initially the outcomes of market reforms will be unknown, however, after some years (in our analysis regarding new investment we focus on a 10-year time horizon) investors have more complete information regarding asset utilisation and that is when the transitional premium is no longer relevant. We re-emphasise here that the premiums present only apply where investors do not consider material upside potential from reforms.

5.89 The full methodology underlying our calculations for the risk premium are set out in *Appendix I*.[93]

5.90 Table 19 below shows that as the proportion of operating costs which are fixed rises, then the premium required increases – this result is intuitive.[94] However, the risk premium is not always increasing as market share losses rise. The reason for this seemingly anomalous results is that the market share losses begin in the early years of contestability. In the very first year, the "new RCV" has yet to accumulate, while the "old RCV" is still undepreciated. As the capital costs associated with the old RCV are protected through allowed revenue (as are expected operating costs) revenue is very insensitive to market share loss in the early years of contestability. Meanwhile outturn operating costs (which differ from expected operating costs) fall with lower output - especially when the proportion of fixed costs is low. This widens margins when output falls. If we were to consider later years where the "old RCV" has largely depreciated away, this effect would not be present, but, by such time a transitional WACC premium would not be necessary.

[93] One limitation of note is that investors do not adjust their capex in response to market share loss in the initial years under consideration. In practice where market share was lost, capex may adjust more rapidly in response.

[94] Although output falls where market share is lost, depending on the asset type in question, opex may not be fully variable in the short to medium term, particular where assets run at lower capacity rather than being mothballed – and even in the latter case there will still be some fixed costs present.

5.91 Focusing on the assumption that 25% of operating costs are fixed, the transitional risk premia to the WACC is 0.2% at 10% market share loss. Where fixed costs are 75% (an extreme assumption) the premium is 0.3% for a 25% market share loss. These figures are substantially lower relative to the case where the full RCV is exposed to competition risks, demonstrating that regulatory protections can limit investor impacts in downside scenarios.

Table 19: Transitional risk premium to the WACC– new investment exposed to competition

		Proportion of operating costs which are fixed			
		10%	**25%**	**50%**	**75%**
Market share loss	**5%**	0.1%	0.1%	0.2%	0.2%
	10%	0.1%	0.2%	0.3%	0.3%
	15%	0.2%	0.2%	0.3%	0.3%
	20%	0.2%	0.2%	0.3%	0.3%

Source: PwC analysis

Notes: Premia presented represent illustrative upper bound values.

5.92 **Conclusion**: Where investors anticipate very limited upside potential from market reforms, a transitional WACC premium could be warranted, but where only new investment is exposed through regulatory protection of the existing RCV, the premiums are at most 0.3%. Where investors' expectations are not so heavily orientated to downside scenarios, the premium required could be substantially less than this or even negated entirely.[95]

5.93 In the following sections, we move from a general framework into assessing the specific reform options for water resources and sludge.

[95] Premiums may even be negative where expectations are orientated to the upside; this could occur where there was spare capacity available to an incumbent, with potential new sources of income and where logistical barriers were low.

6. Water resources reform options

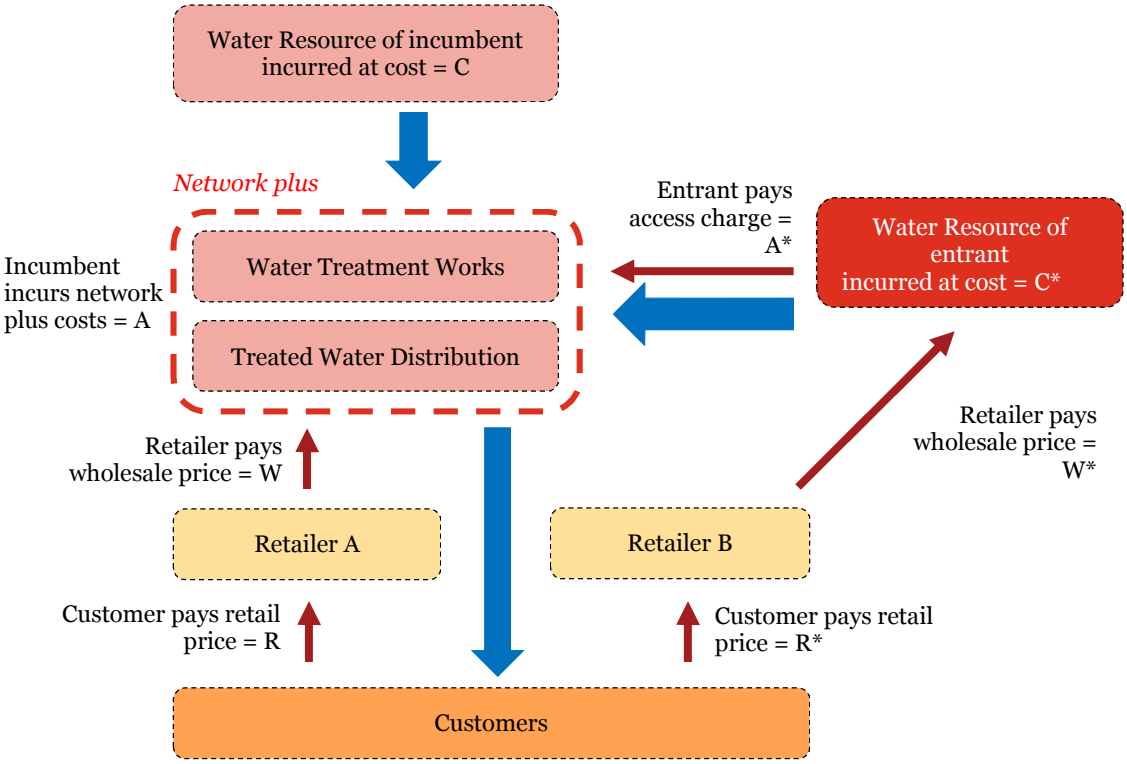
Market design for water resources

6.1 In the water wholesale value chain, Ofwat is considering making water resources a contestable area. Under the current reform proposals, water treatment and treated water distribution segments would remain monopoly elements – together these are referred to as "network plus".[96]

6.2 Regarding the market design of water resources, Ofwat has indicated to us that the design of access pricing and the allocation of RCV will mean that entry to compete for existing resources is unlikely to be feasible. Therefore market reforms will be focussed around the direct procurement framework, where companies bid to build/provide water resource as and when tender opportunities arise. Once new investments are made by the successful bidder, there is not expected to be cost recovery risk, for example through long-term contracting. In the absence of guarantees regarding cost recovery it would be unlikely that entrants would invest in high value assets with long lives (characteristics of the water resources part of the value chain). Therefore, competition will be for new capacity only and not existing capacity.

6.3 For water resource providers who are providing incremental services i.e. new capacity, market access (to retailers) would be provided through access prices paid to access the "network plus" element of the incumbent's value chain – covering water treatment and treated water distribution. The figure below illustrates this market structure.

Figure 29: Stylised water resources access pricing



[96] There is some scope for entry into water treatment where it is efficient to do so for a new resource providers, however, the water treatment still remains in the protected RCV.

Description of reform options

6.4 We consider four reform options in Table 20.

Table 20: Water resources options

Reform features	Reform 1	Reform 2	Reform 3	Reform 4
Price controls	Integrated wholesale control	Integrated wholesale control	Separate binding control	Separate binding control
Enabling mechanisms	None	None	CFD / split contracts	CFD / split contracts
RCV allocation	None	Unfocused MEAVs or unfocused capex	Unfocused MEAVs or unfocused capex	Unfocused MEAVs or unfocused capex
Access pricing	Wholesale minus	Wholesale minus	Wholesale minus	LRIC
Treatment of pre-2015 RCV	Not at risk	Not at risk	Not at risk	Exposed to markets
Treatment of 2015-2020 RCV	Not at risk	Not at risk	Exposed to markets	Exposed to markets
Treatment of new investment	Exposed to markets	Exposed to markets	Exposed to markets	Exposed to markets

6.5 Key aspects for each of these reforms include:

- For Reform 1, there is little departure from the current market design under which the NAV (New Appointment or Variation) regime operates. The most significant change is that markets will be introduced for new investment. Under this reform, new water resource providers can sell new capacity to retailers through paying a charge to access the incumbent companies "network plus" value chain segments.
- Reform 2 introduces RCV allocation on an unfocussed basis. Allocation of RCV on this basis allows the monopoly network elements of the wholesale water value chain to retain the substantial amount of the RCV. Consistent with option 1, new investment being exposed to markets takes the form of direct procurement.
- Reform 3 creates a separate binding control for water resources along with enabling mechanisms (such as contracts for difference). Additionally, less RCV protection is offered, as not only is new investment into the RCV exposed to competition, but any RCV from the 2015-20 period is also exposed.
- Reform 4 has access prices paid for accessing the "network plus" elements of the water value chain which are set by applying a long-run incremental cost ("LRIC") rather than a wholesale minus approach. Furthermore, RCV protections are removed entirely, and the full RCV (both existing and new) which has been allocated on an unfocussed basis to water resources is exposed to competition. As existing assets are exposed to competition we assume that markets are introduced for existing capacity, exposing some existing assets in the contestable segment to cost recovery risk.

Potential for market entry

6.6 As the market designs are orientated towards direct procurement for customers, the potential for market entry is limited to the provision of new capacity. Given the long-asset lives present in water resources, we would therefore expect the pace of market entry under this design to be very gradual.

6.7 If design options are orientated towards markets for existing capacity in water resources, the potential for entry into the water resources market is still expected to be limited. This expectation is formed from a combination of water resource scarcity where demand is high or current abstraction is unsustainable,[97] and the costly nature of transporting water over long-distances. Due to high pumping costs, for a new entrant to be competitive it would require a source to be located near the network of an incumbent company.[98] Company comments highlighted in the Cave Review support this view. For example, Severn Trent stated that, '*the risk of stranding is likely to be low due to the cost of introducing links to transport water from one area to another, and because increased resource capacity is needed to meet the impact of climate change and environmental pressures on existing abstractions.*'[99] Over the longer-term barriers to entry could be reduced through technological advancements, but in the near-term the scope for such advancements in water resources appears limited.

Impact of reform options

6.8 Table 21 below shows the potential cost of capital impacts across each of the four reform options we consider. We discuss the result of each reform in more detail below.

Table 21: Summary of reform options for water resources

<table>
<tr><th>Cost of capital component</th><th>Reform 1</th><th>Reform 2</th><th>Reform 3</th><th>Reform 4</th></tr>
<tr><td>Beta</td><td colspan="4">No change to current risk assessment betas across the value chain.</td></tr>
<tr><td>Gearing</td><td colspan="3">No change to gearing in the contestable area.

No change to gearing in "network plus" value chain.</td><td>Potential gearing reductions of 10% to 20% for contestable segment. However, in practice barriers to entry in the water resources market may mean that potential market share losses for incumbent's existing capacity is very limited.</td></tr>
<tr><td>Transitional premium above WACC</td><td colspan="3">Where there is direct procurement for customers, existing investors are not exposed to new cash flow uncertainties. Market design also restricts cost recovery risk on new investments once sunk. No premium required.</td><td>Up to 1% premium above WACC where water investors do not view material potential upsides from reform.</td></tr>
</table>

Source: PwC analysis

[97] Predominantly in the South East of England.

[98] Potential will be higher where the incumbent is currently pumping water long distances and a potential entrant has closer resources.

[99] Cave (2009) *Independent review of competition and innovation in water markets: final report*, paragraph 4.25.

Reform 1

6.9 Reform 1 does not present a significant departure from the new appointments or variations (NAVs) regime currently in place. Ofwat already has the power to determine the access price paid by new appointments where parties cannot agree bilaterally. There are no changes to price control format and no RCV allocation for the incumbent.

6.10 Although new investment is exposed to competition, this competition will operate only at the point of procurement and once procured, investment will not be exposed to stranding risk. As such, we do not consider that any adjustment to beta, gearing or transitional premium to the WACC are necessary.

Reform 2

5.94 Relative to Reform 1, Reform 2 differs only through an RCV allocation to water resources activities. The extent to which the incumbents will be able to cover the costs associated with this capital will depend on the degree of competition. This in turn is partially dependent on the extent to which the estimate of costs avoided in the wholesale minus framework reflect the economic costs of new entrants. As shown in Figure 27 above an unfocussed RCV allocation will result in approximately 13% of water RCV being allocated to water resources.

6.11 The level of gearing for this option could be negatively impacted by investor perceptions of the RCV split. In this instance, investors are likely to be less concerned about market share loss through competition given the direct procurement framework, concerns about whether debt covenants are at risk is mitigated by the form of market proposed.

6.12 We do not find that competition or entry incentives are likely to be systematic for water resources, nor is there any adjustments to price control format, therefore we do not consider there is a need to adjust beta. Lastly, there is no change to capital intensity relative to the current risk landscape due to unfocussed allocation, and hence no alteration to beta through capital intensity effects.

6.13 Overall Reform 2 shows negligible difference (namely in the short-term) to the current risk landscape. This is consistent with previous direct procurement experience such as Thames Tideway, which had a low cost of capital.

Reform 3

6.14 Under Reform 3, water resources would have a separate binding control. This change is not expected to have a material impact on the cost of capital where there is no material divergence of incentives between the separated controls. As Reform 3 remains a revenue control, we see no reason to make an adjustment to beta as there is no material change to the intensity of regulation.

6.15 Reform 3 also involves the 2015-2020 RCV being exposed to competition (for discussion on markets for all existing capacity see Reform 4). Evidence set out in box 1 above found that gearing could be lower under a regime of long-term contracts. However, given that this regime would only apply to new incremental investments any transition would be gradual. We also note that investor perceptions of regulatory risk may increase if exposing the 2015-2020 RCV to competition, as such a change could be interpreted as retrospective i.e. AMP6 investment plans for water resources have been prepared under the assumption that efficiently incurred capital costs could be fully recovered. Gearing may be reduced due to increased perception of regulatory risks, but we address this point in full in Reform 4 below.

Reform 4

6.16 In Reform 4, the pre-2015 RCV is exposed to competition. This approach would be incompatible with a market design option where there were not markets for existing capacity. Therefore, we assume for this option there is the introduction of markets for existing capacity. Under such a design, the market share of existing capacity would be at risk, and in a situation where an incumbent lost market share, there could be risks of asset stranding.

6.17 In addition to the introduction of asset stranding risk on the existing RCV for water resources, placing the pre-2015 RCV at risk would represent a retrospective adjustment by Ofwat, and would contradict previous statements about regulatory commitments to protecting this RCV. The latter point would increase investor perceptions of regulatory risk across the value chain, and may be particularly acute in the segments where markets are introduced.

6.18 In addition, Reform 4 applies a LRIC approach to access pricing (rather than wholesale minus). The introduction of LRIC will introduce additional investor uncertainty, as past regulatory experience has shown that different judgemental inputs can lead to substantially different outputs.

6.19 The combination of LRIC and exposing the pre-2015 RCV to competition is likely to lead to a significant reduction in gearing relative to current levels as investor uncertainty will increase substantially.

6.20 Furthermore, a LRIC approach may provide greater entry incentives relative to other options, leading to higher expectations of market share losses. However, because of the high barriers to entry in water resources, particularly for displacing existing capacity, we would expect any market share losses to be minimal (see transitional premium to the WACC below).

Transitional risk premium to the WACC: markets for existing capacity

6.21 Where we consider a design where there are markets for existing capacity, and without RCV protections, then the existing RCV is exposed to cost recovery risk. Under this design, the need for a transitional risk premium to the WACC is more likely. This is because out-turn cash flows from assets under this market design have the potential to be reduced compared to a baseline scenario of full monopoly market share. Where investors consider there to be greater potential of downside risks and limited upside potential, a transitional risk premium to the WACC can be quantified.

6.22 The transitional risk premium estimates in the table below, have been calibrated to the water resources segment post-reform where RCV has been allocated on an unfocussed basis. This shows the premium required for various downside scenarios where the RCV is fully exposed to competition.

6.23 As we do not have information on the balance of fixed versus variable costs, our analysis models a range of fixed cost assumptions from 10% to 75% - as shown in the columns of Table 22. In the rows of the table we show market share loss sensitivities ranging from 2.5% to 10%.[100] In practice we expect that market share losses could be restricted to an even narrower band than this due to low potential for entry into the existing capacity market. As discussed above, there are significant entry barriers which are likely to prevent the displacement of existing capacity, the main drivers of this are the cost of transporting water and water resource scarcity.

6.24 Due to model limitations the results should only be interpreted as illustrative. The full methodology underlying our calculations for the risk premium are set out in *Appendix I*.

[100] Larger market share losses are considered for the sludge segment of the value chain reflecting its relatively higher potential for new entry.

Table 22: Transitional risk premium to the WACC - full RCV exposed to competition

		Proportion of operating costs which are fixed			
		10%	**25%**	**50%**	**75%**
Market share loss	**2.5%**	0.1%	0.1%	0.2%	0.3%
	5.0%	0.2%	0.3%	0.4%	0.6%
	7.5%	0.2%	0.4%	0.6%	0.9%
	10.0%	0.3%	0.5%	0.8%	1.1%

Source: PwC analysis

Notes: Premia presented represent illustrative upper bound values.

6.25 Although we consider that market share losses approaching 10% would be high in the water resources segment, this exercise is useful in order to find the limit to the size of a transitional premium to the WACC.

6.26 Focusing on all but the most extreme combinations of market share loss and fixed costs assumptions, we find that a transitional WACC premium is unlikely to exceed 1%. Moreover, we note that a premium approaching 1% in size would only be suitable where investors expected significant downside risks relative to upside potential. Where operating costs are more variable, the premium could also be substantially lower, as shown by the observations in the upper-left hand quadrant of the table.

Transitional risk premium to the WACC: competition for new capacity

6.27 Where we consider competition for new capacity, then a transitional premium to the WACC is not required. Under this design, there is no asset stranding risk for existing assets. Therefore, the cash flow profile associated with investments in existing assets remain unaffected by the market design.

6.28 Additionally, once investments relating to the provision of new capacity are made, Ofwat will mitigate cost recovery risk through contracting provisions (or through other regulatory protections). Had there been more significant asset stranding risk associated with new investment i.e. through an alternative market design, then a transitional premium may have been required due to the uncertainty regarding future cash flow profiles.

6.29 Introducing competition for new capacity could ultimately affect the size of the incumbent's water resources business, but there is no reliable link between company size and the cost of capital.[101] Moreover, given the long-asset lives present in water resources, any potential change would take place very slowly.

[101] See discussion in PwC (2014) *Company specific adjustments to the WACC: a report prepared for Ofwat*.

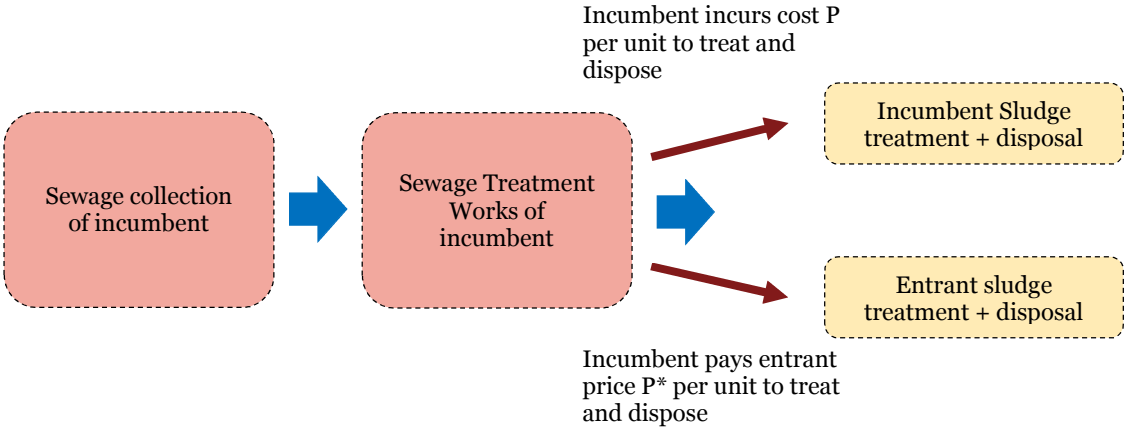
7. Sludge reform options

Market design for sludge

7.1 The proposed market design of sludge takes a different form to that of water resources. As set out in the figure below, rather than an "access price", there is a "gate price" for sludge.

7.2 For entrants providing sludge services, the price paid/received[102] is a gate price paid by the incumbent wastewater business. In the stylised arrangement shown in the figure below, this gate is situated after the sewage treatment works. However, there could be additional points of access within the sludge chain of activities.

Figure 30: Stylised sludge gate pricing



7.3 Regarding the market design for sludge, Ofwat has indicated that it will introduce markets for existing as well as new capacity. Under this design there could be asset stranding risks for incumbents where entrants can offer treatment and/or disposal at more competitive rates. Depending on the degree of RCV protection, these asset stranding risks could apply to just new investments or the entire RCV allocated to sludge.

Description of reform options

7.4 We consider four reform options in Table 23.

[102] If sludge has a negative value, then there is a market for its disposal rather than purchasing a good per se.

Table 23: Sludge options

Reform features	Reform 1	Reform 2	Reform 3	Reform 4
Price controls	Integrated wholesale control	Separate binding control	Separate binding control	Separate binding control
RCV allocation	None	Focused MEAVs	Focused MEAVs	Focused MEAVs
Access pricing	Wholesale minus	NA (reflects MEAV allocation)	NA (reflects MEAV allocation)	NA (reflects MEAV allocation)
Treatment of pre-2015 RCV	Not at risk	Not at risk	Not at risk	Exposed to markets
Treatment of 2015-2020 RCV	Not at risk	Not at risk	Exposed to markets	Exposed to markets
Treatment of new investment	Exposed to markets	Exposed to markets	Exposed to markets	Exposed to markets

7.5 Key aspects for each of these options include:

- For Reform 1, there is little departure from the current market design.[103]
- In contrast to Reform 1, Reform 2 introduces a series of changes. These changes include a separate binding control for sludge – which would most likely take the form of a price-cap; RCV allocation is done on a focussed basis raising the capital intensity of the sludge segment of the value chain; and an access price which reflects this RCV allocation is established.
- Reform 3 and Reform 4 are then identical to Reform 2 in all aspects except for the level of RCV protection. Reform 3 exposes the 2015-20 RCV to competition and Reform 4 exposes the full sludge RCV to competition.

Potential for market entry

7.6 The potential for market entry in sludge is greater than that of water resources, but some barriers to entry still exist. One of the key opportunities in the sludge market is the opportunity to earn revenue from energy generation. Our conversations with industry experts highlighted that these opportunities could be capitalised through the combination of sludge with the processing of other organic wastes. Therefore, there is not just scope for WaSCs to compete with one another, e.g. if one WaSC had under-utilised sludge assets near the sewage treatment works of another neighbouring WaSC, but also scope for organic waste treatment and disposal companies to compete in the market.

7.7 Two constraining factors on market share losses are the logistics between sewage treatment and sludge, and also the costs of transport. Specifically, the incumbent WaSC will require clear visibility over which entities are providing sludge treatment/transport capacity, i.e. which parties have capacity to take given quantities. This is because the flow of wastewater to the sewage treatment works is largely out of the control of the incumbent WaSC, and hence so are sludge volumes. Any back-up through the system where sludge is not taken away can have serious cost implications, and can harm both the incumbent's assets and its performance against pollution targets. Agreeing to process or transport a large proportion

[103] Upside may be limited as revenue generated from outside the sector through sludge activities is treated as a negative cost, and therefore there is sharing with customers on a 50:50 basis.

of sludge from an incumbent can therefore represent a substantial logistical commitment for an entrant.

7.8 Furthermore, the scope for competition at some sewage treatment works (particularly larger works) is restricted by the Sludge Treatment Centre (STC) being co-located. The OfT's market study into the organic waste market estimated that 60 to 70% of total sewage sludge produced in the UK is treated on the same site at which it is produced.[104]

7.9 Regarding transport costs, where sludge is transported, it is typically by road, and, as sludge is a heavy good and hazardous in nature, it has high transport costs. As a result, where sludge treatment is not co-located with sewage treatment, entry is still constrained by the location of that sewage treatment works relative to the assets of potential competitors. Analysis of potential entry is shown in the table below, and shows that the majority of WaSCs only have one STC within a 50km radius.[105]

Table 24: Number of rival WaSCs with STC within 50km

Number of WaSCs	Proportion of STCs (%)
Three	2%
Two	23%
One	42%
Zero	33%

Source: Ofwat

7.10 Overall, the market evidence suggests there is clear entry potential, particularly as energy generation opportunities evolve. However, there are material barriers that prevent incumbents losing large proportions of their existing markets.

Impact of reform options

6.30 Table 25 below shows the potential cost of capital impacts across each of the four reform options we consider. We discuss the result of each reform in more detail below.

[104] Office of Fair Trading (2011) *Organic waste: An OFT market study*, paragraph 3.17.

[105] Of these sites it is not apparent which of these are also co-located.

Table 25: Summary of reform options for sludge

Cost of capital component	Reform 1	Reform 2	Reform 3	Reform 4
Beta	No change in beta.	Overall impact on beta is close to zero as increase due to the shift to a price-cap is broadly offset by increase in capital intensity as a consequence of a focussed RCV allocation. No change to beta in "network plus" segment		
Gearing	No change in gearing.	Gearing reduced by around 2.5%. in sludge No change in gearing in "network plus" segment provided debt covenant thresholds can be updated for new regulatory regime.	Gearing impacts likely to fall between option 2 and option 4, – but weighed towards the premium set out in option 2.	Gearing benchmark for sludge business with competition and volume risk ~40%. Reductions may apply to "network plus" due to regulatory risk from RCV commitments.
Transitional premium above WACC	Very limited expected market-share loss, no premium.	Up to 0.4% premium above WACC where water investors do not view material potential upsides from reform, but this could be substantially negated where investors anticipate potential gains from market reform.	Up to 0.8% premium above WACC where water investors do not view material potential upsides from reform, but this could be substantially negated where investors anticipate potential gains from market reform.[106]	Up to 3% premium above WACC where water investors do not view material potential upsides from reform, but this could be substantially negated where investors anticipate potential gains from market reform.

Source: PwC analysis

Reform 1

7.11 Reform 1 does not represent a significant departure from the current risk landscape. This options makes no adjustments to the price control or RCV allocation. We therefore see no reasons to adjust beta or gearing.

Reform 2

7.12 Reform 2 introduces several changes relative to the current risk landscape. Firstly, the introduction of a separate binding price-control for sludge means that the intensity of the regulatory regime will increase. As discussed in the review of features, such an adjustment could lead to an adjustment of up to 0.04 on the asset beta.

7.13 Allocating RCV on a focussed MEAV basis, and then setting access prices which reflect this MEAV allocation means that sludge gate prices are likely to reflect the full economic costs facing potential entrants. The combination of these two features is likely to facilitate entry. Over the long-term entry to this market may increase commercial focus on energy generation, this could arguable have some impact on systematic risk exposure, but this is not an immediate direct impact.

[106] With an assumption of constant RCV and a sludge asset life of 30 years, the proportion of RCV attributable to the 5 year period 2015-20 is one sixth of the total sludge RCV. We therefore add to the premium for new investment "exposed to competition", one sixth of the premium where the full RCV is exposed to competition.

7.14 A consequence of a focussed RCV allocation, through increasing the capital intensity of sludge, would be lower operational leverage. If the increase in capital intensity is sufficiently large, it may offset any operational leverage increase identified under the current risk landscape.

7.15 Overall the combined asset beta affects from the transition to the price-cap and increase capital intensity are expected to broadly offset each other, as a result the asset beta is unlikely change relative to our current state assessment.

7.16 Gearing is likely to be reduced under this option, as competition risks are increased. Gearing may decrease further if investors are concerned about the implications of splitting the RCV on debt covenants, however, some of these risks could be mitigated through engagement with investors during the consultation process.

7.17 Under Reform 2, conditions are likely to accommodate entry, raising the possibility of market share losses for the incumbent. We discuss the results of the risk premium to the WACC which would be required under different sets of assumptions below.

Reform 3

7.18 The only difference between Reform 3 and Reform 2 is that the 2015-20 RCV is exposed to competition. As this is a regulatory change which increases exposure to competition, this should not affect beta compared to Reform 2.

7.19 Gearing will reside between the gearing levels discussed in option 2 and option 4, reflecting the removal of RCV protections for the 2015-2020 RCV.

Reform 4

7.20 The only difference between Reform 4 and Reform 3 is that the pre-2015 RCV is exposed to competition. As this is, again, a regulatory change which increases exposure to competition, this should not affect beta compared to Reforms 2 and 3.

7.21 As the full RCV is exposed to competition under this option, the risk in the sludge business is more comparable to that of the competitive benchmarks set out in *Appendix C*. For "sludge plus" and "solid waste plus" combined the average gearing is approximately 40%. However, gearing could drop even lower than this is there are further reduction to regulatory uncertainty – this would stem from the rescindment of the pre-2015 RCV commitments.

7.22 Where the RCV is fully exposed to competition, a transitional premium to the WACC could be required where investors' expectations are weighed to the downside. We go onto discuss this is more detail below.

Transitional risk premium to the WACC

7.23 As the market design for sludge is expected to apply markets to all capacity, this gives rise to asset stranding risks which were not previously present where the sludge element of the value chain was part of monopoly wholesale sale activities of the vertically integrated incumbent. Where investors anticipate that there is limited upside potential to the new market design, a transitional WACC premium may be justified where Ofwat is seeking to fully compensate investors for the risks they bear.

7.24 The level of risk investors are exposed to will depend on the degree of protections afforded to them by Ofwat, of key importance is the treated of the pre-2015 RCV given that the return and depreciation elements associated with this RCV compromise a significant proportion of allowed revenues. Therefore we assess how the magnitude of a transitional premium is impacted by different levels of RCV protection.

7.25 The transitional risk premium to the WACC estimates set out in the table below, have been calibrated to the sludge segment after reform, where RCV has been allocated on a focussed basis. In the absence of

data on cost structure, we model a range of fixed cost assumptions from 10% to 75% (as shown by the columns in the table). We also show a range of market share loss scenarios, which vary from 5% to 20%. As discussed above, industry fundamentals are likely to restrict market share losses, and losses as large as 20% should therefore be considered an extreme downside outcome.

7.26 Due to model limitations the results should only be interpreted as illustrative. The full methodology underlying our calculations for the risk premium are set out in *Appendix I*.

Table 26: Transitional risk premium to the WACC – full RCV exposed to competition

		Proportion of operating costs which are fixed			
		10%	**25%**	**50%**	**75%**
Market share loss	**5%**	0.4%	0.5%	0.6%	0.8%
	10%	0.7%	0.9%	1.2%	1.6%
	15%	1.1%	1.4%	1.9%	2.3%
	20%	1.5%	1.9%	2.5%	3.1%

Source: PwC analysis

Notes: Premia presented represent illustrative upper bound values.

7.27 Although we anticipate that market share losses approaching 20% would be high, particularly given the high proportion STC's co-located with sewage treatment works, in order to find the limit to the size of a transitional premium to the WACC we test estimates to this bound.

7.28 Focusing on all but the most extreme combinations, we find that where no RCV protections are provided in the market design that a transitional WACC premium could be up to 3% in size. Where a higher degree of operating costs are variable and investors are less pessimistic about downside risks relative to upside potential, the maximum transitional WACC premium could be closer to 1%.

7.29 We now consider how the magnitude of the transitional premium to the WACC would change where RCV protections are given to the pre-2020 RCV.

7.30 Here the premium reflects the uncertainty investors face regarding the cash flow profile of new investments into the RCV. Initially the outcomes of market reforms will be unknown, however, after some years (in our analysis regarding new investment we focus on a 10-year time horizon) investors have more complete information regarding reform impacts and that is when the transitional premium is no longer required.

7.31 The table below shows the premium where only new investment is exposed to competition. We maintain the same range of market share losses for illustrative purposes but we consider that the range may be narrower in practice.

Table 27: WACC risk premium – new investment exposed to competition

		Proportion of operating costs which are fixed			
		10%	**25%**	**50%**	**75%**
Market share loss	**5%**	0.1%	0.2%	0.2%	0.3%
	10%	0.1%	0.2%	0.3%	0.4%
	15%	0.1%	0.2%	0.3%	0.4%
	20%	0.1%	0.1%	0.3%	0.4%

Source: PwC analysis

Notes: Premia presented represent illustrative upper bound values.

7.32 Where only new investment is exposed to competition, we anticipate that investors will consider the balance of risk to be weighed less to the downside. Furthermore, capex plans may be more responsive to early market signals than our modelling takes account of. For these reasons we consider that where the existing RCV is protected against asset stranding, and only new investment is exposed to competition, an appropriate transitional premium to the WACC is unlikely to be larger than 0.4%.

7.33 Compared to analysis set out in Section 5, the difference between the premiums under the full RCV exposure relative to only the new investment being exposed is smaller. In other words, the RCV based regulatory protections appear to have proportionally less of a benefit for sludge. This result can be explained by the depreciation rate applied to the sludge RCV and the nature of the RCV allocation assumed.

7.34 Regarding the depreciation rate, the model has been calibrated to have faster RCV run-off for the sludge RCV compared to the other segments modelled. This is consistent with shorter asset lives in sludge. As a result of faster RCV run-off, the protected revenue associated with the assets in the old RCV fades more quickly.

7.35 Regarding the RCV allocation, the focussed allocation means that sludge segment of the value chain is now significantly more capital intensive. As a result a far larger proportion of revenue for the sludge segment is comprised of return on capital and depreciation. A repercussion of this is that where market share falls a large amount, and there is an associated fall in output, the reduction in variable opex is small in comparison to revenue. Where revenue is largely protected and variable opex decreases a large amount, margins can be enlarged; this effect is diminished in the case of sludge as variable opex changes are far less material.

7.36 Despite the thinner safety cushion provided by RCV protections to the sludge segment, it should be noted that the premiums presented in Table 27 are still indicative downside scenarios investors could factor into their return requirements. These figures should therefore be considered alongside growth opportunities which may become available to WaSCs when assessing expected impacts.

8. Conclusion

8.1 This report has considered the current risk profile across the different segments of the water value chain and then considers how these risks may change as a result of reform options, both to the form of the regulatory framework and those aimed at introducing contestable markets.

8.2 Given the available data and feedback from investors we consider that the findings in this document provide a plausible indication of the directional differences in both the current distribution of risk in the value chain and the impacts of reforms. Our key findings are set out below.

Current risk landscape

8.3 We find that sludge has the highest level of total risk with water resources considerably less risky. The monopoly infrastructure assets (treated water distribution and sewage collection) are found to be the lowest risk segments of the value chain using our preferred value-at-risk measure.

8.4 As the largest segment of the value chain, it is mathematically difficult for the asset beta for sewage collection to differ significantly from the current wholesale beta. Relevant benchmarks and analysis of systematic risk exposures suggest that the beta for sewage collection is unlikely to be lower than 0.25. At the top end of the beta range across the value chain, relevant benchmarks and the directional impacts of cost exposures and operating leverage suggest that the asset beta is unlikely to be higher than 0.4. The decision of whether to apply differential betas in the context of segmental controls will need to consider further analysis as well as the variation in the estimation of beta across companies and over time.[107]

8.5 Based on market and regulatory benchmarks, likely financial gearing of the different segments could range from 50% to 64%.

Assessment of reform options

8.6 **Water resources**: We find for the water resources that there is unlikely to be any change to beta across the value chain. For most reform options we consider, we expect there to be very limited changes to gearing also (particularly in the short-term), principally because the existing RCV is not exposed to new markets. We find no reason for Ofwat to provide a transitional WACC premium unless an alternative design is selected, where markets are introduced for existing capacity.

8.7 **Sludge**: We find for the sludge market that there are no material changes to beta across all the reform options we consider. We find the use of a focussed RCV allocation in setting gate prices can raise total risks though, as gate prices are likely to reflect the full economic costs of the sludge activity, thereby adding to competition risks. This will, in-turn, place downward pressure on gearing where the reform creates an environment most similar to that of a fully competitive market. Most reform options considered for sludge have the potential to require a transitional premium to the WACC, however, the magnitude of this can be substantially reduced through RCV protections, and may fully dissipate if investors see upside potential to reforms.

Conclusion

8.8 Our review of reform options indicates that there are some potentially significant impacts on the cost of capital and required returns *without additional regulatory protections*. Where these risks are ignored by Ofwat, then this could result in significant value impacts as well as regulatory uncertainty for

[107] We note that between 2001 and 2015 the asset betas for the three listed WaSCs (Pennon Group, Severn Trent, and United Utilities) have ranged between c. 0.1 and 0.4. This is a wider range than the potential range we have identified across the different segments of the value chain.

investors and could result in a regulatory risk premium in the future (for both equity and debt investors). If this risk is dealt with appropriately, then there could be a cost to consumers associated with this risk introduced, but no impact on regulatory risk.

8.9 One way of dealing with these risks is to provide various changes to the regulatory regime. These include allowing a higher cost of capital, when investor risks have increased and mitigating the impact of downside risks through RCV protections. These protections should substantially limit the potential size of any cost of capital effects.

8.10 Future work in this area could seek to refine the outputs in this report. Specific areas of work could include:

- the use of more, higher quality, data disaggregated across the value chain;
- a more detailed analysis of both opportunities and the likely provider changes resulting from proposed reforms, which will inform the degree of asset utilisation, market share risk and exposure to net upside / downside risks; and
- greater work on the nature of cost structures, i.e. fixed v. variable, in each segment of the value chain to inform the quantification of any WACC premia.

Appendix A - Granular business risk approach detail

This appendix sets out in detail our review / identification of granular business risks in each element of the value chain.

For each segment, we set out the core assets,[108] the most significant risks we identified through scoring post mitigation impact, the evidence gathered to support the risk scores and case studies illustrating where the risk has materialised. We also include narrative on how we expect the risk landscape to evolve in each segment, in the context of known future challenges such as climate change, but excluding the impact of any potential policy changes. At the end of the appendix we include the long list of risks we considered for each segment.

Water resources

Water resources is the first element of the water service value chain. It includes two elements – **abstraction licences** and **raw water abstraction**.

Abstraction licences refer to activities related to negotiating with third parties to obtain abstraction rights and to agree charges as well as the cost of the licence itself. This *does not* include activities that are incurred in choosing abstraction sites, optimising abstraction or ensuring compliance with licence conditions (these are covered under the "raw water abstraction" element of the value chain).

Raw water abstraction includes the identification of new sources (including catchment management[109]), licence management, and the abstraction infrastructure. This includes the following assets:

- Reservoirs and lakes – dams, control rooms, valves, sluices
- Abstraction sites (rivers and boreholes) – pumping equipment, buildings and other on-site sundry equipment
- River abstraction infrastructure – intakes, screens, inlet works
- Pipework between raw water sites (pumped storage)
- Pumps and valves
- Abstraction meters
- Weirs and fish passes
- IT assets – abstraction sites control
- Vehicles
- Premises

[108] The list of assets included in this Appendix are taken from Ofwat's regulatory accounting guidelines (RAGs).

[109] The process through which potential sources of pollution entering water resources are managed and prevented with the aim of providing customers with better water quality and lower treatment costs.

Significant risks – water resources

Table 28: Summary of significant granular risks – water resources

Water resources	• Shortage of water during a drought • Catchment management measures are ineffective • Dam failure	• Source works failure at a critical asset • Source contamination • Over-abstraction

Source: PwC analysis

Evidence for significant risks – water resources

Table 29: Evidence for significant granular risks – water resources

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
Shortage of water during a drought	During droughts, water resources fail to recharge as they would in a normal year, resulting in a shortage of water. During a summer drought, this may be exacerbated by increased customer demand for water. Companies may need to abstract more in the short term through drought permits, which can place pressure on their resources and adds risk through temporary unsustainable abstraction. They may also	Company: supply side measures include replacement/alternative water source; maintenance; drought permits/ drought orders. Demand side measures include "use water wisely" notices, media campaigns, sprinkler bans, hosepipe bans, non-essential use bans, rota cuts standpipes. Target headroom included in water resources management plans as a buffer for uncertainty. Industry average	1.5	4	6	Frequency: The return period for droughts is not predictable, and tends to be measured on average over a long time period. Over the past 40 years, the most recent notable droughts were in 1975-6, 1989-92, 1995-6, 2004-6 and 2010-12. The most severe drought in living memory occurred from May 1975 to August 1976[111]. Companies plan for a given return period, hence the mitigated consequence is a more severe drought than is planned for. Most companies plan to apply for drought permits/ drought orders at a frequency of one year in twenty or less[112]. The minimum level of service is to plan for meeting demand plus target headroom for a return period of one year in ten based on historic drought frequency and impact. However, as the climate is changing the

[111] http://utilityweek.co.uk/news/environment-agency-sets-out-water-company-drought-guidelines/1148012#.VjvPlNInwiQ

[112] Water UK (2013). *Managing through drought: code of practice and guidance for water companies on water use restrictions*, page 37, https://dl.dropboxusercontent.com/u/299993612/Publications/Guidance/Drought/managing-through-drought-code-of-practice.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
	need to restrict demand from customers.	target headroom for 2014-15 was around 4.2% of distribution input[110]. Regulation: investment allowed at price reviews, menu to mitigate unplanned investment; EA drought plans and WRMPs. EA grants drought permits for additional abstraction, and makes drought orders requiring businesses to restrict their water use.				actual current drought return period may be more than one year in ten on average. Hydrologic literature suggests short-term summer drought is projected to increase in England & Wales, although the longest droughts are projected to become shorter and less severe. This suggests that many water supply companies may need to plan for more intense short-term droughts but may experience fewer longer duration events under future climate change[113]. Manifestation of drought risk can be seen in examples such as the United Utilities drought permit application in 2010 to increase abstraction at Ennerdale reservoir[114] and Southern Water's drought permit granted in February 2012 to increase the level of Bewl Reservoir[115]. Mid Kent Water and Southern Water had drought order hearings in 2006 (the drought order was not imposed in the end because the drought ended)[116]. Impact: United Utilities spent £2.4m in 2010/11 executing its drought plan by moving water around its network and balancing supply to compensate for drought conditions[117]. Companies make significant investments to mitigate this risk. For example, Anglian Water have invested £63m from 2012 to 2015 to improve the resilience of water supply system against severe drought events[118].

[110] Water resources management plans 2014.

[113] https://www.staff.ncl.ac.uk/s.blenkinsop/drought_JH.pdf

[114] http://waterbriefing.org/home/company-news/item/1222-united-utilities-applies-for-drought-permit

[115] http://www.bbc.co.uk/news/uk-england-17196707

[116] http://www.edie.net/library/Dealing-with-drought/3701

[117] http://corporate.unitedutilities.com/documents/june-return-2011-overview.pdf

[118] http://www.anglianwater.co.uk/_assets/media/2014_Drought_Plan.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						Affinity Water claim that the cost of increasing resilience against severe drought will cost them £15.5Million from 2015 and 2020[119]. Potential implications of risk manifesting: Opex (pumping, treating water from more expensive sources, leakage control, media campaigns, public information, permit applications), reputation, environmental impact.
Catchment management measures are ineffective		Company: Target activities towards physical interventions more likely to have an impact. Companies have acquired new skills through their new catchment management teams Regulation: EA has included catchment management in the RBMP2 programme of measures and DWI has accepted these changes (outside its own enforcement notice regime). Ofwat has funded companies' catchment management schemes. Efficient overspends will be subject to menu cost sharing.	2	4	8	Frequency: United Utilities' SCaMP project claims measurable, albeit slight, raw water quality improvements at a site in Goyt but seems to be unable to improve raw water colour at Whitendale and have seen no improvement in turbidity at Ashway Gap. The scheme generally seems to be seeing mixture results in terms of water quality benefits[120]. This indicates that the risk that catchment management projects will not deliver sufficient benefit to mitigate larger capital schemes later on is likely to be significant. Impact: Cholderton Water has put in a leased nitrate removal plant temporarily while it carries out catchment management and while local wastewater treatment works reduce the amount of nitrate in effluent released to the environment. The leasing costs for the nitrate plant (£20k) make up around a quarter of the company's planned investment for AMP6[121]. The costs relative to the company's total totex needs over the period show how having to install treatment at a dominant source if catchment management

[119] https://www.affinitywater.co.uk/docs/dWRMP-for-publication-17-05-13%20FINAL.pdf

[120] http://corporate.unitedutilities.com/documents/SCaMP_Interim_Monitoring_Report_July_2014.pdf

[121] Cholderton & District Water Company Water Resources Management Plan: http://www.sitesplus.co.uk/user_docs/274/File/WRMP-v7%201%202014%20Final_compressed.pdf; Presentation to customers: http://www.sitesplus.co.uk/user_docs/274/File/CDWC%20-%20PR14%20Presentation%203.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						approaches fail could present significant costs for a company. Catchment management is generally likely to be lower cost for the company, and hence is both a useful mitigation measure and a way of encouraging the polluter to pay/ to stop the pollution at source. The majority, if not all water companies are making significant investment in catchment management in AMP6. For example, Severn Trent Water are planning a £19.7m AMP6 investment in catchment management[122]. Schemes such as South West Water's "Upstream Thinking" (£14.3m AMP6 investment) and United Utilities' "SCaMP" (£11.6m AMP5 investment) demonstrate the extent of the investment into catchment management to ensure it is effective. If the schemes do not deliver the benefits, significant investment will be called into question, and raw water quality and quantity issues will remain unresolved. Potential implications of risk manifesting: Need for more expensive capital investment to meet drinking water quality standards (e.g. nitrate removal plants).
Dam failure	There is a remote (heavily mitigated) risk that an impounding dam could burst, especially during periods of heavy rainfall, leading to the need to evacuate properties,	Company: regular dam inspections; emergency maintenance works; emergency reservoir drawdown; insurance; up to date emergency plans; co-	1.5	5	7.5	Frequency: There have been incidents which highlight the risk of dam failure in recent years, with 41 safety incidents in the last 6 years, 14 of which were serious incidents, with many dam owners threatened with legal action[123]. However, only a small proportion of these will relate to statutory undertakers. In 2014, the Environment Agency was notified of five incidents

[122] http://www.ofwat.gov.uk/pricereview/pr14/pap_tec1412feederrbrtemplatewsvtfd.xlsm

[123] http://www.independent.co.uk/news/uk/home-news/safety-incidents-at-uk-dams-are-going-unreported-warn-experts-7944475.html

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
	and potentially damage to property, and infrastructure. The cost to a company if a major dam burst occurred is likely to be very high, and there would be significant damage to the company's reputation.	ordination with other bodies' emergency plans. Regulation: inspection requirements; maintenance funding. EA can designate "high risk" reservoirs and make provision for a specific inspection regime (Reservoirs Act 1975 as modified).				(again, many of which will not be owned by water companies)[124]. While the majority of failures appear to be on dams not owned by statutory water undertakers, the frequency of minor failures is probably in the 'remote' category. A more major breach is likely to be a highly improbable event, as companies inspect their dams frequently and mitigate heavily against failure. Water seepage at United Utilities' Rivington Reservoir, which led to an emergency drawdown in January 2002[125]. If the dam had burst, flooding risk would have included the M62, a high pressure gas main and Manchester city centre. Similarly, Welsh Water found leaks in a dam in South Wales in July 2012, triggering monitoring and targeted grouting to resolve the leaks126. In early 2013, a spillway failed at Welsh Water's Rhymney Bridge 2 reservoir and needed urgent repairs[127]. In 2015, Yorkshire Water faced opposition and an appeal for its plans to replace a Victorian spillway on one of its dams. This is an example where public desire to maintain historic engineering structures is at odds with safety needs. The Pitt Review describes the near failure of Ulley Reservoir (previously used for public water supply but no longer owned by a water company at the time) during the 2007 floods. Over 1,000 people were evacuated from villages near the Ulley reservoir dam near Rotherham after a torrent of water caused

[124] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/457832/Post_Incident_Review_2014.pdf

[125] http://www.britishdams.org/2012conf/synopses/7%20Incidents%20and%20remedial%20works%20to%20existing%20dams/Synopses/7.1%20Synopsis%20-%20Gardiner%20-%20Remedial%20grouting%20works%20at%20Upper%20Rivington%20Reservoir.pdf

[126] http://www.britishdams.org/meetings_events/welsh_reservoirsafetydcww_080114.pdf.pdf

[127] http://www.britishdams.org/2014conf/synopsis/Monitoring%20and%20Incidents%20at%20Dams/6.5%20The%20Rhymney%20Bridge%20Incident.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						significant structural damage to the dam. This led to the M1 being closed for 40 hours as a precaution. The absence of prior information with which to prepare contingency plans meant responders had to improvise by drawing floods maps and making evacuation plans on the spot[128]. Catastrophic dam failures are rare, but do happen internationally. For example, the sequential failure in 1975 of the Banqiao Reservoir Dam and more than 60 others in Henan Province, China, which killed an estimated 171,000 people[129]. In May 2015, a dam on the Padera River in Texas nearly burst releasing 35m gallons and washing out the uninhabited surrounding area[130]. Record rainfall, faulty gates and inherent design issues contributed to the July 2010 breach of Iowa's Delhi Dam. The overtopping caused the earthen embankment to erode and eventually emptied Lake Delhi, causing millions in property damage[131]. Impact: The impact of a dam burst would be catastrophic. The examples above illustrate the need to evacuate properties and infrastructure in the likely footprint of the flood, as well as damage to the dam itself. Potential implications of risk manifesting: Capex to fix broken assets. Potentially large compensation payouts for damage to property (possibly covered by insurance), opex for emergency plan deployment/ evacuating people. Potential environmental damage, potentially severe reputational damage,

[128] NOT owned by an E&W water company (sold for £1 in the 1980s to the local authority as no longer needed for PWS).

[129] http://www.eeo.com.cn/ens/2013/0208/240078.shtml

[130] http://www.air-worldwide.com/Blog/The-Growing-Risk-Associated-With-Dam-Failure/

[131] http://www.hydroworld.com/articles/hr/print/volume-30/issue-6/lead-story/dam-safety-what-happened-to-lake-delhi-dam.html

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
Over-abstraction	Over-abstraction can result from over-licensing leading to over-abstraction from specific sources. It may either result because multiple parties are abstracting from a water body or because the sustainable source yield has changed. Companies may need to adjust sustainable yield downwards. Abstraction may also be re-assessed as over-abstraction because there are environmental disbenefits. In this case the Environment Agency may reduce or revoke abstraction licences to protect habitats.	Company: replacement/alternative water source/ demand side measures (e.g. leakage control, water efficiency); conjunctive use; yield write downs to sustainable level and replacement water Regulation: investment allowed at price reviews, menu to mitigate unplanned investment; EA drought plans and WRMPs. EA can use "over-riding public interest" to revoke licences or apply sustainability reductions to companies' licences (based on evidence gathered through investigations into sustainability). Abstraction reform is progressing with Defra developing policy and legislation to follow. The aim is to restore sustainable abstraction by the mid-2020s.	2	3	6	Frequency: The probability of over-abstraction is limited by abstraction licensing. Companies found to be breaching licences face enforcement, including criminal sanctions (warnings, formal cautions and prosecution, with fines up to £20,000) and can also include civil sanctions[132]. There are > 21,000 UK abstraction licences, and, in the past three years, about 100 have been revoked, while more than 200 have been reduced[133]. 8% of water abstraction licences are for public water supplies[134], but this accounts for 18% of all volume abstracted under licence. Total abstraction for public water stands at 9.6bn m^3 and decreased 14% from 2000 to 2013[135]. Even within the licensing environment, over-abstraction is still threatens sustainability of water sources and associated ecosystems, according to WWF[136]. The EA's Restoring Sustainable Abstraction (RSA) and the government's creation of the Abstraction Reform Advisory Group are evidence that over-abstraction is already an issue. Water companies are also taking action, for example, from 2020 SEW will reduce the annual average yield of Bewl Water by 5.5 Ml/d and by 6 Ml/d on peak yield as part of its 2014 WRMP (a 34% reduction in average yield and a 29% reduction in peak yield)[137].

[132] https://www.gov.uk/guidance/water-management-managing-your-water-abstraction-or-impoundment-licence

[133] http://www.independent.co.uk/news/uk/home-news/uk-weather-britain-must-be-ready-for-worst-droughts-in-modern-times-9746455.html

[134] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/422251/3_21_2013_bypurpose.ods

[135] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/422252/3_22_2013_allsources.ods

[136] http://assets.wwf.org.uk/downloads/riverside_tales.pdf?_ga=1.51989482.2129144158.1445872414

[137] http://www.southeastwater.co.uk/media/187752/Appendix_3_3Crevised.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						Impact: If over-abstraction/lack of availability of additional water sources does materialise, unconventional water sources will be very expensive as evidenced by the £200m investment by Thames Water in a desalination plant[138]. An another example is Thames Water's North London Artificial Recharge Scheme which recharges an aquifer with treated water in wet periods and abstracts from it in drought. It had a £6m upgrade in 2006 to increase its capacity. The main cost in running the NLARS is in the cost of recharging the aquifer at a rate of 40 Ml/d with treated water, which will need re-treating on abstraction. United Utilities' Thirlemere transfer scheme costs are an example of a high impact replacement water scheme (at £215.45m allowed totex[139]) following notice from the Environment Agency that it would revoke an abstraction licence. Potential implications of risk manifesting: Environmental damage, cost of providing replacement water (usually capex).
Source contamination at a critical asset	Water resource become contaminated and are either temporarily or permanently unavailable for use. Contamination at a critical asset would disrupt service to groups of customers due to the source being large/strategic and single source dependence. Contamination could be accidental, deliberate or	Company: site security; monitoring water quality/ shut down; boil water notices or bottled water; increased dosing (e.g. UV/ chlorine); improved treatment; full or partial replacement water by blending/ alternative source (where possible); catchment management; sustainable abstraction.	1	4	4	Frequency: There are multiple cases of source contamination each year. Raw water quality is tested by the DWI and their annual reports show multiple instances of contamination test failures. For example, in relation to Cryptosporidium and tightened turbidity standards DWI reports that '*In 2014, testing of raw water for Cryptosporidium verified a potential risk at 149 out of a total of 376 abstraction points serving 127 treatment works operated by 16 water companies. Despite good compliance with the turbidity standard of*

[138] http://www.policyexchange.org.uk/images/publications/untapped%20potential%20-%20jul%2011.pdf

[139] http://www.ofwat.gov.uk/pricereview/pr14/pap_tec1412feederrbrtemplatewuufd.xlsm

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
	involve gradual increases in contaminants through diffuse pollution, or natural contamination such as saline incursion. Contamination could involve microbes or chemicals. There are also risks of deliberate contamination through terrorism. Source contamination is a risk that could generate cost for companies through needs to improve treatment or blending arrangements to deliver DWI standards.	This risk tends to manifest with greater impact at the treatment works - raw water may be blended prior to treatment or short term contamination diluted. If the treatment works is able to treat for the contaminant, the risk is mitigated at this stage in the value chain. Regulation: investment allowed at price reviews and menu cost sharing for efficiently incurred costs. DWI sampling and compliance; DWI notices: short- and long term mitigation measures/ requirements. EA regulation: drinking water protected areas (WFD and Groundwater Daughter Directive); abstraction licencing and regulation.				*1NTU (99.98% in 2014) there have been two further small water – related outbreaks of human cryptosporidiosis (Northamptonshire 2008 and Bournemouth 2013) due to site-specific failures in maintenance and operational knowledge. This demonstrates the need for continuous risk assessment and a rigorous application of knowledge about this particularly hazard.'*[140] However, note that the report covers both private suppliers and statutory undertakers so a proportion of the failures will relate to companies regulated by Ofwat. Companies generally mitigate for emerging source contamination issues as DWI standards start to be breached. For example, Welsh Water were served a DWI notice for unclean water supply from Tynywaun Water Treatment Works due to source contamination in 2014[141]. Impact: Source contamination events can contaminate water with types or quantities of impurities that are not removed by water treatment works (which is tailored to the expected raw water quality). If this is the case, companies would need to shut down the water treatment works either until the raw water quality returned to normal or until treatment could be put in place. For a critical asset, where an alternative source or blending with another source to dilute the contaminant is not possible, the results are likely to be similar to contamination at treatment works (e.g. the need to provide bottled water or bowser water to customers while supply is restored). It is in companies' interests to restore supply quickly, which could require

[140] http://dwi.defra.gov.uk/about/annual-report/2014/sum-eng.pdf, page 11.

[141] http://dwi.defra.gov.uk/stakeholders/improvement-programmes/dwr/dwr3334.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						significant investment in treatment if the contaminant is likely to persist. Several companies had un-modelled PR14 costs for addressing raw water deterioration (mitigation), for example Portsmouth Water - £5.4m, Welsh Water - £24.6m, Wessex Water - £13.3m[142]. Bromate contamination at a Three Valleys Water source cost them £2m due to reduction in yield, as well as a protracted legal battle with the polluter, demonstrating the impact of source contamination[143]. Potential implications of risk manifesting: Capex to treat or replace water source, potentially opex for court proceedings if the polluter is identifiable (pursuing "polluter pays"), environmental damage.

Source: PwC analysis

Forward-looking assessment: water resources

Table 30: Future risks – water resources

Future risk	Impact
Climate uncertainty puts further pressure on abstraction[144]	Further pressure on abstraction/ reduction in sustainable source yield because: • Increased intensity of winter storm events means that aquifer recharge is less effective, potentially placing greater burden on groundwater sources • Summers will be drier meaning that there will be less recharge of surface water sources during the summer.

[142] https://www.ofwat.gov.uk/pricereview/pr14/prs_web1412feederrbrtemplatepopfd

[143] http://www.hertsdirect.org/statweb/meetingsnov04toapr13/River%20Quality%20Topic%20Group/20101028/Rivers%20of%20England%20Briefing%20-%20Oliver%20Heald%20MP.doc

[144] Yorkshire Water, UU and Anglian Water (2015) '*Water 2020' Long term challenges and uncertainties for the water sector of the future.*

	Longer term source yield issues might arise due to companies needing to revise the control curves and therefore sustainable source yield at their sources following a dry summer or drought. Climate change will impact long term sustainable source yield – increased climatic variability and temperature rise will have an impact on source replenishment and therefore on the amount of water that can reliably be taken from that source.
Dry weather abstraction	Demands increase during periods of hot and dry weather, especially for irrigation and leisure use. As climate change will lead to hotter drier summers, the seasonality of demand for water is likely to increase, meaning that there is even greater pressure on summer abstraction.
Abstraction impact on habitats	Abstraction levels need to reduce to achieve "good" ecological status to meet the targets set by EU legislation (Water Framework Directive, Habitats Directive). As the evidence base improves around the ecological impact of companies' abstractions, further reductions in licensed volume are likely to be needed to meet the needs of the environment. Climate change is likely to exacerbate this as the balance between the need to support habitats and the need to provide water for public supply increasingly come into conflict.
Fracking	There is a potential contamination risk to aquifers of unconventional gas extraction. However, the consequences are not yet clear because there are significant differences between Europe and North America (where shale gas extraction has been undertaken extensively) in environmental standards and regulation. Fracking will probably be more difficult and expensive for shale gas producers to achieve in Europe due to tighter standards.
Aging asset base	Applies especially to dams and impounding structures, many of which are over 100 years old. The probability of failure of other assets, such as boreholes is more limited.
Restoring sustainable abstraction programme	The programme of restoring abstraction licences to a sustainable level will have an impact on all abstractors, including the water companies. They will need to find replacement, sustainable sources of water to replace the volumes of water lost to yield write downs and licence revocation (either through supply side measures, demand side leakage reduction or customer demand management).
Loss of availability of power	Power is used to pump water out of sources. There is a risk that energy security will reduce over time, as supply margins erode and the UK becomes increasingly dependent on imports. This creates a risk that unavailability of power will impact the water supply.
Population growth in south east England	Population is forecast to grow the most in south east England. This is also where climate change is likely to manifest most and therefore will place the greatest pressure on water resources. Providing for customers' demands in the south and east of England is therefore likely to be particularly challenging.

Source: PwC analysis

Raw water distribution

Raw water distribution is **the transport of raw water and partially treated (non-potable) water from abstraction site to treatment works** (including where small numbers of customers are supplied direct from the pipe – with onsite treatment facilities) or to end user customer.

This segment includes the following assets:

- Pipework and aqueducts
- Pumping stations into treatment sites
- Booster pumps, valves and other equipment within the raw water distribution network
- Storage reservoirs for raw or partially treated (non-potable) water
- Leakage detection equipment
- IT assets – network control
- Vehicles
- Premises

Significant risks – raw water distribution

Table 31: Summary of significant granular risks – raw water distribution

Raw water distribution	• Aqueduct failure • Other distribution asset failure • Contamination/infiltration

Source: PwC analysis

Evidence for significant risks – raw water distribution

Table 32: Evidence for significant granular risks – raw water distribution

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
Aqueduct failure or outage (critical asset)	Bursts or damage to a raw water aqueduct lead to leakage. For a critical asset, and a major burst this could lead to disruptions in supply to customers.	Company: Maintenance, inspection, resilience investment (e.g. remove single source dominance – increased connectivity, mains duplication). Regulation: Investment allowed at price reviews. SEMD gives requirements for	2	4	8	Frequency: Aqueduct failure is relatively low probability. Dee Valley Water asset inventory PR09 gives a burst frequency for its raw water aqueducts of 22 bursts in 22 years[145].

[145] http://www.deevalleywater.co.uk/article_files/131/welsh/SECTION-C3.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
		resilience investment. Government also has critical national infrastructure plans and water companies prepare resilience plans. Water Act 2014 introduced a primary resilience duty for Ofwat.				This will include both critical and non-critical assets. There is a distinction between critical assets and all other raw water aqueducts. For most assets, the length of main is short, and there may be resilience-based solutions if the main is taken out for maintenance (e.g. providing water from another source). For critical assets, where customers are served by a single source the impacts and costs are significant, especially if large numbers of customers are potentially impacted. Impact: For critical assets, the impact of a failure or outage would be considerable with companies needing to find alternative raw water networks to avoid loss of supply[146]. Mitigation and strategic planning is important for these assets, which may be very old. An example of investment in securing water supplies is the £242m Birmingham Resilience Project, which will provide an alternative water supply to the treatment works whilst the Elan Valley Aqueduct is refurbished[147]. The significance of this project is highlighted by Ofwat's ODI – Severn Trent Water could face penalties of up to £52m per year for timing delays. Hence, there is additional risk to the water companies of delivering such high profile

[146] http://www.southwestwater.co.uk/media/pdf/8/d/Formatted_B3.3.1_for_Review_IM_excised.pdf

[147] http://wwtonline.co.uk/features/project-focus-severn-trent-s-birmingham-resilience-project#.Vi-J2bfhCM8

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						schemes on time and with minimal disruption to customers[148]. Potential implications of risk manifesting: Capex for replacement assets (and opex for short term repairs). Logistical issues with minimising length of outage.
Other distribution asset failure (e.g. pipes, air valves, pumps)	Minor asset failures happen frequently on companies' networks, and are usually covered by companies' estimates of reactive maintenance needs, which Ofwat allows for at price controls. These failures are potentially low level and less likely to cause a major outage unless they occur on a critical asset.	Company: asset investment planning; asset security; monitoring/shut down; insurance. Storage on the treated water distribution network can mitigate for maintenance requirements on critical assets upstream (i.e. if the company has 12 hours' storage in its water towers and service reservoirs, it can perform maintenance on its critical raw water mains without compromising continuity of supply). Regulation: investment allowed at price reviews.	3	2	6	Frequency: Asset failures do occur as evidenced by their business plan spending data. For example, 5 schemes in United Utilities' PR09 business plan addressing leakage, valves etc[149]. Impact: This risk is likely to be relatively easy to mitigate, for example through back up pumps, and back up generation. Again there is a distinction between critical assets and other assets. Most companies assess the main failure risk as a burst on a raw water main leading either to outage or flooding or both[150]. Potential implications of risk manifesting: Capex for replacement assets (and opex for short term repairs).
Contamination/ infiltration	Contamination through groundwater infiltration/ ingress to the raw water main, potentially making the water unavailable for use. Contamination at a critical asset would disrupt service to groups of customers due to the	Company: asset security; monitoring/shut down; boil water notices or bottled water; alternative source. Regulation: investment allowed at price reviews. DWI sampling, although as with water resources the risk tends to manifest more in the treatment works segment where	4	1	4	Frequency: Contamination of raw water during distribution does occur but if the contamination is regularly experienced it tends to be mitigated at the water treatment works. Unusual contaminants in the raw water may present issues, although these tend to manifest through

[148] http://webarchive.nationalarchives.gov.uk/20150624091829/https://www.ofwat.gov.uk/pricereview/pr14/det_pr20141212svt.pdf, Table AA4.1, W-B9

[149] United Utilities' PR09 business plan Part B3, page 10.

[150] See, for example, South West Water PR09 business plan and United Utilities PR09 business plan.

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
	source being large/strategic and single source dependence. Contamination could be accidental, deliberate or involve gradual increases in contaminants through diffuse pollution, or natural contamination such as saline incursion. Contamination could involve microbes or chemicals. There are also risks of deliberate contamination through terrorism. Contamination is a risk that could generate cost for companies through needs to improve treatment or blending arrangements to deliver DWI standards.	there may or may not be capacity to treat or dilute any contamination from the raw water distribution segment.				inability to treat the water to acceptable standards at the treatment works. United Utilities' raw water aqueduct at Thirlemere is prone to infiltration and therefore it is more efficient to treat downstream of the aqueduct rather than at source. For example, during a 2008 maintenance project, an engineer stated that '*The defects that crop up in the surveys are mainly allowing groundwater ingress into the aqueduct. This is not necessarily a bad thing, and in fact the system was never designed to be fully watertight.*'[151] Impact: Treatment works have treatment components that are designed to mitigate for expected raw water quality, hence most contamination that can happen periodically (e.g. Cryptosporidium) is likely to be mitigated in the treatment works segment. Again there is a distinction between critical assets and other assets. United Utilities are refurbishing the Haweswater Aqueduct and are spending £22m on a structural analysis survey of the tunnel sections to detect cracks and ingresses which might cause contamination[152]. Potential implications of risk manifesting: Opex and capex for repairs. Logistical

[151] http://www.edie.net/library/High-standards-in-a-tight-spot/4732

[152] http://www.futurewaterassociation.com/news/j-murphy-sons-wins-united-utilities-haweswater-aqueduct-contract

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						issues with balancing closure of the asset for maintenance with short term in system water storage. Relining or replacement if infiltration becomes a more serious issue – for a critical asset this is potentially problematic.

Source: PwC analysis

Forward-looking assessment: raw water distribution

Table 33: Future risks – raw water distribution

Future risk	Impact
Resilience/ aging asset base	As the asset base ages and needs intervention, companies will increasingly require outages for maintenance on critical assets, potentially lasting for significant time periods. This is likely to mean companies need to invest either in increasing network connectivity where they have single source reliance or on duplicating the raw water main where replacement water from an alternative source is not an option.

Source: PwC analysis

Water treatment

Water treatment includes all the activities in the treatment of raw water, including both chemical and physical treatment. The start point is defined where a works receives raw or partially treated (non-potable) water from raw water distribution system. The output is treated water at the point where it is fed into the treated water distribution network. Assets include:

- Treatment works including on site pipework and pumps
- IT assets – treatment works control
- Vehicles
- Other premises

Significant risks –water treatment

Table 34: Summary of significant granular risks – water treatment

Water treatment	• Critical asset contamination • Core component failure • Non-critical asset contamination	• Security breach including theft of materials • Flood damage

Source: PwC analysis

Evidence for significant risks – water treatment

Table 35: Evidence for significant granular risks – water treatment

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
Critical asset contamination	Contamination of raw water main, potentially making the water unavailable for use (if it cannot be treated). Contamination at a critical asset would disrupt service to groups of customers due to the source being large/strategic and single source dependence. Contamination could also occur during the treatment process, or	Company: increase chemical dosing; boil water notice; replacement bowser/bottled water; works maintenance; treatment works improvements Regulation: investment allowed at price reviews, menu to mitigate efficient unplanned investment; DWI sampling regime; DWI notices and drinking water safety plans.	2	4	8	Frequency: Unmitigated contamination events are relatively unlikely as there is constant monitoring of water quality in a works and automatic shutdown if water quality standards are breached. However, at a critical asset, works shut down will lead to outages for customer groups served exclusively by that works. Impact: Human error at Camelford water treatment works in July 1988 led to contamination of the water supply with aluminium sulphate, which caused corrosion in

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
	due to a failure in the treatment process. Contamination could be accidental, deliberate or involve gradual increases in contaminants through diffuse pollution, or natural contamination such as saline incursion. Contamination could involve microbes or chemicals. There are also risks of deliberate contamination through terrorism. Contamination is a risk that could generate cost for companies through needs to improve treatment or blending arrangements to deliver DWI standards.					the distribution system picking up other contaminants and heavy metals. The water authority failed to realise the extent of contamination and declared the water still safe to drink. This caused short and long term public health issues in the area. The incident cost the South West Water Authority around £400k in damages and significant long term reputational damage[153]. Decades later, media reports state that people are still calling for a public inquiry after two inquiries failed to link the contamination to health effects, despite new evidence that challenges that. United Utilities' recent boil water notices in Lancashire were linked to the failure of membranes at a treatment works leading to contamination. United Utilities ultimately resolved the issue through a combination of installing ultraviolet rigs and flushing the network. It is estimates that compensation and repairs will cost them around £25m[154]. Another Cryptosporidium contamination incident in Bolton earlier in the year resulted in compensation payments of £15 per property (totalling £13.5m)[155]. Companies are investing in additional measures to avoid this risk, for example South East Water

[153] http://news.bbc.co.uk/1/hi/england/1908534.stm

[154] http://www.theguardian.com/business/2015/sep/23/united-utilities-faces-25m-bill-over-water-contamination-scandal

http://www.investegate.co.uk/united-utilities-grp--uu--/rns/united-utilities-trading-update/201509230700088739Z/

[155] http://www.theguardian.com/environment/2015/aug/21/lancashire-boil-water-alert-anger-residents-united-utilities-cryptosporidium

http://utilityweek.co.uk/news/uu-starts-15m-compensation-payout/1166612#.Vi5XpLfhCM9

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						invested £2.5m in Cryptosporidium mitigation programme in 2012, 3% of their total capex[156]. Potential implications of risk manifesting: Opex and capex for repairs, issuing/ publicising boil water notices, and compensation. Prosecution and fines for supplying water unfit for human consumption. Reputational damage.
Core component failure	Failure of critical components in the treatment process could compromise a works' ability to treat for specific contaminants (either found constantly or sporadically in the raw water). This would mean works shut down until compliant water quality standards could be restored. On a critical asset, this might result in an outage to customers. On a non-critical asset, the company might incur additional costs to transport and treat water from another source.	Company: outage; replacement/alternative water source; maintenance Regulation: investment allowed at price reviews, menu to mitigate unplanned investment; EA WRMPs; DWI notices and DWSPs.	3	2	6	Frequency: The DWI annual reports cite several examples of core component failures at water treatment works which are commonly the root cause of DWI inspection failures. For example, control failure of the ozonation process and UV system failure were identified in the 2014 DWI London/South East region report[157]. Impact: Most incidents are monitored and mitigated (e.g. by detecting the failure, preventing the water from leaving the works and re-routing the supply) so the impact of this risk is relatively low. Routine maintenance and failsafe systems are the main cost of this risk to the water companies. Maintenance costs for water treatment works at quite significant, for example United Utilities spent over £150m in AMP5[158]. Potential implications of risk manifesting: Opex and capex for repairs, insufficient treatment if raw water contains specific contaminants – breach of water quality standards, additional

[156] http://www.southeastwater.co.uk/media/124619/SEW_Annual_Report1_2012.pdf

[157] http://www.dwi.gov.uk/about/annual-report/2014/london-se.pdf

[158] http://corporate.unitedutilities.com/documents/B3_-_Section_3_Water_Business_Cases.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						opex for providing water from an alternative source (where this is possible).
Security breach including theft of materials	Most treatment works and source works are fitted with security (e.g. palisade fences, lockable kiosks, and lockable gates). However, thieves break into treatment works from time to time (and in specific vulnerable locations) and steal materials from sites. The most common materials stolen are metals. A more remote threat is that vandals or terrorists access water treatment works potentially with the intention to damage assets or contaminate the water supply. A break in might occur, or human error on the part of water company staff could result in a lapse in security.	Company: Site security; avoiding human error; tracing water company assets to mitigate theft Regulation: SEMD; allowance of sufficient investment in site security	2	3	6	Frequency: Experts estimate that security breaches or theft could occur about 2-3 times per year for each water company. Impact: In 2012, Thames Water reported that it was losing £1.2m per year from metal theft (which will relate to theft both from water treatment works and wastewater treatment works). Thames invested in using "smart water" to trace the stolen metals[159]. Security breaches could have significant impact as seen in an incident in Georgia, USA in 2013 when chlorine and fluorine controls were tampered with and approximately 400 residents were advised not to drink the water. The FBI investigation that followed was based on concerns that the perpetrators intended greater harm[160]. Potential implications of risk manifesting: Opex and capex for repairs/ replacement materials, automatic works shut down if treatment process tampered with (and therefore potential need to provide replacement water from alternative sources).
Flood damage	Flood damage is a potential hazard for water treatment works where they lie on the flood plain (e.g. to treat river water). There	Company: flood defence walls, flood barriers, drainage around site boundary, wetland	2	2	4	Frequency: Five water treatment works were flooded in the summer 2007 floods[161].

[159] http://www.thameswater.co.uk/media/press-releases/15254.htm

[160] http://www.wwdmag.com/security-breaches-impact-two-us-water-treatment-facilities

[161] Sir Michael Pitt (2008) *Learning lessons from the 2007 floods.*

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
	are fewer of these works than there are wastewater treatment works on the flood plain, and companies have mitigated heavily since the floods in 2007 highlighted this risk. But some residual risk remains nonetheless.	systems/washlands, catchment management Regulation: resilience investment allowed at PR14. Menu for efficiently incurred unplanned/ emergency works				Impact: The Pitt Review gives the example of the loss of Mythe water treatment works (Severn Trent Water) which left 350,000 people without mains water supply for up to 17 days. Since then, a semi-permanent flood defence has been built around the Mythe works. The Pitt Review recommended Government and infrastructure operators should work together to build a level of resilience into critical infrastructure assets that ensures continuity during a worst-case flood event. Potential implications of risk manifesting: Opex and capex for repairs, compensation to customers for loss of supply, reputational damage.
Contamination at non-critical assets	Contamination through groundwater infiltration/ ingress to the raw water main, potentially making the water unavailable for use. Contamination at a non-critical asset might increase costs to the company, but continuity of supply would not be compromised. Contamination could be accidental, deliberate or involve gradual increases in contaminants through diffuse pollution, or natural contamination such as saline incursion. Contamination could involve microbes or chemicals. There are also risks of	Company: shut down works and provide water from an alternative works; draw down storage or emergency storage Regulation: SEMD, Ofwat resilience duty	2	2	4	Frequency: Severn Trent's PR09 outage allowance analysis included an assumption of one automatic shutdown per week at its treatment works, two at critical works[162]. South Staffordshire Water's PR09 outage assessment included actual turbidity events, oil and other contamination. Turbidity was a factor in 5 of the 11 years considered and pollution in one year[163]. Impact: For a non-critical asset, the impact of the risk is around the costs associated with repairs to the works when contamination is detected. The 2014 DWI annual report highlight many instances where treatment works output has not met the required standards and repairs are needed following an investigation to the cause of the failure. Following a coliform failure affecting

[162] http://s3-eu-west-1.amazonaws.com/media.aws.stwater.co.uk/upload/pdf/F1_-_final.pdf

[163] https://www.south-staffs-water.co.uk/publications/community_environment/wrmp2014/Appendix_H_Outage.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
	deliberate contamination through terrorism. Contamination is a risk that could generate cost for companies through needs to improve treatment or blending arrangements to deliver DWI standards.					South East Water at Headley Park works, an investigation identified potential ingress points in the final water contact tank, which was repaired. All further results have proved satisfactory[164]. This is typical of many similar instances recorded by the DWI. Potential implications of risk manifesting: Opex and capex for repairs, additional opex for supplying water from an alternative source.

Source: PwC analysis

Forward-looking assessment: water treatment

Table 36: Future risks –water treatment

Future risk	Impact
Climate change mitigation (energy use)	Companies will increasingly need to reduce their reliance on energy, or switch to renewable sources to play their part in mitigating climate change. It is possible that energy mitigation schemes such as the CRC will become more punitive in their penalties for emissions in future, in which case companies may need to pay more to self-generate or source energy from sustainable sources.
Loss of availability of power	Power is used to treat and pump water at treatment works. There is a risk that energy security will reduce over time, as supply margins erode and the UK becomes increasingly dependent on imports. This creates a risk that unavailability of power will impact the water supply.
Future tightening of drinking water quality standards	Although tightening of drinking water quality standards is less likely than tightening of effluent consents, there is potential for additional chemicals to be added to the substances whose concentration is controlled in drinking water. Examples might include pharmaceuticals/ pharmaceutical by-products that find their way into water sources, or new pesticides. This would potentially create additional costs for companies to put treatment in place, and if treatment were difficult to achieve to meet new compliance standards, it could also create compliance risk.

Source: PwC analysis

[164] http://dwi.defra.gov.uk/about/annual-report/2014/london-se.pdf, page 23.

Treated water distribution

Treated water distribution is the **transport of treated (potable) water from treatment sites to customer properties and new appointees**. This activity includes intermediate storage facilities (e.g. reservoirs and storage towers) with possible further treatment taking place within the network. Assets include:

- Water mains and pipework up to meter point or curtilage in customer premises or new appointee boundary
- Booster pumps, valves and other equipment within the distribution system
- Storage reservoirs, service reservoirs. and water towers within the distribution system
- Leakage detection equipment
- Customer meters
- IT assets – network control
- Vehicles
- Premises
- Meter chambers

Significant risks – treated water distribution

Table 37: Summary of significant granular risks – treated water distribution

Treated water distribution	• Ground movements/freeze-thaw cause leakage • Bursts cause flooding • Supply interruptions and low pressure	• Contamination • Street works cause disruptions to traffic etc. • Water theft

Source: PwC analysis

Evidence for significant risks – treated water distribution

Table 38: Evidence for significant granular risks – treated water distribution

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
Ground movements/ freeze-thaw cause leakage	During cold snaps, or a hard winter when the ground freezes and thaws, and potentially also in clay soils where wet and dry	Company: additional leakage control in advance of/ following the winter; additional focus after a cold snap	2	5	10	Frequency: The frequency of leakage target failures depends on the frequency of cold winters, which is not necessarily predictable. For example, none of the water companies failed their leakage targets in 2014-15 (following a mild winter)[165]. However, during

[165] http://www.ofwat.gov.uk/regulated-companies/comparing-companies/performance/companies-performance-2014-15/reliability-and-availability/

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
	conditions can lead to ground movements, mains (especially those made of more brittle materials) are vulnerable to bursts. The risk is that a hard winter means the company cannot meet its economic level of leakage (ELL) target, resulting in enforcement action from Ofwat. Companies cannot necessarily control soil movements and resultant bursts, but they can prepare for a hard winter, or mitigate after a hard winter through additional investment in leakage control. This means that the cost of meeting the ELL in years with a cold winter is significantly higher than during a warmer winter.	Regulation: reporting and monitoring; ODIs. EA WRMPs annual updates on the water balance				years when there are significant winter cold snaps multiple companies are likely to fail. In 2009-10 three companies (Northumbrian Water, Yorkshire Water and Southern Water) failed to meet their leakage targets due to a cold winter. Ofwat required additional leakage reporting from the companies. In 2010-11 six companies failed their leakage targets with the level of failure ranging from 3% above to 11% above ELL. Ofwat reported that the total failure of total of 15Ml/d was the equivalent of supplying a city about the size of Exeter with water for a year. December 2010 was reported by the MET office to be the coldest December since records began with widespread snowfall[166]. Impact: Failures tend to involve costly and resource intensive solutions, and as companies do not have control over weather-related ground movements the impact is difficult for them to mitigate. Ofwat made the following statement about the impact of the breaches of ELL in 2010-12: '*Missing leakage targets is a serious failure. Where companies have consistently failed to manage leakage in the past, Ofwat has made them invest £195 million from their own pockets putting the problem right*[167].' Affinity Water invested £100m between 2010 and 2015 on improving the water mains, replacing weaker iron pipes with more durable plastic networks[168]. Potential implications of risk manifesting: Opex for additional active leakage control, capex for replacing vulnerable assets. Reputational impact (heavy customer, regulatory and media focus on leakage).

[166] http://www.ofwat.gov.uk/mediacentre/ibulletins/prs_ib0811leakage

[167] http://www.ofwat.gov.uk/ib-0811-ofwat-investigating-leakage-failures/

[168] https://www.affinitywater.co.uk/planned-work-mains-renewal.aspx

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
Bursts cause flooding (critical asset)	When a trunk main bursts, it can cause considerable disruption and damage through flooding (especially if it happens in an urban area), as well as outages downstream of the main. If water enters gas mains there is a potentially serious hazard.	Company: insurance; risk based maintenance; emergency plans; flood risk management Regulation: GSS Regulations; ODIs on supply interruptions and low pressure; EA outage assessment and planning in WRMPs	3	3	9	Frequency: Flooding events can happen occasionally, with varying degrees of impact. The media reports significant water main flooding, affecting roads or properties, in the order of about once a month, so on average perhaps once per year per company. Impact: Flooding to about 36 properties caused by a major burst on Thames Water's network in Herne Hill in 2013. A burst main flooded Kennington High Street in June 2015 and was attended by the fire service. It resulted in 0.5m of surface flooding, property and basement flooding in the area, and several house of disruption on the roads and to buses[169]. The cost to companies is in mending the burst, compensation for any supply interruption (discussed below) and potentially compensating customers for flood damage if not covered by customers' insurance. Thames water donated £200k to the Herne Hill area after the floods in 2013 but that was dwarfed by the £4m damages bill for Thames Water and its insurers. Potential implications of risk manifesting: Opex for repairs and compensation for damage or longer interruptions to supply. Reputational damage. Bigger risks to public health and safety if water enters the gas supply system.
Supply interruptions and low pressure	Bursts either locally or on trunk mains can cause interruptions to supply. Companies have targets for maximum duration, beyond which they must pay compensation to customers. Bursts or network constraints can cause low	Company: risk based leakage control; minimise operational response time; works gang protocols for minimising interruptions, build in system redundancy to allow rezoning; monitoring of low water pressure areas; booster pumps; mains replacement	4	2	8	Frequency: In 2014/15 customers, on average, experienced between 0.3 hours per property served and 2.61 hours per property[170]. Most customers will not experience an interruption in a given year. Two companies (Bristol Water and Portsmouth Water) were operating significantly below target, Sutton & East Surrey Water was operating marginally below target. Impact: Recent examples of interruptions include outage as a result of a UU burst in Wigan on 9 September lasting c.4.5 hours[171]. An Anglian Water burst on 28 September in

[169] http://www.bbc.co.uk/news/uk-england-london-23598335

[170] http://www.ofwat.gov.uk/regulated-companies/comparing-companies/performance/companies-performance-2014-15/customers/

[171] http://www.wigantoday.net/news/local/no-water-after-pipe-bursts-1-7452750

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
	pressure to customers. Companies must pay compensation to customers if they complain of multiple instances of low pressure in a given year.	Regulation: Companies given totex allowance to improve level of service where customers are willing to pay; GSS Regulations; reporting and monitoring; ODIs				Northampton left 6,000 customers without water for at least 15 hours[172]. Companies hold registers of the properties in areas of their network that have a higher risk of low pressure (e.g. during periods of heavy demand) and will prioritise the alleviation of low pressure in accordance with customer willingness to pay for improvements. Potential implications of risk manifesting: Opex for repairs and compensation for damage or longer interruptions to supply. Reputational damage.
Contamination	As well as contamination on the network itself (especially contamination of service reservoirs and water towers), companies' legal duties with respect to contamination manifest in this part of the value chain because their water quality obligation relates to the quality of drinking water at customers' taps. Contamination could be accidental or deliberate, and in more remote circumstances could involve terrorist activity.	Company: risk based maintenance; specific asset interventions to remedy asset contamination Regulation: DWI DOMS and DWSPs; DWI sampling and monitoring regime; sufficient investment allowance at price controls; ODIs	2	3	6	Frequency: Evidence of failures of core components are seen in the DWI annual reports, highlight incidents when failures have caused contamination to the water. DWI has made 65 prosecutions of statutory water undertakers between 1990 and 2014, the majority of which occurred in the first 15 years following privatisation. In 2014, there were 12 serious events, including 4 relating to microbial contamination, 2 treatment failures and 3 relating to chemical contamination[173]. For example, several companies have detected Coliform and E Coli bacteria in water towers caused by ingress into water towers and service reservoirs, leading to cost of identifying the root cause, making repairs and wasted water from the affected zones. This happens relatively frequently, for example, the Northern DWI region recorded 51 significant drinking water quality events in 2014[174]. Impact: Companies also mitigate heavily for contamination in their networks through investment at price controls. Dee Valley

[172] http://www.northamptonchron.co.uk/news/business/business-news/burst-main-leaves-northampton-homes-and-businesses-with-no-water-1-3068042

[173] http://dwi.defra.gov.uk/about/annual-report/2014/sum-eng.pdf (p15)

[174] DWI annual reports http://dwi.defra.gov.uk/about/annual-report/2014/northern.pdf http://dwi.defra.gov.uk/about/annual-report/2014/london-se.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						Water's Llwyn Onn Service Reservoir project was funded in PR14, where water ingress to the service reservoir was causing risk of microbial contamination[175]. Their Wrexham Ring Main cleaning scheme was also logged up at PR14, where residual manganese needed to be flushed out of the main following a treatment works upgrade to remove manganese from the source[176]. Potential implications of risk manifesting: Opex for repairs, opex for providing water from an alternative source (where feasible), boil water notices while the contamination event is being addressed. Reputational damage.
Streetworks cause disruptions to traffic etc.	Companies may need to close the road, put traffic lights in place or narrow the road/ cause obstruction with roadworks to repair and replace mains. This can result in traffic disruption and potentially lane rental charges where there are schemes in place.	Company: avoiding lane rental charges and complaints/ reputational damage by planning activities outside lane rental hours. Use of "no-dig" technology; co-operation with other utilities. Regulation: Local authority lane rental schemes under the Traffic Management Act	2	3	6	Frequency: Thames Water's Thames Water LIVE website shows where there are current works on the network likely to cause traffic disruptions[177]. It shows that there are multiple network issues at any time in most sizeable towns that are likely to cause disruption (which will be a mixture of work on mains and sewers). Impact: TfL implemented a lane rental scheme from June 2012, covering 57% of the TfL road network with daily charges for traffic disruption at busy times of day (either £800 or £2,500 for different categories of road). Reporting on the scheme for a one year period over 2013 and 2014 showed that utilities work during critical periods reduced by 70-80%, showing utilities would have incurred costs for the 20% of schemes they were not able to reschedule. Charges of £797k were recovered from water companies (which would cover work on the water and sewerage networks)[178].

[175] http://dwi.defra.gov.uk/stakeholders/improvement-programmes/dvw/dvw3373.pdf

[176] http://www.deevalleywater.co.uk/category_files/13/english/mains_cleaning_oct2013.pdf

[177] www.thameswater.co.uk/live

[178] https://www.ukpowernetworks.co.uk/internet/en/help-and-advice/documents/Transport%20for%20London%20lane%20rental%20scheme.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						Thames Water have invested in developing the website Thames Water LIVE to show where there are current works on the network likely to cause traffic disruptions[179]. Potential implications of risk manifesting: Opex for "lane rental" charges in urban areas, Reputational damage/ disruption to transport infrastructure.
Water theft		Company: Security; enforcement via legal action against people stealing water; monitoring night lines/ demands on network to detect theft Regulation: Theft is illegal so companies can take action through the courts against water thieves. Prosecution resulting in fines for the risk of contamination via unauthorised standpipes.	3	2	6	Frequency: This risk is relatively frequent. Experts estimate that there a many incidents of small-scale water theft, and fewer, but still relatively frequent, incidents of large-scale water theft events. South West Water prosecuted four companies for water theft in 2014, and highlighted the risk from unauthorised standpipe use[180]. In 2010 Yorkshire Water reported 78 instances of theft and prosecuted 5 businesses for stealing water[181]. Impact: There is no estimate on the amount of water stolen each year in the UK. Experts' assessment is that the level of casual water theft may be greater than companies realise, as access to water networks (e.g. through fire hydrants or using unauthorized standpipes) is available at multiple points on the network and is very difficult to restrict/ police. Potential implications of risk manifesting: Loss of revenue, potential for contamination through unauthorised use of water.

Source: PwC analysis

Forward-looking assessment: treated water distribution

Table 39: Future risks – treated water distribution

Future risk	Impact

[179] www.thameswater.co.uk/live

[180] http://wwtonline.co.uk/news/water-theft-could-lead-to-prosecution-warns-south-west-water#.ViuAS9KFMiQ

[181] http://www.bbc.co.uk/news/uk-england-11022975

Aging asset base and resilience	The water network is being replaced at a relatively slow rate, and contains a significant proportion of older assets, which means there is an increasing risk of failure as the average age of the asset base increases.
Loss of availability of power	Power is used to pump water on the network. This is one of the more energy intensive parts of the value chain. There is a risk that energy security will reduce over time, as supply margins erode and the UK becomes increasingly dependent on imports. This creates a risk that unavailability of power will impact the water supply.
Climate change mitigation (energy use)	Companies will increasingly need to reduce their reliance on energy, or switch to renewable sources to play their part in mitigating climate change. It is possible that energy mitigation schemes such as the CRC will become more punitive in their penalties for emissions in future, in which case companies may need to pay more to self-generate or source energy from sustainable sources.

Source: PwC analysis

Sewage collection

Sewage collection consists of three main components. These are referred to as “foul”, surface water drainage, and highway drainage.

Foul relates to the activities of collecting foul sewage from customers’ properties, activities relating to the development, repair and maintenance of the sewage collection infrastructure. This also includes the provision and maintenance of ancillaries such as overflows, screens, on-line and off-line retention tanks, rising main wells and pumps and flow measurement.

This begins with the receipt of sewage from the retail customer or new appointee and ends with the sewage arriving at the inlet to sewage treatment works or discharging through CSOs in adverse weather conditions.

Surface water drainage relates to the activities related to the collection of surface water from exterior areas of customers’ properties, activities related to the development, repair and maintenance of the sewage collection infrastructure, and the provision and maintenance of ancillaries such as overflows, screens, on-line and offline retention tanks, rising main wells and pumps and flow measurement.

This begins with the receipt of surface water drainage from retail customer or new appointee and ends with the sewage arriving at the inlet to sewage treatment works or discharging through CSOs in adverse weather conditions.

Highway drainage includes the activities related to collection of surface water that runs off roads and pavements, activities related to the development, repair and maintenance of the sewage collection infrastructure, the provision and maintenance of ancillaries such as overflows, screens, on-line and off-line retention tanks, and rising main wells and pumps and flow measurement

This begins with the receipt of highway water drainage into sewage collection infrastructure and ends with the sewage arriving at the inlet to sewage treatment works or discharging through CSOs in adverse weather conditions.

All three of these sub-elements utilise similar assets in their operations. This includes:

- Sewers and pipework – from customer premises/new appointees to sewage treatment works
- Pumping stations and other assets within the sewerage network (such as manholes and inspection chambers)
- Storm overflows and screens
- Street furniture and other ancillary assets
- Emergency outflows
- IT assets – network control
- Vehicles
- Premises

Significant risks – sewage collection

Table 40: Summary of significant granular risks – sewage collection

Sewage collection	• Private sewer transfer and private pumping station transfer • Sewer flooding • Hydraulic flooding/CSOs	• Misuse of sewers • Flow variation

Source: PwC analysis

Evidence for significant risks – sewage collection

Table 41: Evidence for significant granular risks – sewage collection

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
Private sewer transfer and private pumping station transfer	The transfer of private sewers in 2011 led to a significant increase in network size for all sewerage companies. The assets were poorly identified at the transfer date and often in a poor state of repair. This has led to significant additional planned and reactive maintenance costs for the companies. Private pumping stations will transfer to the companies in 2016, and hold a similar degree of uncertainty over the volume of assets likely to transfer and the likely maintenance costs.	Company: understand/map/collect observations from asset base, invest to reduce risk from asset base. Until the assets are brought to stable condition, the industry is likely to have to take on a degree of reactive maintenance and backlog base expenditure. Regulation: Defra legislation to enable private sewer transfer on 1 July 2011 and private pumping station transfer in 2016. Allowance at PR14 for logging up of historic private sewer costs as well as forecast costs for sewers and pumping stations. Totex menu cost sharing.	3	4	12	Frequency: 2011 private sewerage transfer caused a 70% average increase in sewer length for water companies, increasing associated maintenance costs. A significant proportion of the inherited sewer infrastructure is poor quality. Impact: Companies logged up expenditure for private sewers at PR14. Assuming costs started at handover in July 2011, the aggregate industry annual impact of private sewer transfer on companies' revenue requirement is estimated at around £66m. *'More immediately, the doubling of our sewerage network following the private sewer transfer in 2011 brings challenges and opportunities. Many private pumping stations will transfer in 2016 and while it will take time to understand the condition and performance of this 1infrastructure, it will deliver a more integrated approach to sewerage services for our customers.'*[182]

[182] Wessex Water long-term strategy, page 4.

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						Potential implications of risk manifesting: Larger than anticipated reactive maintenance bills, larger than anticipated numbers of private pumping stations transferring and therefore larger operating costs than anticipated.
Sewer flooding	Blocked or overloaded sewers may back up into properties causing internal sewer flooding or into gardens causing external flooding to customers' land.	Company: sewer flooding risk registers, resolve risk for all properties at risk on a given return period and resolution is cost beneficial (based on customer willingness to pay). Surveys where new properties are put on the "at risk" register and make system improvements/repairs where cost efficient. Planning to meet demands of a growing population and hence to maintain an acceptable number of customers "at risk". Wessex Water states that investment in sewerage over the past decade has significantly reduced the risk of flooding but they still need to invest to counter increases in the impermeable areas connected to the sewer network and the more extreme rainfall events associated with climate change[183]. Regulation: Totex menu cost sharing	4	2	8	Frequency: There were 1,551 internal sewer flooding incidents in 2014/15, 4.2 incidents per day across England and Wales or around 65 incidents per million properties. The best performing regions had just under 1 incident per week (0.8) and the worst had c. 8.5 incidents per week[184]. Impact: The cost to wastewater companies is in the sewerage network. For example, South West Water are spending £9m over AMP6 on their Downstream Thinking scheme including drainage management schemes to address the risk of flooding[185]. Potential implications of risk manifesting: Opex and capex to clear sewer blockages/ sewer collapses or to mitigate properties/ the network against flooding caused by insufficient capacity. Compensation payments to affected customers. Reputational damage (e.g. Wessex Water lists this as one of the top three customer priorities for investment at PR14[186]).

[183] Wessex Water long-term strategy, page 26.

[184] http://www.ofwat.gov.uk/regulating/casework/reporting/rpt_los2014-15customer

[185] http://waterfuture.southwestwater.co.uk/sites/default/files/South%20West%20Water%20Business%20Plan.pdf

[186] Wessex Water long-term strategy, page 26.

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
Hydraulic flooding/ CSOs	Overloaded sewers may overflow into public spaces/ other parts of the environment, or through "combined sewer overflows" (CSOs) into watercourses. This is exacerbated by heavy rainfall where the sewerage system consists of combines surface and foul water sewers, or where there are hydraulic constraints on the network.	Company: increase storage, sewer separation, storm tanks at WwTW, potentially sustainable drainage systems. Acting as flood risk partners in regional flood risk committees. *'The last few years have seen increased public attention on combined sewer overflows (CSOs) which act as relief valves when sewers are full of rainwater. By installing monitors at coastal sites, we now know exactly where spills have occurred and for how long. We pass this information immediately to local authorities and interest groups through our Coastwatch initiative, as well as providing an interactive map on our website.'*[187] Regulation: Totex menu cost sharing, minimum statutory standards, ODIs	4	2	8	Frequency: The risk of hydraulic flooding of sewers is relatively frequent: There were 796 sewerage pollution incidents in 2014/15 (around 2 per day) and 22.1 serious pollution incidents. The best performing company had 0.85 events per week and the worst had 3.3 per week[188]. Impact: There is obvious impact on the public and the environment, but there is also financial consequence for the water companies. The largest fine raised against a sewerage company in 2014 was for Southern Water (£500k) for a pollution event at a pumping station. Southern Water was fined a further £40k for a second breach at a pumping station and Anglian Water £50k for a breach at a pumping station[189]. Northumbrian Water has created a partnership approach with the Environment Agency and local authorities to implement sustainable drainage (SuDS) projects in its region, while other measures include insourcing CCTV work for reactive flooding, which has resulted in quicker response to incidents. It plans to spend around £8m on projects that will mitigate sewer flooding[190]. Significant capex is likely to be needed to mitigate flooding caused by insufficient capacity (e.g. through sewer separation). The Thames Tideway Tunnel is one example of an engineering based solution to overcome lack of capacity for storm water in London. It is estimated it will cost £4.2bn[191]. Other solutions involving the sewerage network might include local

[187] Wessex Water long-term strategy, page 20.

[188] http://www.ofwat.gov.uk/regulated-companies/comparing-companies/performance/companies-performance-2014-15/environmental-impact/

[189] Environment Agency public registers http://epr.environment-agency.gov.uk/ePRInternet/SearchRegisters.aspx

[190] http://wwtonline.co.uk/news/northumbrian-reveals-8m-suds-plans#.VjwlftInwiQ

[191] http://www.tideway.london/the-tunnel/history/. This has been updated from the figure initially published, following feedback from "Tideway" (Bazalgette Tunnel Limited).

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						sewer separation in the most constrained parts of the network (likely to be disruptive e.g. road closures). Potential implications of risk manifesting: Compensation payments to affected customers. Environment Agency prosecution and fines.
Misuse of sewers	Customers place inappropriate items down the sewer causing blockages and sewer flooding. Common items wrongly put down sewers include nappies, fats oils and greases.	Company: Public education, inspection and maintenance Regulation: Totex menu cost sharing	2	3	6	Frequency: Water UK estimates that companies respond to 200,000 blockages per year, 75% of which are caused by fats oils and grease. More than 3,000 homes are flooded as a result of blockages each year (which Water UK estimates is 55% of total flooding)[192]. Customer education is important to water companies. 70% of sewer flooding incidents are caused by factors other than excessive rainfall – one example is Northumbrian Water's PR campaign featuring the mascot "Dwaine Pipe" and the slogan '*only toilet paper, pee and poo goes down the loo*'[193]. Impact: £15m per year is spent annually on clearing blockages (plus more on cleaning up after sewer flooding)[194]. Potential implications of risk manifesting: Opex for additional sewer maintenance (e.g. jetting, clearing blockages). Additional sewer flooding occurs due to blockages.
Streetworks cause disruptions to traffic etc	Companies may need to close the road, put traffic lights in place or narrow the road/ cause obstruction with roadworks to repair and replace mains. This can result in traffic	Company: avoiding lane rental charges and complaints/ reputational damage by planning activities outside lane rental hours.	3	2	6	Frequency: Thames Water's Thames Water LIVE website shows where there are current works on the network likely to cause traffic disruptions[195]. It shows that there are multiple network issues at any time in most sizeable towns that are likely to cause disruption

[192] http://www.water.org.uk/policy/environment/waste-and-wastewater/fats-oils-and-grease

[193] http://wwtonline.co.uk/features/interview-richard-warneford-wastewater-director-northumbrian-water#.Vi9_obfhCM8

[194] http://www.water.org.uk/policy/environment/waste-and-wastewater/fats-oils-and-grease

[195] www.thameswater.co.uk/live

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
	disruption and potentially lane rental charges where there are schemes in place.	Use of "no-dig" technology; co-operation with other utilities. Regulation: Local authority lane rental schemes under the Traffic Management Act				(which will be a mixture of work on mains and sewers). Impact: TfL implemented a lane rental scheme from June 2012, covering 57% of the TfL road network with daily charges for traffic disruption at busy times of day (either £800 or £2,500 for different categories of road)[196]. Reporting on the scheme for a one year period over 2013 and 2014 showed that utilities work during critical periods reduced by 70-80%, showing utilities would have incurred costs for the 20% of schemes they were not able to reschedule. Charges of £797k were recovered from water companies (which would cover work on the water and sewerage networks)[197]. A report on progress on the Kent Lane Rental Scheme quoted charges of £300-£800 per day in lane rental hours for lane closure and £1,600-£2,000 for road closure. A base study covers a 20 week Southern Water sewer scheme in Margate to dig a 12m trench to access the sewer for repairs. Closing the road would have cost Southern Water £112k and the scheme commencement would need to be delayed until after Christmas as increased shopper traffic was expected. Southern Water found a way to avoid lane rental fees and maintain 2 way traffic by closing off only one side of the road. It also reduced the scheme delivery time to 15 weeks and saved £84k on lane rental as a result. Potential implications of risk manifesting: Opex for "lane rental" charges in urban areas, Reputational damage/ disruption to transport infrastructure.

Source: PwC analysis

[196] https://www.ukpowernetworks.co.uk/internet/en/help-and-advice/documents/Transport%20for%20London%20lane%20rental%20scheme.pdf

[197] http://content.tfl.gov.uk/lane-rental-monitoring-report-oct-2013-jun-2014.pdf

Forward-looking assessment: sewage collection

Table 42: Future risks – sewage collection

Future risk	Impact
Aging asset base and resilience	The water network is being replaced at a relatively slow rate, and contains a significant proportion of older assets, which means there is an increasing risk of failure as the average age of the asset base increases.
Population growth	As population grows and connects to the sewerage system, existing hydraulic constraints on the network may be exacerbated, and new constraints may start to arise. If not mitigated, this will manifest in increasing frequency of sewer flooding, sewer overflows and breaches at wastewater treatment works.
Loss of availability of power	Power is used to pump waste water in the sewerage network. There is a risk that energy security will reduce over time, as supply margins erode and the UK becomes increasingly dependent on imports. This creates a risk that unavailability of power will impact the water supply.
Climate change	Climate change is likely to lead to increasingly intense rainfall events, which will place additional pressure on combined sewers and may result in a larger number of sewer overflows and consents breaches at treatment works in the future.

Source: PwC analysis

Sewage treatment

Historically, sewage treatment has included two components: **sewage treatment & disposal** and **sludge transport**. Sewage treatment and disposal involves the receipt and treatment of untreated sewage from the sewage collection system and discharging treated wastewater into rivers and sewage sludge to treatment processes. Sludge transport includes the transport of sludge from the sewage to the sludge treatment plant (from 2015-16 this will be included as part of the sludge element of the value chain).

Assets in this segment include:

- Sewage treatment plants – tanks, filters, strainers etc
- Pumps, valves and other ancillary assets
- Sludge holding tanks
- IT assets – treatment works control
- Vehicles
- Other premises

Significant risks – sewage treatment

Table 43: Summary of significant granular risks – sewage treatment

Sewage treatment	• Major compliance breaches • Flooding of treatment works • Health and safety	• Failure of key assets • Poisoning of microbes

Source: PwC analysis

Evidence for significant risks – sewage treatment

Table 44: Evidence for significant granular risks – sewage treatment

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
Major compliance breaches	When the sewerage system is overloaded or problems arise either with treatment processes or with storage, companies may experience pollution events from wastewater treatment works.	Company: Monitoring of location and frequency of pollution events, storm water storage, maintenance and inspection regime	3	3	9	Frequency: On average, companies achieved 98.8% compliance with their consents at wastewater treatment works in 2014/15. Three companies were considered to be operating below target performance levels with 96.1%-98.6% compliance levels. The Environment Agency reports that there were 61 incidents in 2014 attributable to water companies, 82% of which were

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
	The Environment Agency will prosecute sewerage companies for serious pollution events, and they incur fines for the worst events.	Regulation: Performance incentives, minimum statutory standards				due to containment and control failures. These will be a mixture of incidents at treatment works, pumping stations and sewers. Serious pollution incidents at wastewater treatment works decreased substantially in 2014, from 27 in 2013 to 16 in 2014. 2013 performance is more typical of the past 5 years, whereas 2005 performance was similar to 2014[198]. Impact: Prosecutions resulting in fines in 2014 included 5 charges against South West Water, attracting fines totalling £275k; and one fine against Southern Water of £10k. There were also a number of cautions and enforcement notices[199]. Potential implications of risk manifesting: Opex for clean-up, prosecution by the Environment Agency and fines, reputational damage.
Flooding of treatment works	Wastewater treatment works are often situated close to rivers and are therefore particularly prone to flooding. Since the 2007 floods, companies have invested to mitigate this so that all but the more extreme events are mitigated.	Company: Use of overflow/excess capacity storage, flood defence Regulation: Totex menu cost sharing, performance incentives	2	3	6	Frequency: The Pitt review states that 322 wastewater treatment works were affected by the 2007 floods (and five water treatment works showing that the risk is much greater for wastewater – wastewater treatment works are more often next to rivers as the treated effluent needs to discharge)[200]. Since the Pitt review, companies have invested to improve the flood resilience of their works, hence while this risk remains significant, it is likely to be substantially lower than it was in 2007. Impact: Blackburn Meadows is situated next to the River Don in Sheffield and was heavily flooded in 2007. Two infrastructure assets are located on the site: a wastewater treatment works and electricity substation. The operator of the substation had undertaken an audit of its assets following the flooding of 2000 and invested in defences at a number of the highest risk sites. The effectiveness of the defences at Blackburn Meadows substation meant that flood water was largely kept out. However, the

[198] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/448728/LIT_10127.pdf

[199] Environment Agency public registers http://epr.environment-agency.gov.uk/ePRInternet/SearchRegisters.aspx

[200] Sir Michael Pitt (2008) *Learning lessons from the 2007 floods*, paragraph 14.2.

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						neighbouring wastewater treatment works had not been defended. The result was that the wastewater treatment works, which serves 500,000 people, flooded. Sewage flowed into the river for 5 days following the event. Repair costs are estimated at £17 million[201]. Potential implications of risk manifesting: Opex and capex costs for repairs, pollution/ environmental damage due to waste water mixing with the flood waters.
Grit build up	If the initial screens at wastewater treatment works are operating ineffectively, grit can get into the wastewater and sludge treatment processes, making these processes less effective, and building up in the works.	Company: Filtration, draining down and cleaning out a primary tank Regulation: Allowance for this at price review	2	3	6	Frequency: Grit removal is required every five to seven years Impact: Draining down and cleaning out a primary tank can cost as much as £100,000 and is repeated each time. It is calculated that for every 1% increase in grit downstream, there is a 1% increase in wasted energy[202]. Potential implications of risk manifesting: Opex and capex costs for maintenance, cost of inefficiencies in downstream processes.
Health and safety	Working with wastewater on a treatment works is potentially hazardous to health if proper precautions are not taken, and if aerosols are allowed to form.	Company: H&S plans, H&S policy, staff training, protective clothing (e.g. gloves, masks) kept for work use on site only and washed separately when contaminated; facilities for thorough handwashing and showering in the higher risk facilities; adequate first aid equipment; health monitoring for staff; learning from incidents and illness; separate clean and contaminated equipment; disinfectant available; ventilation	3	2	6	Frequency: HSE guidance states that each year some workers will suffer from at least one work related illness. HSE believes the true levels of illness may be underestimated as employees fail to make the link[203]. Impact: The majority of illnesses are relatively mild cases of gastroenteritis, but potentially fatal diseases, such as leptospirosis (Weil's disease) and hepatitis, are also reported to HSE. Since micro-organisms are an inherent part of sewage, the hazard cannot be eliminated, but can be mitigated. Potential implications of risk manifesting: Risk adjusted salaries for people exposed to waste water, cover for sickness absence.

[201] Sir Michael Pitt (2008) *Learning lessons from the 2007 floods*, page 253.

[202] http://wwtonline.co.uk/features/technically-speaking-grit-removal#.Vi98VrfhCM8

[203] http://www.hse.gov.uk/pubns/indg198.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
		Regulation: HSE, COSHH				
Failure of key assets	Failure of key assets can disrupt the wastewater treatment processes and where there is insufficient storage this will result in pollution events or consents breaches.	Company: Maintenance plans, inspection, proactive maintenance to optimise asset performance; trade effluent monitoring and non-compliance enforcement policy; use of monitors for key failures (e.g. dinitrogen oxide monitor to warn of nitrification failure) Regulation: EA through discharge consents	3	3	9	Frequency: Asset failures are relatively frequent, are factored into companies maintenance plans and are Impact: South West Water 2009 business plan identifies broken screens as having an adverse impact on the treatment process and ability to meet consents as rags found their way into the treatment process and interfered with it. This could also arise from unauthorised trade effluent or breaches in trade effluent consents causing damage to equipment on site (e.g. Yorkshire Water trade effluent enforcement policy identifies oil, grease, sulphate and pH as having potential to damage the treatment works)[204]. Potential implications of risk manifesting: Capex and opex for replacements and repairs.
Poisoning of microbes	Microbial digestion of wastewater is disrupted, for example anoxic conditions develop in aerobic treatment processes, killing the digestion microbes in the process, or the microbes are poisoned by chemicals in the wastewater.	Company: Use of indicators of anaerobic conditions; trade effluent monitoring and non-compliance enforcement policy Regulation: EA through discharge consents	1	4	4	Frequency: For example, this can arise if an unauthorised trade effluent discharge is made that poisons the biological treatment process. UU[205] and Yorkshire Water's[206] trade effluent policies both refer to trade effluent having the potential to damage the biological treatment process. It could also arise through effluent with a high biological or chemical oxygen demand (which may be trade effluent) starving the aerobic bacteria of oxygen and therefore inhibiting the process. Impact: The impact is disruption to specific parts of the wastewater treatment process, for example failure to remove pathogens during aerobic digestion. This results in the sludge and effluent produced in the treatment works containing unacceptable concentrations of pathogenic bacteria which cause health risks and consents breaches/ pollution events

[204] https://www.yorkshirewater.com/sites/default/files/downloads/Trade-Effluent-Enforcement-Policy.pdf

[205] http://www.unitedutilities.com/documents/Trade_Effluent_Information_PACK.pdf

[206] https://www.yorkshirewater.com/sites/default/files/Trade%20effluent%20code%20of%20practice.pdf, see paragraph 25d.

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						Potential implications of risk manifesting: Opex to revive the process, restock with appropriate bacteria.

Source: PwC analysis

Forward-looking assessment: sewage treatment

Table 45: Future risks – sewage treatment

Future risk	Impact
Micro-pollutants or pharmaceutical by-products/ Endocrine disruptors/ other emerging substances [207]	There is a risk that certain micro-pollutants/ chemicals that are not currently listed as priority hazardous substances become listed in future, leading to the need to put in place very costly treatment solutions.
Population growth	As population grows and connects to the sewerage system, existing hydraulic constraints on the network may be exacerbated, and new constraints may start to arise. If not mitigated, this will manifest in increasing frequency of sewer flooding, sewer overflows and breaches at wastewater treatment works.
Phosphorus removal	'*By 2040 the world may also have reached a peak in global phosphorus production, with big impacts on agriculture. We will be expected to recover as much phosphorus from waste water as possible, which in turn would benefit the water environment.*'[208]
Loss of availability of power	Power is used treat wastewater. There is a risk that energy security will reduce over time, as supply margins erode and the UK becomes increasingly dependent on imports. This creates a risk that unavailability of power will impact the water supply. '*Other natural resource constraints could become critical issues – the most prominent of which is peak oil. Energy intensive businesses such as ours could be hit hard by rising energy prices.*'[209]
Climate change mitigation (energy use)	Companies will increasingly need to reduce their reliance on energy, or switch to renewable sources to play their part in mitigating climate change. It is possible that energy mitigation schemes such as the CRC will become more punitive in their penalties for emissions in future, in which case companies may need to pay more to self-generate or source energy from sustainable sources.

Source: PwC analysis

[207] Yorkshire Water, UU and Anglian Water (2015). *'Water 2020' Long term challenges and uncertainties for the water sector of the future.*

[208] Wessex Water long-term strategy, page 5.

[209] Wessex Water long-term strategy, page 5.

Sludge treatment and disposal

Historically, sludge treatment has included both **sludge treatment** and **"liquor" treatment**[210]. While different technologies exist for sludge treatment, it has been defined as a technology-neutral service for the purpose of accounting separation.

Sludge treatment includes the following assets:

- Pre-treatment sludge blending tanks
- Sludge treatment plants – thickeners, digesters, centrifuges, vacuum presses, belt presses, other dewatering assets, sludge dryers, drying beds
- Composting vessels and facilities
- Incinerators
- Pumps, valves and other ancillary assets
- Treated sludge storage facilities
- Vehicles
- IT assets
- Premises
- Gas treatment and energy generation equipment (such as combined heat and power (CHP) plants)
- CHP electrical connection to the grid

Liquor treatment involves all activities in transporting and treating liquors generated during the sludge treatment process. The liquors may be treated either on site at a sludge treatment plant or at a sewage treatment plant. Liquor treatment includes the following assets[211]:

- Liquor pipework from sludge treatment to sewage treatment site
- Sludge liquor treatment plants
- Pumps, valves and other ancillary assets
- Vehicles
- IT assets
- Premises

The configuration of sludge treatment processes are not standardised in the sector. Some sludge treatment facilities will be co-located with a sewage treatment works, but not all sewage treatment works will have sludge treatment facilities. Other sludge processing centres are stand-alone and will be strategically located to be accessible to a number of sewage treatment works and therefore minimise the cost of transporting sludge.

There are significant linkages between the sludge treatment component of the value chain and the sewage treatment element. This can make the delineation between sewage and sludge treatment unclear. For example, the thickening (or "dewatering") of sludge is often carried out as part of the sewage treatment process, especially if the resulting thickened sludge will be transported to a remote sludge treatment centre.

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[210] From 2015-16 onwards liquor treatment will be included within wastewater treatment, rather than sludge, treatment.

[211] As stated above, from 2015-16 these activities will be included in sewage treatment.

Sludge disposal is the final part of the value chain where treated sludge is collected from the collection point, for onward transport and disposal of treated sludge in various forms including ash disposal, disposal to landfill, disposal of composted sludge, sludge cake disposal, and export of treated sludge for disposal.

Assets in this segment include:

- Vehicles
- IT assets
- Premises
- Landfill sites or sludge tips

Significant risks – sludge treatment and disposal

Table 46: Summary of significant granular risks – sludge treatment and disposal

Sludge (treatment & disposal)	• Loss of sludge processing capability • Flood damage • Feedstock quality	• Logistical inefficiencies • Inadequate wastewater treatment or sludge treatment

Source: PwC analysis

Evidence for significant risks – sludge treatment and disposal

Table 47: Evidence for significant granular risks – sludge treatment and disposal

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
Loss of sludge processing capability	If companies lose the ability to process sludge, and storage is poorly set up, anaerobic bacterial can proliferate and septic conditions are experienced, creating a health hazard.	Company: Building in sufficient emergency storage, proper maintenance of assets, long term planning and robust contingency planning Regulation: investment allowed at price reviews.	3	3	9	Frequency: Mechanical problems with sludge handling facilities can mean that sludge must be stored on site whilst the facilities are repaired. Sludge samples from outlying sites can be days or in the worst case weeks old when they arrive at sludge handling sites. Bacteria will proliferate in the sceptic conditions, creating a health hazard. Solutions to maintain facilities so that sludge can be processed when it is fresher, have additional aeration available, or as a last resort chemical dosing could be used to reduce the length of the bacterial filaments, improving settlement[212].

[212] http://wwtonline.co.uk/features/technically-speaking-sludge-under-the-microscope#.Vi9_e7fhCM8

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						South West Water BP09 states that data from their telemetry network demonstrates that the power generated from its CHP plant was on average around forty percent of the level which should be achieved. The company planned to improve performance level through improvements to thickening, sludge import facilities, and the installation of cell lysis[213]. Impact: Companies are investing to avoid this risk, for example South West Water spent £2.8m on maintenance of sludge treatment works in 2013/14, which is 3% of total spend in wastewater[214]. Potential implications of risk manifesting: Potential for pollution events if insufficient capacity to store sludge, potentially leading to Environment Agency prosecutions and fines; opex to manage bacterial growth.
Suboptimal sludge throughput	Suboptimal throughput increases the potential for sludge needing to be stored on wastewater treatment works before it can be processed and risks the sludge going septic. If the throughput is too slow, the AD plant will operate sub-optimally as it requires a steady flow of feedstock.	Company: building in sufficient emergency storage, proper maintenance of assets, long term planning and robust contingency planning WRAP report on improving feedstocks for AD states that thermal hydrolysis can break down biological material making it easier to digest; autoclaving can be used to remove contaminants for the feedstock prior to the process. In-vessel cleaning systems can remove	3	2	6	Frequency: Anglian Water odour control investment in AMP6 at Great Billing WwTW references lack of throughput and need to store sludge as a factor. Anglian Water states that a lack of buffer capacity which led to a backlog of sludge compromised the treatment processes prior to the scheme[216]. Impact: Companies are investing to avoid this risk, for example South West Water spent £2.8m on maintenance of sludge treatment works in

[213] http://www.southwestwater.co.uk/media/pdf/6/c/Formatted_B3.7.6_for_Review_IM_excised.pdf, page 11.

[214] http://www.sww-annual-reports-2014.com/pdf/sww-capr-report-2014-final.pdf

[216] Anglian Water representation, page 104.

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
		contaminants such as heavy metals, sand and grit that accumulate in the bottom of the vessel and can reduce performance[215]. Regulation: Totex menu cost sharing				2013/14, which is 3% of total spend in wastewater[217]. Potential implications of risk manifesting: Potential for pollution events if insufficient capacity to store sludge, potentially leading to Environment Agency prosecutions and fines; opex to manage bacterial growth.
Poor quality feedstock	Poor feedstock quality (e.g. low calorific value due to contaminant such as grit and rags) leads to suboptimal energy generation, and the need to remove material from the digester periodically.	Company: Monitoring and testing processes for *processed* sludge, sufficient dewatering Regulation: Totex menu cost sharing	2	3	6	Frequency: A WRAP report on improving feedstocks for AD states in-vessel cleaning systems can remove contaminants such as heavy metals, sand and grit that accumulate in the bottom of the vessel and can reduce performance[218]. Impact: The impact of poor quality feedstock is that the process is less efficient than it could be (as the calorific value of the sludge is lower than it should be) leading to additional costs and suboptimal energy generation from the AD plant. Potential implications of risk manifesting: Capital and opex costs of maintenance (e.g. to grit screens on wastewater treatment works). Cost of cleaning vessels out (and managing throughput of the treatment works during the resultant outage in the AD plant).
Inadequate sludge treatment	Inadequate sludge treatment may mean that the sludge is not fit for disposal to land, and the sewerage	Company: Monitoring and testing processes for *unprocessed* sludge; pre-	2	3	6	Frequency: Relatively low likelihood – compliance with the "sludge to land" requirements/ safe

[215] http://www.wrap.org.uk/sites/files/wrap/Digestates%20from%20Anaerobic%20Digestion%20A%20review%20of%20enhancement%20techniques%20and%20novel%20digestate%20products_0.pdf

[217] http://www.sww-annual-reports-2014.com/pdf/sww-capr-report-2014-final.pdf

[218] http://www.wrap.org.uk/sites/files/wrap/Digestates%20from%20Anaerobic%20Digestion%20A%20review%20of%20enhancement%20techniques%20and%20novel%20digestate%20products_0.pdf

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
	company must therefore find an alternative disposal route.	treatment of sludge prior to entering AD process Regulation: Totex menu cost sharing				sludge matrix in 2014-15 was 100%[219], and there has been 100% compliance for some time. This shows that the risk is very heavily mitigated. Where sludges are likely to fail the requirements either for microbial content or heavy metals companies will use a different disposal route (e.g. incineration) or undertake further treatment to make the sludge suitable for disposal. Impact: Sludge cannot be used so will need to be re-treated, costing valuable time and resources and could cause a build-up Potential implications of risk manifesting: Inability to dispose of sludge via preferred route, potential need to transport sludge (e.g. to incineration plant).
Methane storage	Methane is a flammable and explosive gas, and hence is potentially hazardous to handle and store. The biogas from anaerobic digestion is not pure and may contain other hazardous gases.	Company: Safe gas handling procedures, maintenance of gas handling facilities Regulation: Gas handling and storage regulations	2	2	4	Frequency: Gas escape can occur if equipment fails or is misused. Impact: United Utilities has been fined £400,000 for polluting the area around its wastewater works site in Stockport. The company was prosecuted by the Environment Agency following an incident at Stockport Waste Treatment Works. A gas holder at the site, which was part of the sludge treatment system, failed leading to 50,000 cubic metres of biogas - containing methane and hydrogen sulphide - to escape for three weeks. Firefighters were called to the incident, which happened in October 2011, because of the potential for explosion.[220] Potential implications of risk manifesting: Pollution (greenhouse gas emissions), flammable

[219] http://www.ofwat.gov.uk/regulated-companies/comparing-companies/performance/companies-performance-2014-15/environmental-impact/

[220] http://www.manchestereveningnews.co.uk/news/greater-manchester-news/united-utilities-stockport-waste-treatment-7070289

Risk	Description	Risk mitigation	Frequ-ency	Impact	Net exposure	Evidence
						gas, hence potential cost of damage, odour nuisance (from hydrogen sulphide).

Source: PwC analysis

Forward-looking assessment: sludge treatment and distribution

Table 48: Future risks – sludge treatment and distribution

Future risk	Impact
Loss of sludge disposal route	If there is a tightening of EU standards for the content of sludge disposed to land, or if there are any events that impact the industry's reputation for disposing of sludge to land safely, companies could be left with much more limited disposal routes for sludge (i.e. incineration only). This could potentially add cost for companies.
Loss of availability of power	Power is used in the sludge treatment process. There is a risk that energy security will reduce over time, as supply margins erode and the UK becomes increasingly dependent on imports. This creates a risk that unavailability of power will impact the water supply.
Climate change mitigation (energy use)	Companies will increasingly need to reduce their reliance on energy, or switch to renewable sources to play their part in mitigating climate change. It is possible that energy mitigation schemes such as the CRC will become more punitive in their penalties for emissions in future, in which case companies may need to pay more to self-generate or source energy from sustainable sources.
Micro-plastics	Micro-plastics (generally 5mm in size or less) are increasingly present in the water and sewerage value chain. The two largest sources are road run-off (mainly car tyres) and washing machines (due to a trend towards synthetic clothing). It has been found that some of these micro-plastics carry priority substances (see below) into the treatment chain. Although this issue has been identified relatively recently (i.e. there is no accepted method for sampling and analysis), already some jurisdictions, e.g. the Netherlands, have seen major manufacturers voluntarily ceasing the production of manufactured micro-plastics. Ongoing work in academia is looking at how micro-plastics flow through the wastewater value chain. It is likely that some, but not all, micro-plastics will end up in the sludge treatment phase of wastewater.
Impact of EU legislation/ consents on sludge composition	If standards are tightened around removal of additional priority hazardous substances (e.g. in the third River Basin Management Planning Cycle of the Water Framework Directive) this could have an implication for the composition of sludges, and therefore for their compliance with the "safe sludge matrix" and their acceptability for disposal to land. It is becoming evident that some treatment technologies do not completely chemicals identified as "priority substances", but simply move them from the liquid phase i.e. the waste water, into the solids phase i.e. the sludge. As these chemicals are no longer discharged in the effluent of the Wastewater Treatment Works then compliance with the Water Framework Directive requirement will be achieved. However, the final destination of these chemicals once in the sludge is undetermined. There is a risk that these chemicals may leach back into the watercourse or could contaminate the land. These risks could therefore limit feasible and sage disposal routes. These risks could be mitigated through additional requirements that force the adoption of technologies which actually destroy these chemicals; however, this would likely have significant cost implications.

Source: PwC analysis

Sludge treatment and distribution: risks for a new entrant

Table 49: Sludge treatment and distribution – potential risks for a new entrant

Risk	Consequence	Impact
Small reduction in volume of sludge treated by water utility (e.g. 10%)	Results in all water utility assets still being utilised but as the volume of sludge has decreased the cost per unit of sludge treated increases.	If the "new entrant" facility is unable to treat the sludge then it is relatively easy to accommodate this volume at the "old" facility.
Significant (40%) to major (70%) reduction in volume of sludge treated by water utility	Results in a modification of water company sludge management plans, with some sludge treatment facilities either partially or fully decommissioned.	If the "new entrant" facility is unable to treat the sludge then transportation costs may be incurred to take sludge to other facilities, or at worst decommissioned water company facilities may need to be brought back into service.
Thickening stage failure	Thickening stage fails resulting in dilute sludge being fed to the digester resulting in a drop in gas yield.	Probably containable at the "new" facility *e.g.* hire in emergency equipment, and therefore no impact on the "old" facility.
Digestion stage failure - minor mechanical	Digester suffers from a minor mechanical failure *e.g.* feed pump, resulting a reduced feed and a drop in gas yield.	Probably containable at the "new" facility *e.g.* hire in emergency equipment, and therefore no impact on the "old" facility.
Digestion stage failure - major mechanical	Digester suffers from a major mechanical failure *e.g.* mixing system breaks loose, resulting in a severe drop in gas yield.	A major failure will require a digester shut down at the "new" facility and provision of treatment elsewhere *e.g.* potentially at the "old" facility.
Dewatering stage failure	Dewatering stage fails resulting in an inability to feed suitable sludge to the disposal route.	Probably containable at the "new" facility *e.g.* hire in emergency equipment, have an emergency storage tank, and therefore no impact on the "old" facility.
Disposal route failure - short term	Minor failure *e.g.* incinerator feed failure, resulting in a temporary inability to maintain the disposal route.	Probably containable at the "new" facility by stockpiling the sludge cake.
Disposal route failure - long term	Major failure *e.g.* land no longer available, resulting in a significant inability to maintain disposal route.	Impact on "old" facility depends on disposal route. If *e.g.* incineration, may require recommissioning.

Source: PwC analysis

Summary long list of risks

The table below sets out a longer list of risks we considered in compiling the most significant risks for each segment of the value chain. We considered the risk score after mitigation for each of the risk we identified and ranked the risks according to the post-mitigation score. Although the aim was to generate a list of the top five most significant risks for each segment, we included fewer risks or more risks where we judged that they were significant. Where there were multiple risks with the same post-mitigation score, we used a secondary ranking of the pre-mitigation scores to generate a list of five or six key risks.

The risks and risk scores were tested through an initial workshop with Tony Conway. Subsequently, we researched evidence to support our initial scoring for the most significant risks, as presented in the preceding tables. In some cases, we adjusted our scores to reflect the evidence.

Table 50: Granular risks - water

Water resources	Raw water distribution	Water treatment	Treated water distribution
Significant risks: • Shortage of water during a drought • Catchment management measures are ineffective • Dam failure • Over-abstraction • Source contamination	**Significant risks:** • Aqueduct failure • Other distribution asset failure • Contamination/infiltration	**Significant risks:** • Critical asset contamination • Core component failure • Security breach including theft of materials • Flood damage • Non-critical asset contamination	**Significant risks:** • Ground movements/freeze-thaw cause leakage • Bursts cause flooding • Supply interruptions and low pressure • Contamination • Street works cause disruptions to traffic etc. • Water theft
Other risks considered • Flood damage • Energy costs (pumping) • Risk of ODI penalties • Health and safety • Damage to habitats or species through asset failures or breaches • Theft or damage of water company assets, including theft of materials. • Contractor or resourcing issues • Risk of outage in 24/7 monitoring/ control room issues • Trespass/ unauthorised access/ third party use/ security breaches • Personal security of staff working on site	**Other risks considered:** • Raw water used for potable purposes • Risk of ODI penalties • Health and safety • Damage to habitats or species through asset failures or breaches • Theft or damage of water company assets, including theft of materials. • Trespass/ unauthorised access/ third party use/ security breaches	**Other risks considered:** • Control system failure/ loss of telemetry link • Chemicals and energy costs • Health and safety • Damage to habitats or species through asset failures or breaches • Chemicals used in treatment cause pollution	**Other risks considered:** • Energy costs (pumping) • ELL not achieved (included in ground movements) • Lack of asset location data leads to difficulty with responding to network failures • Security breach • Flood damage at pumping stations • Infiltration at service reservoirs (included in contamination) • Health and safety • Contamination during new connections (included in contamination) • Poor reinstatement • Contractor or resourcing issues

Source: PwC analysis

Table 51 Granular risks - sewerage

Sewage collection	Sewage treatment	Sludge (treatment & disposal)
Significant risks: • Private sewer transfer and private pumping station transfer • Sewer flooding • Hydraulic flooding/CSOs • Misuse of sewers • Street works cause disruptions to traffic etc.	**Significant risks:** • Major compliance breaches • Flooding of treatment works • Grit build up • Health and safety • Failure of key assets • Poisoning of microbes	**Significant risks:** • Loss of sludge processing capability • Suboptimal sludge throughput • Poor quality feedstock • Inadequate sludge treatment • Methane storage
Other risks considered: • Lack of asset location data leads to difficulty with responding to network failures • Health and safety • Misconnections • Poor reinstatement • Contractor or resourcing issues • Damage to habitats or species through asset failures or breaches	**Other risks considered:** • Materials / energy costs/ chemicals costs • Inadequate treatment levels (e.g. excess phosphates in effluent) • Odour control • Minor compliance breaches/ minor breach of discharge consent • Theft or damage of water company assets, including theft of materials. • Contractor or resourcing issues • Damage to habitats or species through asset failures or breaches	**Other risks considered:** • Asset failure (digester bacteria poisoned) • Methane handling • Failure to remove pathogens from sludge • Heavy metal content • Nowhere to dispose of the sludge • Health and safety • Damage to habitats or species through asset failures or breaches

Source: PwC analysis

For the purposes of this study, retail was considered already separated with regards to the price control, and therefore the risks are already disaggregated. Hence, we did not consider this segment further beyond generating an initial list of risks set out in the table below.

Table 52: Granular risks - retail

Retail - household	Retail – non-household
• Bad debt • Cost to serve • Costs not linked to RPI • Complex compliance regime • Reactive environment –keeping KPIs on track • Staff conduct-related risks (e.g. failing to spot vulnerability) • IT failure or new IT system bedding in • Customer dissatisfaction/ reputational damage	• Level playing field/ CA98 • Working capital • Building skills/ competitiveness • Reducing costs • Customer dissatisfaction/ reputational damage

Source: PwC analysis

Appendix B - Competition and beta

A key objective of Ofwat's market design options is to facilitate competition and the development of new market mechanisms. Competition risk is likely to increase the cost of capital, but the degree to which this adjustment occurs through the cost of equity rather than the cost of debt or gearing depends on whether competition risk is systematic. In this appendix we assess how different cost of capital components should adjust to changes in competition risk. In doing so, we review relevant academic literature as well as relevant previous regulatory debates.

Overall, we find that the relationship between competition and beta is not straightforward in its application. We find that total risk will be higher as a result of competition, but we do not consider this will be driven by increases to systematic risk. Opening up a segment of the value chain to contestability will put market share at risk. But regardless of the cause of market share loss, there may not necessarily be an increase in beta. This is because in a CAPM framework equity investors are assumed to hold diversified portfolios. Therefore, as one firm's market share loss is another firm's market share gain, sufficiently diversified investors could be neutral at the portfolio level. In other words, diversification means although one stock value may fall, there are offsetting increases elsewhere in the portfolio. Based on this rationale, we suggest that adjustment to beta is made on account of competition risks.

This remainder of this appendix is structured as follows:

- Academic evidence – this subsection sets out the findings of several academic papers regarding competition and beta;
- Past regulatory discussions – this subsection summarises past discussion regarding the relationship between competition and beta;
- Application to market reform – this subsection discusses the applicability of both academic evidence and past regulatory discussions in the context of Ofwat's market design options, and concludes.

Academic evidence

Academic evidence on the linkage between competition and beta does not show consensus. Earlier papers on the topic such as Chen et.al (1986) and Subrahmanyam and Thomadakis (1980) suggest that increased levels of competition (i.e. reduced market power) will lead to higher betas.[221]

Subrahmanyam and Thomadakis (1980) investigates the relationship between systematic risk and the theory of the firm – developing a model which shows the relationship between beta and firm variables such as monopoly power, demand elasticity and the labour:capital ratio. The model is very theoretical in construct – it has the following features:

1. A single period model i.e. there are no dynamics.
2. Every firms sets an optimal level of output – this is set such that value is maximized.
3. Each firm faces variable levels of demand - prices are a function of output, but prices are set to vary randomly, generating uncertainty regarding the outturn price (which is not known when output decisions are made).

[221] Chen, K., Cheng, D. and Hite, G. (1986) *Systematic Risk and Market Power: An Application of Tobin's q*, Quarterly Review of Economics and Business, 26:3; and Subrahmanyam, M. and Thomadakis, S. (1980) *Systematic Risk and the Theory of the Firm*, The Quarterly Journal of Economics, 94:3.

One of the papers most relevant findings was that for firms with similar production techniques, lower monopoly power will lead to higher betas.

Chen et.al (1986) states that it is difficult to assess what proportion of return variation is caused by systematic risk differentials versus market power. Moreover, this is further complicated as systematic risk can be a function of market power. Previous studies that have found mixed results regarding the directional relationship between systematic risk and market power are also cited.

The authors build on the model structure set out by Subrahmanyam and Thomadakis (1980). Applying 'Tobin's q' as a measure of market power. When a firm earns economic rents typically reflected in market prices, its market value exceeds the replacement costs of its capital stock. Such a situation would lead to a Tobin's q value greater than one.[222] The model and empirical results from their paper conclude that beta is negatively related to market power (as measured by Tobin's q).

More recent research by Bustamante and Donangelo (2014) which discusses produce market competition and industry returns finds that market competition has two opposing effects on asset returns.[223]

1. The first is an investment channel, where competition erodes the value of growth options to a given firm. This is associated with firms in competitive industries have higher "earnings to price" ratios – where more value is generated by existing assets rather than potential growth options. Through this channel competition decreases expected asset returns.

2. The second is an operating leverage channel, where firms in more fiercely contested industries have lower profit margins. As profit margins act as a buffer to shocks to the firm, firms in competitive industries have operating profits which are proportionally more sensitive shocks. Through this channel competition increases expected returns.

Bustamante and Donangelo find that competition reduces the value of a firm, but that competition does not necessarily increase beta, and may even reduce it. This is because the first effect (the investment channel) dominates the second effect (the operating leverage channel). As the threat of entry or expansion by competitors can be pro-cyclical, the dominating investment channel effect can mean that expected returns decrease for more competitive industries as returns across the economy generally rise. In other words, the pro-cyclical nature of value destruction lowers exposure to systematic risk where competition is greater.

Summary

Overall, we find that there is no consensus within the academic literature as to the directional impact of competition on beta. Given the constrained features of each of the models set out above, we also have reason to question the applicability of these findings to a regulated sector such as water (see discussion below).

Past regulatory discussions

Following the break-up of the BAA Group and the acquisition of Gatwick and Stansted by different owners, the competitive dynamics of the airport sector changed. In their submission to the CAA, Gatwick Airport (supported by work from Oxera) cited the increase in competition as introducing greater demand volatility – directly impacting the risk profile of the airport- and in principle leading to higher asset betas.

As the cost of capital advisors to the CAA, we reviewed the arguments presented by Gatwick airport, concluding that:

[222] Tobin's Q is defined as the ratio of a firm's market value to the replace costs of its capital stock.

[223] Bustamante and Donangelo (2014) P*roduct Market Competition and Industry Returns*, Financial Markets Group Discussion Paper no.728.

> *'We consider is unlikely that competition would have any direct impact on the systematic risk profile of the industry… One airport's market share gain is another airport's market share loss and these risks can be diversified in a broad portfolio.'*[224]

We did however see some merit in Gatwick airport's conceptual argument that competition could inhibit a regulated firm's ability to price to the cap and hence impacts profit margins. In order to increase systematic risks, airports would need to price below the cap in downturn scenarios, and pricing to (or closer to) the cap in other times. Despite this conceptual validity we understood that even with increased competition, Gatwick had not priced below the price-cap at the time of our assessment.

Overall, in the context of airports, it was not clear that the competition risks discussed would increase systematic risk (or beta). But through the total risk of the airport being increased, there could be an impact on capacity to maintain as high gearing levels compared to a pure monopoly situation.

Building on the past discussion of competition and beta during the CAA's Q6 determination, we distinguish between two different impacts competition can have on firms below – market share loss and pro-cyclicality of prices.

Market share loss

Opening up a segment of the value chain to contestability will put market share at risk. But regardless of the cause of market share loss, there may not necessarily be an increase in beta. This is because in a CAPM framework equity investors hold diversified portfolios. Therefore, as one firm's market share loss is another firm's market share gain, sufficiently diversified investors could be neutral at the portfolio level.

Pro-cyclicality of prices

Although market volumes may not be any more cyclical as a result of competition, in some circumstances, competition may lead to prices becoming more pro-cyclical as a result of competition. Where there are greater pressures to cut prices in order to retain market share in a downturn, this can lead to lower returns across an industry i.e. not just at a single firm. From an investors perspective this is a non-diversifiable risk - as the impact on returns is spread across a larger set of companies there is not offsetting benefit. For regulated industries this is particularly relevant where a price-cap is in operation, and where prices may fall below cap in a downturn. Under a revenue cap, there is likely to be less of an impact on returns, as this form of control is less binding and lower risk.

Application to market reform in the UK water industry

In this subsection we review the applicability of academic evidence and past regulatory discussions on competition and beta to the market reforms being considered in the water industry.

Academic evidence

We find that most academic discussions of the relationship between competition and beta lack features which would make their findings relevant for a regulated sector such as water. For example, the features of the Subrahmanyam and Thomadakis (1980) model set out above, show little relevance to the realities of the water companies in England and Wales. Firstly, there is no scope for the dynamics of sector regulation in their static framework. Secondly, the model is orientated around firms who "choose" their output level. In practice the companies regulated by Ofwat (as with many other utilities) have to provide a minimum level of service to prescribed standards. Lastly, except for uncertainty during regulatory determinations, there is very little revenue uncertainty due to the regulatory framework in place.

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[224] PwC (2013) *Estimating the cost of capital in Q6 for Heathrow, Gatwick and Stansted*, A report prepared for the Civil Aviation Authority, April 2013.

Similar concerns also apply to Chen et.al (1986) as this paper used a similar framework to Subrahmanyam and Thomadakis (1980). Furthermore, as this paper's measure of market power was Tobin's q, and the analysis was related to changes in this parameter, it has limited applicability to regulated industries. Regulatory determinations are calibrated such that monopoly firms do not earn economic rents i.e. the regulator tries to establish conditions to those that would be experienced under competition. Indeed, one '*test of the appropriateness of the regulator-set cost of capital*' is how close Tobin's q is to one.[225]

Similar critiques can be applied to Bustamante and Donangelo (2014), in that the paper does not take account for any of the nuances of sector regulation.

Overall, we do not find a compelling case to placing weight on any particular piece of the academic literature, and note the mixed findings across the literature regarding the directional relationship between competition and beta.

Past regulatory discussions

For water resources we do not find incentives for entry/competition to be systematic, and therefore consider the increased risks as specific. We do not propose an adjustment for the risk of market share loss, because a diversified equity investor may be neutral at the portfolio level.

For sludge, we find that a future expansion of the energy generation elements of the business could mean that prices are more closely linked to macroeconomic factors. Our discussions with water industry experts suggest that there are opportunities for expansion of sludge activities, particularly those linked to energy generation, for example, through combining sludge with food wastes to increase calorific value. This view is echoed by Ofwat who see sludge as increasingly having a value (rather than simply being a disposal cost). If, competition were to catalyse increased commercial focus on maximising energy generation revenues. This would increase the size of the sludge business that is linked to energy generation relative to the current landscape, and this is the component that potentially faces higher systematic risk. As a result of this commercial focus, the net costs of sludge disposal could be more sensitive to energy price movements. Therefore, under this scenario, sludge prices could eventually become more systematic in aggregate – this risk could not be diversified away by an equity investor. Such an effect is not direct impact of reforms, rather an expected evolution of the sludge segment of the value chain, if these industry trends materialise.

Summary

Overall, we find that the relationship between competition and beta is not straightforward in its application. We find that total risk will be higher as a result of potential market share losses, but we do not consider that there is a clear case for increases in systematic risk – and therefore suggest that no adjustment to beta is made on account of competition risks.

[225] Stern, J (2013) *The role of the regulatory asset base as an instrument of regulatory commitment*, CCRP discussion paper.

Appendix C - Cost of capital benchmarks

Table 53: Benchmarking the value chain

Comparator group	Applies to the following value chain segments	Company or determination	Beta	Gearing
Regulated Benchmarks				
UK Sewerage – based on implied asset beta from *CEPA briefing note – 25th August 2015*	• Sewage collection	Thames tideway tunnel (TTT)	≈ 0.23	57.5%
UK Energy – covering the parameters applied in Ofgem's RIIO determinations as well as recent observed parameters	• Treated Water Distribution • Sewage collection	RIIO ED1 (Ofgem)	0.38	65%
		RIIO ET1 (Ofgem)	0.38	60%
		RIIO GT1 (Ofgem)	0.34	62.5%
		RIIO GD1 (Ofgem)	0.32	65%
		National Grid (estimated asset beta)	0.25 – 0.38	54%
		Centrica (estimated asset beta)	0.47 – 0.52	27%
		SSE (estimated asset beta)	0.39 – 0.49	33%
UK Telecoms – covering the parameters applied by Ofcom as well as observed parameters	• Treated Water Distribution • Sewage collection	Openreach copper (Ofcom 2015)	0.50	30%
		BT Group (Ofcom 2015)	0.74	30%
		BT Group (estimated asset beta)	0.55 – 0.74	33%
Australian water and wastewater – Parameters from regulated water company determinations in Australia	• Whole value chain	SA Water (2015)	0.28	60%
		Victorian water businesses (2013)	0.26	60%
US water and wastewater – covering more water resources focused comparators, and an average of water-only companies and water and sewerage companies	• Water resources	Cadiz – Water resources and agriculture (estimated)	0.53	37%
	• Water value chain	Water only companies (estimated)	0.55	34%
	• Whole value chain	Water and sewerage companies (estimated)	0.52	37%
Competitive benchmarks				
"**Sludge plus**" – comparators here have some segment of their business in sludge activities. Synagro deals with biosolids, fertilizers and renewable energy. Daiseki treats and recycles, waste oil, wastewater and sludge. China Everbright engages in waste water treatment and sludge. Aquasystems treats industrial and	• Sludge • Sewage treatment	Synagro Technologies (US)	0.23 – 0.29	44%
		Daiseki (Japan)	0.82 – 0.84	2%
		China Everbright (China)	0.35 – 0.41	44%
		Aquasystems Int. (Belgium)	NA	49%

household wastewater and sludge (not listed).				
"Solid waste plus" – comparators here deal primarily with solid waste including transport, treatment and disposal. Casella and Pizzorno are mostly refuse focused. A segment of Waste Connections deals with oil exploration waste. Shanks has organics activities including waste to fertilizer and energy in addition to solid waste.	• Sludge	Casella Waste Systems (US)	0.29 – 0.41	76%
		Groupe Pizzorno Environment (France)	0.14 - 0.22	72%
		Waste Connections (US)	0.50 – 0.58	25%
		Shanks Group (UK)	0.33 – 0.65	51%
"Other waste plus" – comparators here deal with hazardous and industrial waste. US Ecology engage in cleaning and hazardous waste disposal (including wastewater). Clean Harbors are industrial waste and energy focused.	• Sludge	US Ecology (US)	0.89 – 1.06	6%
		Clean Harbors (US)	0.52 – 0.65	23%
"Treatment" – comparators here build, operate and transfer wastewater treatment facilities. CITIC provide different combinations of build, operate, own and transfer. Beijing Enterprises engages in water and wastewater treatment construction and operation (as well as desalination).	• Water treatment • Sewage treatment	CITIC Envirotech (Singapore)	0.52 – 0.61	37%
		Beijing Enterprises Water Group (China)	0.48 – 0.59	42%
"Capital intensive plus inelastic demand" – comparators here were selected on the basis that their business had a high capital intensity and that demand in their product markets was likely inelastic. Therefore sharing some features of water/waste treatment and sludge – but participating in a very competitive environment. The comparators cover large brewers and packaging and plastics companies which provide packaging for staple goods.	• Sludge • Water treatment • Sewage treatment	SAB Miller (UK)	0.74 – 0.80	26%
		Heineken (Netherlands)	0.57 – 0.66	30%
		Carlsberg (Denmark)	0.50 – 0.71	34%
		RPC Group (UK)	0.58 – 0.62	28%
		PSB Industries (France)	0.29 - 0.38	50%
		Fuji Seal International (Japan)	0.70 – 0.71	13%
Other benchmarks				
UK Designated airports – comparators general considered to have a larger degree of demand risk than water utilities. Regulated under a price-cap.	NA	CAA Q6 Heathrow Airports Limited	0.50	60%
		CAA Q6 Gatwick Airport Limited	0.56	55%

Note 1: Beta ranges based on a five year average of rolling 5yr monthly beta estimates and two year average of rolling 2yr daily beta estimates. Latest available estimates used.

Note 2: Gearing shows total debt as a proportion of total enterprise value – book value of total equity used in place of market-cap where the company is not listed. Gearing typically averaged over the period FY2010 to FY2014 depending on data availability.

Table 54: CMA energy firms beta benchmarks

Comparator group	Applies to the following value chain segments	Company	Levered beta (equity beta)	Unlevered beta (asset beta)
Six large energy firms		Centrica plc	0.46 – 0.47	0.41 – 0.42
		SSE plc	0.31 – 0.46	0.24 – 0.36
		EDF SA	0.93 – 1.05	0.67 – 0.75
		E.on SE	0.70 – 0.97	0.50 – 0.70
		Iberdola SA	0.85 – 1.01	0.55 – 0.66
		RWE AG	0.59 – 0.86	0.45 – 0.67
Vertically integrated firms (non-GB)	• Whole value chain	Enel S.p.A	0.86 – 0.99	0.41 – 0.47
		Gas Natural SA	0.76 – 0.77	0.49 – 0.49
		EnBW AG	0.32 – 0.35	0.25 – 0.27
		Verbund AG	0.58 – 0.72	0.44 – 0.54
		Fortum Oyj	0.77 – 0.95	0.59 – 0.72
		Contract Energy Limited	0.83 – 0.89	0.70 – 0.76
		TrustPower Limited	0.34 – 0.39	0.28 – 0.32
		NRG Energy Inc	0.78 – 1.12	0.42 – 0.60
		Origin Energy	0.34 – 0.57	0.27 – 0.45
		AGL (Australia Gas Light co.)	-0.12 – 0.43	-0.11 – 0.38
Generation firms		GDF Suez	0.64 – 0.77	0.45 – 0.54
		Drax plc	0.35 – 0.42	0.34 – 0.40
		AES corp	1.33 – 1.56	0.60 – 0.71
		American Electric Power Corp	0.51 – 0.54	0.33 – 0.35
		Calpine Corp	1.19 – 1.56	0.63 – 0.82

Source: Competition & Markets Authority (2015) *Energy market investigation*, Provisional findings report.

Note 1: Betas have been unlevered using the following formula: Unlevered Beta = Levered Beta / (1 + ((1 – Tax Rate) x (Debt/Equity))), where the tax rate used is the average statutory corporate tax rate in the country in which each firm has its headquarters. Beta range shown are based on betas of a monthly and quarterly frequency.

Appendix D - Approaches to value chain and beta disaggregation

Telecoms (Ofcom)[226]

In January 2005 Ofcom issued a consultation document on risk and the cost of capital which proposed that the equity beta should be lower for BT's copper access business than for the BT group as a whole. Given the lack of existing evidence on this approach, Ofcom commissioned PricewaterhouseCoopers LLP, in consultation with Professor Julian Franks of the London Business School, to examine in more detail whether a disaggregation of BT Group's beta was appropriate, and if so, what evidence there was to enable the different beta figures to be calculated.

Summary of approach

In the paper *Disaggregating BT's betas*, qualitative and indicative quantitative evidence for a lower beta in BT's copper access business are found according the following approaches:

- **A first principles assessment:** This considers the extent to which variations in profits or cash flow of the access business (revenues and costs attributable to a particular activity) are correlated with variations in general market returns.
- **Income elasticity estimation:** This approach compares elasticities between the access business and a telecommunication group providing both access and call services.
- **Historical changes in BT's group beta:** This approach seeks to infer the contribution to the group beta of the different parts of the BT business from changes in BT's historic beta as the composition of its business changed.
- **Quantitative analysis of the betas of a cross section of telecommunications businesses**: This examines how overall group betas vary between telecommunications companies which differ in the proportions of their business. A sample of 56 companies across 29 countries in Europe, Asia-Pacific, the USA and Canada was created. Company's overall equity beta are computed as a weighted average of the betas of the various separate investments or activities in which the company is engaged:

$$\beta = W_1 \beta_1 + W_2 \beta_2 + ... + W_n \beta_n$$

where the company's overall beta is β, and the company is comprised of n different investments or activities with different betas, whose shares of the business are denoted by the weights $W_1 ... W_n$.

Using the sample of companies considered, regression analysis is carried out to estimate the following equation:

$$\beta_{a(company)} = = \beta_{a(fix)} S_{fix} + \beta_{a(mob)} S_{mob} + \beta_{a(ICT)} S_{ICT} + \beta_{a(other)} S_{other} + \text{other variables}$$

where βa denotes the asset beta and S denotes the share of a particular activity in the overall activities of the business. In principle the weighting factors (S_{fix}, S_{mob} etc.) should be calculated as the contribution to the total market or economic value made by each investment or activity. However, because of the lack of data, revenue weights are used instead.

[226] PricewaterhouseCoopers LLP (2005) *Disaggregating BT's betas*.

The result of this econometric analysis is that the asset beta for ICT activities is significantly higher than for the other businesses, and that the estimate of the asset beta for the fixed line business is sometimes statistically significantly different from the estimates of asset betas for the other two businesses (mobile and other).

The inclusion of the dummy for emerging markets makes little difference to the results; it is statistically significant at the 10% level in only the monthly and daily global regressions. Inclusions of USA and/or Asia-Pacific dummies are also not significant.

However, an argument is made that the reliability of findings could be affected and that the evidence of results could be just directional, given the following issues:

1. Revenue weights are used instead of share of economic value weights in the regression, because of lack of readily available data.
2. Fixed line business data are used as the closest proxy available for a copper access business, because of a lack of data.
3. The different methods of calculation of beta available (monthly, weekly, daily measures against the local and global market indices) give a wide variation in the dependent variable data, implying very different results from the regression analysis.

Quantitative analysis of BT betas over time: This approach estimates the implied beta for BT's copper access by examining the statistical evidence for a correlation of historical movements in the group beta with changes in the share of the access business within the overall group. The following regression is estimated:

$$\beta_t = \alpha_1 + \alpha_2\left(\frac{EV_t - RAV_t^{access\ or\ access\&core}}{EV_t}\right) + \varepsilon_t$$

where RAV is the regulatory asset value measured annually, for either the access business, or using a wider definition including the core network ("access & core"). A positive coefficient on the dependent variable, where it is used to explain movements in BT's group beta (i.e. a bigger proportion of the business which is not access or access & core results in a higher beta), confirms the hypothesis of the paper.

However, again, the support to the result is just directional, and not too much emphasis should be placed on the absolute numbers, given certain limitations of the analysis, such as:

1. the implicit assumption that the betas associated with the access & core business and the rest of the business do not change over the ten years of the dataset;
2. the inability to use the copper access business in the specification, and instead proxy it with the access & core business, as with the cross section analysis;
3. the considerable uncertainty regarding the calculation basis for the dependent variable beta, as with the cross section work.

Gas distribution and transmission (Ofgem)[227]

In the paper *Relative risk and the cost of equity*, CEPA considers the evidence on relative risk presented by Ofgem in its operational risk review and by Oxera in its review of market data. In the *Gas Distribution Price Control Review, Final Proposal* of 2007, Ofgem, in fact, suggested that the GDNs should be viewed as being at least as risky as transmission, and thus they should potentially have a higher cost of equity than transmission operators.

Both a bottom-up and a top down approach were used in the analysis.

[227] Ofgem (2007) *Gas Distribution Price Control Review, Final Proposals*.

Bottom-up analysis:

The study by Ofgem focuses on relative risk measured as differences between allowed and actual costs across the categories of capital expenditure, replacement expenditure, operating expenditure and tax. Their analysis concludes that the cost variability faced by GDNs is higher than that faced by Transmission Operators (TOs) and this difference is statistically significant. However CEPA concluded that ex post differences between actual and allowed costs are not a valid measure of differential non-diversifiable (i.e. systematic) risk. Large cost differences can arise simply because companies are less efficient than they should be. Cost risks can be decomposed into input price and input volume risk. While the former is, in part, a systematic risk (for example, unanticipated cost inflation affecting the entire industry), the latter is principally a diversifiable and largely controllable risk.

Ofgem arrived at their conclusion that the risk differential is statistically significant on an annual basis by applying a Monte Carlo programme from Excel on a point estimate. However CEPA found the following limitations in the analysis:

- It ignored the information contained in the actual variation data and utilised a different assumed standard deviation on costs.
- It required assumptions about an underlying continuous probability distribution, which may not be realistic given the lumpy nature of some of the cost categories, such as capital expenditure.

Top down analysis:

On behalf of Ofgem, Oxera performed a cross-sectional analysis based on ordinary least squares (OLS) so that each company's asset beta was determined by the share of its business in network and production activities for gas and electricity. The segment share was measured by one of the three measures: profit, revenues or asset size. Since there are no pure gas distribution or transmission network owners traded within the UK, this study was based on international data. 50 energy firms (38 US and 12 EU) were included in Oxera's final sample. For each firm in this sample the latest financial statements were analysed, and from this analysis, Oxera obtained the proportion of firms' activities attributable to the different following business segments:

- electricity transmission;
- electricity distribution;
- gas transmission;
- gas distribution;
- other sectors (e.g. telecoms, electricity generation and supply, and gas production and supply).

The following regression are run:

- **Model 1:** Company asset beta = β_{EG}(electricity generation) + β_{ET}(electricity transmission) + β_{ED}(electricity distribution) + β_{GP}(gas production) + β_{GT}(gas transmission) + β_{GD}(gas distribution)
- **Model 2**: Company asset beta = β_{ET}(electricity transmission) + β_{ED}(electricity distribution) + β_{GP}(gas production) + β_{GT}(gas transmission) + β_{GD}(gas distribution)
- **Model 3**: Company asset beta = $\beta_{transmission}$(electricity and gas transmission) + $\beta_{distribution}$(electricity and gas distribution)
- **Model 4**: Company asset beta = $\beta_{electricity}$(electricity transmission and distribution) + β_{gas}(gas transmission and distribution)

For these regressions, the company's asset beta and the proportion of the company's various business segments are inputs. The coefficient estimates on the business segments are outputs, which are then used to test whether the asset beta of various companies differ according to the size of their distribution and transmission activities for gas and electricity.

In the original paper *Is there a risk differential between energy networks?* Oxera checks for significance of the individual betas, and compares the raw numbers in order to identify any difference.

In its analysis, instead, CEPA performs the following tests:

- hypothesis testing whether the asset beta for gas distribution is statistically different from the asset beta for gas transmission at the 5 per cent significance level (t-test);
- hypothesis testing whether the asset betas for electricity and gas distribution are jointly different from those from electricity and gas transmission at the 5 per cent significance level (F-test);

Moreover, according to CEPA, Oxera's cross-country analysis omitted a potentially important variable, namely, differences in the regulatory regime. Thus, CEPA ran the analysis again including a variable reflecting the nature of the financial risks arising from the form of the regulatory regime. Specifically, regulatory regimes are classified as either "high-powered" incentive regimes, "low-powered" rate of return regimes or "medium-powered" hybrid regimes.

A USA dummy and regulatory regime ordinal variable are added to the regression. The USA dummy takes the value of one when the company is based in the USA and zero when it is not. The regulatory ordinal variable is one when the regulatory regime is incentive regulation, three when it is rate of return and two when the regulatory approach is a mixture or the company is affected by both types of regulation

As far as model 1 and 2 are concerned, CEPA was not able to conclude that the asset betas for gas distribution and transmission were statistically different from one another. However, they were able to conclude that asset betas are different for distribution and transmission in relation to gas and electricity jointly at the 10 per cent significance level.

In terms of model 3, CEPA was able to reject the null hypothesis that the asset betas for distribution and transmission for electricity and gas are the same as one another, at the 5 per cent significance level. However, when the USA dummy and regulatory regime ordinal variable were included, the result found by Oxera was reversed and it was then possible that the asset betas for distribution and transmission for electricity and gas were the same.

In conclusion, when CEPA repeated Oxera's analysis, they were unable to find the conclusion that there was a statistically significant difference between gas transmission and gas distribution companies. Moreover, when the new control variables were included, the Oxera results were further weakened.

Conclusions by Ofgem

In response to the CEPA argument, the GDNs submitted an updated report from Oxera. This report argued that not only did the risk analysis support a higher cost of equity for the gas distribution networks, but that, even if the conclusion was that of no risk differential, then the higher gearing levels used in setting the cost of capital for the gas distribution networks necessitated a higher cost of equity, using fundamental corporate finance theory (Modigliani-Miller).

In its final decision, Ofgem accepted Oxera's view and accepted the risk differential between gas transmission and distribution:

> '*Our review of relative risk indicates that, under these price control conditions, GDNs are overall no less risky, and may be somewhat more risky, than the transmission companies under their current price controls. This supports the view that the allowed rate of return on equity for GDNs should be no lower, and could be somewhat higher,*

than the 7.0 per cent rate assumed in TPCR. In updated proposals, we indicated we would consider a range of 7.0 per cent to 7.5 per cent for final proposals.'[228]

Airports (CC / CAA)[229]

In the context of recommending to the Civil Aviation Authority (the CAA) maximum level of airport charges that Heathrow Airport Ltd (HAL) and Gatwick Airport Ltd (GAL) may levy during the period of five years beginning on 1 April 2008, the Competition Commission estimated the equity beta for the whole BAA group, and disaggregated it into Heathrow, Gatwick and other services, in order to capture any relevant differences in the cost of capital.

Summary of approach

In terms of equity beta estimation for the whole BAA group, according to the CC, much more weight should be given to the direct estimates of the betas from historical data. The indirect estimation would estimate the beta for Heathrow and Gatwick from other airport companies around the world. However, the fact that other airports have different regulatory frameworks and risk profiles makes this methodology not fully desirable. Moreover, this approach lacks robust validation. It is not clear whether the single betas for Heathrow, Gatwick and Stansted estimated with this methodology would add up to the BAA plc beta. The BAA's equity beta is thus estimated by measuring the correlation between movements in the returns accruing to individual shareholders and movements in the returns on the market portfolio as a whole. FTSE All Share index is used as a proxy for the market and for the beta estimates one and two years of daily data are used.

In order to set different price limits for Heathrow and Gatwick, the Competition Commission suggested the following formula to disaggregate the obtained asset beta into the different airports:

$$\beta_a^{BAA} = \frac{\beta_a^H K^H + \beta_a^G K^G + \beta_a^O K^O}{K^H + K^G + K^O}$$

where β_a is an asset beta, BAA is the BAA group, H is Heathrow, G is Gatwick, O is other BAA businesses (including Stansted) and K is the value of assets (of Heathrow, Gatwick and BAA group's other assets).

The formula basically imposes that the "asset weighted average" of the betas across the different parts of BAA plc group must equal the asset beta for the whole group. This make intuitive sense since splitting a certain business into parts for the purpose of the analysis, should not impact the risk of the business as a whole.

Following this, a qualitative assessment of the different levels of risk to which the two airports are exposed is presented:

- **Demand Risk:** the response to the terrorist attacks of 11 September provides useful insight into the relative sensitivity to a systematic shock. The financial impact of that event was twice as high for Gatwick and four times as high for Stansted as compared to Heathrow.
- **Riskiness of airline customers**: the airline betas, representing the riskiness of airlines, could be linked with the riskiness of airports if both are affected by demand risks. According to BAA calculations, Heathrow was less exposed to this type of risk than Gatwick and Stansted.
- **Operational leverage:** higher fixed costs to total costs, which prevent a company with high operational leverage to reduce costs substantially in case fluctuations in demand occur. According to BAA calculations, Heathrow is less hindered by this kind of risk with respect to Gatwick and Stansted.

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[228] Ofgem (2007) *Gas Distribution Price Control Review, Final Proposals.*

[229] Competition Commission (2007) *Competition Commission report on Heathrow and Gatwick price controls 2007*, Appendix F.

Pulling the above evidence together, it is clear that Heathrow will be perceived as the lowest risk airport in the BAA plc group. On the basis of CAA and BAA assumptions, the following simplifying assumptions are outlined:

$$\beta_a^G = \beta_a^H + 0.05$$

This is based on the expectation that Gatwick risk will be higher than Heathrow, but not by a substantial amount. Both airports, in fact, are regulated businesses, subject to five-year price cap resets, and both operate in the same capacity-constrained market.

$$\beta_a^{BAA} = \beta_a^H$$

This is based on the CC's assessment that there should not be any significant difference between the risk of Heathrow and the risk of the BAA plc group as a whole.

These assumptions, together with the result obtained from the β_a^{BAA}estimation, make it possible to solve the beta disaggregation equation outlined above and obtain the following beta breakdown:

$$\beta_a^H = 0.47$$

$$\beta_a^G = 0.52$$

Appendix E - Financing risk

In Section 3 of this report, we explained financing risk is concentrated in the risk of unexpected changes to a company's debt costs. Additionally, we identified that the key source of financing risk is that related to the cost of new debt. As part of the regulatory price control, Ofwat sets the cost of new debt, which is included in the weighted average cost of capital (WACC), with reference to forecast interest rates. In the case of PR14, the cost of new debt was higher than the rate observed in the market at the time the cost of debt was being determined to allow for expected interest rate rises between 2015 and 2020.

In order to quantify this financing risk, we have carried out analysis to estimate a reasonable confidence interval around the cost of new debt estimate set during PR14 at the company level – specifically, the confidence interval around the point estimate for the cost of new debt of 2.0%. In order to estimate this confidence interval, we calculated the historical estimation error between forward rates, derived using a bootstrapping methodology, and the actual yield on 10-year UK government index-linked gilts (ILGs). We used index-linked gilts because the 2.0% cost of new debt is expressed in real terms.

This analysis used the following steps:

- We calculated the forward rates for 10-year index-linked gilts (ILGs) 2, 3, 4, 5, and 6 years in advance of a particular date. This provided forecast yields in each year during a 5-year period two years in the future. Our analysis began at 31 March 1995, so the 2-year forward rate as at this date would be for 31 March 1997, the 3-year forward rate would be for 31 March 1998, and so forth.
- We calculated the estimation error for each forward rate by subtracting the actual yield at the forward rate date from the forward rate. For example, the 2-year forward rate calculated at 31 March 1995 was 4.65%, whereas the actual yield on 10-year ILGs at 31 March 1997 was 3.53. This results in an estimation error of 1.12%.
- This analysis is repeated on a 6-month rolling basis between 31 March 1995 and 30 September 2011. Specifically, we calculate an average estimation error across each of the data points in the 5-year period from the forward rate date. An excerpt of this analysis is set out in the table below.

Table 55: Excerpt of forward rate estimation error analysis

Forward rate date	Forward rate projection as at 31 March 1995	Actual rate at forward rate date	Estimation error
	A	B	C = B-A
Forecast yield as at March 1997 (2-year forward rate)	4.65%	3.53%	1.12%
Forecast yield as at March 1998 (3-year forward rate)	3.92%	2.96%	0.96%
Forecast yield as at March 1999 (4-year forward rate)	3.91%	1.75%	2.16%
Forecast yield as at March 2000 (5-year forward rate)	3.90%	2.13%	1.77%
Forecast yield as at March 2001 (6-year forward rate)	3.89%	2.49%	1.40%
Average estimation error across 5-year period			**1.48%**

Source PwC analysis, Bank of England

The analysis set out in the table above was replicated at 6-month intervals between March 1995 and September 2007. This provided 26 average estimation errors across 5-year periods. We then calculate an 80% confidence interval by inferring a P10 and P90 value from the set of estimation errors The P10 and P90 values from this sample were used to derive an 80% confidence interval of approximately +/- 60 bps.

We can apply this risk range to the latest RCV value using the PR14 assumptions for gearing and the proportion of new debt. This provides us with a monetary value of the financing risk at the industry / company level.

Table 56: Value of cost of debt risk

Item	Calculation	Value
Industry RCV (2014-15)	A	64,747.3
Gearing (PR14)	B	62.50%
Proportion of new debt (PR14)	C	25%
RCV funded by new debt (£m)	D = A×B×C	10,116.8
80% confidence interval (cost of debt risk)	E	+/- 60 bps
Cost of new debt risk (£m)	**F = D×E**	**+/- 60.7**
Cost of new debt risk (% of regulatory equity)	**G = E / [A×(1-B)]**	**+/- 0.25%**

Source: PwC analysis, Ofwat, Bank of England

We can also use our analysis of the current risk landscape to consider how this financing risk may be spread across the value chain. We use the MEAV proportions for each segment to allocate RCV across the value chain, i.e. an "unfocussed" allocation approach, and assign a likely gearing value based on an assessment of the market benchmarks (see *Appendix C*) and our knowledge of the financial characteristics of the different segments. The company level financing risk is also allocated to the segments using the MEAV proportions.

Table 57: Cost of debt risk, segmental analysis

Value chain segment	MEAV	Gearing	Allocated RCV (£m)	Regulatory equity (£m)	Financing risk (£m)	Financing risk (% of regulatory equity)
Company level (wholesale)	**100%**	**62.5%**	**64,747**	**24,280**	**+/-60.7**	**+/-0.25%**
Water resources	3.6%	62.5%	2,347	880	+/-2.2	+/-0.25%
Raw water distribution	1.5%	62.5%	947	355	+/-0.9	+/-0.25%
Water treatment	1.8%	50%	1,140	570	+/-1.1	+/-0.19%
Treated water distribution	20.4%	64%	13,228	4,762	+/-12.4	+/-0.26%
Sewage collection	68.4%	64%	44,267	15,936	+/-41.5	+/-0.26%
Sewage treatment	3.7%	62.5%	2,367	888	+/-2.2	+/-0.25%
Sludge	0.7%	50%	451	225	+/-0.4	+/-0.19%

Source: PwC analysis, Ofwat, Capital IQ
Note: RCV and MEAV data is based on 2014-15 RCV for the industry

As set out in the table above, those segments with a large MEAV and regulatory equity base (sewage collection and treated water distribution) should be able to take on a larger quantity of debt in monetary terms and also bear higher financing risk in regulatory equity terms. The amount of debt financing risk in relation to capital employed is primarily driven by the gearing level for each segment, where segments with higher gearing will be bear greater debt financing risk.

However, as discussed in Sections 5, 6 and 7, the reforms may also have an impact, via changes to gearing, to financing risk.

Appendix F - WaSC v. WoC cost volatility

As part of our risk analysis work, we have carried out a number of high level calculations to determine whether there is likely to be a material difference in risk between water and sewerage companies (WaSCs) and water-only companies (WoCs). Specifically, we have considered the differences between WaSC and WoC operating costs.

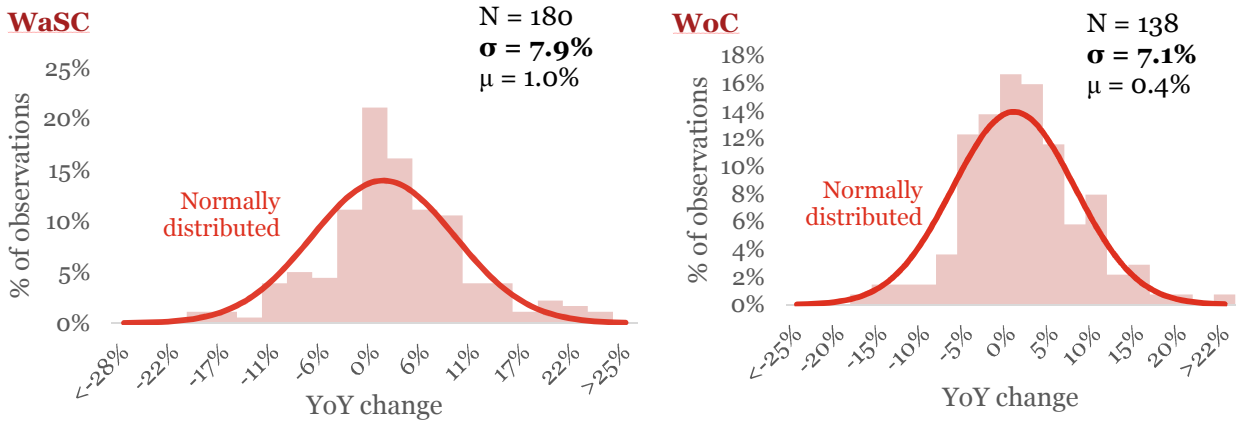
The charts to the left set out the variation in WoC and WaSC operating costs between 1997/98 and 2014/15. The distributions appear to be broadly normally distributed and the summary statistics in each chart indicate a similar level of volatility between WaSCs and WoCs with standard deviations of 7.9% and 7.1%, respectively.

In order to test whether the YoY variation in WaSC and WoC operating costs are significantly different from one another we carry out two tests:

- We first test if the mean from each distribution are statistically different from each other using a t-test for the difference between means. This results in a t-statistic of 1.05, which is not significant at a level of 10% and implies that the average variation for WaSCs and WoCs are not significantly different.
- Given that the focus of our analysis is on risk, i.e. volatility, we also test whether the sample standard deviations are statistically different using an F-test for the equality (inequality) of variances. This results in an F-statistic of 1.26. Similar to the-test for the difference between means, the F-statistic is not significant at a level of 10% and therefore suggesting that the variances (standard deviations) of changes in WoC and WaSC operating costs are not statistically different from each other.

Based on the results of the tests above, we do not consider there to be a significant difference between the volatility of WaSC and WoC operating costs.

Figure 31: Total opex ex. third party services, actual distribution and normally distribution of YoY changes, 1997-98 to 2014-15



Source: PwC analysis, Company data

Appendix G - Benchmarks for cost exposure analysis

Power v. non-power intensive summary

Table 58: Power / energy intensive benchmarks

Capital IQ industry classification	Equity beta (5-year average)
Aerospace and Defense	0.64
Air Freight and Logistics	0.36
Airlines	0.99
Airport Services	0.75
Alternative Carriers	0.58
Building Products	0.47
Coal and Consumable Fuels	0.61
Commodity Chemicals	0.48
Construction and Engineering	0.66
Construction Materials	0.44
Diversified Metals and Mining	1.41
Electric Utilities	0.30
Gold	0.72
Healthcare Distributors	0.43
Industrial Conglomerates	0.52
Industrial Machinery	0.90
Integrated Oil and Gas	0.87
Metal and Glass Containers	0.51
Multi-Utilities	0.39
Oil and Gas Exploration and Production	0.99
Oil and Gas Storage and Transportation	0.29
Paper Products	1.22
Precious Metals and Minerals	0.95
Silver	0.95
Specialty Chemicals	0.77
Steel	1.41
Technology Distributors	0.82
Tobacco	0.44
Trading Companies and Distributors	0.82
Trucking	0.74
Water Utilities	***0.38***
Average	**0.77**

Source: PwC analysis, Capital IQ

Note: "Average" is the average of individual companies as opposed to the average across industry classifications.

Table 59: Non-power / energy intensive benchmarks

Capital IQ industry classification	Equity beta (5-year average)
Advertising	0.75
Apparel Retail	0.56
Apparel, Accessories and Luxury Goods	0.60

Application Software	0.62
Asset Management and Custody Banks	0.53
Automotive Retail	0.69
Broadcasting	0.69
Casinos and Gaming	0.61
Catalog Retail	0.79
Computer and Electronics Retail	0.48
Consumer Electronics	0.18
Consumer Finance	0.76
Data Processing and Outsourced Services	0.55
Department Stores	0.50
Diversified Banks	1.21
Diversified Capital Markets	0.95
Diversified Real Estate Activities	0.54
Diversified REITs	0.50
Diversified Support Services	0.65
Food Retail	0.45
General Merchandise Stores	0.40
Household Products	0.43
Human Resource and Employment Services	0.85
Industrial REITs	0.43
Insurance Brokers	0.37
Internet Retail	0.99
Internet Software and Services	0.90
Investment Banking and Brokerage	0.95
IT Consulting and Other Services	0.38
Life and Health Insurance	0.91
Marine	0.36
Marine Ports and Services	0.46
Movies and Entertainment	0.47
Multi-line Insurance	1.07
Office REITs	0.56
Office Services and Supplies	1.18
Property and Casualty Insurance	0.50
Real Estate Services	0.46
Research and Consulting Services	0.49
Residential REITs	-0.05
Restaurants	0.70
Retail REITs	0.72
Security and Alarm Services	0.41
Specialized Consumer Services	0.16
Specialized Finance	0.80
Specialized REITs	0.70
Technology Hardware, Storage and Peripherals	0.50
Thrifts and Mortgage Finance	0.60
Wireless Telecommunication Services	0.47
Average	**0.60**

Source: PwC analysis, Capital IQ

Note: "Average" is the average of individual companies as opposed to the average across industry classifications.

Labour v. non-labour intensive summary

Table 60: Labour intensive benchmarks

Capital IQ industry classification	Salary costs as a % of total revenue (5-year average)	Equity beta (5-year average)
Advertising	56.8%	0.93
Aerospace and Defense	31.1%	0.61
Apparel Retail	13.9%	0.87
Asset Management and Custody Banks	36.1%	0.79
Auto Parts and Equipment	25.1%	1.40
Brewers	15.0%	0.77
Building Products	19.9%	0.52
Commercial Printing	29.0%	0.52
Commodity Chemicals	20.5%	0.68
Construction and Engineering	9.4%	0.49
Construction Materials	17.8%	0.44
Diversified Banks	39.5%	1.18
Diversified Capital Markets	9.9%	0.74
Diversified Metals and Mining	9.7%	1.22
Diversified Real Estate Activities	56.0%	0.83
Diversified Support Services	27.1%	0.78
Gold	13.9%	1.03
Healthcare Equipment	28.9%	0.23
Healthcare Facilities	10.0%	0.80
Hotels, Resorts and Cruise Lines	11.2%	1.51
Industrial Machinery	18.4%	0.88
Internet Software and Services	13.9%	1.08
Investment Banking and Brokerage	64.3%	0.95
Leisure Facilities	25.0%	0.62
Metal and Glass Containers	17.1%	0.63
Multi-line Insurance	9.7%	0.84
Multi-Utilities	10.1%	0.28
Office REITs	5.3%	0.19
Paper Products	14.6%	1.22
Publishing	41.0%	0.40
Real Estate Services	42.6%	0.48
Residential REITs	22.8%	-0.05
Retail REITs	10.8%	0.47
Specialized Finance	20.9%	0.99
Specialty Chemicals	26.3%	0.69
Thrifts and Mortgage Finance	14.3%	0.64
Tobacco	14.4%	0.50
Water Utilities	***13.8%***	***0.38***
Average	**25.5%**	**0.74**

Source: PwC analysis, Capital IQ

Note: "Average" is the average of individual companies as opposed to the average across industry classifications. There are a small number of sectors that appear in both the labour intensive and non-labour intensive groups due to an equal number of comparators falling into each group.

Table 61: Non-labour intensive benchmarks

Capital IQ industry classification	Salary costs as a % of total revenue (5-year average)	Equity beta (5-year average)
Aerospace and Defense	0.02%	0.53
Application Software	0.01%	0.64
Automotive Retail	0.02%	0.93
Catalog Retail	0.04%	0.91
Coal and Consumable Fuels	0.02%	0.33
Computer and Electronics Retail	0.03%	0.61
Construction and Engineering	0.05%	0.80
Department Stores	0.03%	0.71
Distributors	0.02%	0.90
Diversified Metals and Mining	0.06%	1.85
Diversified Support Services	0.00%	0.34
Electric Utilities	0.06%	0.30
Electrical Components and Equipment	0.00%	0.41
Electronic Components	0.03%	1.00
Electronic Equipment and Instruments	0.04%	0.84
Environmental and Facilities Services	0.04%	0.60
Food Distributors	0.00%	0.56
Food Retail	0.03%	0.34
Healthcare Distributors	0.01%	0.43
Home Improvement Retail	0.01%	0.82
Homebuilding	0.03%	0.98
Human Resource and Employment Services	0.01%	1.13
Industrial Conglomerates	0.01%	0.65
Integrated Telecommunication Services	0.01%	0.49
Leisure Products	0.01%	0.63
Movies and Entertainment	0.01%	0.35
Oil and Gas Equipment and Services	0.02%	0.99
Packaged Foods and Meats	0.01%	0.40
Pharmaceuticals	0.01%	0.14
Property and Casualty Insurance	0.05%	0.72
Publishing	0.03%	0.42
Real Estate Development	0.01%	0.80
Research and Consulting Services	0.03%	0.47
Restaurants	0.04%	0.86
Soft Drinks	0.01%	0.42
Specialty Chemicals	0.05%	0.96
Trading Companies and Distributors	0.05%	1.06
Trucking	0.02%	0.71
Average	**0.03%**	**0.71**

Source: PwC analysis, Capital IQ

Note: "Average" is the average of individual companies as opposed to the average across industry classifications. There are a small number of sectors that appear in both the labour intensive and non-labour intensive groups due to an equal number of comparators falling into each group.

Capex v. non-capex intensive summary

Table 62: Capex intensive benchmarks

Capital IQ industry classification	Capex-to-Opex ratio (5-year average)	Equity beta (5-year average)
Agricultural Products	31.5%	0.33
Airlines	10.2%	0.79
Alternative Carriers	53.1%	0.73
Apparel Retail	8.0%	0.87
Apparel, Accessories and Luxury Goods	7.6%	0.60
Biotechnology	16.3%	0.82
Brewers	11.0%	0.77
Coal and Consumable Fuels	205.7%	0.61
Commercial Printing	7.1%	0.35
Commodity Chemicals	10.0%	0.28
Computer and Electronics Retail	8.3%	0.61
Distillers and Vintners	7.6%	0.47
Diversified Capital Markets	7.8%	1.16
Diversified Metals and Mining	36.8%	1.38
Diversified Real Estate Activities	45.2%	0.26
Diversified Support Services	68.4%	0.64
Electrical Components and Equipment	7.6%	0.36
Electronic Equipment and Instruments	11.8%	0.93
Environmental and Facilities Services	9.2%	0.72
Food Retail	7.4%	0.36
Gold	54.3%	0.75
Healthcare Equipment	11.8%	0.43
Healthcare Facilities	15.4%	0.37
Hotels, Resorts and Cruise Lines	11.1%	0.80
Independent Power Producers and Energy Traders	8.8%	0.38
Industrial Machinery	10.2%	1.31
Industrial REITs	12.3%	0.97
Integrated Oil and Gas	79.8%	0.99
Integrated Telecommunication Services	17.6%	0.74
Internet Retail	9.9%	1.53
Internet Software and Services	52.2%	0.48
Leisure Facilities	20.1%	0.62
Leisure Products	11.0%	0.63
Life and Health Insurance	34.7%	0.35
Metal and Glass Containers	7.0%	0.63
Movies and Entertainment	8.5%	0.35
Multi-Utilities	29.0%	0.28
Office Services and Supplies	13.8%	1.18
Oil and Gas Equipment and Services	43.3%	0.91
Oil and Gas Exploration and Production	89.6%	0.99
Oil and Gas Storage and Transportation	7.1%	0.29
Packaged Foods and Meats	21.8%	0.35
Paper Products	8.1%	1.22
Pharmaceuticals	7.3%	0.60
Precious Metals and Minerals	47.8%	0.95
Renewable Electricity	32.9%	0.21
Restaurants	15.6%	0.72

Retail REITs	28.0%	0.87
Semiconductors	11.7%	1.06
Silver	50.3%	0.95
Specialized Consumer Services	12.1%	0.16
Specialty Chemicals	14.6%	0.72
Steel	17.1%	1.86
Technology Hardware, Storage and Peripherals	15.0%	0.50
Thrifts and Mortgage Finance	9.8%	0.87
Water Utilities	***40.3%***	***0.38***
Wireless Telecommunication Services	13.4%	0.47
Average	**32%**	**0.76**

Source: PwC analysis, Capital IQ

Note: "Average" is the average of individual companies as opposed to the average across industry classifications. There are a small number of sectors that appear in both the labour intensive and non-labour intensive groups due to an equal number of comparators falling into each group.

Table 63: Non-capex intensive benchmarks

Capital IQ industry classification	Capex-to-Opex ratio (5-year average)	Equity beta (5-year average)
Advertising	0.9%	0.71
Air Freight and Logistics	1.1%	0.41
Asset Management and Custody Banks	0.6%	0.76
Automotive Retail	0.6%	0.36
Biotechnology	0.3%	0.36
Cable and Satellite	0.9%	0.40
Catalog Retail	1.2%	0.70
Communications Equipment	1.2%	0.98
Computer and Electronics Retail	0.5%	-0.11
Construction and Engineering	0.5%	0.64
Consumer Finance	1.2%	1.64
Data Processing and Outsourced Services	1.2%	0.55
Distributors	0.9%	0.60
Diversified REITs	0.4%	0.50
Environmental and Facilities Services	1.0%	0.56
Food Distributors	0.5%	0.56
Homebuilding	0.3%	0.95
Human Resource and Employment Services	0.6%	0.94
Industrial Conglomerates	0.8%	0.65
Industrial Machinery	0.7%	0.43
Internet Retail	0.9%	0.46
Internet Software and Services	0.8%	1.08
Investment Banking and Brokerage	1.0%	0.85
IT Consulting and Other Services	0.8%	0.46
Life and Health Insurance	0.3%	0.98
Movies and Entertainment	0.4%	0.59
Multi-line Insurance	0.2%	1.29
Office REITs	0.3%	0.45
Property and Casualty Insurance	0.5%	0.51
Publishing	1.0%	0.49
Real Estate Development	0.3%	0.56
Real Estate Operating Companies	-0.8%	0.48
Research and Consulting Services	1.1%	0.65

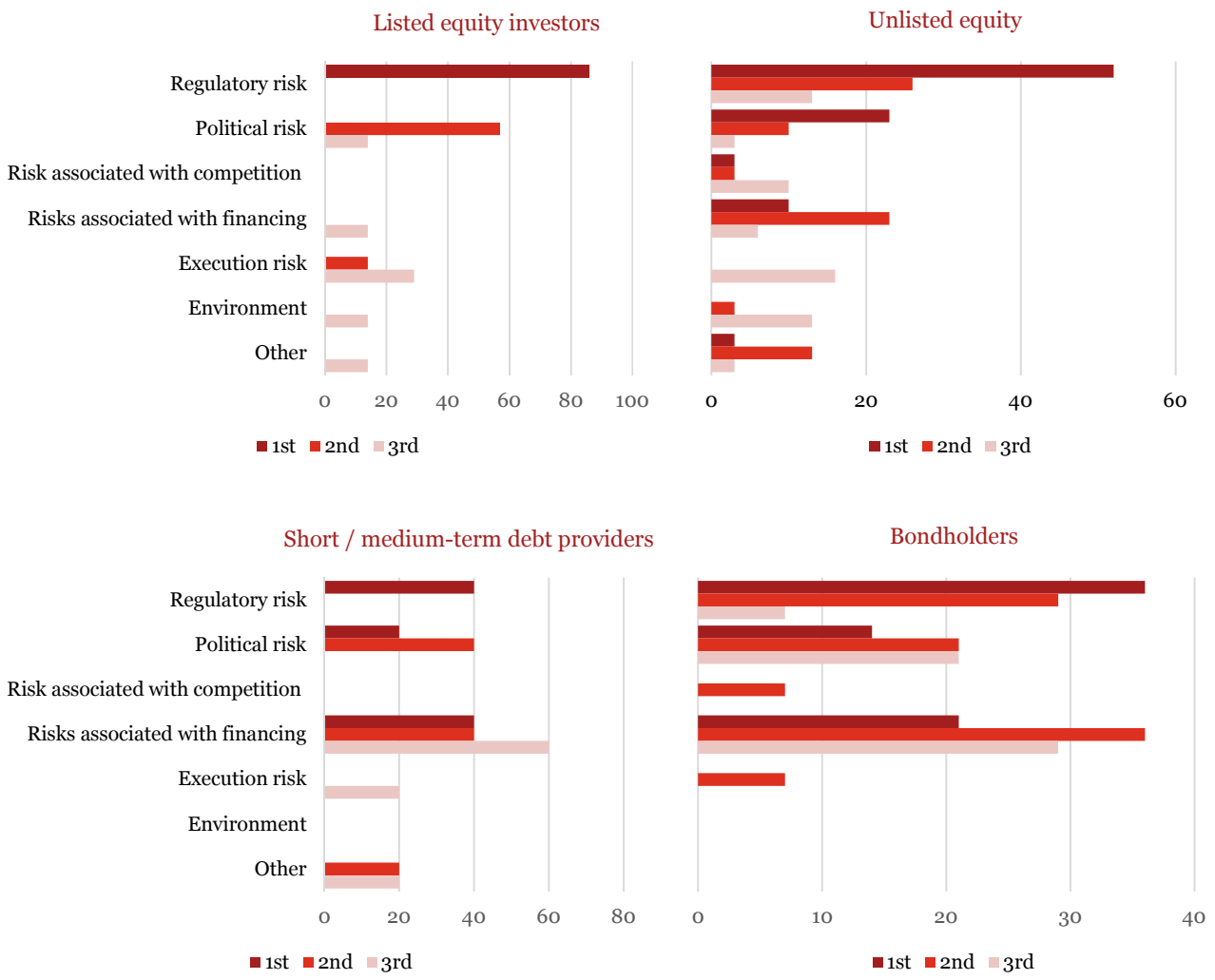
Specialized Finance	0.7%	0.78
Technology Distributors	0.7%	0.75
Tobacco	1.1%	0.38
Trading Companies and Distributors	0.9%	0.70
Trucking	1.2%	0.87
Average	**0.6%**	**0.70**

Source: PwC analysis, Capital IQ

Note: "Average" is the average of individual companies as opposed to the average across industry classifications. There are a small number of sectors that appear in both the labour intensive and non-labour intensive groups due to an equal number of comparators falling into each group.

Appendix H - Investor views

Figure 32: What are the top three risks affecting the water sector?



Source: All charts recreated from data from Indepen (2014) *2014 survey of investors in the water sector: A report by Indepen for Water UK*

Appendix I - Transitional premium to the WACC

In this appendix we set out our approach to estimating the transitional premia to the WACC. The appendix is structured into five parts:

- when a transitional premium is required;
- how we estimate the transitional premium;
- assumptions and calibration of inputs;
- transitional premium outputs; and
- limitations of the analysis.

In all sections we focus in particular on market share loss in the water resources and sludge segments of the value chain as Ofwat identified these segments as candidates for contestability.

When a transitional premium is required

Where the funds for investment were originally committed under the expectation that the assets purchased would be part of a vertically integrated monopoly, reforms for the introduction of markets proposed by Ofwat will create unforeseen cash flow uncertainty. Investors thus face a new risk profile associated with the cash flows on the assets they funded.. We consider how large an adjustment to the WACC should be for investors to be neutral to reform options – where risk changes are captured through considering downside market share loss scenarios. By focussing on downside risks, we are capturing pessimistic or "worst-case" scenarios for the purposes of this analysis.

We distinguish between two scenarios when assessing the premium required:

1. Where the recovery of capital costs associated with **total** RCV is at risk - including existing sunk investments. Under this scenario, the timescale over which a transitional risk premium is required corresponds to the remaining lives of sunk assets. This timescale reflects the expectation of full market share which investors would have held at the time of funding.
2. Where the recovery of capital costs associated with **new** RCV is at risk - excluding existing sunk investments. Under this scenario, the timescale over which a transitional premium is required corresponds to the uncertainty investors' face regarding the cash flow profile of new investments into the RCV. Initially the outcomes of market reforms will be unknown, however, after some years investors will have more complete information regarding reforms and that is when the transitional premium is no longer required. At this early stage of reform development, ascertaining precise timescales for transition is challenging and therefore we take conservative views where appropriate.

How we estimate the transitional premium

We begin by assessing the baseline value to investors, where the incumbents' business retains full market share and allowed revenue is estimated using the typical building blocks approach.[230] In calculating an allowed revenue figure inputs for PAYG, RCV and RCV-run-off were calibrated using information provided to us by Ofwat. A price for a hypothetical unit of production was then estimated using this allowed revenue.

[230] Our analysis abstracts from taxation for simplicity.

We then estimate the NPV under the baseline of full market share over a period that corresponds to the timescales discussed under each of the scenarios above (denoted by "T"). We assume that cash-flows to investors are closely approximated by the return on capital element of revenue.

The present value is estimated using the following formula:

$$PV = \sum_{t=1}^{T} D_t C_t$$

Where C_t is the annual return on capital, and D_t the discount factor is calculated as follows:

$$D_t = \frac{1}{(1+r)^{t-1}}$$

The next stage is then to assess the NPV under a market share loss scenario. This required three key inputs:

- the extent of market share loss;
- how quickly market share loss takes place; and
- the proportion of operating costs that are fixed as oppose to variable with output[231].

For the given price per unit estimated under the baseline of full market share, revenue under market share loss is calculated by multiplying this price by a reduced number of units "sold". Where the extent of this reduction varies in direct proportion to the market share loss assumed. Return on capital is then estimated by deducting RCV-run off and operating costs from revenue. The degree to which operating costs will vary with output levels depends on the proportion of costs that are assumed to be fixed.

We then estimate the average increase in WACC required under the market share loss scenario for the investors to be NPV neutral. We do this by applying the following formula (see technical box 1 for derivation):

$$\Delta WACC = \frac{\overline{C_2} - \overline{C_1}}{\frac{\sum_{t=1}^{T} RCV}{T}}$$

Technical Box 1:

Considering a simplified constant annual cash flow per annum $\overline{\boldsymbol{C}}$, allows to re-write the PV equation as follows:

$$\boldsymbol{PV} = \overline{\boldsymbol{C}} \sum_{t=1}^{T} \boldsymbol{D_t}$$

Given information on the present value pre-market share loss ($\boldsymbol{PV_1}$), the present value under market share loss ($\boldsymbol{PV_2}$) and $\boldsymbol{D_t}$: $\overline{\boldsymbol{C_1}}$ and $\overline{\boldsymbol{C_2}}$ can be estimated as follows:

$$\overline{\boldsymbol{C}}_x = \frac{\boldsymbol{PV}_x}{\sum_{t=1}^{T} \boldsymbol{D_t}}$$

The WACC increase implied is then estimated by expressing the increase in annual return on capital (£) by the average RCV (where only new investment is at risk, this is the sum of the average old and average new RCV).

$$\Delta \boldsymbol{WACC} = \frac{(\overline{\boldsymbol{C_1}} - \overline{\boldsymbol{C_2}})}{\left[\frac{\sum_{t=1}^{T} \boldsymbol{RCV}}{\boldsymbol{T}}\right]}$$

[231] Assumes that PAYG is approximately equal to operating costs incurred for simplicity.

Assumptions and calibration of inputs

To calibrate the model to the reform options being considered by Ofwat we required inputs for a range of parameters. We discuss each in turn below:

- **RCV** – opening RCV is set equal to the level consistent with the main reform option being considered by Ofwat. For sludge this is a £m MEAV allocation of RCVRCV (focussed allocation), and for water resources this is a proportional MEAV allocation of RCV (unfocussed allocation). These figures were provided to us by Ofwat.).
- **New additions to the RCV** – these are set to offset any reductions to the existing RCV due to RCV-run-off, maintaining RCV at its opening level over time.[232]
- **RCV run-off rate** – this is set at a level consistent with average asset lives across each segment. Estimates were based on figures provided to us by Ofwat. A straight line method is applied in converting asset lives to an RCV run-off-rate.
- **Total PAYG expenditure** – these figures were provided to us by Ofwat on a forward looking basis for each segment.
- **Proportion of fixed operating costs** – there is considerable uncertainty regarding the proportion of operating costs that are invariant to output levels, this is because of a lack of data on operating costs. We therefore show a range of values when assessing the magnitude of the transitional premium to the WACC. We note that over the medium-term operating costs are likely to be highly variable, however, the extent of this depends on the type of assets in question.[233]
- **Allowed rate of return (wholesale WACC)** – this parameters is required to estimate allowed revenue under the baseline full market share scenario. F or simplicity we hold this fixed at 3.60% for the entire period (equal to the wholesale WACC set at PR14).
- **Discount rate** – for simplicity this is set at the same level as the wholesale WACC of 3.60%.
- **Market share loss** – We apply a range of market share losses, but tailor the level of maximum market share loss to the segment in question. We do so because the potential for market entry is not the same for all segments (see discussions in sections 6 and 7). Where market share is lost we apply the reduction in a linear fashion during the first five years of contestability, however we note there is considerable uncertainty over the pace and extent of market share loss at this time as Ofwat is still developing market reforms.
- **Time periods** – Under the first scenario discussed above, where the total RCV is at risk, we assess the present value to investors over a 25 year horizon, reflecting the long asset lives present in the water industry. We find that outputs are not sensitive to incremental extensions in horizon above 25 years due to the large size of the discount factor. Under the second scenario discussed above, where only new RCV is at risk, we assess the present value to investors over a shorter 10 year horizon, we assume after this time that investors have more complete information regarding cash flows and asset utilisation.

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[232] As we are considering market share losses, maintaining a constant RCV arguably implies a sanguine view of capex. However, as we are estimating "worst-case" premia and in the interests of keeping modelling tractable we see merits in applying this assumption. Furthermore, the market share losses under consideration are limited due to restricted potential for entry.

[233] Although output falls where market share is lost, depending on the asset type in question, opex may not be fully variable in the short to medium term, particular where assets run at lower capacity rather than being mothballed – and even in the latter case there will still be some fixed costs present.

Transitional premium outputs

Based on the inputs discussed above, we present the outputs for the transitional premium to the WACC below. We begin with a discussion of the first scenario where the total RCV is at risk and then discuss the difference in outputs where only the new RCV is at risk.

Full RCV exposed to competition

In this subsection, the results are calibrated to a scenario where the full RCV is exposed to competition. This means that there is a risk to investors of asset stranding on both sunk investment and new investment. Where market share is lost there is no mitigation against revenue falling i.e. there are no cost categories which are guaranteed to be recovered. In this scenario conditions are similar to that of a fully competitive industry, however, for both water resources and sludge there are factors which limited the potential for new entry (see sections 6 and 7 for discussion).

Table 64 below shows the outputs under this scenario for the sludge segment of the value chain. The outputs shows that the size of the risk premium increases with the proportion of operating costs which are fixed. This results is intuitive, as a business which a higher proportion of fixed costs has profits that vary proportionally more as revenue changes. The premium also increases as market share losses rise and revenue decreases by larger amounts. The table shows that depending on the combination of market share loss and proportion of operating costs which are fixed, the premium can vary significantly. We find that figures towards the bottom right-hand region of the table are likely to upper-bound, maximum outcomes.

Table 64: transitional premium to the WACC - full RCV exposed to competition

		Proportion of operating costs which are fixed			
		10%	**25%**	**50%**	**75%**
Market share loss	**5%**	0.4%	0.5%	0.6%	0.8%
	10%	0.7%	0.9%	1.2%	1.6%
	15%	1.1%	1.4%	1.9%	2.3%
	20%	1.5%	1.9%	2.5%	3.1%

Source: PwC analysis

New investment exposed to competition

In this subsection, the results are calibrated to a scenario where only the new RCV is exposed to competition. This means that there are no risks to investors of asset stranding on existing RCV, because the capital costs associated with the existing RCV (that which was already sunk) are protected through revenue guarantees. There is a minimum level of protected revenue which the incumbent sludge business is allowed to earn regardless of market share loss.

We assume that protection against asset stranding is administered through a two part tariff. Here the incumbent's business is allowed to collect "guaranteed" revenue compromised of PAYG and the capital costs on the old RCV.[234] For simplicity we assume that any revenue shortfall (i.e. where out-turn revenue is less than the guaranteed level) is recovered within year. Any capital costs associated with the new RCV are not protected and are at risk of not being fully recovered. Therefore, the proportion of revenue that is at risk grows over time as the new RCV accumulates and the old RCV runs down.

Consistent with the 5-year cycle of price controls in the water industry, we reset the PAYG amount which comprises part of the protected revenue for the incumbent business at the 5-year interval, at which point PAYG is set to a level commensurate with the realised market share at the time.

[234] We assume that PAYG is approximately equal to operating costs incurred for simplicity.

Table 65 below shows the outputs under this scenario for the sludge segment of the value chain. The outputs show that as the proportion of operating costs which are fixed rises, then the premium required increases – this result is intuitive. However, as market share losses increase, the change in the transitional premium to the WACC is not always positive. The reason for this seemingly anomalous result is that the market share losses begin in the very first year of contestability. In the first year, the new RCV has yet to accumulate, while the old RCV is still fully intact. As the capital costs associated with the old RCV are protected through allowed revenue, as are expected operating costs, revenue is very insensitive to market share loss in the early years of contestability. Meanwhile outturn operating costs fall in line with lower output - especially when the proportion of fixed costs is low – boosting margins when output falls in line with reduced market share.

Table 65: transitional premium to the WACC: – new investment exposed to competition

		Proportion of operating costs which are fixed			
		10%	**25%**	**50%**	**75%**
Market share loss	**5%**	0.1%	0.2%	0.2%	0.3%
	10%	0.1%	0.2%	0.3%	0.4%
	15%	0.1%	0.2%	0.3%	0.4%
	20%	0.1%	0.1%	0.3%	0.4%

Source: PwC analysis

Compared to the outputs where the full RCV was exposed to competition, the premiums here are substantially smaller. Furthermore, these outputs should be viewed as "worst-case" scenario outcomes where investors see very limited upside potential from market reforms.

Limitations of the analysis

As set out above, there are number of assumptions required in estimating transitional premia to the WACC. The analysis has several limitations which mean the results have limited applicability, particularly in the longer-term. Therefore the outputs above should be considered illustrative. We discuss these limitations below:

- The precise magnitude of the risk premium is dependent upon when market share losses, and how abruptly they occur e.g. where there is a step change in market share, or whether it is lost gradually. Anticipating the magnitude and pace of market share changes is very challenging at this early stage of proposals.
- The analysis does not incorporate future regulatory determinations. In practice, future controls could adjust the parameters which have been held constant of the discount period for simplicity. For example, the wholesale WACC may not remain at 3.60% as assumed. Regulation is likely to adapt as market information is gathered.
- Over the long-term, all costs are variable. Our analysis holds the proportion of fixed costs static over time for simplicity.
- Incumbent WaSCs who are less efficient in sludge activities may be more likely to outsource more of their activities, meaning that in the longer-term their RCV's in the contestable segment may decline. Our analysis does not capture this evolutionary element.

Appendix J - Commentary on accounting separation

This appendix sets out an overview of the accounting methodology and approach to separation used by water companies. There have been a number of changes to the way that companies record their data over time that are relevant to the analysis carried out for this project. There are two main issues:

- The definition of value chain segments as presented in company accounts
- The definition of cost lines used in company analysis of operating costs

Definition of value chain segments

Companies have only reported operating cost data in line with Ofwat's current definition of the value chain since 2012-13.[235] Prior to 2012-13, the value chain elements were defined as follows. For the purposes of our analysis we have assumed that the old value chain definitions map to the new definitions as set out in the table below. This allows us to carry out risk analysis on the various segments of the value chain on a relatively consistent basis. The main limitation is that prior to 2012-13 Water resources, raw water distribution and water treatment cannot be differentiated for most cost types.

Table 66: Value chain segmentation

Water services	
Pre 2012-13	Current
Resources and treatment	Water resources
	Raw water distribution
	Water treatment
Distribution	Treated water distribution

Sewerage services	
Pre 2012-13	Current
Sewerage	Sewage collection
Sewage treatment	Sewage treatment
Sludge treatment and disposal	Sludge treatment
	Sludge disposal

Definition of cost lines

The tables below set out the current breakdown of operating expenditure reported in company accounts as well as the breakdown prior to 2012-13. As shown, the pre 2012-13 approach was significantly more disaggregated than the current breakdown. Due to this, our risk analysis draws heavily on the data from before 2012-13 as this allows a more focused assessment of cost risks.

One item that has changed significantly between the two periods is the recording of "Power" costs. The current format includes power costs as well as "income treated as negative expenditure". This second item is the income received from energy generation, which primarily derives from the sludge segment of the value chain. Prior to 2012-13 these two cost components were grouped together in the single "Power" cost line. Due to this the power cost data before and after 2012-13 are not directly comparable. In particular, the year-on-year variation for sludge power costs between this accounting change is affected significantly.

[235] From financial year 2015-16 onwards, Sludge treatment and sludge disposal will be grouped as a single value chain element.

Table 67: Current operating expenditure breakdown

Cost line item	Description
Power	All energy costs, including the climate change levy and the carbon reduction commitment
Income treated as negative expenditure	Income received from energy generation, input as a negative number
Service charges	Total cost of service charges by the Environment Agency or canal & river trust for discharge consents
Bulk supply imports	Total payments for bulk imports/exports
Other operating expenditure	Any other operating costs excluding interest, taxation and local authority rates
Local authority rates	Includes both the local authority rates, cumulo rates and sewerage site rates
TOTAL OPERATING EXPENDITURE EX. THIRD PARTY SERVICES	Total operating costs excluding third party services

Source: Ofwat regulatory accounting guidelines (RAG)

Table 68: Pre 2012-13 operating expenditure breakdown

Cost line item	Description
Direct operating expenditure (allocated to activities)	
Employment costs	The sum of the total costs of non-manual and manual manpower, including gross salaries and wages of all employees, payments resulting from bonus and profit-related payment schemes, employer's National Insurance contributions, superannuation, unfunded pension liabilities, sick pay, sickness benefits, private health insurance, retirement awards, death in service benefits, private health insurance, retirement awards, paid leave, subsistence, travel, entertaining and conference expenses
Power	All energy costs, including power costs and the climate change levy. Income from energy generation should be treated as negative operating expenditure
Agencies	All Section 73 costs of subcontracting services to local authorities
Hired and contracted services	All hired and contracted equipment and services. Hired services exclude the hire of vehicles and plant, which is included in general and support activities. Contracted services include all contracted labour; professional advice (such as lawyers and consultants); computer software; and local authority contracts for the collection of water and sewerage charges.
Associated companies	The total cost of associated companies
Materials and consumables	All materials and consumables that are not in Hired and contracted services. This includes equipment (such as small tools and clothing), provisions, tarmac and backfill materials, but excludes all items capitalised or included within infrastructure renewals expenditure.
Service changes	Total costs of service charges by the Environment Agency or BWB (British Waterways Board) for discharge consents.
Other direct costs	Any other operating costs, but excluding interest and taxation, on an aggregated basis
TOTAL DIRECT COSTS	Sum of above items
General and support expenditure	General and support activities include all centrally provided services, including administrative; financial; legal and property management; research and development; policy determination, implementation and monitoring; audit; public and employee relations; data processing; planning liaison; vehicles and plant (including hired vehicles and plant, and leased company cars); electrical and mechanical maintenance; land and

	property maintenance; materials storage; operational and technical support; and general and support buildings.
FUNCTIONAL EXPENDITURE	Sum of "Total direct costs" and "General and support expenditure"
Indirect operating expenditure (allocated to activities)	
Customer services	Total costs directly associated with customer services, including customer accounting, the reading of meters, debt recovery, customer enquiries relating to tariff matters and charging/billing, and complaints handling.
Scientific services	Total costs directly associated with scientific services including the costs of scientific and laboratory services, and of the monitoring of quality.
Other business activities	Total costs directly associated with other business activities including the cost of regulation, including all incremental managerial costs of regulation, viz. licence fees payable to Ofwat and Defra in respect of regulation; certification fees associated with the Licence requirements and staff and associated costs incurred in the preparation of submissions to, and liaison with, regulators.
TOTAL BUSINESS ACTIVITIES	Sum of "Customer services", "Scientific services" and "Other business activities"
Local authority rates	Includes both the both the Uniform Business Rate and the National Non-Domestic Rate
Doubtful debts	The charge/credit to the profit and loss account for bad and doubtful debts.
Exceptional items	Exceptional items are defined in FRS3, 'Reporting financial performance'
TOTAL OPERATING EXPENDITURE EX. THIRD PARTY SERVICES	Sum of "Total business activities", "Local authority rates", "Doubtful debts" and "Exceptional items"

Source: Ofwat's regulatory accounting guidelines (RAGs), March 2010

Appendix K - Wholesale asset beta

In this appendix we set our calculations in relation the industry wholesale beta. The appendix is structured as followed:

- Wholesale beta from PR14 final determination – this subsection recaps the wholesale WACC calculation applied in the final determination for PR14, and sets out calculations for the corresponding wholesale beta.
- Wholesale beta for PR19 – this subsection rolls forward the calculation of the wholesale beta for PR19.

Wholesale beta from PR14 final determination

The table below sets out the calculation of the wholesale WACC applied in the PR14 final determination. One of the key inputs in estimating of the appointee WACC was the asset beta of 0.3. Having estimated an appointee level WACC, Ofwat then estimated a wholesale WACC where an appropriate deduction to the appointee WACC was made. This deduction was to take account of the retail net margin, which is a component of overall returns. Without making this deduction the retail business of companies would have been rewarded twice.

Table 69: PR14 final determination WACC

Parameters	PR14 FD value
Gearing	62.5%
TMR	6.75%
EMPR	5.50%
RFR	1.25%
Asset beta	0.30
Equity beta	0.80
Cost of equity	5.65%
Cost of new debt	2.00%
Cost of embedded debt	2.65%
Ratio	75%
Allowance for debt fees	0.10%
Overall cost of debt	2.59%
Appointee WACC (vanilla)	**3.74%**
Retail margin	0.14%
Wholesale WACC (vanilla)	**3.60%**

Source: PR14 final determination

Having made the deduction to the appointee WACC to reach a point estimate for the wholesale WACC of 3.60%, we can infer the beta for the wholesale part of the appointee business. Assuming that the cost of debt, gearing, TMR and RFR parameters remain constant, we can solve for a wholesale cost of equity figure. Using the PR14 final determination parameters this yields a figure of 5.28% (as shown in Table 70 below). Having inferred a wholesale cost of equity, we can then solve for wholesale level equity and asset betas.

Table 70: Wholesale beta associated with PR14 WACC

Parameters	PR14 FD value
Wholesale cost of equity	5.28%
Wholesale equity beta	0.73
Wholesale asset beta	0.27

Source: PwC analysis

As set out in Table 70, the implied wholesale asset beta from the PR14 wholesale WACC of 3.60% is 0.27.

Wholesale beta for PR19

Even when we assume that all parameters used in estimate the appointee WACC remain constant between PR14 and PR19, we still expect the wholesale asset beta to be different from 0.27. This is because the size of the retail return deduction from the appointee return will change over time. The table below sets out the calculation of the retail return deduction from the appointee return for PR14.

Table 71: retail margin deduction to calculate wholesale WACC

Component	Calculation	Point estimate
Vanilla WACC	A	3.74%
Retail net margin (after tax)	B	0.90%
Revenue requirement (2015-20) (£m) - Average	C	£10,812
RCV (2015-20) (£m) – Average	D	£63,072
Retail return (£m)	E = B*C	£97
Return on replaced retail assets not added to RCV[236]	F	£7
Retail return deduction from appointee return	G= E-F	£90
Retail return deduction as % of Wholesale RCV	H = G / D	0.14%
Wholesale WACC	**I = A – H**	**3.60%**

Source: PwC (2014) 'Updated evidence on the WACC for PR14'

As the table above shows, having estimated the retail return component of £97m, we then deducted an allowance for the return on replaced retail assets not added to the RCV. The reason for this deduction was that the £97m retail return assumes that retail assets are part of the RCV. However, over time the separate retail control will accumulate its own assets – reaching some steady state level of assets. And hence a deduction is required to avoid double counting.

In the table above, which was applied at PR14, the return on replaced retail assets not added to the RCV reflected the growing level of assets in the retail control over the 2015-2020 period. This level of assets was assumed to start from a base of zero in the initial year of the 2015-2020 period, reaching a state level of £459m by the end of the period.

Whereas at PR14 the retail assets outside the RCV were growing, looking forward to PR19 (and beyond), we assume that the retail assets accumulated outside of the RCV remained at a steady state level of £459m. This assumption has a bearing on the magnitude of the retail margin adjustment applied when transitioning from an appointee WACC to a wholesale WACC. The updated PR19 parameters for this calculation are set out in the table below.

[236] This assumes new retail assets replace depreciation assets, with no retail assets in the wholesale RCV by 2020.

Table 72: updated retail margin deduction to calculate wholesale WACC

Component	Calculation	Point estimate
Vanilla WACC	A	3.74%
Retail net margin (after tax)	B	0.90%
Revenue requirement (2015-20) (£m) - Average	C	£10,812
RCV (2015-20) (£m) – Average	D	£63,072
Retail return (£m)	E = B*C	£97
Return on replaced retail assets not added to RCV	F	£17
Retail return deduction from appointee return	G= E-F	£80
Retail return deduction as % of Wholesale RCV	H = G / D	0.13%
Wholesale WACC	**I = A – H**	**3.61%**

Source: PwC analysis

Comparing the outputs in Table 72 to those in Table 71, we can see that there only a minor change to the return deduction from the appointee return for PR19 (holding all other parameters constant for simplicity). However, the wholesale WACC does rise to 3.61%. Repeating the calculations set out in the subsection above, but with a new updated wholesale WACC of 3.61%, we calculate a long-term wholesale beta of 0.28.

Table 73: updated long-term wholesale asset beta

Parameters	PR14 final determination value
Wholesale cost of equity	5.31%
Wholesale equity beta	0.74
Wholesale asset beta	0.28

Source: PwC analysis

Based on the point estimate for the wholesale asset beta set out Table 73, we apply a figure of 0.28 throughout the report, as this reflects the build-up of retail assets outside the RCV that will have occurred by PR19.