Bristol Water plc: A reference under section 12(3)(a) of the Water Industry Act 1991

Appendices 1.1 – 4.3

Appendix 1.1: Notice of reference and Notice of extension

Appendix 2.1: Ofwat's duties under section 2 of the Water Industry Act 1991

Appendix 2.2: Retail price controls

Appendix 2.3: Ofwat approach to cost assessment

Appendix 2.4: Ofwat's menu scheme

Appendix 2.5: Submissions from other parties

Appendix 3.1: Ofwat's approach to special cost factors

Appendix 4.1: Review of Ofwat's top-down econometric models

Appendix 4.2: Supporting information on alternative econometric models

Appendix 4.3: Assessment of special cost factors

WATER SERVICES REGULATION AUTHORITY
WATER INDUSTRY ACT 1991, SECTION 12

BRISTOL WATER PLC

Notice of Reference: Determination of Price Controls for the period from 1 April 2015

4 March 2015

1. (a) Bristol Water plc ("the Company") holds an Appointment as a water undertaker for the purposes of Chapter I of Part II of the Water Industry Act 1991 ("the Appointment");

1. (b) on 12 December 2014, the Water Services Regulation Authority ("Ofwat") gave notice to the Company of a determination under Condition B of the Appointment of the Price Controls for the period from 1 April 2015 ("the Disputed Determination"). The terms of the Disputed Determination are set out in Schedule 1 hereto;

1. (c) the Company has required Ofwat to refer the Disputed Determination to the Competition and Markets Authority ("CMA"). The terms of the Company's notice are set out in Schedule 2 hereto.

2. Ofwat, as required by section 12(3)(a) of the Water Industry Act 1991 and the Appointment, refers the Disputed Determination to the CMA.

3. The CMA shall report on and determine the Disputed Determination within a period of six months beginning with the date of this reference.

Signed for and on behalf of the
Water Services Regulation Authority

Keith Mason
Senior Director of Finance and Networks

Schedule 1: Final determination letter

Luis Garcia
Chief Executive
Bristol Water plc
PO Box 218
Bridgwater Road
Bristol
BS99 7AU

12 December 2014

Dear Luis

Final determination of price controls

I enclose the formal notification of the determination by the Water Services Regulation Authority (Ofwat) of Price Controls for Retail Activities and for Wholesale Activities. This sets out:

- the designation of Retail Activities;
- the Price Controls in respect of Retail Activities;
- the Price Control in respect of Wholesale Activities; and
- (in the attached annex) the Notified Item and Land sales assumptions.

We will publish information about the annual regulatory reporting and assurance requirements early in 2015.

This final determination letter has been published on our website. We are also publishing the outcomes and associated performance commitments for the company to deliver, together with information on our general approach and the reasons for our decisions.

A key feature of our price review has been clarity about the outcomes that you will deliver and the performance commitments that you have set out. So while not part of the detail set out in the enclosed notification, the set of outcomes, performance commitments and outcome delivery incentives (as detailed in Annex 4 to the published appendix that is specific to your company) should be seen as an essential part of both the price review package and what you need to deliver for your customers.

You must notify us of your menu choice by 16 January 2015 (see IN 14/15, '2014 price review – timetable for setting charges for 2015-16 and making menu choices' (September 2014)).

You have two months from today to decide whether to ask us to refer the determination to the Competition and Markets Authority. If you wish to refer the determination you must let us know in writing no later than 12 February 2015.

Yours sincerely

Cathryn Ross
Chief Executive

Notification by the Water Services Regulation Authority of its determination of Price Controls for Retail Activities and for Wholesale Activities for Bristol Water plc ("the Determination")

Introduction

This is the Determination by the Water Services Regulation Authority ("Ofwat") as to the Price Controls for Retail Activities and for Wholesale Activities. It is made by Ofwat in accordance with Part III of Condition B (Charges) of your Appointment as a water undertaker, having had regard to all the circumstances which are relevant in the light of the principles which apply by virtue of Part I of the Water Industry Act 1991, including, without limitation:

- any change in circumstance which has occurred since the last Periodic Review or which is to occur; and
- the guidance issued by the Secretary of State for Environment, Food and Rural Affairs under section 2A of the Water Industry Act 1991.

The Price Controls will apply to the Charging Year starting on 1 April 2015 and subsequent Charging Years.

You must levy charges in a way best calculated to comply with the Price Controls.

Unless the contrary intention appears, words and expressions used in this document shall have the same meaning as in the Conditions of the Appointment.

Designation of Retail Activities

For the purposes of the Determination, Ofwat confirms the designation under sub-paragraph 8.9 of Condition B of (in summary) the following activities and costs as Retail Activities:

Customer services including:

- billing;
- payment handling;
- remittance and cash handling;
- charitable trust donations;
- vulnerable customer schemes; and
- network and non-network customer enquiries and complaints.

Debt management and doubtful debts.

Meter reading.

Other operating costs including:

- decision and administration of disconnections and reconnections;
- demand-side water efficiency initiatives;
- customer-side leaks;
- attributable other direct costs;

- attributable general and support expenditure; and
- attributable other business activities.

Developer services:

- providing developer information; and
- administration for new connections.

Attributable Business Rates (referred to as Local authority rates in Regulatory Accounting Guideline (RAG) 4.04).

These are, with one change, the retail activities summarised in Table 1 of 'Setting price controls for 2015-20 – final methodology and expectations for companies' business plans' (July 2013) and defined in more detail in section A5.4 of Appendix 5 (Guidance on business plan tables) to that document. The one change is that our definition of Retail Activities was subsequently updated to exclude all scientific services (see IN 13/10, 'Change to company business plan guidance for the 2014 price review – costs of scientific services' (September 2013)).

All activities undertaken as part of the Appointed Business that are not designated as Retail Activities are Wholesale Activities.

This designation is treated for the purposes of sub-paragraph 15.1 (References to the Competition and Markets Authority) of Condition B as part of the Determination.

Price Control for Wholesale Activities

In respect of the Appointed Business's Wholesale Activities, except those activities for which there are Excluded Charges, for the five consecutive Charging Years starting on 1 April 2015 there shall be one single Price Control.

Such Price Control shall consist of, in each Charging Year:

- the percentage change (expressed, in the case of an increase, as a positive number, in the case of a decrease, as a negative number, and, in the case of no change, as zero) in the Retail Prices Index between the published for the month of November in the Prior Year and that published for the immediately preceding November; and
- a number, "**K**", which may be a positive number or a negative number or zero

which together shall be expressed as a percentage, and which shall limit the change in the revenue allowed to the Appointed Business in each Charging Year in respect of the Wholesale Activities concerned.

For the purpose of this Price Control, the revenue in respect of the Wholesale Activities concerned includes capital contributions such as cash receipts from connection and infrastructure charges (including requisitions and self lay).

For each Charging Year starting on or after 1 April 2016 the revenue allowed to the Appointed Business in respect of the Wholesale Activities concerned will be the product of the following formula:

$$R_t = R_{t-1} \times (1 + (RPI + K_t)/100)$$

Where:

R_t = Revenue allowed to the Appointed Business in Charging Year t;
R_{t-1} = Revenue allowed to the Appointed Business in the Prior Year;
$RPI + K_t$ = a number which is the sum of:

(i) the percentage change (expressed, in the case of an increase, as a positive number, in the case of a decrease, as a negative number, and, in the case of no change, as zero) in the Retail Prices Index between that published for the month of November in the Prior Year and that published for the immediately preceding November; and

(ii) a number, "K_t" for Charging Year t, which may be a positive number or a negative number or zero.

For the Charging Year starting on 1 April 2015 the revenue allowed to the Appointed Business in respect of the Wholesale Activities concerned is the product of the same formula except that R_{t-1} = the relevant revenue allowance (as set out below). This is because (as the form of Price Controls has since changed) at the last Periodic Review no revenue allowance in respect of Wholesale Activities was set for the Charging Year that started on 1 April 2014.

The starting point for the calculation of the change in the revenue allowed to the Appointed Business in the Charging Year starting on 1 April 2015 (the wholesale water revenue allowance) is £100.247 million. The "K" numbers for each Charging Year are set out in Table 1.

Table 1 Water services "K" numbers

Charging Year beginning 1 April	K
2015	0.0
2016	-6.33
2017	0.72
2018	-0.16
2019	0.06

Note:

There is no Table 2 in this Determination. This is a deliberate omission that ensures consistency in Table numbers between water undertakers and water and sewerage undertakers.

Price Controls for Retail Activities

In respect of the Appointed Business's Retail Activities, Ofwat has decided that there shall be:

- one single Price Control in respect of the Appointed Business's Household Retail Activities; and
- one single Price Control in respect of the Appointed Business's Non-household Retail Activities.

For the purposes of the Determination:

- "**households**" has the same meaning as:
  (i) the regulatory reporting definition of that term set out in section A5.4 of Appendix 5 (Guidance on business plan tables) to 'Setting price controls for 2015-20 – final methodology and expectations for companies' business plans' (July 2013); or (if different)
  (ii) such definition as may be included in Regulatory Accounting Guidelines issued under paragraph 5 of Condition F (Accounts and accounting information) of the Appointment;
- "**Household Retail Activities**" means Retail Activities relating to the supply of water to households;
- "**Non-household Retail Activities**" means Retail Activities relating to the supply of water to premises other than households;
- "**metered**" means that all or some of the charges for a supply of water are based on measured quantities of volume; and
- "**unmetered**" means that none of the charges for a supply of water are based on measured quantities of volume.

Price Control for Household Retail Activities

The Price Control for Household Retail Activities:

- shall consist of a limit on the total revenue allowed to the Appointed Business in each Charging Year in respect of the Retail Activities concerned; and
- is set for a period of five consecutive Charging Years starting on 1 April 2015.

The total revenue allowed to the Appointed Business in each Charging Year in respect of the Retail Activities concerned (Household retail allowed revenue) shall be the relevant amount set out in Table 3 as modified in accordance with the following formula:

$$\text{Revenue modification for charging year y} = \sum_{c=1}^{2} (\text{actual customer numbers}_{y,c} - \text{forecast customer numbers}_{y,c}) . \text{modifcation factor}_{y,c}$$

Where:

y = Charging Year;
c = customer type (unmetered water only, metered water only);
"**customer numbers**" means the average number of individual households supplied or served by the Appointed Business in a Charging Year; and
"**forecast customer numbers**" and "**modification factors**" are set out in Tables 4 and 5.

Table 3 Household retail allowed revenue

Charging Year beginning 1 April	£million
2015	10.434
2016	10.875
2017	11.371
2018	11.856
2019	12.484

Note:

There is no Table 2 in this Determination. This is a deliberate omission that ensures consistency in Table numbers between water undertakers and water and sewerage undertakers.

Table 4 Household retail allowed revenue modification factors by class of customer (£/customer)

	Revenue modification per:	2015-16	2016-17	2017-18	2018-19	2019-20
1	Unmetered water only customer	17.81	18.40	19.14	19.91	20.69
2	Metered water only customer	25.56	25.63	25.88	26.17	26.94

Table 5 Forecast customer numbers for household retail allowed revenue (thousands)

	Number of customers	2015-16	2016-17	2017-18	2018-19	2019-20
1	Unmetered water only	245.697	226.342	208.302	191.497	175.847
2	Metered water only	237.002	261.797	285.272	307.437	328.367

Price Control for Non-household Retail Activities

The Price Control for Non-household Retail Activities:

- consists of limits on the average revenue allowed to the Appointed Business in each Charging Year in respect of the Retail Activities concerned for specific customer types;
- is set for a period of two consecutive Charging Years starting on 1 April 2015;
- does not impose any limit on the revenue allowed to the Appointed Business in respect of the Retail Activities concerned where a customer freely chooses to pay different charges to those that they would otherwise be liable for; and
- does not impose any limit on any revenue in respect of Retail Activities from Excluded Charges, charges (including charges for developer services) that are not Standard Charges or any miscellaneous charges that are not directly related to the supply of water.

The total revenue allowed to the Appointed Business in each Charging Year in respect of the Retail Activities concerned for a specific customer type shall not exceed R calculated in accordance with the following formula:

R = [((rc x cn) + w) / (1 - m)] - w

Where:

rc = the allowed average retail cost component for a given customer type (in pounds) as set out in Table 6;
cn = the customer numbers for a given customer type;
w = the wholesale revenue for a given customer type; and
m = the allowed net margin for a given customer type (expressed as a percentage) as set out in Table 6.

For the purposes of the Price Control for Non-household Retail Activities:

- a "**customer type**" is a class of customers described in Table 6 by reference to the type of charge (known as a default tariff), fixed by or in accordance with a charges scheme under section 143 of the Water Industry Act 1991 or

agreements with the persons to be charged, that is payable by them for any water supply provided by the Appointee;

- "**customer numbers**" means the average number of individual premises supplied or served by the Appointed Business in a Charging Year; and
- "**wholesale revenue**" means the revenue that the Appointee recovers in a Charging Year in respect of Wholesale Activities relating to the supply of water to premises other than households (assuming for these purposes that the Appointee offered itself no more favourable terms in relation to payment than would be offered to any other person in respect of Wholesale Activities).

Table 6 Non-household customer types, allowed average retail cost components and allowed net margins

Customer type	Term (units)	2015-16	2016-17	2017-18	2018-19	2019-20
Band A - 250Ml+	r_c (£)	1,885.72	1,825.36	1,731.02	1,736.03	1,740.96
	m (%)	2.0%	2.0%	2.1%	2.2%	2.2%
Band B - 100-250Ml	r_c (£)	992.90	966.33	924.79	927.00	929.17
	m (%)	1.9%	1.9%	2.0%	2.1%	2.1%
Band C - 50-100 Ml	r_c (£)	749.59	745.23	738.41	738.78	739.13
	m (%)	1.9%	1.9%	2.0%	2.1%	2.1%
Band D - 15-50 Ml	r_c (£)	484.16	489.15	496.94	496.53	496.12
	m (%)	2.0%	2.1%	2.1%	2.1%	2.2%
Band E 5-15Ml	r_c (£)	201.57	196.21	187.83	188.27	188.71
	m (%)	2.1%	2.1%	2.1%	2.2%	2.2%
Band F - 1-5Ml	r_c (£)	49.13	46.53	42.48	42.69	42.91
	m (%)	1.7%	1.8%	1.8%	1.8%	1.8%
Band G - 0-1Ml	r_c (£)	23.62	23.95	24.46	24.43	24.41
	m (%)	4.2%	4.0%	3.8%	3.7%	3.7%
Band U	r_c (£)	7.12	7.34	7.67	7.65	7.64
	m (%)	2.9%	4.7%	4.3%	4.2%	4.1%

Demonstrating Compliance

In September 2014 Ofwat published a consultation on proposals for an integrated annual regulatory report that would be one of the ways in which the Appointee would demonstrate compliance with the Price Controls. We will publish information about the annual regulatory reporting and assurance requirements that will apply to the Appointee early in 2015.

Annex: Notified Item and Land Sales

Notified Item: Water Business Rates

For the purposes of the Determination Ofwat gives notice that it has not allowed in full for the effect from 1 April 2017 on the Appointed Business of the coming into force on 1 April 2017 of a new central non-domestic rating list in relation to water supply hereditaments to the extent that the effect could not have been avoided by prudent management action.

This Notified Item is a two-way Notified Item: that is, Ofwat may instigate an interim determination or, if the Appointee instigates an interim determination, Ofwat may take into account any effect on the Appointed Business whether favourable or unfavourable for the Appointee.

The costs or savings attributable to this Notified Item shall for each relevant Charging Year comprise the product of the following formula for the Appointee:

(Water Business Rate Sharing Rate – Menu Cost Sharing Rate) X (Applicable Water Business Rate Costs$_t$ – (Water Business Rate Cost Allowance$_t$ X Menu Choice Expenditure Factor))

For the purposes of this Notified Item:

Words and expressions used in this Notified Item have the same meaning as in the Conditions of the Appointment unless the contrary intention appears.

"**Water Business Rates**" means the rateable value determined under the Local Government Finance Act 1988 of water supply hereditaments used wholly or mainly for the purposes of a water undertaker or for ancillary purposes as shown in the central rating list;

"**central rating list**" shall be construed in accordance with section 52(1) of the Local Government Finance Act 1988;

"**water supply hereditaments**" means the hereditaments described:

- in relation to England, in regulation 15(1) of the Central Rating List (England) Regulations 2005 (SI 2005/551); and
- in relation to Wales, in regulation 15(1) of the Central Rating List (Wales) Regulations 2005 (SI 2005/422);

"**Applicable Water Business Rate Costs$_t$**" means, to the extent that they could not have been avoided by prudent management action, the amount(s) payable in respect of Water Business Rates (such amount(s) payable being a function of rateable value multiplied by uniform business rate (UBR) (rate in the pound) less transitional relief) in Charging Year t minus any contributions towards Water Business Rates received, or likely to be received, by the Appointed Business in that year;

"**Menu Choice**" means the Appointee's menu choice on the menu set out in Table A3.7 of 'Final price control determination notice: policy chapter A3 – wholesale water

and wastewater costs and revenues'. All references to the menu for the purposes of this Notified Item refer to that table;

"**Menu Choice Expenditure Factor**" means the allowed expenditure under the Appointee's Menu Choice divided by what would have been the allowed expenditure if the Appointee's Menu Choice had been 100;

"**Menu Cost Sharing Rate**" means the cost sharing rate set out in the menu that follows from the Appointee's Menu Choice;

"**Water Business Rate Sharing Rate**" = 75%;

"**prudent management action**" shall be assessed by reference to the circumstances which were known or which ought reasonably to have been known to the Appointee at the relevant time; and

"**Water Business Rate Cost Allowance$_t$**" means the figure for the relevant Charging Year set out in Table 7 (the "**Water Business Rate Constant$_t$**") multiplied by the Inflation Factor and for these purposes:

- "**Inflation Factor**" = RPI_{t-1} / RPI_{2013};
- "**RPI_{t-1}**" means the Retail Prices Index published, or likely to be published, for November in Charging Year t-1; and
- "**RPI_{2013}**" means the Retail Prices Index for November 2013.

Table 7 Water Business Rate Constant$_t$

Charging Year beginning 1 April	£million
2017	4.731
2018	4.731
2019	4.731

Land sales

For the purposes of the Determination Ofwat gives notice that for each of the five consecutive Charging Years starting on or after 1 April 2015:

- the value attributable to Relevant Disposals of Land allowed for in making this determination is zero; and
- variations in value received or expected to be received from Relevant Disposals of Land shall constitute a Relevant Change of Circumstance.

Schedule 2: Letter to Ofwat referring Final Determination for Bristol Water plc

Cathryn Ross
OFWAT
Centre City Tower
7 Hill Street
Birmingham
B5 4UA

12 February 2015

By Fax, email and Post

Dear Cathryn,

Final Determination for Bristol Water plc

Following on from our discussion on 5 February 2015 and your letter dated 11 February 2015, on behalf of my Board, I confirm that we formally dispute your wholesale water price control as set out in the Final Price Control Determination Notice dated 12 December 2014, and that we accept the price controls for Retail Household and Retail Non-Household for the period 2015-2020. We understand that the scope of the referral to the CMA is a matter for Ofwat to determine in accordance with the relevant provisions of the WIA '91 and our Instrument of Appointment. We also understand that Ofwat considers that these three price controls form part of a single determination.

Accordingly, and on the basis of the rejection of the wholesale price control, we require Ofwat to refer the disputed determination for Bristol Water plc published by Ofwat on 12 December 2014 to the Competition & Markets Authority ("CMA") for determination in accordance with Section 12 of the Water Industry Act 1991 (as amended) ("WIA'91") and paragraph B 15 of our Instrument of Appointment.

As we have discussed we will continue to work with you and the rest of the industry on the Ofwat forward work programme and on implementing the reforms for retail Competition in parallel with the CMA process.

I would appreciate your confirmation that you have received this letter and that it fully meets your notification requirements.

Yours sincerely

Luis García
Chief Executive

WATER SERVICES REGULATION AUTHORITY
WATER INDUSTRY ACT 1991, SECTION 14A(3)

BRISTOL WATER PLC

Notice of Extension of Reference: Determination of Price Controls for the period from 1 April 2015

11 August 2015

1. On 4 March 2015, the Water Services Regulation Authority ("Ofwat") made a reference to the Competition and Markets Authority ("CMA") under section 12 of the Water Industry Act 1991 in relation to Bristol Water plc ("the Reference").

2. The terms of the Reference required the CMA to report on and determine the Disputed Determination (as defined in the Reference) within a period of six months beginning with the date of the Reference.

3. Ofwat, having received and considered representations from the CMA, is satisfied that there are special reasons why the report cannot be made within the period specified in the Reference and extends the period specified in the Reference by two months.

4. The CMA shall report on and determine the Disputed Determination within a period of eight months beginning with the date of the Reference.

Signed for and on behalf of the
Water Services Regulation Authority

Cathryn Ross
Chief Executive

Ofwat's duties under section 2 of the Water Industry Act 1991

1. This appendix sets out Ofwat's duties as presented to us by Ofwat.

2. Ofwat's general duties are set out in Part I of the WIA 91 and in particular, section 2, as amended (in relation to relevant undertakers whose area is wholly or mainly in England).

3. In the remainder of this appendix we set out the relevant elements of section 2 of the WIA 91 as annotated by Ofwat.

General duties with respect to the water industry

(1) This section shall have effect for imposing duties on the Secretary of State and on [the Authority] as to when and how they should exercise and perform the following powers and duties, that is to say—

(a) in the case of the Secretary of State, the powers and duties conferred or imposed on him by virtue of the provisions of this Act relating to the regulation of relevant undertakers and of licensed water suppliers; and

(b) in the case of [the Authority], the powers and duties conferred or imposed on [it] by virtue of any of those provisions, by the provisions relating to the financial conditions of requisitions or by the provisions relating to the movement of certain pipes.

(2A) The Secretary of State or, as the case may be, the Authority shall exercise and perform the powers and duties mentioned in subsection (1) above in the manner which he or it considers is best calculated—

(a) to further the consumer objective;

(b) to secure that the functions of a water undertaker and of a sewerage undertaker are properly carried out as respects every area of England and Wales;

(c) to secure that companies holding appointments under Chapter 1 of Part 2 of this Act as relevant undertakers are able (in particular, by securing reasonable returns on their capital) to finance the proper carrying out of those functions;

(d) to secure that the activities authorised by the licence of a licensed water supplier and any statutory functions imposed on it in consequence of the licence are properly carried out; and

(e) to further the resilience objective.

(2B) The consumer objective mentioned in subsection (2A)(a) above is to protect the interests of consumers, wherever appropriate by promoting effective competition between persons engaged in, or in commercial activities connected with, the provision of water and sewerage services.

(2C) For the purposes of subsection (2A)(a) above the Secretary of State or, as the case may be, the Authority shall have regard to the interests of—

(a) individuals who are disabled or chronically sick;

(b) individuals of pensionable age;

(c) individuals with low incomes;

(d) individuals residing in rural areas; and

(e) customers, of companies holding an appointment under Chapter 1 of Part 2 of this Act, whose premises are not eligible to be supplied by a licensed water supplier,

but that is not to be taken as implying that regard may not be had to the interests of other descriptions of consumer.

(2D) For the purposes of subsection (2C) above, premises are not eligible to be supplied by a licensed water supplier if—

(a) they are household premises (as defined in section 17C below); or

(b) the total quantity of water estimated to be supplied to the premises annually for the purposes of subsection (2) of section 17D below is less than the quantity specified in that subsection.

(2DA) The resilience objective mentioned in subsection (2A)(e) is—

(a) to secure the long-term resilience of water undertakers' supply systems and sewerage undertakers' sewerage systems as regards environmental pressures, population growth and changes in consumer behaviour, and

(b) to secure that undertakers take steps for the purpose of enabling them to meet, in the long term, the need for the supply of water and the provision of sewerage services to consumers,

including by promoting—

(i) appropriate long-term planning and investment by relevant undertakers, and

(ii) the taking by them of a range of measures to manage water resources in sustainable ways, and to increase efficiency in the use of water and reduce demand for water so as to reduce pressure on water resources.

(2DB) For the purposes of subsection (2DA)—

(a) the reference to water undertakers' supply systems is to be construed in accordance with section 17B;

(b) the reference to sewerage undertakers' sewerage systems is a reference to the systems comprising—

(i) the systems of public sewers, the facilities for emptying public sewers and the sewage disposal works and other facilities for dealing effectually with the contents of public sewers that undertakers are required to provide by section 94, and

(ii) the lateral drains that undertakers are required to maintain by section 94.

(2E) The Secretary of State and the Authority may, in exercising any of the powers and performing any of the duties mentioned in subsection (1) above, have regard to—

(a) any interests of consumers in relation to electricity conveyed by distribution systems (within the meaning of the Electricity Act 1989);

(b) any interests of consumers in relation to gas conveyed through pipes (within the meaning of the Gas Act 1986);

(c) any interests of consumers in relation to communications services and electronic communications apparatus (within the meaning of the Communications Act 2003), which are affected by the exercise of that power or the performance of that duty.

(3) Subject to subsection (2A) above, the Secretary of State or, as the case may be, the Authority shall exercise and perform the powers and duties mentioned in subsection (1) above in the manner which he or it considers is best calculated—

(a) to promote economy and efficiency on the part of companies holding an appointment under Chapter 1 of Part 2 of this Act in the carrying out of the functions of a relevant undertaker;

(b) to secure that no undue preference is shown, and that there is no undue discrimination in the fixing by such companies of water and drainage charges;

(ba) to secure that no undue preference (including for itself) is shown, and that there is no undue discrimination, in the doing by such a company of—

(i) such things as relate to the provision of services by itself or another such company, or

(ii) such things as relate to the provision of services by a water supply licensee or a sewerage licensee;[1]

(c) to secure that consumers are protected as respects benefits that could be secured for them by the application in a particular manner of any of the proceeds of any disposal (whenever made) of any of such a company's protected land or of an interest or right in or over any of that land;

(d) to ensure that consumers are also protected as respects any activities of such a company which are not attributable to the exercise of functions of a relevant undertaker, or as respects any activities of any person appearing to the Secretary of State or (as the case may be) the Authority to be connected with the company, and in particular by ensuring—

(i) that any transactions are carried out at arm's length;

(ii) that the company, in relation to the exercise of its functions as a relevant undertaker, maintains and presents accounts in a suitable form and manner;

(iii) …

(e) to contribute to the achievement of sustainable development.

(4) In exercising any of the powers or performing any of the duties mentioned in subsection (1) above in accordance with the preceding provisions of this

---

[1] Paragraph (ba) of subsection (3) was inserted into section 2 of the WIA91 with effect from 1 January 2015 in relation to relevant undertakers whose area is wholly or mainly in England and therefore did not apply when Ofwat made the disputed determination.

section, the Secretary of State and the Authority shall have regard to the principles of best regulatory practice (including the principles under which regulatory activities should be transparent, accountable, proportionate, consistent and targeted only at cases in which action is needed).

(5) In this section the references to water and drainage charges are references to—

(a) any charges in respect of any services provided in the course of the carrying out of the functions of a relevant undertaker; and

(b) amounts of any other description which such an undertaker is authorised by or under any enactment to require any of its customers or potential customers to pay.

(5A) In this section—

"consumers" includes both existing and future consumers; and

"the interests of consumers" means the interests of consumers in relation to—

(a) the supply of water by means of a water undertaker's supply system to premises either by water undertakers or by licensed water suppliers acting in their capacity as such; and

(b) the provision of sewerage services by sewerage undertakers.

(6) For the purposes of this section—

(a) subject to subsection (6A) below, the reference in subsection (1) above to the provisions of this Act relating to the regulation of relevant undertakers and of licensed water suppliers is a reference to the provisions contained in Part 2 of this Act (except section 27A, and Schedule 3A), or in any of sections 37A to 38, 39, 39B, 39C, 66B, 66D, 66F to 66H, 66K, 66L, 95, 96, 153, 181, 182, 192A, 192B, 195, 195A and 201 to 203 below;

(b) the reference in that subsection to the provisions relating to the financial conditions of requisitions is a reference to the provisions contained in sections 42, 43, 43A, 48, 51C, 99, 100 and 100A below; and

(c) the reference in that subsection to the provisions relating to the movement of certain pipes is a reference to the provisions of section 185 below.

(6A) Subsections (2A) to (4) above and section 2A below do not apply in relation to anything done by [the Authority] in the exercise of functions assigned to [it] by section 31(3) below ("Competition Act functions").

(6B) [The Authority] may nevertheless, when exercising any Competition Act function, have regard to any matter in respect of which a duty is imposed by any of subsections (2A) to (4) above and section 2A below, if it is a matter to which [the CMA] could have regard when exercising that function.

(7) The duties imposed by subsections (2A) to (4) above and section 2A below do not affect the obligation of the Authority or, as the case may be, the Secretary of State to perform or comply with any other duty or requirement (whether arising under this Act or another enactment, by virtue of any [EU] obligation or otherwise)."

Retail price controls

Introduction

1. This appendix concerns the retail price controls that Ofwat determined for Bristol Water. It is structured as follows:

   (a) Ofwat's determination of retail price controls.

   (b) Submissions on the retail price controls.

   (c) Our assessment of whether to redetermine the retail price controls.

Ofwat's determination of retail price controls

2. This section introduces the four different price controls set by Ofwat across water and wastewater activities and then summarises the two retail price controls.

Separate price controls for wholesale and retail

3. For all price control periods running up to 31 March 2015, Ofwat set a single price control for each water company.

4. Following formal changes to each company's Licence (conditions of appointment), Ofwat's price controls from 1 April 2015 comprise four separate price controls (three for water-only companies). These cover:

   (a) wholesale water activities;

   (b) wholesale wastewater activities (not relevant to Bristol Water);

   (c) retail supply to households; and

   (d) retail supply to non-households.

5. The allocation of activities between wholesale and retail is specified in the Licence, or otherwise determined by Ofwat.

6. The development of these separate price controls reflects, in part, a number of legislative and regulatory changes in the water industry in England which are intended to support the development of competition, particularly for the supply of retail water and wastewater services to non-household customers.

7. Ofwat summarised the benefits of setting separate price controls for wholesale and retail as follows in its final determinations:[1]

> This creates important benefits – it provides greater transparency, and therefore understanding, of costs. It also provides more effective incentives and supports the development of effective competition in the relevant markets where appropriate, in line with the provisions of the Water Act 2014.

8. Bristol Water agreed with the rationale for separate price controls:[2]

> We understand why Ofwat has introduced separate controls for retail household, retail non-household, and wholesale, and consider that it will help to improve incentives and performance within each of these parts of the business.

9. The operation and determination of Ofwat's two sets of retail price controls is quite different to that for wholesale controls. We provide an overview of the retail price controls below.

Retail services to household customers

10. Ofwat described the form of the household retail control as a 'total revenue control with annual revenue adjustment factors to reflect differences between actual and forecast customer numbers and meter penetration'.[3] It is a five-year price control from 1 April 2015.

11. Ofwat made an assessment of the appropriate allowance for total household retail revenue by combining three main elements:

    (a) Its assessment of the average (retail) cost to serve (ACTS) per customer, which included what Ofwat referred to as an 'efficiency challenge'.

    (b) The projected customer numbers in the company's revised business plan.

    (c) An allowance for a net (profit) margin for retail supply to household.

12. The average (retail) cost to serve was based on benchmarking analysis across the water companies in Ofwat's sample. The margin was 1% of forecast wholesale and retail costs.

---

[1] Ofwat (December 2014), *Final price control determination notice: policy chapter A1 – introduction*, p3.
[2] Bristol Water SoC, paragraph 398.
[3] Ofwat (March 2015), *Referral of Bristol Water's determination of price controls for the period from 1 April 2015 – introduction for the Competition and Markets Authority*, p49.

13. Ofwat reported that its final determinations for Bristol Water's household retail price control were based on an allowance for the relevant retail revenue of £57 million.[4]

14. Bristol Water suggested that Ofwat's final determinations for the household retail price control could best be compared with its own proposals by looking at proposed retail revenues excluding the retail margin. This comparison excludes differences caused by inconsistent assumptions on wholesale revenues, which affect the retail margin. On this basis, the allowance from Ofwat's final determinations was £52.7 million, which is 1% less than Bristol Water's proposal of £53.1 million.[5]

15. Ofwat said the following on outcomes and performance commitments related to the household retail control:[6]

> Bristol Water has committed to delivering outcomes which reflect its customers' views. Our assessment of the specific PCs [performance commitments] proposed by each company for household retail focused on a company-specific assessment to ensure that the performance proposed by each company was challenging, appropriately incentivised and supported by customer engagement.
>
> We did not intervene in any of the PCs and incentives types proposed by Bristol Water. We considered that the company put forward a set of effective incentives that would allow for customers protection [sic] against under-delivery.

Retail services to non-household customers

16. Ofwat's price controls for retail services to non-household customers are actually a series of separate average revenue controls that apply to different types of customers or services.

---

[4] Ofwat (March 2015), *Referral of Bristol Water's determination of price controls for the period from 1 April 2015 – introduction for the Competition and Markets Authority*, p19.
[5] Bristol Water SoC, Table 145.
[6] Ofwat submission, p32.

17. Ofwat said that companies must offer 'default tariffs' for the relevant customer type which comply with these average retail revenue controls. The control for each customer type in each year is given by the formula below:[7]

$$R = [(r_c \times c_n) + w)] / (1 - m)$$

Where:

R = the estimated total allowed revenue for a given customer type

r_c = the allowed average retail cost for a given customer type

c_n = the forecast customer numbers for a given customer type

w = the forecast wholesale revenue for a given customer type

m = the allowed net margin for a given customer type

18. The elements of this formula that were set by Ofwat in its final determinations were the allowance (£ per customer) to cover the retail costs (c_n) and the profit margin (m).

19. As an example, Ofwat specified that the 2015/16 control for retail supply to 'band D' non-household customers, who consume between 15 and 50 megalitres of water per year, should be calculated using a cost per customer (r_c) of £484.16 and a margin (m) of 2%.[8]

20. Under this formula, the level of the maximum retail revenue in each year will depend on the applicable wholesale charges for the customer type. Ofwat said that under the controls 'allowed revenue is dynamically pegged to underlying wholesale revenues in order to avoid insufficient margins occurring due to changes in the wholesale charges'.[9]

21. Ofwat reported that its final determinations for Bristol Water's non-household retail price control were based on (or indicative of) an allowance for the relevant retail revenue of £7.8 million (in total if expressed over a five-year period).[10]

22. Bristol Water suggested that Ofwat's final determinations for the non-household retail price controls could best be compared with its own proposals

---

[7] Ofwat (December 2014), *Final price control determination notice: policy chapter A6 – non-household retail costs and revenues*, p11.
[8] Ofwat, *Final price control determination notice: company-specific appendix – Bristol Water*, p47.
[9] Ofwat (March 2015), *Referral of Bristol Water's determination of price controls for the period from 1 April 2015 – introduction for the Competition and Markets Authority*, p55.
[10] Ofwat (March 2015), *Referral of Bristol Water's determination of price controls for the period from 1 April 2015 – introduction for the Competition and Markets Authority*, p19.

by looking at proposed retail revenues excluding the retail margin. This comparison excludes differences caused by inconsistent assumptions on wholesale revenues, which affect the retail margin. On this basis, the allowance from Ofwat's final determinations was £4.7 million, which is 35% less than Bristol Water's proposal of £7.2 million.[11]

Submissions to the inquiry on the retail price controls

23. We summarise relevant aspects of submissions from the following parties:

(a) Bristol Water.

(b) Ofwat.

(c) CCWater.

(d) Wessex Water.

Bristol Water

24. In its SoC, Bristol Water said:[12]

> Whilst there are some differences in view between Ofwat and ourselves in relation to the two retail price controls, on balance we consider that the PR14 process for retail has been challenging but reasonable. Accordingly, our Board accepted both retail price controls.

25. Similarly, Bristol Water explained that:[13]

> The Board of Bristol Water accepted Ofwat's FD14 on the Retail Household price control. This decision was made because, in the round, FD14 was assessed to provide an appropriate level of costs to cover retail activities.

26. Nonetheless, Bristol Water recognised that the CMA's determination may consider retail and its SoC accordingly covers retail as well as wholesale price control matters:[14]

> We understand, however, that the redetermination means that all aspects of FD14 may be reviewed, and not just areas where there

[11] Bristol Water SoC, Table 157.
[12] Bristol Water SoC, paragraph 4.
[13] Bristol Water SoC, paragraph 2056.
[14] Bristol Water SoC, paragraph 4.

is disagreement between the parties. We have, therefore, provided full oversight of all elements of FD14.

27. Bristol Water identified some specific issues on the calculation of the household retail price control:[15]

> Allowed costs for Bristol Water are set with reference to the industry average cost to serve, whereby companies are allowed the lower of their own costs or the industry average. Bristol Water is below the industry average for both metered and unmetered cost to serve, but Ofwat's methodology has resulted in a reduction being applied to Bristol Water's allowed metered costs that Bristol Water considers to be incorrectly applied, reducing allowed revenue by £1.8 million. This balances against a calculative approach to price basing by Ofwat which, if corrected, would reduce Bristol Water's revenue by £1.3 million.

28. On the non-household retail price control, Bristol Water said the following:[16]

> The Board of Bristol Water accepted Ofwat's FD14 on the Retail Non-Household price control. This decision was made because, whilst Bristol Water remains concerned that the level of costs allowed for the set-up of the competitive market is inappropriate and that Ofwat has not allowed inflationary increases to non-household retail costs, the amount of difference between the Business Plan and revenues allowed in Ofwat's FD14 was not considered to be sufficiently material to warrant rejection of the Retail Non-Household price control.

29. Bristol Water's position is that it has accepted the non-household retail price control and it has not argued for us to review this price control. However, Bristol Water identified some issues that would be relevant in the event that we were to examine the non-household retail control. In particular, Bristol Water said that if we were to choose to redetermine the retail non-household price control, it would like us to:[17]

(a) set a net profit margin equal to or greater than that set by Ofwat;

(b) make an allowance for the forecast costs associated with arrangements to establish competitive retail markets (Bristol Water would like an

[15] Bristol Water SoC, paragraph 2057.
[16] Bristol Water SoC, paragraph 2151.
[17] Bristol Water SoC, paragraph 2244.

uncertainty mechanism to allow pass-through of these uncertain costs to customers); and

(c) take account of input cost pressures on operating costs.

30. In its reply to Ofwat's response to its SoC, Bristol Water said that, for both the household and non-household retail price controls, 'it agreed with Ofwat's position that if the CMA is satisfied that this does not deserve further scrutiny it does not intend to pursue the discussion further'.[18]

Ofwat

31. Ofwat's reference to the CMA includes the retail price controls:

> In its letter requesting a reference, Bristol Water indicated that it is content with the retail price controls in the final determination. However, the entire disputed determination (including the wholesale water, household retail and non-household retail price controls and the designation of retail activities) has been referred to the Competition and Markets Authority (CMA).[19]

32. Although the household retail price control forms part of the reference it made to the CMA, Ofwat did not consider that we should make any changes to the household retail price controls that Ofwat developed for Bristol Water:[20]

> We consider that, as Bristol Water's Board has accepted the final determination for household retail, and we have not identified any further material issues, it would be appropriate not to make further interventions in the household retail control.

33. On the non-household retail price control, Ofwat said the following:

> Bristol Water's Board has accepted the final determination on non-household retail. In light of this, and in line with our view that there are no significant issues with the Final determination position, we do not consider it appropriate to make further interventions in this area.
>
> [Any] request from Bristol to increase the allowed revenue in this area should be seen as unnecessary, as the company's Board clearly does not consider it to be required in order for them to

[18] Bristol Water reply, paragraph 37.
[19] Ofwat response, paragraph 11.
[20] Ofwat response, paragraph 126.

meet their legal duties and sufficiently serve their customers/other stakeholders.[21]

34. Ofwat's response to Bristol Water's SoC, and its further submissions, responded to a number of specific points that Bristol Water had made about Ofwat's calculation of the retail price controls.

CCWater

35. In its submission to the inquiry, CCWater said the following on the retail price controls:[22]

> We supported the approach that Bristol Water took towards its retail performance commitments and the retail revenue allowance set in the Final Determination. We note that Bristol Water does not dispute the Ofwat decisions relating to the company's retail business.
>
> We have no issues about the retail element of the Determination as the areas of dispute between Ofwat and Bristol Water concern the costs, performance commitments, investment and financing of the company's wholesale business.

Wessex Water

36. Wessex Water made a submission that included comments on the retail price controls. Wessex Water's submission explains as follows:[23]

> Bristol Water's board has accepted the retail household price control – nevertheless because the CMA is required to make a determination on the whole price control Bristol Water has expressed concern about the methodology that underpins the efficiency challenge Ofwat has applied in this element of the price control. In their Statement of Case Bristol Water has referenced the Wessex Water retail household determination as primary evidence of the lack of robustness in Ofwat's efficiency challenge. The evidence we provide in this document clarifies and contextualises the reasons for the apparent inconsistencies.

37. Wessex Water did not seek to argue that the CMA should review Bristol Water's retail price controls. Instead, Wessex Water made points on specific

---

[21] Ofwat response, paragraph 131.
[22] CCWater submission, paragraphs 2.12 & 3.1.
[23] Wessex Water submission, paragraph 7.

aspects of Ofwat's determination of retail price controls (eg cost allocation rules and the treatment of metering costs) that may be relevant if we were to choose to review the retail price controls for Bristol Water.

Assessment of whether to make changes to the retail price controls

38. Bristol Water rejected Ofwat's proposed wholesale price controls and sought a determination of the wholesale price control from the CMA. It accepted Ofwat's proposed retail price controls.

39. We consider that the reference from Ofwat to the CMA enables us to review and, if necessary, redetermine the retail price controls. However, the reference does not require that we review every aspect of Ofwat's final determinations for Bristol Water. In this context, we made an assessment of whether to review the retail price controls as part of our determination.

40. We considered the following:

    (a) Whether the retail price controls are sufficiently separable from the wholesale price controls to enable us to make a reasonable determination of the wholesale price control without adjusting Ofwat's proposed retail price controls.

    (b) Whether any of the submissions to the inquiry identified grounds for us to redetermine the retail price controls for Bristol Water.

    (c) Whether a review of retail price controls would represent a priority area for our inquiry and a proportionate regulatory approach.

41. We discuss each of these in turn below.

Are the wholesale and retail price controls separable?

42. Bristol Water's Licence specifies separate price controls for wholesale and retail activities. Paragraph 8.3 of Condition B provides the basis for the retail price control and paragraph 8.4 provides the basis for the wholesale price control.

43. We did not identify any aspect of Condition B that would prevent us from reaching a different view to Ofwat on the wholesale price control determination while at the same time adopting Ofwat's proposals (accepted by Bristol Water) for retail price controls.

44. This does not mean that the wholesale and retail price controls are completely independent of one another. For example, Ofwat's approach to the allowance

for the cost of capital for the wholesale price control involved calculations to deduct forecast profits from retail activities (under its proposed retail price controls). Bristol Water has disputed Ofwat's calculations of these deductions. We have considered this issue as part of our determination of the cost of capital for the wholesale price control.

45. We found that it was feasible to set a reasonable wholesale price control for Bristol Water while taking as given the retail price controls that Bristol Water accepted.

46. There is one possible qualification to consider. Because Ofwat's retail price controls involve a retail margin on wholesale and retail costs, the calculation of allowed retail revenues used by Ofwat was dependent on the assumed level of wholesale revenues. Bristol Water said that the allowed retail revenues should be recalculated following our determination of the wholesale price control.

47. We could recalculate Ofwat's household retail price control for Bristol Water to take account of any difference in forecast wholesale revenues arising directly from differences between our wholesale price control determination and Ofwat's wholesale price control determination. We considered that we should make an adjustment to the household retail price control on this basis if the difference was significant. This adjustment would not involve any change to the household retail price control beyond addressing a potential inconsistency, arising as a result of our determination, in the wholesale revenue forecast that Ofwat used to calculate the household retail control. However, we found that, on the basis of our determination for the wholesale control, the difference was not significant and no adjustment was necessary.

48. No similar adjustment needs to be considered for the non-household retail controls as these controls are in the form of formulae that adjust the maximum allowed revenue according to factors including the level of wholesale revenues.

49. Overall, we found that our determination of the wholesale price control for Bristol Water does not require that we reopen the retail price controls.

Do any of the submissions identify grounds for us to redetermine retail controls?

50. We have summarised above relevant submissions that we have received on the retail price controls. We did not identify any grounds, from these submissions, for redetermining the retail price controls.

51. Neither Ofwat nor Bristol Water argued that we ought to redetermine the retail price controls that Bristol Water had accepted.

52. To the extent that Bristol Water made submissions on particular aspects of the retail controls, it provided these in case we chose to review the retail price controls. Bristol Water has not sought to advocate that we should review the retail price controls. It accepted the retail price controls. As set out above, Bristol Water said that Ofwat's process for the retail price controls was 'challenging but reasonable'. Bristol Water agreed with Ofwat's position that if we were satisfied that the household and non-household retail price controls did not deserve further scrutiny, it did not intend to pursue these further as a matter for our inquiry.

Priorities for the inquiry and proportionality

53. It is possible that a detailed investigation of the retail price controls accepted by Bristol Water may indicate that these should be adjusted or refined in some way to protect the interests of consumers. However, we did not consider this possibility sufficient to carry out a detailed review of the retail price controls.

54. We considered that we should concentrate on the wholesale price controls and that it would not be proportionate for us to review the retail price controls. Our assessment reflects a number of factors, taken together.

55. First, the retail price controls set by Ofwat are complicated and reflect substantial work developed over several years. It would take considerable time and resource for us to review these retail controls – and for parties involved in the inquiry to participate in our review process.

56. Second, we have not had any submissions to the inquiry setting out aspects of Ofwat's retail price controls that warrant re-examination, for example to protect the interests of consumers. CCWater has supported Ofwat's proposed retail price controls. Any review of retail controls would be an exploratory one. In contrast, for the wholesale price controls there were many significant matters of dispute between Ofwat and Bristol Water.

57. Third, for Bristol Water, the revenues associated with the two retail price controls (in total) represent around 11% of the total allowed revenues across wholesale and retail, with wholesale revenues accounting for 89%.[24] The

[24] This is on Ofwat's final determination allowances. It would be 10% using Bristol Water's forecasts. CMA calculation using data from Bristol Water SoC (p260).

wholesale price control concerns a much larger part of customers' bills than the retail price controls.

58. Fourth, even leaving aside the submissions from the main parties and other stakeholders, and the relative scale of retail activities compared with wholesale activities, we considered the determination of the wholesale control to be more important to review than the retail control. While there are potential risks of inaccuracy in cost assessment for both the retail and wholesale price controls, there are reasons to be more concerned about potential inaccuracies in the cost assessment for wholesale controls than for retail controls. Ofwat's approach to household retail controls used cost benchmarking analysis that we would expect to be less vulnerable to risks of inaccuracy than Ofwat's benchmarking analysis for wholesale activities. Although all benchmarking analysis will be imperfect, the problems in making fair comparisons of retail costs seem smaller than for comparisons of aggregate wholesale expenditure. This is because we would expect retail activities to be more similar across companies than wholesale activities. Wholesale activities may differ between companies according to local operating and environmental conditions and the effects of historical investment decisions.

59. Finally, our assessment is conditional on the circumstances and facts of the case, including the submissions from the main parties and other stakeholders. It should not be taken to imply anything more generally about our views on wholesale and retail price controls.

Ofwat's approach to cost assessment

1. This appendix discusses the following topics in turn:

   (a) Emphasis on totex benchmarking analysis.

   (b) Separate analysis of enhancement expenditure.

   (c) Triangulation.

   (d) Upper quartile efficiency benchmark.

   (e) Costs excluded from benchmarking analysis (policy items).

   (f) Adjustments for special cost factors.

   (g) Further adjustments outside the main special cost factor process.

   (h) Cases where Ofwat's cost assessment exceeded a company's forecasts.

2. In a final subsection, we briefly compare Ofwat's approach to cost assessment for PR14 with its approach to its previous price control reviews.

Emphasis on totex benchmarking analysis

3. Ofwat's approach to PR14 was based on benchmarking analysis that compared measures of totex between companies. Totex represents the expenditure on a cash basis allocated to wholesale activities and does not include depreciation or amortisation of investment.

4. Ofwat used several strands of benchmarking analysis:

   (a) Econometric benchmarking models that make comparisons of measures of totex between companies.[1] The totex measure used for each company in each year was opex on wholesale activities in that year plus average capex on wholesale activities in the last five years.[2]

   (b) Econometric models that compared measures of base expenditure between companies. The base expenditure measure used for each company for each year was opex on wholesale activities in that year plus

[1] Ofwat excluded certain costs from the benchmarking comparisons of totex and base expenditure. It referred to these as policy items and made separate allowances for them.
[2] Ofwat adopted an approach of 'smoothing' capex over a five-year period before making benchmarking comparisons between companies.

average capital maintenance expenditure attributed to wholesale activities in the last five years (ie excluding capex on enhancement projects).

(c) A separate strand of benchmarking analysis focused on enhancement expenditure. This took different categories of enhancement expenditure separately.

5. Ofwat's benchmarking analysis used a number of different models and covered different categories of expenditure (totex, base expenditure and enhancement). Ofwat used an explicit methodology, which it called triangulation, to combine and weight these estimates to produce an overall estimate of each company's totex requirements (see paragraphs 15 to 26). Ofwat then sought to estimate what each company's costs would be if it were at the upper quartile of efficiency within the sample of companies in its analysis of historical data (see paragraphs 27 to 31).

6. The outcome was a single estimate of each company's totex requirements over the period from 1 April 2015 to 31 March 2020. Ofwat referred to this estimate as the 'basic cost threshold', or BCT.

7. In addition to the benchmarking analysis, Ofwat made a series of adjustments to capture specific areas of companies' costs that may not have been assessed sufficiently well by the benchmarking exercise (see paragraphs 34 to 46). These adjustments, as well as allowances for certain types of costs excluded from the benchmarking analysis (see paragraphs 32 and 33), fed into Ofwat's 'final cost threshold'.

Separate analysis of enhancement expenditure

8. Some of the econometric models used by Ofwat compared measures of totex between companies; these models cover both base and enhancement expenditure. In addition, Ofwat also carried out separate analysis for base service and enhancement expenditure.[3] It formed estimates of each company's totex requirements by summing:

(a) estimates of the company's efficient base expenditure requirements derived from econometric models that compare measures of base expenditure across companies; and

[3] Ofwat refers to the combination of *(a)* and *(b)* as its 'bottom-up totex model'. The use of the term 'bottom-up' may be misleading. Ofwat's analysis does not involve what would normally by described as a bottom-up approach to cost assessment in the context of UK price control regulation. For example, it is not a cost forecast built up from the individual investments and activities that are needed to provide the service.

(b) estimates of the company's efficient enhancement expenditure requirements that were built up from a series of separate analyses for different categories of enhancement expenditure.

9. For some categories of enhancement expenditure, Ofwat carried out analysis based on measures or models of the unit cost of historical enhancement expenditure from data across Ofwat's sample of water companies. Table 1 lists the three categories of enhancement expenditure that were treated in this way, and the volume measure used to calculate unit costs.

Table 1: Ofwat's enhancement expenditure unit cost models

Category of enhancement expenditure	*Volume measure used*
Enhancements to supply-demand balance (eg new reservoirs to increase the amount of water available in peak times)	Total enhancements to the supply demand balance (dry year critical / peak conditions) unless zero then used annual/ average
Lead reduction	Number of lead communication pipes replaced for water quality
New developments	Number of new connections

Source: Ofwat (April 2014), Basic cost threshold model Appendix C Enhancement modelling, p12.

10. Ofwat's analysis of the unit costs of these categories of enhancement projects used four different ways to model unit costs: *(a)* calculation of the unweighted average of the unit costs of each company; *(b)* calculation of unit costs at the industry level (ie weighted average across companies); *(c)* OLS regression of costs against the volume measure; and *(d)* OLS regression of the natural logarithm of costs against the natural logarithm of the volume measure. Ofwat had no preference across these models and gave them equal weight in its unit cost analysis.

11. To produce expenditure forecasts for each company, for each of the three categories of enhancement expenditure in the table above, Ofwat combined the results of its unit cost analysis with forecasts prepared by Jacobs of the volumes of each activity that the company will need to carry out in the period 1 April 2015 to 31 March 2015. For some of the volume forecasts, Jacobs' forecasts were simple extrapolations from past trends. For enhancements to the supply/demand balance, for a company with a predicted deficit, Jacobs' forecasts of the relevant volume measures were taken directly from the company's own draft water resources management plan. Jacobs explained that the use of draft Water Resource Management Plan data in its forecasts was a departure from the original aspiration of independent forecasts, but said that the draft Water Resource Management Plans had undergone a level of external scrutiny.[4]

[4] Jacobs (March 2014), *PR14 Forecast of Exogenous Variables Summary Report*.

12. Ofwat found that it was 'not possible to find a robust cost driver for every enhancement cost category' and consequently treated some categories of enhancement expenditure as 'unmodelled' and applied a different approach.[5] Ofwat's approach for unmodelled expenditure was, essentially, to calculate a mark-up or uplift on each company's 'modelled' expenditure to make some allowance for enhancement expenditure not covered by the unit cost models.

13. Ofwat's approach for the unmodelled allowance was as follows:[6]

(a) Ofwat identified the categories of enhancement expenditure that applied over the period from 1 April 2010 to 31 March 2015 and which it had not covered in its unit cost models. For each of these categories, Ofwat decided whether they were:

(i) non-recurring; or

(ii) likely to recur in the period from 1 April 2015 to 31 March 2020.

(b) Ofwat used a data submission from August 2013 to calculate the totex for the recurring categories of enhancement expenditure from *(a)* across the industry over the period 1 April 2010 to 31 March 2015. The expenditure data taken from the August 2013 data submission included a mix of historical costs and companies' forecasts of costs for the remainder of the period to 31 March 2015.

(c) Ofwat calculated the total industry level of 'modelled expenditure' across the industry, over the period from 1 April 2010 to 31 March 2015, using the same data sources as for *(b).* Modelled expenditure comprised base expenditure plus the part of enhancement expenditure covered by Ofwat's unit cost models.

(d) Ofwat calculated a percentage uplift for unmodelled enhancement expenditure as *(b)* divided by *(c)*, multiplied by 100%. This was 8.4% for the water service.

14. Ofwat then made an estimate of each company's unmodelled enhancement expenditure requirements by taking its estimate of the company's modelled expenditure requirements for the period 1 April 2015 to 31 March 2020 and multiplying this by 8.4%.

---

[5] Ofwat (April 2014), *Basic cost threshold model Appendix C Enhancement modelling*, p4.
[6] CMA working interpretation of description from Ofwat (April 2014), *Basic cost threshold model Appendix C Enhancement modelling*, p10.

Triangulation

15. Ofwat used the term ‘triangulation’ to refer to the approach and calculations that it used to bring together the results from its econometric models and its separate analysis of enhancement expenditure.

16. Ofwat told us that it recognised that there may be different plausible ways and models to use to arrive at an expenditure forecast and that, by using a suite of models, it had mitigated the risk of choosing any single model which, for any given company, may have a large variance between the estimate and the ‘correct’ answer.

17. For wholesale water services, Ofwat calculated the basic cost threshold for each company as the unweighted average of results from three modelling approaches:

    (a) results from its ‘full’ totex econometric modelling;

    (b) results from its ‘refined’ totex econometric modelling; and

    (c) results from its separate analyses of base and enhancement expenditure, under which estimates of a company’s totex requirements are calculated by adding an estimate from its base expenditure econometric models to separate estimates of its expenditure requirements across different categories of enhancement.

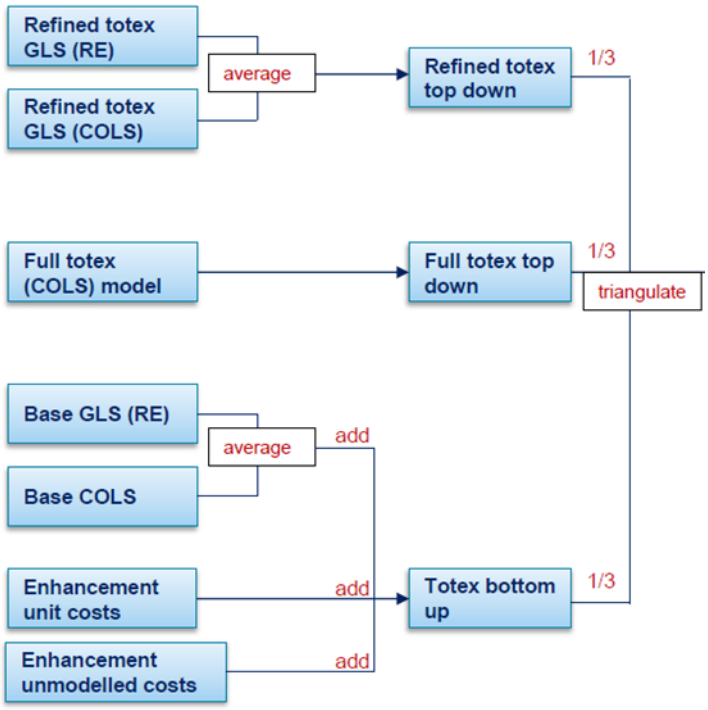
18. We describe Ofwat’s full and refined totex econometric models and its base expenditure econometric models in more detail in Appendix 4.1.

19. The main difference between the full model specification and the refined model specification is that the former is a model with 27 explanatory variables (and a constant term) while the refined models have 11 explanatory variables.

20. For the refined totex econometric modelling, Ofwat used two variants in terms of models specification and estimation technique: *(a)* pooled OLS (which Ofwat also referred to as corrected OLS or COLS); and *(b)* a random effects model estimated using the GLS technique (which Ofwat also referred to as GLS (RE)). Ofwat took the average result from these two different refined totex models as the result for its refined totex econometric modelling work-stream. Similarly, Ofwat’s separate analysis of base expenditure used two different variants of the base expenditure model (pooled OLS and GLS random effects) and took the average of the results from these two models, before adding separate estimates for enhancement expenditure.

21. Ofwat illustrated its approach to triangulation in Figure 1 below.

Figure 1: Ofwat's illustration of its approach to triangulation



Source: Ofwat.

22. We have summarised above the approach to triangulation that Ofwat set out in its price control methodology and its draft determinations. This is also the approach that it applied to most companies for the final determinations.

23. However, in the case of Bristol Water, Ofwat made a decision between its draft and final determinations to apply what was, in effect, a different approach to triangulation. Ofwat made a special adjustment for Bristol Water which it explained as follows:[7]

> In Bristol Water's case we made an adjustment to the refined totex model to increase the allowance for enhancement spend so it is consistent with our bottom up modelling stream. We have done this by increasing the allowance for enhancement in the refined model by £84 million so that it matches the value from our base plus unit cost model of £97 million. Overall totex is taken as the average of the three models and so after triangulation this increases overall totex by £27.8 million.

[7] Ofwat (December 2014), Final price control determination notice: company-specific appendix – Bristol Water, p72.

24. In reaching the decision to make this adjustment, Ofwat had found that its refined totex model gave Bristol Water 'a relatively low allowance for enhancement expenditure of £13 million compared to approximately £80 million from our other models'.[8] Ofwat obtained this figure of £13 million by subtracting the estimated totex for Bristol Water from Ofwat's refined econometric models of totex from the results for Bristol Water from its refined econometric models of base expenditure. The explanatory variables and functional form for these two sets of models were the same, and the only difference in model specification is that the totex models included enhancement expenditure.

25. This adjustment was, in essence, a disapplication of Ofwat's approach to triangulation for the case of Bristol Water. Its effect was that no weight was given in Ofwat's final cost assessment to the results for Bristol Water from the refined totex models and that greater weight was given to the results from the modelling workstream that combined econometric models of base expenditure with separate analysis of enhancement expenditure.

26. Ofwat's final triangulation for Bristol Water seems to be:

    (a) a weight of one-third to the results from the full totex econometric model; and

    (b) a weight of two-thirds to the results from the separate analyses of base expenditure and enhancement expenditure.

Upper quartile efficiency benchmark

27. In applying the results from its benchmarking analysis, Ofwat used an upper quartile efficiency benchmark. The basic cost threshold that Ofwat calculated for each company is an estimate of the level of totex that it would require if it operated at a level of efficiency that reflected the upper quartile of efficiency performance within the companies covered by Ofwat's analysis.

28. To make these estimates, Ofwat used the concept of an efficiency score which it defined as the ratio of the actual cost of the company relative to the level of cost that the models predicts for the company if it were averagely efficient.

29. Using historical data, Ofwat calculated a single efficiency score for each company. This was based on a comparison of each company's actual

[8] Ofwat (December 2014), Final price control determination notice: company-specific appendix – Bristol Water, p72.

historical costs with the average estimated costs from the three modelling workstreams. Ofwat was then able to identify the upper quartile level of performance for the efficiency score among the companies in the sample. Ofwat found that, for wholesale water, the upper quartile efficiency score implied a level of costs that was 6.53% lower than the industry average costs.

30. On this basis, Ofwat made a downward adjustment of 6.53% to the level of predicted expenditure from its modelling workstreams to produce an estimate of each company's expenditure requirements if it were at the upper quartile level of efficiency.

31. The interpretation of the efficiency scores as measures of relative efficiency of companies rests on the assumption that the benchmarking analysis fully accounts for any differences in companies' operating environment and circumstances that affect their costs, besides efficiency. If that is not the case, then differences in the calculated efficiency scores between companies will reflect factors besides efficiency. For example, some of the companies with relatively high efficiency scores may be companies for which Ofwat's modelling overestimates their expenditure requirements, rather than companies which are relatively efficient.

Costs excluded from benchmarking analysis (policy items)

32. Ofwat did not include all of companies' wholesale expenditure within its totex benchmarking analysis and triangulation exercise. Its final determinations explained that some items of expenditure were excluded and that these 'reflect categories of costs excluded from our modelling, typically where future allowed expenditure is not best determined by reference to historical industry trends'.[9]

33. For the wholesale water price controls, the adjustments that Ofwat made for these policy items varied between companies and contributed between 7% and 18% of Ofwat's final totex assessment for each company. The average was 11%. For Bristol Water, it was 7%.[10] The policy items for Bristol Water included local authority rates and Ofwat's allowance for pension deficit repair contributions.

[9] Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p26.
[10] CMA analysis of data from: Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p26.

Adjustments for special cost factors

34. Ofwat's approach included adjustments for special cost factors. Its final determinations said that it considered special cost factor claims made by companies for factors within their business plans that had not been adequately taken into account in Ofwat's basic cost threshold modelling or assumptions on policy items.[11]

35. The process for reviewing special cost factor claims was a substantial part of the cost assessment work for Ofwat's PR14 determinations. Ofwat used its modelling as the starting point for determining each company's cost allowance, rather than companies' business plan forecasts; each company had to explain and justify to Ofwat any difference ('gap') between the projections of expenditure requirements from Ofwat's modelling and the company's business plan forecasts.

36. Ofwat established and applied a set of criteria to assess companies' special cost factor claims. Ofwat also made a small number of negative special cost factor adjustments to reduce the allowances for some companies. We examine Ofwat's approach to special cost factors further in Appendix 3.1.

37. For the wholesale water price controls, the net adjustments that Ofwat made for special cost factors varied between companies. As a proportion of the sum of the basic cost threshold and policy additions, the adjustments for special cost factors varied between –3% and 24%, with an average of 5%.[12] The net adjustment for Bristol Water was 16%.[13]

Further adjustments outside the main special cost factor process

38. Ofwat's final determinations report that it carried out an additional step to consider adjustments outside of its established criteria for the special cost factor process:[14]

> In order to ensure that our final cost thresholds represent efficient cost we have added an additional step to our process that has involved considering whether there was any other evidence that

---

[11] Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p26.
[12] CMA analysis of data from: Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p26.These figures exclude from the special cost factor allowances the large negative adjustment for Thames Water which resulted not from the special factor process but rather from Ofwat's approach to capping, described in a separate subsection below.
[13] This excludes the effect of Ofwat's special adjustment to its triangulation approach in the case of Bristol Water but includes the adjustments for treatment complexity and congestion.
[14] Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p33.

justified a change to the cost threshold, even if an associated special cost factor claim did not meet the established criteria. For instance, in relation to Bristol Water we have made an extra adjustment to correct for a low allowance for enhancement spending associated with the refined totex model, in addition to considering its representations.

39. The specific adjustment for Bristol Water in relation to the refined totex model can be seen as an adaptation of Ofwat's approach to triangulation that led to the basic cost threshold (see paragraph 23).

40. In addition, as a result of its further consideration, Ofwat's final determinations for Bristol Water included upward adjustments for treatment complexity and congestion in the city of Bristol, even though Ofwat had found that Bristol Water's claims for these items had not met the criteria for special cost factor adjustments.

Cases where Ofwat's cost assessment exceeded a company's forecasts

41. For some companies, the sum of Ofwat's basic cost threshold (from its benchmarking analysis, after any further adjustments), and its adjustments for policy items and special cost factors, produced an estimate of totex requirements that was greater than the level of expenditure that the company had forecast, and sought, in its business plan submissions to Ofwat.

42. Two of these companies were the companies that Ofwat had decided to treat as 'enhanced companies', which were given draft determinations earlier than other companies. These companies were South West Water and Affinity Water. Ofwat's assessment of whether to treat companies as enhanced reflected a number of factors, including Ofwat's view of the quality of the company's business plan and the extent to which Ofwat's benchmarking analysis supported the view that the company's business plan expenditure forecasts represented an efficient level of expenditure.[15] For these two companies, Ofwat made an adjustment to the way that it calculated the basic cost threshold, using each company's forecasts of the relevant explanatory variables for the modelling rather than Ofwat's forecasts, before finalising its cost assessment.

43. For South West Water's wholesale water service, the final cost allowance that Ofwat set was 8% higher than the companies' business plan forecasts. For

[15] CMA analysis of data from: Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p37.

Affinity Water, the final cost allowance that Ofwat set was 5% higher than the companies' business plan forecasts.[16]

44. Ofwat adopted a different approach for other companies that it had not treated as enhanced companies. For Thames Water (in respect of its wholesale water service) and Severn Trent (in respect of its wholesale sewerage service), Ofwat adopted an approach whereby the final cost allowance it set was 'capped' at no more than 5% above the company's revised business plan forecast. Ofwat said that this approach reflected 'strong arguments in favour of customer protection'.[17]

45. Ofwat recognised that such an approach of capping expenditure allowances by reference to business plan forecasts 'could have the potential to distort the incentives on preparing business plan forecasts at future price control reviews', and said that it would be mindful of this risk in deciding on its approach to future price control reviews.[18]

46. For the remaining companies, Ofwat's final cost allowance reflected the sum of Ofwat's basic cost threshold, plus allowances for policy items, plus any adjustments for special cost factors.

Comparison between Ofwat's approach for PR14 and PR09

47. Ofwat's approach to cost assessment for the PR14 price control review was different from the approach it had taken at its previous price control reviews.

48. We provide in this subsection a brief overview of Ofwat's approach to cost assessment at its PR09 review, which set price limits for the period from 1 April 2010 to 31 March 2015. Ofwat's approach at PR09 was similar in many ways to that which it had taken at the PR04 price control review, which set price limits for the period from 1 April 2005 to 31 March 2010.

49. Ofwat's approach at PR09 was based on separate assessments of companies' opex requirements and capex requirements. Not only were these assessments separate, but they also involved different types of approach to cost assessment.

[16] CMA analysis of data from: Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p37.
[17] Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p39.
[18] Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p39.

50. Note that, at previous price control reviews, Ofwat set single price controls covering both of what Ofwat now classifies as wholesale and retail. Wholesale costs were the vast majority of these costs.

51. For opex analysis, Ofwat's approach was approximately as follows. Ofwat took each company's opex in a specific base year (the last year of available data) and used this as the basis of a projection of the company's opex requirements over the five-year price control period. Ofwat reviewed and, if necessary, adjusted the base year expenditure figure (eg if it included abnormal costs which were not a good basis for extrapolation). The projection (or 'roll-forward') involved the following adjustments and assumptions:

(a) The application of an annual rate of 'catch-up' efficiency improvement that Ofwat assumed for each company. This rate was calculated using the results from econometric models of opex; these used cross-sectional data from the sample of companies regulated by Ofwat. For the water service, Ofwat used four different econometric models, which related to different parts of the business or different activities. Ofwat used separate models for: (i) water resources and treatment; (ii) water distribution; (iii) power costs; and (iv) business activities. In setting the catch-up rate, Ofwat assumed that around 60% of the difference in costs between companies that was not explained by its econometric models would be gradually caught up by the end of the five-year price control period.

(b) The application of an annual rate of 'continuing efficiency' improvement. This was the same for all companies and applied in addition to the company-specific catch-up assumption. It reflected Ofwat's assumption on the extent to which companies would make cost reductions (relative to the RPI used for price control indexation) in addition to any catch-up efficiency improvements.

(c) Adjustments for some additional operating costs that Ofwat considered that companies would incur in the price control period but which were not adequately captured by its extrapolation from past levels of spend.

52. One point of comparison is that, while Ofwat's opex econometric models were still a matter of dispute with companies at PR09, the effect of the modelling results on companies' price controls was limited to whether the annual assumed catch-up for opex was between 0% and 2.9% per year.[19] The influence of model results on a company's allowed revenues seems less than

[19] Ofwat (November 2009), Future water and sewerage charges 2010-15: Final determinations, p108.

for PR14, where an upper quartile benchmark was imposed from the start of the new price control period.

53. Ofwat's PR14 econometric models differ from those from PR09, not only by taking opex and capex together, but also because for PR14 Ofwat used models that each covered the whole of the water value chain (excluding retail), from raw water abstraction, storage and treatment through to treated water distribution.

54. For capex assessment at PR09, Ofwat took the investment forecasts in each company's business plan as a starting point. Ofwat reviewed and challenged these forecasts on a number of grounds, including (but not limited to) the following:

    (a) **Scope** – for example, whether the proposed volumes of asset replacement activity seemed too high or the plan included unnecessary expenditure projects.

    (b) **Efficiency** – for example, whether the unit costs of specific asset replacement tasks or projects were too high.

55. For the analysis under *(b)*, Ofwat made assumptions on two types of capital efficiency: (i) a single continuing efficiency assumption that was the same for each company; and (ii) a company-specific relative efficiency assumption compared to that of a middle-ranked company. For the analysis under (ii), Ofwat relied on the 'cost base'. This was a data set complied by Ofwat which contained companies' estimates of the unit costs of for a series of defined capex projects (eg relining 100mm water mains in an urban area, or installing a new household meter). Ofwat used the cost base to carry out benchmarking analysis at the granular level of specific types of investment. Ofwat was able to make adjustments to companies' business plan forecasts by applying an efficiency challenge to the companies' cost forecasts. It calculated the efficiency challenge by weighting the difference between companies' unit costs and those of a middle-ranking company for each individual project.

56. Ofwat's approach to capex involved a greater emphasis on engineering assessment of the constituent elements of each company's cost forecasts than Ofwat's approach to PR14.

57. Besides differences in the approach to cost assessment, other parts of the price control framework that applied to companies following the PR09 review were quite different to those from PR14. For instance, the financial incentives on companies for capex were weaker (ie more pass-through of actual expenditure to consumers) than the totex incentives that Ofwat set for PR14.

Ofwat's menu scheme

Introduction

1. This appendix concerns the 'menu regulation' scheme that Ofwat applied to water companies as part of its PR14 price control framework. It is structured as follows:

   (a) The first section provides an overview and explanation of Ofwat's menu scheme. We use some illustrative examples to help show the effects of the scheme. We also provide information on the purposes of the scheme.

   (b) The second section summarises Bristol Water's submissions on Ofwat's menu scheme. These relate in particular to the effect of the scheme on Bristol Water's revenues in the price control period from 1 April 2015 to 31 March 2020, and the way that Ofwat has treated these effects in its financeability analysis.

   (c) The third section presents an assessment of a number of issues concerning Ofwat's use of the menu scheme that were relevant to our determination. It considers, in particular, Ofwat's objectives in using its menu scheme and the interactions between the menu scheme and Bristol Water's revenues in the price control period from 1 April 2015 to 31 March 2020. It also considers the way that Ofwat treated the menu scheme in its financeability analysis.

   (d) The final section discusses the approaches that we could take towards the menu scheme for our determination of a new wholesale price control for Bristol Water.

Overview and explanation of Ofwat's PR14 menu scheme

2. This section is structured as follows:

   (a) We provide an overview of Ofwat's PR14 menu scheme.

   (b) We use an illustrative example to show how such a scheme may provide financial incentives for regulated companies to provide more accurate expenditure forecasts.

   (c) We use an illustrative example to explain how such a scheme may affect the balance of a regulated company's revenues between different price control periods.

(d) We provide information on the original objective of this type of incentive scheme.

(e) We provide information on Ofwat's stated approach and rationale for its PR14 menu scheme.

(f) We highlight some practical implementation issues that arose under Ofwat's scheme, due to companies providing menu choices to Ofwat after it had published its final determinations.

Overview of Ofwat's PR14 menu scheme

3. Ofwat's menu regulation scheme for PR14 was a development and extension of the CIS which it applied to capex at PR09. The CIS that Ofwat introduced at PR09 was, in turn, based on the IQI that Ofgem had used as part of its regulation of electricity distribution companies and gas distribution companies in Great Britain.[1] Ofgem first introduced the IQI to have effect for the electricity distribution price controls that were effective from 1 April 2005.

4. Ofwat's PR14 menu scheme applied to a measure of total expenditure, including both opex and capex. In contrast, Ofwat's previous CIS scheme had applied only to capex. The extension of the scheme to cover both opex and capex followed Ofgem's development of its own scheme. Ofwat excluded some costs from the PR14 menu scheme. These related to pension deficit repair, third party services and an allowance for costs incurred in 2014/15 in relation to the Open Water programme.[2] Ofwat's PR14 menu scheme applied to the majority of companies' wholesale expenditure.

5. Ofwat's menu scheme and Ofgem's IQI are complicated regulatory mechanisms that are vulnerable to misinterpretation. We seek to provide a description below that draws out the important elements. It is not intended as a full explanation of the scheme or its properties.

6. Ofgem explained the purpose of the IQI (on which Ofwat's menu scheme was based) as follows:[3]

> The aim of the IQI is to encourage companies to submit more accurate expenditure forecasts in their business plans.

---

[1] Ofgem previously used the term 'sliding scale' but now uses the term IQI.
[2] Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p39.
[3] Ofgem (4 March 2013), Strategy decision for the RIIO-ED1 electricity distribution price control: overview, p34.

7. We focus in this subsection on this interpretation of the scheme. We consider in a subsequent section the wider set of objectives that Ofwat seems to have had for the scheme for PR14.

8. To help understand the menu scheme, it is useful to set out the main elements of the price control framework that interact with it. Table 1 highlights five elements. We refer to these five elements repeatedly in the remainder of this appendix. Apart from the additional income element, each of these elements can be relevant to price control frameworks that do not employ similar menu schemes. The essence of the menu scheme lies not so much in its use of these five elements but in the relationships it determines between them.

Table 1: Key elements of Ofwat's menu scheme

Element	*Summary description*
Cost sharing incentive	The cost sharing incentive (also known as the efficiency incentive rate in Ofgem's scheme) is a parameter of the price control framework that determines the proportion of any over- or under-spend against the wholesale expenditure allowance (described below) that is not subsequently passed through to consumers. It affects the degree of profit incentives that the company has to operate efficiently during the price control period, and the financial risk that the company faces in relation to the outcome of Ofwat's cost assessment. The cost sharing incentive applies equally to opex and capex. A lower rate for the cost sharing incentive means that, over time, consumer bills will be more reflective of the company's outturn expenditure than Ofwat's wholesale cost baseline. The cost sharing incentive can only be implemented once the company's outturn expenditure is known. In the case of Ofwat's scheme, it is implemented through financial adjustments to the calculation of the company's allowed revenue in future price control periods.
Ofwat wholesale cost baseline	This is Ofwat's assessment of the regulated company's efficient expenditure requirements for its wholesale activities, over the price control period. It reflects the outcome of Ofwat's cost assessment, including the results of its econometric modelling and special cost factor adjustments. The Ofwat wholesale cost baseline refers to the outcome of the cost assessment process before any adjustments that arise from the application of the menu scheme.
Company's expenditure forecast	A necessary input to the menu scheme is the company's estimate of its expenditure requirements over the price control period. This is fed into the menu scheme expressed as a percentage of the Ofwat wholesale cost baseline. Ofwat refers to this percentage as the company's 'menu choice'. The company forecast could be the expenditure forecast from the company's business plan or a separate forecast that the company makes purely for the purposes of the menu scheme. For PR14, Ofwat took the latter approach.
Wholesale expenditure allowance	This is the expenditure allowance for the price control period which is taken as an input to the price control financial model and used to calculate the company's maximum allowed wholesale revenue and RCV for the price control period. Under Ofwat's scheme the wholesale expenditure allowance is calculated as the weighted average of Ofwat's cost assessment and the company's expenditure forecast (or menu choice), with a 75% weight for the former and 25% for the latter.
Additional income element	This is a parameter of the menu scheme. It may be positive or negative.

Source: CMA analysis.

9. Perhaps the core feature of the menu scheme is that it determines the cost sharing incentive as a declining function of the company's expenditure forecast. The higher the company's expenditure forecast relative to Ofwat's

wholesale cost baseline, the lower the cost sharing incentive (and the greater proportion of any variations in outturn expenditure that is passed through to consumers). This feature of the scheme enables it – under certain assumptions – to provide financial incentives for the regulated company to submit an expenditure forecast that reflects its own expectations of what it will need to spend during the price control period (hence Ofgem's terminology of the scheme as the Information Quality Incentive).

10. A second relevant feature of the menu scheme is that the wholesale expenditure allowance, which feeds into the calculation of the maximum allowed revenue for the company in the price control period from 1 April 2015 to 31 March 2020, is not simply Ofwat's best assessment of the company's efficient expenditure requirements (if it operates and invests efficiently) over that period (ie Ofwat's wholesale cost baseline). Instead, it is a weighted average of Ofwat's cost assessment and the company's forecast. The greater the company forecast, the higher is the allowed revenue in the price control period from 1 April 2015 to 31 March 2020.

11. While this second feature may appear to provide for a price control that represents a compromise between Ofwat's assessment and the company's own expenditure forecast, this is illusory – at least if a perspective beyond a single price control period is considered. The 25% weight to the company forecast has an effect on the revenues allowed during the price control period, but this effect will be offset by financial adjustments that are made, under the terms of the scheme, in future price control periods. In net present value terms, and using the same discount rate as Ofwat applies to implement the scheme, the overall effect of the 25% weighting to the company's forecast is zero. If this were not the case, the scheme would provide companies with an incentive to submit higher expenditure forecasts than they otherwise would, as doing so would mechanically increase future revenues and profits.

12. Ofwat's menu scheme is presented in the form of a table or matrix, which shows the relationship between the five elements highlighted in Table 1. Table 2 below provides, for the purposes of illustration, a short extract from the menu scheme that Ofwat set out for its PR14 final determinations.

Table 2: Extract from Ofwat PR14 menu scheme

	Company forecast*		
	100	*115*	*130*
Cost sharing incentive	50	47	44
Additional income*	0	–1.99	–4.2
Wholesale expenditure allowance for price control*	100	103.75	107.5

Source: Ofwat PL14W004 - Wholesale water menu model.
*As percentage of Ofwat wholesale cost baseline.

13. Table 2 shows how the cost sharing incentive, additional income element and wholesale expenditure allowance for the price control period vary according to the company's forecast. For example, we can see that if the company submits a company forecast of 115% rather than 100%, its cost sharing incentive reduces from 50% to 47%, it faces a negative additional income adjustment of 1.99%, and its wholesale expenditure allowance increases by 3.75%.

14. The cost sharing incentive rates in the table are substantially above zero. The company can, in each case, expect to profit from expenditure reductions and by avoiding inefficient expenditure. Thus, the scheme can help provide financial incentives for the company to restrain expenditure and operate efficiently during the price control period.[4] Cost incentives such as these (sometimes known as efficiency incentives) are not an integral part of the menu scheme and can be applied without using a menu scheme.

15. We use the example above to illustrate two features of the menu scheme:

    (a) The scheme may provide financial incentives for companies to submit more accurate expenditure forecasts.

    (b) While the scheme sets a wholesale expenditure allowance giving a 25% weight to the company forecast, this has little (if any) effect on the total revenues that the company can collect over the long term and mainly affects the balance of revenues between different price control periods.

Financial incentive for more accurate expenditure forecasts from companies

16. The original intention of this type of regulatory scheme was to provide financial incentives for companies to submit more accurate business plan expenditure forecasts, which could feed into the regulatory assessment of the company's expenditure requirements over the price control period. We illustrate below how this works.

17. Suppose we have a hypothetical company that expects to spend 115 compared with the Ofwat baseline of 100. Suppose the company is faced with the menu scheme set out in Table 2 above. We can consider the net financial effect of the company submitting different expenditure forecasts.

18. Specifically, we consider three possible forecasts: 100, 115 and 130. Table 3 shows the outcome of the company submitting these alternative forecasts

[4] These efficiency incentives might be undermined if the regulator uses past spend, and hence past efficiency savings, to set more challenging price controls for the company in the future. This is an argument for placing little, if any, weight on each company's own past spend when carrying out cost assessment under this type of price control framework.

under the menu scheme above. The net overall outcome reflects three different ways in which the company forecast affects the company's revenues. First, through the 25% contribution to the wholesale expenditure allowance. Second, through the impact of the forecast on the additional income adjustment. And third, through the impact of the forecast on the financial adjustment that the company expects from the implementation (in future price control periods once outturn expenditure is known) of the cost sharing incentive, for which the applicable rate depends on the company forecast.

19. We can see from the table that the company's aggregate expected future revenues are (slightly) greater if the company submits a forecast of 115 rather than 100 or 130. This feature of the scheme provides the basis for the purported incentive properties of the scheme: encouraging companies to submit more accurate expenditure forecasts in their business plans. The menu scheme works in a similar way across all scenarios for the Ofwat wholesale cost baseline such that, in all cases, its expected revenue is greatest if it submits a forecast in line with what it expects to spend. Because of this, the financial incentive applies even if the company submits its forecast (or makes its menu choice) before Ofwat has determined its wholesale cost baseline.

Table 3: Illustrative scenarios where company expects to spend 115

Company forecast	*Wholesale expenditure allowance**	*Additional income adjustment*	*Expected future adjustment to implement cost sharing incentive†*	*Net effect on company's expected revenues over long term‡*
100	100	0	7.5	107.5
115	103.75	–1.99	6.0	107.7
130	107.5	–4.2	4.2	107.5

Source: CMA analysis.
*This is calculated as 0.75 multiplied by the Ofwat wholesale cost baseline plus 0.25 multiplied by the company forecast.
†This is calculated as (1 – applicable cost sharing incentive) * (Company's expected future spend minus wholesale expenditure allowance).
‡This is calculated as the wholesale expenditure allowance plus the additional income adjustment plus the expected future adjustment to implement cost sharing incentive

20. There are a number of qualifications and caveats to the incentive properties of the scheme. We draw attention to the following:

(a) The financial incentive properties of the menu scheme (as a means to encourage a company to submit an accurate forecast of its expenditure requirements) may weaken – and may even be undermined – if the company expects the regulator to put weight on the company's expenditure forecast in making its own cost assessment and setting the company's wholesale cost baseline.

(b) If the company has a preference for a relatively high or relatively low cost sharing incentive – ie it is not indifferent to the rate of the cost sharing incentive – this may affect the expenditure forecast it submits. The

company will be aware that submitting a higher forecast will, all else equal, reduce its cost sharing incentive.

(c) If the company uses a different discount rate (or has a different implied discount rate) to that used by Ofwat to calculate financial adjustments to implement the cost sharing incentive, this may affect the expenditure forecast it submits. The company will be aware that submitting a higher forecast will, all else equal, increase revenues in the coming price control period and decrease revenues in future periods.

21. In its response to our provisional findings, Ofwat argued that if a regulator were to use the information from a company's forecast under the menu scheme to inform its own cost assessment during the price control review process, this would undermine the credibility of the regulator to use the menu scheme in the future, because a 'pre-requisite' for the scheme identified by Ofwat (that the company must believe that its forecast will not affect the regulator's baseline) would have been shown not to hold.[5] This argument reflects the qualification we identified at point *(a)* above. However, we did not agree with Ofwat's view that the menu scheme would necessarily be undermined in this way. If the company expects the regulator to place some weight on the company's forecast, alongside a range of other evidence, in making its regulatory cost assessment, the menu scheme may still provide some financial incentives to improve the accuracy of the company's forecasts. Ofwat's view that any use of the company forecast as part of the cost assessment process would undermine the scheme seemed overstated, and this view is clearly not compatible with the approach that Ofgem has taken in developing and implementing the menu scheme.

22. Bristol Water argued that the 'truth telling' incentives of the menu scheme are likely to be very small in practice. The differences in expenditure forecasts of 15 in the example in Table 3 would affect revenue by 0.2 (the difference between 107.7 and 107.5). Bristol Water said that this difference is less than the inherent uncertainty in company cost estimates to deliver the required outcomes and that reputational and consumer-facing incentives are likely to be much greater than the incentive effect from the menu scheme. More generally, Bristol Water highlighted that reputational and wider incentives on companies in respect of their business plans would be more important than a narrow consideration of menu incentives.

[5] Ofwat response to the CMA's provisional findings, paragraphs 101–103.

The effect on the balance of revenues between different price control periods

23. We now turn to consider the impact of the 25% weighting of the company forecast in the wholesale expenditure allowance. We highlighted above that this is a temporary effect that is offset over the longer term.

24. In Table 4, we compare the Ofgem menu scheme for PR14 with three alternative versions of the menu scheme which would give different weight to the company forecast in setting the wholesale expenditure allowance. Rather than the 25% weight under the Ofwat scheme, these would give 50%, 100% or 0% weight to the company forecast in setting the wholesale expenditure allowance. We also compare these scenarios with a further scenario that has no menu scheme and the same cost sharing incentive that applies in the other cases.

25. Under Ofwat's menu scheme, both the wholesale expenditure allowance and the additional income adjustment feed into the level of revenues the company can collect in the price control period 1 April 2015 to 31 March 2020. Only part of the wholesale expenditure allowance is remunerated through revenues in that five-year period (this proportion depends, in particular, on the PAYG rate). In contrast, the adjustment to implement the cost sharing incentive will not be implemented until subsequent price control periods.

26. We can see by comparing the scenarios in Table 4 that increasing the weight given to the company business plan in the calculation of the wholesale expenditure allowance will act to increase revenues in the price control period 1 April 2015 to 31 March 2020. However, there is little (if any) effect on total revenues over the longer term as the increase is offset by a reduction to the future revenue adjustments that implement the cost sharing incentive.

27. The main effect of the weight given to the company forecast, in the calculation of the wholesale expenditure allowance, is to affect the balance of revenue that is remunerated in the forthcoming price control period compared to subsequent periods.

Table 4: Alternative scenarios for wholesale expenditure allowance

Scenario	*Wholesale expenditure allowance*	*Additional income adjustment*	*Expected future adjustment to implement cost sharing incentive*	*Net effect on company's expected revenues over long term*
Ofwat scheme 25% weight to company forecast Company forecast 115	103.75	–1.99	5.96	107.73
50% weight to company forecast Company forecast 115	107.5	–3.75	3.98	107.73
100% weight to company forecast	115	–7.28	0	107.72
0% weight to company forecast Company forecast 115	100	–0.40	7.95	107.55
No menu scheme Wholesale expenditure allowance set equal to wholesale cost baseline Cost sharing incentive of 47%	100	N/A	7.5	107.50

Source: CMA analysis based on Ofwat menu feeder model.

28. The example above helps to demonstrate how the menu scheme can affect the balance of revenues that the company collects during different price control periods. However, in practice, the effects on revenues in different time periods may not be material for some companies.

The original objective of this type of incentive scheme or menu scheme

29. We have set out some of the important features of Ofwat's menu scheme. We now turn to the role and purpose of the scheme in Ofwat's PR14 review. We first consider the original objective of this type of scheme.

30. As stated above, Ofwat's PR14 menu scheme was based on Ofgem's IQI scheme. There does not appear to be a material difference between Ofwat's PR14 menu scheme and Ofgem's IQI in terms of the matrix or formulae that underpin the scheme, besides the calibration of the parameters of the scheme.

31. In its recent review of electricity distribution company price controls, Ofgem applied its IQI scheme and was clear that the purpose of the IQI concerns the accuracy of companies' business plan forecasts:[6]

> The aim of the IQI is to encourage companies to submit more accurate expenditure forecasts in their business plans.

[6] Ofgem (4 March 2013), Strategy decision for the RIIO-ED1 electricity distribution price control: overview, p34.

32. Similarly, Ofgem explained that:[7]

> The IQI is designed to encourage [electricity distribution network companies] to provide business plans that reflect best available information about future efficient expenditure requirements.

33. At its PR09 price control review, Ofwat explained the purpose of the CIS in a manner consistent with this:

> The CIS is an important new feature for this price review. It provides strong incentives for companies to put forward challenging and efficient business plans before our determinations and to strive to beat our price limit assumptions after them.

34. Similarly, in its 2010 determination for Bristol Water, the CC interpreted the CIS as a scheme to encourage more accurate business plan expenditure forecasts from companies:[8]

> The CIS is a method that Ofwat has devised to encourage companies to make realistic and well-evidenced capex plans without undermining their incentives to achieve efficiencies in realising those plans. It is intended to penalise companies that do not make such plans.

Ofwat's stated approach and objectives for its PR14 menu scheme

35. In its decision paper on the methodology for its PR14 price control review, Ofwat confirmed its use of menu regulation and said the following:[9]

> Menu regulation can provide extra incentives for companies to reveal information, allows for some extra flexibility in setting totex baselines, provides some additional flexibility in setting efficiency sharing factors and allows companies to better manage risks and rewards. Menus can be constructed such that menu choices are incentive consistent, in that companies gain from both revealing information and achieving greater efficiencies. Customers gain from sharing in these efficiencies.

---

[7] Ofgem (28 September 2012), Strategy consultation for the RIIO-ED1 electricity distribution price control: overview, p33.
[8] CC10 Final determination, paragraph 5.2.
[9] Ofwat (July 2013), Setting price controls for 2015-20 – final methodology and expectations for companies' business plans, p88.

36. Ofwat went on to say that it had considered two alternative approaches to the implementation of menu regulation:[10]

> *(a)* Using information in companies' business plans to determine which menu option the company should receive in the light our assessment of its costs (the broad approach used by Ofgem for its Information Quality Incentive, and by [Ofwat] for the CIS at the last price review).
>
> *(b)* Allowing companies to choose their own menu option later in the price setting process after we have prepared our own independent cost assessments.

37. Ofwat said that the advantage of the first approach was that 'it would further encourage companies to reveal information during the business planning process'.[11] However, it identified that this approach has tended to be used where regulators asked for two rounds of business planning information (which was not what Ofwat had envisaged for PR14). Furthermore, Ofwat identified the following drawback of the first approach:[12]

> It also does not allow companies any choice – and so contributes less to an efficient approach to risk management.

38. Ofwat ultimately decided to adopt the second approach. Companies were allowed to 'choose their menu option' in January 2015, after Ofwat had completed its own final cost assessment and published its final determinations. Ofwat identified that this approach would be compatible with a single stage approach to business plans and that it would have advantages in terms of 'baseline flexibility, setting differential efficiency factors and risk management'.[13] Ofwat clarified its view on these benefits as follows:[14]

> A menu provides a framework which allows companies a degree of flexibility to determine its price control baseline and cost sharing incentive rate.

---

[10] Ofwat (July 2013), Setting price controls for 2015-20 – final methodology and expectations for companies' business plans, pp88–89.
[11] Ofwat (July 2013), Setting price controls for 2015-20 – final methodology and expectations for companies' business plans, p89.
[12] Ofwat (July 2013), Setting price controls for 2015-20 – final methodology and expectations for companies' business plans, p89.
[13] Ofwat (July 2013), Setting price controls for 2015-20 – final methodology and expectations for companies' business plans, p89.
[14] Ofwat (April 2014), Setting price controls for 2015-20 – policy and information update, p34.

39. The following features of the menu scheme, as discussed above, are relevant in understanding Ofwat's view on the role of the menu scheme for PR14:

(a) Under the menu scheme, different companies are likely to face different cost sharing incentive rates and each company's forecasts (or menu choice) will affect the rate that it faces. This feature relates to Ofwat's view that the menu scheme is beneficial because it allows differential efficiency factors (cost sharing incentive rates).

(b) Under the menu scheme, the revenues allowed during the price control period will be affected by the company's menu choice, through the 25% weight to the company business plan in the wholesale expenditure allowance. This feature relates to Ofwat's view that the menu scheme brings benefits by allowing 'baseline flexibility'.

40. From this perspective, Ofwat's approach to the choice between the two implementation options it identified reflects a trade-off between different potential roles for the scheme:

(a) If each company is asked to provide its expenditure forecast for use in the menu scheme before Ofwat has completed its cost assessment, this may contribute to Ofwat's overall cost assessment.[15] However, because the company will not know the level of Ofwat's wholesale cost baseline, it will not have certainty as to how its forecast will affect the cost sharing incentive and the wholesale expenditure allowance that it faces.

(b) If each company is asked to provide its expenditure forecast for use in the menu scheme after Ofwat has completed its cost assessment, this would be too late for it to contribute to Ofwat's cost assessment. However, the company would know exactly what expenditure forecast it would need to submit to achieve any desired cost sharing incentive or wholesale expenditure allowance (subject to the upper and lower limits that applied to these under Ofwat's scheme).

41. In its response to our provisional findings, Ofwat sought to emphasise that, even if the menu scheme did not provide information for use during the price control cost assessment process under *(a),* it could still provide a useful incentive for companies to reveal truthful information, just at a different stage, once the price control process was completed (see paragraph 68 below).[16]

42. Nonetheless, during its PR14 process, Ofwat had identified a choice between using the menu scheme as a means to 'encourage companies to reveal

---

[15] Subject to the limitations discussed at paragraphs 20–21 above.
[16] Ofwat response to our provisional findings, paragraphs 99–106.

information during the business planning process',[17] and using the menu scheme to allow a company 'a degree of flexibility to determine its price control baseline and cost sharing incentive rate'.[18] Ofwat's approach for PR14 adopted the second option. This is reflected in the language it used. Ofwat referred to its scheme as 'menu regulation' and consistently referred to the company forecast, which was an input to the scheme, as the company's 'menu choice'.

43. Ofwat's submissions also emphasised the role of its PR14 scheme in providing companies with flexibility in relating to the cost sharing incentives, which affect a company's financial exposure to over- and under-spend against the wholesale expenditure allowance used to calculate the price control:[19]

> The PR14 methodology provides companies with enhanced ability to manage risk by their menu choices, which determine risk sharing on totex outperformance.
>
> Companies can choose their point on the menu and so the sharing rate for outperformance and underperformance of the expenditure allowances.

Practical implementation issues with the January 2015 menu choice

44. While Ofwat's clear intention for PR14 was that companies would make menu choices after it had published final determinations, this raised a practical problem. Companies made menu choices in January 2015. At that stage it was too late to reflect the impact in final determinations. Ofwat addressed this practical issue as follows:[20,21]

(a) The calculations of allowed revenues in Ofwat's final determinations are based on an 'implied' menu choice for each company, which was determined by Ofwat, based on the company's business plan. In the case of Bristol Water, Ofwat used a menu choice of 130 (ie company forecast 130% of Ofwat's wholesale cost baseline), which was the upper bound in Ofwat's menu scheme.

---

[17] Ofwat (July 2013), Setting price controls for 2015-20 – final methodology and expectations for companies' business plans, p89.
[18] Ofwat (April 2014), Setting price controls for 2015-20 – policy and information update, p34.
[19] Ofwat (March 2015), Referral of Bristol Water's determination of price controls for the period from 1 April 2015 – introduction for the Competition and Markets Authority, pp56–58.
[20] Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p42.
[21] Ofwat (March 2015), Referral of Bristol Water's determination of price controls for the period from 1 April 2015 – introduction for the Competition and Markets Authority, p20.

(b) The cost sharing incentive that is applicable during the period 1 April 2015 to 31 March 2020 is the one arising from the application of the company's January 2015 menu choice (not the implied menu choice).

(c) Ofwat said that it would make financial adjustments, as part of the subsequent price controls from 1 April 2020 onwards, that will give effect to the company's actual menu choice made in January 2015 (ie to adjust for any differences between Ofwat's implied menu choice and the company's actual menu choice).

Bristol Water's submissions

45. In its SoC, Bristol Water raised several specific concerns with Ofwat's approach to the PR14 menu scheme.

46. First, Bristol Water argued that while it is open to each company to choose a menu position, the effect of that choice does not impact a determination until AMP7 (ie from 1 April 2020 onwards) and that for AMP6 (ie 1 April 2015 to 31 March 2020) Ofwat has assumed a menu choice based on companies' business plan submissions.[22] Ofwat's implied or inferred menu choice, on which its final determinations were based, was higher than Bristol Water's actual menu choice. Bristol Water said that, following Ofwat's final determinations, Bristol Water made a menu choice of 125, which reflected its view of the costs of delivering its plan excluding the costs of Cheddar 2. Cheddar 2 was not part of the outcomes required from Bristol Water under Ofwat's final determinations.[23]

47. Second, Bristol Water was concerned that Ofwat applied penalties (that reflect a cost-share of overspend between companies and customers) to revenue despite overspend relating to opex and capex.[24]

48. Bristol Water said that if the regulatory cost assessment for wholesale totex was at, or close to, an appropriate level, the impact of these weaknesses would not be material, but where a large difference in views on totex exists, the size of penalty is significant and may lead to possibly unintended financeability issues.[25]

[22] Bristol Water SoC, p408.
[23] Bristol Water SoC, p409.
[24] Bristol Water SoC, p408.
[25] Bristol Water SoC, p408.

49. Third, Bristol Water went on to identify further concerns with the analytical approach that Ofwat took towards the menu scheme in its analysis of Bristol Water's financeability:[26]

> While Ofwat's wholesale totex estimate for Bristol Water was £409 million, through the menu choice mechanism Ofwat has assumed Bristol Water will spend £437 million, partially reflecting our Business Plan. Revenues have been set based on this higher level of spend. To reflect a cost-sharing mechanism between Bristol Water and its customers for an overspend compared to its estimate, a revenue penalty of £17 million has also been included. The penalty is large due to the size of the wholesale totex gap created by FD14.
>
> Ofwat has assessed financeability assuming the higher revenues and higher costs associated with £437 million, with allocations to revenue and RCV and operating and capital expenditure in line with the PAYG ratio. The penalty is then fully applied to revenues. The result is that the additional revenue is cancelled by the penalty, leaving an assumption of higher operating costs and therefore lower profitability.
>
> As Ofwat has excluded the penalty from its financeability calculations, the assumption of lower profitability is ignored.

50. Bristol Water set out in its SoC two options for how we should approach the menu scheme for the inquiry:[27]

> We believe Ofwat's cost assessment process has been too narrow and that it has inherent weaknesses. The menu choice penalty therefore reflects the results of a weak process, rather than acting as a genuine efficiency incentive. In reaching a redetermination, we consider it would be appropriate for the menu penalty to be based on our response to the CMA's provisional findings or simply assume 100. In effect, this would replicate the process that other water companies have gone through, where the cost assessment process appears to have been satisfactory.

[26] Bristol Water SoC, p569.
[27] Bristol Water SoC, p571.

Our assessment

51. This section presents our assessment of a number of issues concerning Ofwat's use of the menu scheme which were relevant to our determination. We take the following in turn:

    (a) Ofwat's use of the menu scheme for PR14.

    (b) The implications of Ofwat using an implied menu choice in its final determinations.

    (c) Ofwat's treatment of the menu scheme in its financeability analysis.

    (d) The effects of the scheme on Bristol Water's revenues in the period from 1 April 2015 to 31 March 2020.

Ofwat's use of the menu scheme for PR14

52. In contrast to both the practice of Ofgem and Ofwat's own approach at PR09, Ofwat applied its PR14 menu scheme in a way that departed from the original objective of this type of scheme – providing financial incentives to submit more accurate business plan expenditure forecasts that could feed into the regulatory cost assessment for the price control review. Ofwat used its menu scheme in a different way for PR14.

53. Ofwat did not present its PR14 menu scheme primarily as a means to provide financial incentives for water companies to submit more accurate business plan forecasts. Instead, Ofwat treated the following properties of its menu scheme as beneficial:

    (a) It allowed a company to influence the cost sharing incentive that it faces (within a range of 44 to 54%).

    (b) It allowed a company to influence the wholesale expenditure allowance (up to a maximum of 107.5% of the Ofwat wholesale cost baseline).

54. Ofwat implemented the menu scheme in a way that prioritised these features.

55. We did not identify how the menu scheme that Ofwat implemented would have made an effective contribution to the original Ofgem objective of providing financial incentives for companies to submit more accurate business

plan expenditure forecasts, as a means to contribute to the cost assessment during the price control review. This was for two reasons:

(a) The scheme did not apply to companies' business plan forecasts.[28] Instead, the scheme applied to a decision (menu choice) that companies made in January 2015, after Ofwat had completed its review and assessment of companies' business plans and after it had published final determinations.

(b) Even if the scheme encouraged each company to submit an accurate forecast, in January 2015, of its expenditure forecasts over the period 1 April 2015 to 31 March 2015, this would have been too late to contribute to the cost assessment on which the PR14 price controls were based.

56. Ofwat's approach to the PR14 menu scheme raised two questions:

(a) Should it be a regulatory objective to provide a company with the ability to choose its own cost sharing incentive (within the range 45 to 55%) or to choose the wholesale expenditure allowance that it faces (up to a maximum of 107.5% of the Ofwat wholesale cost baseline)?

(b) Is Ofwat's menu scheme likely to be an effective and proportionate way to meet such an objective?

57. The submissions that we received from Ofwat on its menu scheme did not provide a good explanation of the rationale for providing companies with some limited flexibility on the cost sharing incentives. Ofwat said that flexibility on the cost sharing incentive may enable a risk averse company to 'buy additional insurance from customers' by transferring additional risk to its customers, for a fee set by the menu scheme.[29] We did not see why this would be in the interests of consumers.

58. We discuss the question at *(b)* in more detail below.

59. Any attempt to present the menu scheme as a scheme that provides companies with choice or flexibility on price control parameters such as the cost sharing incentive or the wholesale expenditure allowance must confront the incentive properties of the scheme.

60. Ofwat's PR14 menu scheme was based on a scheme that was originally designed to provide financial incentives for a company to submit an

[28] Other than through the implied menu choice, the effect of which Ofwat plans to cancel out in the next price control period.
[29] Ofwat response to our provisional findings, paragraph 101(ii).

expenditure forecast that fits with its estimates of what it will spend during the price control period. It was unclear whether the scheme in practice provided companies with much flexibility to make choices.

61. While it is true that the company forecasts that are taken as inputs to the scheme affect the cost sharing incentive and the wholesale expenditure baseline, these are not free choices for the company to make. Attempting to use the scheme to achieve a specific cost sharing incentive or wholesale expenditure allowance comes at a price.

62. The properties of the menu scheme mean that a company will tend to maximise the expectation value of its future revenues (and profits) if it chooses to submit a forecast for use in the menu scheme that is consistent with its expenditure requirements over the price control period (subject to any differences in its discount rate compared to that used in Ofwat's calculations). Submitting such a forecast will lead to it facing a specific value for the cost sharing incentive and wholesale expenditure allowance. If the company wishes to face a different rate for the cost sharing incentive, or to have a different wholesale expenditure baseline, it must accept a lower level of expected future revenues. There is, in effect, a financial penalty for making such choices.

63. Table 5 illustrates the financial penalty under Ofwat's scheme that a company must accept if it wishes to achieve a specific rate for the cost sharing incentive. The table considers the two extremes of the range allowed by Ofwat. The penalty varies according to the ratio of the company's own expenditure forecast to the Ofwat baseline.

Table 5: Illustration of penalty from targeting a specific cost incentive rate

	% of Ofwat wholesale cost baseline	
Company's expected expenditure during price control period	*Penalty from submitting forecast that achieves 54% cost sharing incentive**	*Penalty from submitting forecast that achieves 44% cost sharing incentive**
80	0.0	–2.5
90	–0.1	–1.6
100	–0.4	–0.9
110	–0.9	–0.4
120	–1.6	–0.1
130	–2.5	0.0

Source: CMA analysis of Ofwat menu feeder model.
*This calculation assumes the company has the same discount rate for future revenues as Ofwat uses (eg to implement the cost sharing incentive).

64. A similar analysis could be provided to show the implied revenue penalties for a company that wishes to use the menu scheme to achieve a specific wholesale expenditure allowance.

65. The penalties identified in Table 5 above are, in some cases, significant. These penalties are an integral part of the menu scheme and would tend to limit its effectiveness in providing choice and flexibility to companies over the cost sharing incentive rate.

66. Bristol Water told us that it agreed with our analysis that Ofwat's PR14 menu scheme did not represent a good way to provide companies with flexibility on the cost sharing incentives.

67. Ofwat told us that while the flexibility with respect to cost sharing rates was limited, 'the broader flexibilities and truth telling characteristics that menus provide remain beneficial additions to the regulatory regime'. Ofwat did not elaborate on what the 'broader flexibilities' were. We did not identify any beyond the limited influence on the cost sharing rate and wholesale expenditure allowance discussed above.

68. We sought further information from Ofwat on what it saw as the truth telling characteristics of the scheme it had used for PR14. More specifically, we asked Ofwat to explain the benefit from providing companies with incentives to reveal information at a point in time when it had already published its final determinations. Ofwat told us that the menu choices that companies made subsequent to its final determinations provided information on what level of total expenditure companies were targeting. Ofwat said that this was information that would be useful for the purposes of Ofwat's next price control review, PR19, when it starts to consider potential changes to its econometric benchmarking models.

69. We considered that it was possible that Ofwat's menu scheme would help provide some relevant information for its PR19 price control review. However, we did not consider this a compelling reason for using the scheme. This was for two reasons:

    (a) This potential future benefit of the scheme for the purposes of PR19 had not been highlighted in Ofwat's original submissions to us or its PR14 methodology documents which, as explained above, had instead emphasised the desire to provide companies with flexibility. If the benefits to Ofwat's PR19 price control review were very important, we would have expected Ofwat to have mentioned them at an earlier stage.

    (b) The information from companies' menu choices in January 2015 did not seem to lead to strong conclusions about the approach to cost assessment for PR19. Indeed, Ofwat provided alternative interpretations of the menu choices. First, Ofwat told us that the fact that seven companies submitted menu choices (expenditure forecasts) in January

2015 that were lower than the ones Ofwat had assumed for its final determinations (based on companies' price control review business plans) showed that Ofwat's PR14 approach had worked for consumers because the companies that had provided an explanation of their choice said that they took the opportunity to further challenge themselves. Subsequently, Ofwat agreed that it was possible that, for companies whose January 2015 menu choices were below what Ofwat had assumed, its models had provided estimates that were too high. These examples illustrate the difficulty of drawing firm conclusions from the January 2015 menu choices, which limits the value of the information generated by the scheme.

Ofwat's use of an implied menu choice for its final determinations

70. Because Ofwat asked companies to make their menu choices after it had published final determinations, it was not practical for the price controls from 1 April 2015 to 31 March 2020 to give full effect to the company's menu choice. Instead, as an interim measure, Ofwat used an implied or inferred menu choice based on company business plans. Ofwat said that it intended to make financial adjustments in the subsequent price control period to give effect to the company's actual menu choice (to the extent that it differs from the implied menu choice that Ofwat used for final determinations).

71. This aspect of Ofwat's approach may reduce or undermine the value of the scheme in providing companies with flexibility on the wholesale expenditure allowance, which Ofwat had originally intended in its comments about 'baseline flexibility'. What Ofwat referred to as the company menu choice under the PR14 menu scheme could not actually affect a company's allowed revenues in the price control period from 1 April 2015 to 31 March 2020.

Ofwat's treatment of the menu scheme in its financeability analysis

72. Bristol Water raised concerns about Ofwat's treatment of the menu scheme in its financeability analysis.

73. Our reading of Ofwat's financeability analysis for Bristol Water was that the approach was as follows:

    (a) It assumed revenues for Bristol Water that were based on the post menu wholesale expenditure allowance of around £438 million.

    (b) It assumed that Bristol Water's wholesale expenditure over the price control period would also be £438 million.

(c) It did not take account of the negative adjustment from the menu scheme for Bristol Water of around £17 million over the price control period (Bristol Water referred to this as a penalty).

74. We did not fully understand Ofwat's approach to financeability analysis in the context of its menu scheme.

75. Ofwat's approach seemed to involve an inconsistency in the way that the effects of the menu scheme featured in the analysis. Ofwat's analysis seemed to take account of the positive effect on revenues of the menu scheme: the uplift to the wholesale expenditure allowance arising from the implied Bristol Water menu choice of 130, which was given a 25% weight in the wholesale expenditure allowance on which the price control is based. However, it did not seem to account for the negative effect on revenues: the additional income adjustment, which takes a negative value because of the implied menu choice of 130. One way to see this inconsistency is to consider an alternative scenario in which Bristol Water had a menu choice of 100. In this scenario, it would face an additional income adjustment of zero rather than £17 million (no 'penalty' in Bristol Water's terminology). However, its wholesale expenditure allowance would be around £30 million lower and the revenues used for the financeability analysis would need to be adjusted downwards accordingly.

76. A further issue was the assumption made about Bristol Water's level of expenditure over the five-year period from 1 April 2015. Ofwat's financeability analysis was based on the assumption that Bristol Water would incur expenditure of £438 million. This seemed difficult to explain because:

(a) £438 million was not the efficient level of expenditure arising from Ofwat's cost assessment for Bristol Water. On a comparable basis, Ofwat's assessment implies wholesale expenditure of £409 million; and

(b) £438 million was not the level of expenditure forecast by Bristol Water; Bristol Water's forecast was substantially higher.

77. Ofwat had repeatedly told us that the financeability assessment should be based on an efficient company.[30] However, if Ofwat had wanted to carry out a financeability assessment for what it considered to be an efficient company, it would have been more logical to use the figure of £409 million for the

[30] Ofwat (March 2015), Referral of Bristol Water's determination of price controls for the period from 1 April 2015 – introduction for the Competition and Markets Authority, pp56–58.

assumed level of Bristol Water's expenditure and then to take either of the following steps:

(a) Exclude both of the menu scheme financial adjustments (the upward adjustment to the wholesale expenditure allowance to move from £409 million to £438 million and the downward adjustment of £17 million). This approach would provide a financeability analysis for a notional company whose costs were at the estimated efficient level and whose expenditure forecast (menu choice) was the same as that efficient level of costs. This would be more consistent with the aim of carrying out financeability analysis for a notional efficient company (which would imply efficient costs and efficient expenditure forecasts).

(b) Include both of the menu scheme financial adjustments. This approach would provide a financeability analysis for a notional company whose costs were at the estimated efficient level, but whose expenditure forecast (menu choice) was at the level submitted by the company of interest (Bristol Water). This would better reflect the shorter-term cash flow implications arising from the menu scheme.

78. If Ofwat had applied this alternative approach, it may have obtained similar results from its financeability analysis for the period from 1 April 2015. Reducing both the assumed wholesale expenditure allowance and the assumed Bristol Water expenditure by a similar amount would tend to have effects that offset each other. Thus, although we did not fully understand the logic for Ofwat's approach, it may not have introduced any significant problems for the overall analysis.[31]

79. In its response to our provisional findings, Ofwat sought to rationalise the approach that it had taken to financeability analysis in the context of its PR14 menu scheme.[32] We did not understand the explanation provided by Ofwat.

80. For the purposes of our determination, it was not necessary to assess whether or not Ofwat's approach to the PR14 menu scheme in its financeability analysis was appropriate.

81. Instead, the implication that we drew was that the PR14 menu scheme was a complex part of Ofwat's regulatory framework and that there was uncertainty and dispute as to the appropriate way to take account of the scheme in the financeability analysis. We did not consider it unreasonable for Bristol Water to have raised concerns about Ofwat's treatment of the menu scheme in its

[31] We did not consider this in detail because we decided not to apply the menu scheme for our determination, so this was not relevant to our financeability analysis.
[32] Ofwat response to our provisional findings, paragraphs 111–121.

financeability analysis. We did not find it straightforward to identify the appropriate approach, not least in the light of Ofwat's submissions.

The effects of the scheme on Bristol Water revenues up to 31 March 2020

82. We carried out some analysis to better understand the effects of Ofwat's menu scheme on Bristol Water's revenues in the period 1 April 2015 to 31 March 2020 and the implications for its financeability in that period.

83. We considered three scenarios. In each scenario, we took as given Ofwat's wholesale cost baseline of £402.4 million.[33] The scenarios vary in whether Ofwat's menu scheme applies and, if so, what the menu choice for Bristol Water is:

    (a) In scenario *(a)*, Ofwat's menu scheme is retained and the implied menu choice for Bristol Water is 130. This scenario is based on Ofwat's final determinations in respect of the period from 1 April 2015 to 31 March 2020 (under Ofwat's approach, Bristol Water's actual menu choice in January 2015 would not have affected revenues before the subsequent price control from 1 April 2020). In this scenario the expenditure allowance ultimately feeding into the financial model used to calculate price control revenues is £432.6 million.[34]

    (b) Scenario *(b)* is a hypothetical scenario in which Ofwat's menu scheme is retained, but Bristol Water's menu choice is 100. In this case the wholesale expenditure allowance feeding into the financial model used to calculate price control revenues is the same as Ofwat's wholesale cost baseline (£402.4 million).

    (c) Scenario *(c)* is a hypothetical scenario. Ofwat's menu scheme is abandoned and the wholesale expenditure allowance feeding into the financial model used to calculate price control revenues is simply Ofwat's wholesale cost baseline (£402.4 million).

84. Table 6 below shows indicative figures for revenues relating to the expenditure allowance covered by the menu scheme.[35] Our focus here is revenue impacts over the five-year price control period from 1 April 2015 to 31 March 2020: the tables are not representative of the overall impacts of the different scenarios on revenues (the menu scheme has potentially substantial

[33] Ofwat final determination cost threshold of £409.2 million less £6.7 million costs excluded from the menu.
[34] This expenditure allowance gives a 25% weight to the company forecast (menu choice) and a 75% weight to Ofwat's wholesale cost baseline. With a forecast of 130% of the baseline, this works out as an expenditure allowance of 107.5% of Ofwat's wholesale cost baseline.
[35] In these three scenarios we leave aside the costs such as pension deficit repair that are treated outside of the menu.

impacts on revenues in future price control periods). These calculations are based on data from Ofwat's final determinations menu feeder model, an average PAYG rate of 55% and RCV additions depreciated straight line over 30 years. The figures are indicative and have not been verified through separate scenario modelling using Ofwat's financial model.

Table 6: Indicative revenues allowance 1 April 2015 to 31 March 2020

£m

Scenario	*2015-2020 revenue from wholesale expenditure allowance*	*Additional income adjustment*	*Net effect*
(a) Ofwat menu with Bristol Water at 130	296	(17)	280
(b) Ofwat menu with Bristol Water at 100	276	0	276
(c) No menu applies	276	N/A	276

Source: CMA analysis.

85. The figures in Table 6 are indicative only, but they suggest that the differences between the scenarios are small, less than £1 million per year (which is below 1% of revenues). Under Ofwat's menu scheme, the impact of a menu choice of 130 versus 100 seems to have little impact on revenues. This is because, under the menu choice of 130, the positive impact on revenues from the 25% weight to the company forecast (menu choice) is mostly offset by the negative additional income adjustment.

86. Our analysis is consistent with Ofwat's view that the menu choices have a small impact on revenues in the period 1 April 2015 to 31 March 2020:[36]

> We also noted that menu choices (even extreme ones) are likely to have a relatively small impact on allowed revenue and customer bills in the period from 2015-20 due to the offsetting effects of the allowed expenditure and the menu's 'additional income'. We therefore stated that any adjustment to companies' allowed revenues resulting from their menu choice arising from our PR14 decisions will be made as part of the price control review in 2019 (PR19).

87. Our analysis – and Ofwat's statement above – suggested that, at least for Bristol Water, the Ofwat PR14 menu scheme would make no significant positive contribution to Bristol Water's revenues in the period 1 April 2015 to 31 March 2020. At the same time, the menu scheme did not seem to impose any substantial net financial penalty on Bristol Water in that period.

[36] Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p41.

88. Of course, to the extent that Ofwat's cost assessment (ie its wholesale cost baseline) for Bristol Water was substantially lower than what Bristol Water considered appropriate, this would cause financial detriment from Bristol Water's perspective. But this is simply a result of Ofwat's cost assessment and is not attributable to the menu scheme.

Approach to menu scheme for our determination

89. We considered whether, and how, to use the menu scheme for the purposes of our determination.

90. We faced a practical issue. Ofwat's menu scheme was predicated on the assumption that Bristol Water would make a menu choice in January 2015 in the knowledge of the wholesale cost baseline. Our determination lead to changes to the wholesale cost baseline. It did not seem consistent with Ofwat's approach to the PR14 menu to simply use Bristol Water's January 2015 menu choice, which was made before our assessment of the appropriate level of the wholesale cost baseline.

91. We considered whether it would make sense to retain the spirit of Ofwat's approach and do the following:

    (a) Make our determination on an implied or inferred menu choice for Bristol Water (eg comparing Bristol Water's business plan forecasts with our final cost assessment).

    (b) Provide for Bristol Water to make a menu choice after our final determination has been published. We would then look to Ofwat to give effect to that menu choice through financial adjustments to the subsequent price control from 1 April 2020 onwards.

92. We found limited grounds for adopting this approach within the context of our determination.

93. We recognise that a menu scheme along the lines of that used in the past by Ofwat (the CIS), and originally developed by Ofgem (the IQI), may contribute to the accuracy of companies' business plan forecasts as a means to improve the regulator's cost assessment during the price control review process. This objective may justify the use of such schemes and there would be concerns about undermining the incentive effects of such schemes if the CMA departed from them retrospectively. However, the specific way in which Ofwat implemented its PR14 menu scheme, with companies making menu choices after final determinations, did not target the accuracy of the company business plan forecasts that fed into Ofwat's PR14 cost assessment.

94. We did not consider Ofwat's argument that its menu scheme provided useful information for PR19 to be sufficiently strong that we should retain the scheme for our determination. As explained above, we did not consider that to be a compelling argument in favour of the scheme. Furthermore, that argument seemed less relevant for our determination for Bristol Water than for Ofwat's approach to water industry price controls. Regardless of the approach that we took for Bristol Water, our approach would not affect Ofwat's ability to use the information from the menu choices from the other 17 water companies when developing its approach for the PR19 review.

95. Apart from information revelation, Ofwat saw its PR14 menu scheme as a scheme to provide flexibility to companies, in particular in relation to the cost sharing rate (within a range defined by Ofwat). This was reflected in its language; it referred to a company's 'menu choice' for what was previously treated as the company's expenditure forecast. However, Ofwat's PR14 menu scheme provided somewhat limited flexibility to companies on the choice of the cost sharing incentive rate. Bristol Water's view was that Ofwat's PR14 menu scheme was not a good way to provide companies with flexibility on the cost sharing incentives. Furthermore, we did not identify why it was important or in consumers' interests to provide water companies with a choice over their cost sharing incentive rate within the range of 44 to 54%.

96. We identified an alternative approach:

(a) We would not apply Ofwat's PR14 menu scheme for our determination. There would be no implied or actual menu choice available for Bristol Water.

(b) The wholesale expenditure allowance for Bristol Water, which feeds into the calculation of allowed revenues and RCV for the period 1 April 2015 to 31 March 2020, would be based directly on our assessment of Bristol Water's expenditure requirements over that period.

(c) The cost sharing incentive would be 50%.

97. This approach has equivalent effect, in technical terms, to retaining the Ofwat PR14 menu scheme and assuming a Bristol Water expenditure forecast (menu choice) as 100% of our allowance. This approach was consistent with one of the two suggested approaches that Bristol Water advocated for our determination.[37]

[37] Bristol Water SoC, paragraph 2405.

98. Under this approach, there would be no weighted average between a Bristol Water forecast and our assessment. The price control would be set giving 100% weight to the outcome of our cost assessment (though our cost assessment could draw on Bristol Water's business plan forecasts insofar as we considered appropriate). While this might seem a change from Ofwat's PR14 scheme, this has a limited effect. Our analysis above, and statements from Ofwat, indicate that the menu scheme would have limited effect on revenues in the period 1 April 2015 to 31 March 2020.

99. An approach to our determination that does not involve the menu scheme has some further benefits. In particular, it is not vulnerable to two specific concerns that Bristol Water raised about Ofwat's PR14 menu scheme, which were that:

(a) For the period 1 April 2015 to 31 March 2020, Ofwat set the price control using an assumed menu choice based on companies' business plan submissions. This differed from Bristol Water's actual menu choice.

(b) Bristol Water said that the additional income adjustment applied by Ofwat was implemented entirely as a revenue adjustment (or penalty) during the price control period despite the adjustment relating to both opex and capex. If part of wholesale totex is to be expensed during the period (through the PAYG rate) and part is to be added to the RCV, it would seem more consistent for the revenue adjustment to be applied partly to revenues during the price control period and partly to the RCV.

100. This approach would also help to avoid the need to resolve the uncertainty and dispute in relation to the appropriate treatment of the PR14 menu scheme within the financeability assessment.

101. We shared our proposed approach to the menu scheme with the main parties.

102. Bristol Water told us that it welcomed our proposal to dis-apply the scheme and set a cost sharing incentive of 50%. Bristol Water said that this would result in slightly higher incentive risk for Bristol Water, but more importantly it would avoid unintended financeability consequences.

103. Ofwat identified that our proposed approach would increase the cost sharing rate from 45 to 50% and that this would provide a stronger efficiency incentive for Bristol Water, but also expose customers further to the risk of over-spend. We agreed that the incentive rate would be slightly higher, but did not consider this to be problematic.

104. Ofwat expected that, while the price impact of our proposal would depend on our cost assessment for Bristol Water, the impact of dis-applying the menu scheme on Bristol Water's revenues and cash flow would be small.

105. Ofwat said that it would be reviewing the use and operation of menus at PR19 drawing on how well the mechanism has worked and that it would be premature to draw conclusions at this stage about the use of menus in future price control reviews. We can confirm that our assessment of an appropriate approach towards the menu scheme is exclusively an assessment of an appropriate approach for our determination for Bristol Water. There are significant differences between the context for our determination and Ofwat's periodic price control reviews. While we consider that the analysis we have set out in this appendix would be relevant to Ofwat's future consideration of the menu scheme, our decision on the approach for our determination is not intended to constrain the approach that Ofwat may take at future price control reviews.

Submissions from other parties

1. Submissions from other parties about the Ofwat PR14 approach were received from:

   (a) Bristol Water's LEF;

   (b) CCWater;

   (c) DWI;

   (d) Anglian Water;

   (e) Dŵr Cymru Welsh Water;

   (f) South West Water; and

   (g) Wessex Water.

2. Submissions were received in response to our provisional findings from:

   (a) Bristol Water's LEF;

   (b) CCWater;

   (c) South West Water;

   (d) Peter Weeks; and

   (e) Thames Water.

Bristol Water's LEF

3. In its submission to the CMA,[1] the LEF said that it was difficult for it to understand how Bristol Water could deliver the proposed totex investment for significantly less than Bristol Water's estimates. The LEF was concerned that, as a result of Ofwat's investment allowances, Bristol Water's customers would not receive the levels of service and enhancement to their water supply in the period 2015 to 2020 on which they were consulted extensively and found to be acceptable.

[1] LEF submission, p9.

4. The LEF said that it was content with the independent assurance (from Bristol Water's consultants) on Bristol Water's cost estimates and the asset planning methodologies employed, and that the LEF supported the overall package of work and the associated bill impacts.

5. In its response to the CMA's provisional findings,[2] the LEF said it was pleased that the CMA had recognised the importance of the views of customers in relation to the metric associated with negative water quality contacts, but was concerned that the CMA did not appear to have given enough weight to the views of customers in some other areas, in particular:

   (a) the level of maintenance expenditure;

   (b) Cheddar Water Treatment Works (WTW); and

   (c) Cheddar Reservoir Two.

6. On maintenance expenditure, the LEF welcomed the CMA's detailed challenge of the allowance for maintenance, but was concerned that the lower end of the proposed range for maintenance expenditure would appear to pose a risk that current levels of service to customers could deteriorate, which the LEF said would be counter to its expressed views. The LEF was also concerned that some costs may be deferred inappropriately to customers in future periods. The LEF said the CMA should give weight to the evidence of customer views that they do not welcome a trade-off of higher risk from reduced maintenance in return for lower bills, nor would they welcome any shocks in the next AMP arising from the 'sudden' need to catch up with too-long delayed maintenance.

7. On Cheddar WTW, the LEF was concerned that the CMA's provisional findings, involving the use of an uncertainty mechanism during AMP6 to make financial provision for the scheme created delays and uncertainty that was not consistent with the risk based approach to water quality that is for the Company to manage as part of its statutory duties. It also noted that customers' top priority was 'making sure water is always on tap with no interruptions'. It said that Bristol Water's plan, which included this scheme, was acceptable to customers. The LEF believed that there was agreement by all parties that action needed to be taken, and did not believe that excluding the scheme was likely to be in customers' interests.

8. The LEF also noted that provisional findings show the CMA was not persuaded that the case for commencing Cheddar Reservoir Two in AMP6

---

[2] LEF response to our provisional findings.

has been made. It accepted that there was a discussion to be had about the correct time to commence work on this reservoir, and that some delay may be appropriate so that completion is during AMP8. It was concerned that any further delay might expose Bristol Water's customers to an inappropriate level of risk in their supply – something they repeatedly affirmed as a top priority. It considered that a delayed start to the reservoir during AMP6 would be more consistent with customer wishes than a longer deferral.

CCWater

9. CCWater's submission to the CMA said that, in terms of wholesale costs, it sought assurance that the CMA's determination would allow the company to deliver the required outcomes for customers at a cost that reflected an efficient company and represented value for money for consumers. CCWater said that any exceptional costs to be allowed for in Bristol Water's totex must be clearly evidenced to justify why the company had higher input costs or required costs that were higher than comparable costs for other companies.[3]

10. In response to the provisional findings,[4] CCWater said it broadly supported the CMA's overall approach. It said in particular it supported:

    (a) the CMA's challenge to Bristol Water to maintain its network in a cost-effective, efficient way, without reducing service to its customers; and

    (b) the CMA's provisional findings in relation to the performance commitments on interruptions to supply, mean zonal compliance and discoloured water contacts.

11. CCWater said it would like the CMA to give further consideration to the following:

    (a) The CMA's proposal on the cost of capital, which was above what CCWater's consultants advised, and Ofwat concluded, was sufficient to finance water companies given the low risk industry they operate in. CCWater questioned whether the equity beta proposed by the CMA was too high.

    (b) Whether the operation of the Southern Resilience Scheme would be compromised without Rowberrow service reservoir. CCWater noted that in research undertaken by CCWater and by water companies over many years, customers have repeatedly stated that their top priority is a safe

[3] CCWater submission, paragraphs 3.2 & 3.22.
[4] CCWater response to our provisional findings.

and reliable supply of water, and on that basis, together with clear evidence from the company about its customers' views, that it supported the inclusion of the Southern Resilience Scheme within Bristol Water's Business Plan.

DWI

12. DWI noted it had a position on all of the water companies' CCGs in England and Wales. DWI said that Bristol Water submitted six formal proposals for drinking water quality to the Inspectorate and that Bristol Water was to be commended on the quality of the submissions to the DWI, which complied with its PR14 guidance. The DWI was broadly aware of Bristol Water's plans for drinking water quality and was generally supportive of Bristol Water's approach.[5]

13. DWI said it would put legal instruments in place for three schemes (Purton & Littleton Catchment Management, Bristol Water Lead Strategy and Barrow WTW UV irradiation) to make these proposals legally binding programmes of work. It commended for support action to address raw water deterioration at Cheddar WTW, pH correction measures at Cheddar WTW and pH correction measures at Stowey WTW.[6]

Anglian Water

14. Anglian Water provided submissions that it had previously made to Ofwat in June 2014.[7] Anglian Water said that these set out what it considered to be systematic errors in Ofwat's modelling. Anglian Water also disputed Ofwat's approach to triangulation. It said that it was not appropriate to give different econometric models the same weight in the overall assessment when Ofwat's consultants had found that the models used were of differing quality.

15. Anglian Water also criticised Ofwat's approach of not making a separate assessment of RPEs.[8] It did not consider Ofwat's approach of extrapolating the time trend from its econometric models to be appropriate.

16. Anglian Water also commented on the interruptions to supply outcome delivery incentive and had the view that the committed performance level had

[5] DWI submission, pp1-2.
[6] DWI submission, p3.
[7] Anglian Water submission.
[8] RPEs reflect the extent to which the input prices (including wages) that a company faces may grow faster, or slower, than the RPI which is used for the wholesale price control indexation.

been set without reference to the inherent differences in companies' networks which it said inevitably affect performance.

Dŵr Cymru Welsh Water

17. Dŵr Cymru Welsh Water said that overall it found the approach and transparency of PR14 was beneficial to securing the best outcome for its customers. It said there had been some material changes from previous price reviews; arguably the most significant was to the process and methodology for assessing allowed expenditure, in particular the setting of a totex baseline. Dŵr Cymru Welsh Water welcomed the more innovative approach taken which recognised the inherent complexity of modelling heterogeneous companies.[9]

18. Dŵr Cymru Welsh Water said that this approach contrasted with the approach to setting industry-wide performance level targets and ODIs in the autumn of 2014. It said that business plans were constructed after careful consideration of customer preferences and cost and bill impacts of the various options which resulted in a balanced plan submission. Dŵr Cymru Welsh Water said a unilateral change by Ofwat to performance targets at a late stage meant that the outcome was more crude and unsatisfactory than it needed to be.[10]

South West Water

19. South West Water said it would be concerned by a move from the risk-based framework that Ofwat had adopted back to a framework that required the regulator to scrutinise individual companies' plans in detail in a way that was not targeted by a sense of economic value and risk. It said the onus must remain with companies to make the case by understanding the delivery risks from customer and regulatory perspectives rather than the price review process being responsible for achieving this. South West Water said the water industry returning to a performance and comparative measure framework determined *ex ante* by Ofwat was unlikely to be fit for purpose and companies needed to continue to adapt to this.[11]

20. In response to the provisional findings,[12] South West Water noted that Ofwat's use of totex modelling was a specific suggestion from the Gray review and said it was not surprising that Ofwat should in the first instance identify workable totex models. It said that Ofwat had considered other approaches

---

[9] Dŵr Cymru Welsh Water submission, p1.
[10] Dŵr Cymru Welsh Water submission, p1.
[11] South West Water submission, paragraph 33.
[12] South West Water response to our provisional findings.

(for instance bottom-up cost modelling of a stylised network that could then be applied to company circumstances), which may in the future prove to be more workable for sub-elements of the wholesale value chain. It said that it was therefore not surprised that for Bristol Water, simpler 'botex' models and capital enhancement assessments were better for determining the issues associated with this case. South West Water noted that there may be limited read across to the wider challenge that Ofwat faced in assessing the efficiency of company plans where there is a wider variety of opex and capex needs and local factors, with the need for the industry to focus on outcomes.

21. On the cost of capital, South West Water noted that it was broadly unchanged from that identified at PR14, with no material difference overall to the judgement that Ofwat reached and that companies generally accepted. South West Water said that Ofwat should consider cost of capital against the financing duty and use other regulatory tools and mechanisms to consider the specific customer issues. It noted that Pennon paid an RCV premium of 24% for Bournemouth Water's regulated business.

22. South West Water agreed that imposing penalties for upper quartile levels of service risks customers paying for a service level that did not reflect their views. It said that limiting outcome incentive rewards to above an industry upper quartile level was more likely to protect customers' long-term interests than penalties that drive industry performance up to a fixed upper quartile level.

Thames Water

23. In response to the provisional findings,[13] Thames Water said it was important that the CMA was clear in its final determination as to the extent it has analysed and validated Ofwat's price control methodologies across all companies, as opposed to simply adopting parts of the methodology or undertaking analysis specific to Bristol Water. It noted that the CMA had taken a comprehensive approach to assessing Bristol Water's totex allowance (including using top down econometric models and bottom-up assessments of base totex and enhancement expenditure) and said that comments made in the provisional findings about Ofwat's assessment of Thames Water's totex were not underpinned by a similarly comprehensive assessment of costs. It said that operating in densely populated urban areas led to Thames Water having materially higher costs than an equivalent company operating in other urban areas related to street works, slower traffic speeds and restricted storage space. Its view was that these urban area effects were taken into

[13] Thames Water response to the provisional findings.

account through the flexible functional form of Ofwat's econometric models. It said that the CMA should clarify that its review of Bristol Water should not be understood to confer views on the appropriate cost assessment approach and form of totex modelling for other companies.

24. Thames Water said it would be helpful for the CMA to be clear on the extent to which the CMA has reviewed and endorsed (or otherwise) the details of Ofwat's retail price control methodology, and raised concerns with Ofwat's approach to issues such as the changes over time in input prices affecting retail costs, company-specific factors and regional wage differences. It said that many companies were concerned about aspects of the retail price controls and in its submissions to Ofwat it had noted significant concerns about the retail price controls.

25. On performance commitments and outcome delivery incentives, Thames Water said that imposing horizontal benchmarking on all companies was not necessarily in customers' interests, as it could lead to non-economic levels of service that customers are not willing to pay for. It endorsed the CMA's view to encourage Ofwat to take more account of the consumers' views when designing its risk/reward framework.

Peter Weeks

26. Mr Weeks welcomed the provisional findings,[14] noting that the priority for 2015-2020 should be lower water prices for customers. He noted that at a time of historic low interest rates, the Bristol Water suggestion for a weighted cost of capital of 4.37% was too high.

Wessex Water

27. Wessex Water said that[15] it shared Bristol Water's concerns about the appropriateness of the Ofwat cost assessment methodology. While Wessex Water's board had accepted the overall price limits 'in the round', Wessex Water said that, given the shortcomings in Ofwat's modelling approach, its continued use would not be in consumers' interests.

28. Wessex Water said that Ofwat's approach[16] took no account of existing service levels and delivery outcomes – all companies were assumed to deliver a homogenous service level to consumers and the environment.[17] It

---

[14] Peter Weeks response to our provisional findings.
[15] Wessex Water submission, p2.
[16] Wessex Water submission, pp9-10.
[17] It identified variations in companies' performance against the EA's environmental performance that are not taken into account in Ofwat's approach.

also said that Ofwat's approach took limited account of future changes in service levels. It also noted that Ofwat's 'efficiency challenge' had increased since PR09 despite an increase in 'modelling uncertainty'.

29. Wessex Water said that the evidence suggested that the overall totex-based cost assessment approach used by Ofwat rewarded companies that were proposing to spend less rather than those proposing to spend efficiently on the right things. Wessex Water questioned whether Ofwat's approach was in the long-term interests of water consumers. It said that Ofwat's approach meant there was an incentive for companies to avoid proposing cost-beneficial improvements, since companies that avoided additional investment would be subject to less scrutiny; receive a lesser efficiency challenge; were more likely to gain rewards from Ofwat giving the company enhanced status; and would gain a reputation for efficiency.[18]

30. Wessex Water also gave details of discussions with Bristol Water about bulk supply offers made by Wessex Water in 2013 which Wessex Water said could provide Bristol Water with additional annual water resources of 16.9 Ml/d.

[18] Wessex Water submission, paragraphs 36–38.

Ofwat's approach to special cost factors

Introduction

1. This appendix concerns Ofwat's approach to special cost factors, which Ofwat used as a means to mitigate the limitations in the benchmarking models that it used for its cost assessment.

2. We consider that the special cost factor process was an important part of the cost assessment process that Ofwat established for PR14. However, we had two significant concerns, which were:

   (a) risks of asymmetry in the cost assessment process to the detriment of consumers; and

   (b) potential difficulties for companies making effective special cost factor claims.

3. We first describe Ofwat's special cost factor assessment process and then take these two issues in turn, before setting out the implications that we drew for our approach to cost assessment for Bristol Water.

Ofwat's special cost factor process

4. In reviewing submissions from companies on special cost factors, Ofwat first considered whether the submission was supported by substantial evidence and whether it was material. The materiality threshold was 0.5% of the company's business plan totex forecast.

5. Subject to this initial filter, Ofwat made an assessment of the 'implicit allowance' (if any) relating to the company's special cost factor claim. Ofwat's assessment of the implicit allowance is an attempt to estimate what part, if any, of the claim made by the company was already covered by, or allowed for, in the basic cost threshold based on the benchmarking analysis. Ofwat re-ran its materiality test on the value of the claim submitted by the company less Ofwat's assessment of the implicit allowance.

6. Subject to this second materiality test, Ofwat assessed the claim against four criteria, which it described as follows in its final determinations:[1]

   (a) Whether there was persuasive evidence of a need for an adjustment to modelled allowances, as opposed to the claim reflecting no more than business as usual activities for a water company, and whether the programme of work was supported by a clear need case (for instance, a statutory driver or evidence of customer willingness to pay for new outcomes enabled by enhancement investment).

   (b) Whether the claim represented the most cost beneficial solution or (where the decision could not reasonably be guided by cost benefit analysis) the lowest cost option.

   (c) Whether there was persuasive evidence that costs were consistent with upper quartile efficiency.

   (d) Whether adjusting the cost threshold would be consistent with protecting the interests of customers.

7. It seems that point *(d)* went beyond a criterion for accepting a claim and was used to make changes to the price control arrangements for outcomes, as part of Ofwat's adjustment following a special cost factor claim. Ofwat said that where it made a substantial additional allowance it also intervened, where necessary, in outcome delivery incentives to protect customers from the possibility of non-delivery by the company (ie to protect consumers from the risks that the company does not deliver what was intended by the additional allowance under the special cost factor claim).

8. For some claims, Ofwat decided that the criteria under *(b)* and/or *(c)* were not applicable to the assessment of the claim.

9. Ofwat said that following its assessment against its criteria, it did one of the following:[2]

   (a) It accepted a company's claim in full, minus an adjustment for Ofwat's assessment of the implicit allowance, where it had passed a claim against the first three criteria above.

---

[1] Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p27.
[2] Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, pp27–28.

(b) It made a partial adjustment, representing less than the value in *(a)*. Ofwat said that this was typically where it had concerns that the costs proposed by the company did not reflect upper quartile efficiency.

(c) It made no allowance if its assessment failed the claim against one or more of the first three criteria.[3]

10. The main processes described by Ofwat, and summarised above, concerns companies' claims for additions to the calculated basic cost threshold. Ofwat's assessment also included a small number if negative adjustments to the basic cost threshold which had the effect of reducing Ofwat's assessment of the company's expenditure requirements.

Risks of asymmetry in cost assessment process

11. There may be an asymmetry in Ofwat's approach that presents risks that the customers of some companies are not fully protected.

12. The type of benchmarking analysis used by Ofwat cannot be expected to provide an entirely accurate estimate of each company's expenditure requirements. In some cases it will over-estimate costs, and in others it will under-estimate costs. We set out our concerns about Ofwat's benchmarking models in Section 4 of our determination and in Appendix 4.1.

13. Where a company considered that the benchmarking analysis has under-estimated its costs, the company had opportunities to make representations to Ofwat for upward adjustments through the special cost factor process. However, we did not identify an effective process for potential downward adjustments to be assessed in the cases where Ofwat's modelling may have over-estimated a company's costs.

14. The risks from an asymmetric approach seemed particularly high for enhancement expenditure, for which the majority of Ofwat's special cost factor adjustments were made.

15. We did not consider that this issue was fully mitigated by Ofwat's use of an upper quartile efficiency benchmark. The use of such a benchmark would generally lead to lower estimates of each company's efficient levels of totex (before special cost adjustments) than if an industry-average efficiency benchmark were used. But there is no reason why it should compensate for

[3] We note that this statement seems to imply a contradiction. If Ofwat made no allowance at all in every case where a claim failed one or more of the first three criteria, there would be no allowance in all cases that lacked 'persuasive evidence' that the claimed costs were consistent with upper quartile efficiency. But if that was true, Ofwat would not have made the partial adjustments that it refers to.

the possibility that Ofwat's econometric models might significantly overstate expenditure requirements for a specific company.

16. We did not consider that this issue was fully mitigated by Ofwat's approach of 'capping', such that Ofwat's cost allowance for each company was set as the lower of: *(a)* Ofwat's own assessment of the company's total expenditure requirements over the five-year period from 1 April 2015; and *(b)* the company's own (revised) business plan forecasts of its total expenditure, uplifted by 5%.[4] There is no guarantee that companies' business plan forecasts represent an efficient level of expenditure over the five-year period from 1 April 2015. Indeed, it is possible that business plans have a degree of slack in them in anticipation of costs being reduced following review by the regulator. Furthermore, if companies expect Ofwat to adopt such a capping approach, this could provide them with a financial motivation to submit higher forecasts at future price control reviews.

17. In practice, Ofwat made far more upward adjustments for special cost factors than downward adjustments. For the wholesale water price controls, the net adjustments that Ofwat made for special cost factors, expressed as a proportion of the sum of the basic cost threshold and policy additions, varied from –3 to 24%, with an average of 5%.[5]

18. Ofwat made a small number of negative adjustments further to its approach of capping. Ofwat made a negative adjustment for Yorkshire Water's wholesale water service: the adjustment was a 3% reduction to the level of costs from the basic cost threshold and policy additions that Ofwat had calculated for Yorkshire Water. Only two other companies had negative net adjustments for wholesale water activities, both around 1%. The adjustment for Yorkshire Water reflected two separate negative adjustments:

    (a) Ofwat made a negative adjustment of £35 million for Yorkshire Water between draft and final determinations. This reflected a revision to Ofwat's unit cost modelling for enhancement expenditure so that it used Yorkshire Water's updated forecasts from its final water resources management plan rather than forecasts from Yorkshire Water's draft water resources management plan.

    (b) Ofwat made a negative adjustment of £12 million for Yorkshire Water in relation to the area of enhancement expenditure that Ofwat described as

---

[4] Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p38.
[5] CMA analysis of data from: Ofwat (December 2014), Final price control determination notice: policy chapter A3 – wholesale water and wastewater costs and revenues, p26. These figures exclude from the special cost factor allowances the large negative adjustment for Thames Water which resulted not from the special factor process but rather from Ofwat's approach to capping.

unmodelled. Ofwat had identified that its separate analysis of unmodelled enhancement expenditure would provide an allowance to Yorkshire Water of £103 million for these enhancement costs, but Yorkshire Water's own forecast for these costs was £67 million. Ofwat made a downward adjustment of £12 million, rather than an adjustment for the full difference of £36 million, because its separate analysis of unmodelled enhancement expenditure was only given a weight of one third in the triangulation process.

19. Yorkshire Water was the only company for which Ofwat made negative adjustments for wholesale water of more than 1%, and the negative adjustments that Ofwat applied reflect Ofwat making greater use of Yorkshire Water's own forecasts than it had done for its draft determination.

Ofwat's views

20. Ofwat agreed that, in principle, if its basic cost threshold were to over-estimate costs for a particular company, there is no process analogous to the process for special cost factor claims to make a downward adjustment. But Ofwat concluded that in practice there was no evidence that suggested this was a problem at PR14.

21. Ofwat said that in relation to water supply, five out of the 18 companies had business plans forecasts below its cost projections. Ofwat said that Affinity Water and South West Water had particularly strong business plans and a clear focus on efficiency, and once Ofwat has aligned its forecasts of the explanatory variables used for the benchmarking models, their plans were about 5% and 8% below Ofwat's cost threshold. Ofwat considered this to be entirely plausible estimates of efficiency given its view that their business plans were high quality.

22. Ofwat said that Thames Water's business plan forecasts were significantly below the cost threshold and Ofwat subjected its position to detailed forensic assessment. Ofwat said that this revealed evidence suggesting that its modelling may have over-estimated Thames Water's costs because of its particular size and pattern of historical investment. Ofwat said that because these factors did not have a significant impact on the forecast revenues of other companies, it adopted a pragmatic approach of capping the model forecasts of Thames Water rather than revising its modelling.

23. Ofwat said that the other two other companies – Portsmouth Water and Yorkshire Water – both had strong reputations for efficient operation and were no more than 5% below its final determination cost threshold.

Potential difficulties for companies making special cost factor claims

24. The water companies submitted a large number of special cost factor claims to Ofwat, and Ofwat then made a series of adjustments.

25. Nonetheless, it seemed quite possible to us that a company with a good approach to asset management, which had developed good estimates of its efficient expenditure requirements over the five-year price control period, may have struggled to make effective claims for special cost factors even if its modelling substantially under-estimated its costs.

26. We identified several aspects of Ofwat's approach to cost assessment and its special cost factor process that would tend to impede companies' ability to make special cost factor claims, even where warranted.

27. Ofwat focused its benchmarking analysis on comparisons of total expenditure and base expenditure. As a consequence, where Ofwat's models imply that a company ought to spend less than the company had forecast, the models provide little information on which areas of expenditure or which aspects of its approach to asset management are treated as relatively inefficient. In this context, it may be difficult for a company to identify the basis for a special factor claim: the company may be adamant that Ofwat's benchmarking analysis underestimates its expenditure requirements but may be unable to identify the source of the underestimation. In contrast, if Ofwat had carried out more disaggregated benchmarking analysis for different activities and areas of expenditure, this would have identified the areas where the company was seen to be inefficient, which would help the company make relevant special cost factor submissions (or review the relevant parts of its plan to re-examine the potential for cost savings).

28. By its nature, any special cost factor adjustment to the results from benchmarking analysis concerns a difference between a specific company and other companies (or the industry as a whole) that is not adequately captured in the benchmarking. Ofwat's cost adjustment process required companies to explain why they are different or special, compared to other companies in the industry and/or the results from Ofwat's benchmarking analysis. Without access to detailed information on other companies' costs and activities, it may be difficult for a company to identify why, when Ofwat compares its costs to other companies, its costs appears relatively high.

29. Ofwat's adjustments for special cost factors were heavily dependent on Ofwat's assessment of the implicit allowances. We reviewed the way that Ofwat calculated implicit allowances, both for Bristol Water and for some of the other companies' wholesale water activities. We were concerned that

Ofwat's calculation of implicit allowances lacked a logical foundation. This may reflect, in part, the issues in the preceding paragraphs: in short, it may be difficult to estimate the extent to which Ofwat models take effect of a particular aspects of their characteristics or operating environment.

30. One specific issue that we were concerned with was that a company may have relatively high expenditure requirements in the five-year price control period from 1 April 2015 to 31 March 2020, due to the timing of its investment needs and its past profile of investment, but that this would not be captured in Ofwat's benchmarking models. It seemed difficult to deal with such cases well through Ofwat's special cost factor process.

Implications for our approach to cost assessment

31. Ofwat's submissions provided further information on its approach in cases where its cost assessment had produced a higher figure than the company's forecasts. However, we did not find Ofwat's response sufficient to address our concerns that the combination of top-down econometric models and Ofwat's special cost factor adjustments could lead to cost allowances that were too high.

32. Our focus was on the cost assessment for Bristol Water, and we have not sought to examine Ofwat's cost assessment for other companies in any detail. In the case of Bristol Water, we have adopted an approach to cost assessment that provided some further protection against the risks of a cost allowance that is too high, and which also recognises that the special cost factor process used by Ofwat may not have taken full account of Bristol Water's circumstances.

33. Our cost assessment work has included a review of aspects of Bristol Water's business plan expenditure forecasts. This helped to inform our assessment of whether an appropriate allowance would be made for Bristol Water's needs and circumstances. This also allowed us to better understand the risk that the outcome of benchmarking analysis for Bristol Water, plus special cost factors, would tend to overstate Bristol Water's expenditure requirements.

34. For enhancement expenditure, we were particularly concerned about the scale of special cost factors and the risks of asymmetry if applied as a series of upward adjustment to the results from benchmarking analysis. We decided that, overall, it was better to take enhancement expenditure separately and start with Bristol Water's business plan forecasts.

35. We have not automatically accepted any of the special cost factors that Ofwat allowed for Bristol Water as part of its final determinations. We also considered the case for possible negative special cost factor adjustments for Bristol Water.

Review of Ofwat's top-down econometric models

Introduction

1. This appendix provides our review of Ofwat's top-down econometric models. It is structured as follows:

   (a) We describe Ofwat's top-down econometric benchmarking models (paragraphs 2 to 45).

   (b) We present the estimated coefficients from the econometric benchmarking models that formed part of Ofwat's triangulation process (paragraphs 46 to 55).

   (c) We provide analysis of the relationships between expenditure and the cost drivers, in the light of concerns raised in Bristol Water's submissions to us (paragraphs 56 to 116).

   (d) We provide a review of a number of other issues with Ofwat's econometric models (paragraphs 117 to 223).

The econometric models used by Ofwat

2. The econometric models that Ofwat used for its PR14 cost assessment were developed using input from Ofwat's consultants, CEPA. The model selection process, and the detailed specification of the final set of models, were described in two reports produced by CEPA and published by Ofwat.[1] In our description below, we refer to CEPA's approach and CEPA's views in places as our review is based on the information in CEPA's published report. However, we recognised that the model development process also involved input from Ofwat and that the final decisions on model selection were made by Ofwat.

3. CEPA recognised that, given the data limitations and different estimation techniques available, there was not a single model (nor a single estimation procedure) that reflected accurately all companies' characteristics and their impact on costs. CEPA therefore considered a range of different models.

[1] CEPA cost assessment – advanced econometric model, March 2014 and CEPA Cost assessment, January 2013.

4. CEPA used evaluation criteria to select a shortlist of five models that it recommended to Ofwat. Ofwat decided to use these five models for its PR14 cost assessment.

5. CEPA's model development process considered models that varied in a number of dimensions:

   (a) The specification of the dependent variable in the model and, in particular, whether this focused on base expenditure (which Ofwat referred to as 'botex') or included base expenditure and enhancement expenditure (totex).

   (b) Whether the model employed a Cobb-Douglas or translog functional form.

   (c) The explanatory variables included in the model and in particular whether the model should include, as explanatory variables, all the theoretical cost drivers identified by CEPA or whether it should be a refined model that only includes a subset of those cost drivers.

   (d) The econometric estimation technique used (eg whether to estimate the model using the OLS technique, a panel data random effects approach or to use a form of stochastic frontier analysis).

6. We provide an overview of the model development below. We first describe the data source used. We then take each of the four elements of model design and estimation listed above and summarise CEPA's approach. Finally, we summarise the selection process that CEPA used.

7. CEPA's final model selection reflected its view that there was not a single correct model to use. CEPA and Ofwat used the term 'triangulation' to refer to the process and calculations used to weight and combine results from different models and other forms of benchmarking analysis to make an overall assessment for each company. CEPA developed an approach to triangulation that Ofwat subsequently used. This combined the output of the five econometric models recommended by CEPA with results from other cost modelling work that Ofwat developed for enhancement expenditure.

The data set used by CEPA

8. CEPA used a panel data set that had a sample size of 90 observations, which comprised:

   (a) 18 water companies in England and Wales, including Bristol Water; and

   (b) five years of data spanning the period 2008/09 to 2012/13.

9. The data set consisted of measures of costs and data on each of the explanatory variables used in the models, for each company and each year in the sample period.

10. The sample included all the water companies regulated by Ofwat, apart from a few small water companies that were subject to a different type of economic regulation.

11. The sample of companies included both WoCs and WaSCs. The cost data used for the models concerned the costs reported for (or allocated to) wholesale water activities only.

The dependent variable: totex models versus base expenditure model

12. One of the initial choices in specifying an econometric model is the choice of the dependent variable. What is it that we want to compare across companies and explain, in part, by the various explanatory variables in the model?

13. CEPA considered models that used two alternative expenditure measures for the dependent variable, which were:

    (a) measures of 'totex'; and

    (b) measures of 'base expenditure'.

14. The totex (or total expenditure) measure captured most of the expenditure of the wholesale water service, but excluded some specific items of spend that Ofwat did not want to include in its benchmarking analysis (eg business rates and pension deficit repair contributions).

15. The base expenditure measure is the part of the totex measure that excludes capex allocated to enhancement projects (eg projects that add to the capacity of the system or achieve quality of service improvements).

16. In each case, the dependent variable in the models was the natural logarithm of the expenditure measure used.

17. The measure of totex for a given year was the sum of opex in that year and a measure of the average capex over the previous five years. CEPA used this approach in order to smooth the 'lumpy' pattern of observed capex (ie to reduce fluctuations in the capex measure across time). Similarly, the base expenditure measure was the sum of opex plus the average base capex in the last five years.

18. Ofwat carried out separate analysis of enhancement expenditure which it combined with the results from the base expenditure models as part of its approach to triangulation (see Appendix 2.3).

Cobb-Douglas versus translog models

19. CEPA's decisions on model specification placed emphasis on a choice between two types of models, which it referred to as 'Cobb-Douglas' models and 'translog' models.

20. The type of model that CEPA referred to as Cobb-Douglas is a relatively straightforward type of model specification in which the dependent variable of expenditure is expressed in logs (using the natural logarithm) and all explanatory variables are also in logs.

21. CEPA described the Cobb-Douglas model as 'a standard functional form used in cost assessment literature', under which estimated coefficients can be interpreted as the elasticity of cost with respect to the corresponding cost driver.[2] An interpretation of this type of model is that a 1% increase in a cost driver included in the model (eg total length of water mains) would imply an X% increase in expenditure, where X is to be estimated from the model.

22. CEPA described the translog model as follows:[3]

> The translog model is one of the so-called flexible functional forms and is used routinely in the academic literature. In the current context one of its particular advantages is that it allows the degree of returns to scale to vary with firm size. The Cobb-Douglas is nested within the translog so it is possible to test the Cobb-Douglas restriction.

23. CEPA treated the translog model as an extension of the Cobb-Douglas model which allowed for varying economies of scale across companies by introducing interactions and quadratic terms for the explanatory variables.[4]

24. CEPA considered that the translog model allowed for more flexibility as it introduced the possibility of substitution between inputs (through the interaction terms) and for economies of scale (through the square terms).

---

[2] CEPA (March 2014), Cost assessment – advanced econometric model, p7.
[3] CEPA (March 2014), Cost assessment – advanced econometric model, page iv.
[4] To provide an example of the translog approach, a possible simple cost function would be one that says that cost (C) is a function of two inputs A and B. The Cobb-Douglas form that CEPA considered would involve a model specification as follows (where the β terms are coefficients to be estimated by the model and 'ln' denotes the natural logarithm): ln(C) = constant + β1*ln(A) + β2*ln(A). The corresponding model specification for the translog model would be: ln(C) = constant + β1*ln(A) + β2*ln(A) + β3*ln(A)2 + β4*ln(A)*ln(B) + β5*ln(B).

However, the translog model required the estimation of more parameters and the interaction and quadratic terms are more difficult to interpret.

25. The specific implementation of the translog model used by CEPA did not fully implement the standard translog cost function from economic theory. For example, the interaction and square terms applied were only applied to a small subset of the identified cost drivers. In this section, we use the term 'translog' to refer to this aspect of model specification used by CEPA and Ofwat but recognised that this may differ from other translog models.

Choice of explanatory variables: full model versus refined model

26. CEPA said that the first step in its model selection process was to identify the 'theoretical cost drivers', which it incorporated as explanatory variables in its models.[5]

27. Table 1 below shows explanatory variables that CEPA considered in its modelling. The table also indicates whether these explanatory variables featured in the final models that CEPA recommended to Ofwat, which it described as the 'full' model and the 'refined' models (Ofwat ultimately used several different refined models but the set of explanatory variables was the same in each of these). In the table, the first column briefly describes the explanatory variable and the second column provides the short-form names that CEPA gave to the explanatory variable, where this is significantly different or not self-explanatory.

28. CEPA implemented the translog function using the square and cross-product terms of a small subset of the cost drivers it had identified: ln(length of mains), ln(number of properties divided by length of mains) and ln(water delivered per customer). This explains the terms such as 'Length^2' and 'Length * density' in the table. CEPA's initial set of models also included models that excluded these translog elements.

29. CEPA reported that its full totex model for water included all the variables considered to be theoretical drivers of costs, with the exception of the variable for the regional construction price index, which it considered to be correlated with the regional wage measure.[6] CEPA reported that the refined model specification included only the variables which it found to be statistically significant or were important cost drivers from a theoretical perspective.[7]

[5] CEPA (March 2014), Cost assessment – advanced econometric model, page vii.
[6] CEPA (March 2014), Cost assessment – advanced econometric model, p33.
[7] CEPA (March 2014), Cost assessment – advanced econometric model, page viii.

Table 1: Explanatory variables used by CEPA

Summary of explanatory variable	*Short name*	*Inclusion in full model*	*Inclusion in refined model*
Constant term		✓	✓
Ln (total length of mains)	Length	✓	✓
Ln (number of connected properties / length of main)	Density	✓	✓
Ln (potable water delivered / number of connected properties)	Usage	✓	
[Ln (total length of mains (km)] ^ 2	Length^2	✓	✓
[Ln (number of connected properties / length of main (properties/km)] ^ 2	Density^2	✓	✓
[Ln (potable water delivered / number of connected properties (Ml/d per property)] ^ 2	Usage^2	✓	
Ln (total length of mains) * Ln (number of connected properties / length of main)	Length * density	✓	✓
Ln (total length of mains) * Ln (potable water delivered / number of connected properties)	Length * usage	✓	
Ln (number of connected properties / length of main) *Ln (potable water delivered / number of connected properties)	Density * usage	✓	
Time trend		✓	✓
Ln (average regional wage measure)		✓	✓
Ln (regional construction price index)			
Ln (population supplied / number of connected properties)	Population density	✓	✓
Ln (proportion of properties that are metered)		✓	
Ln (total number of sources / total water input to distribution system)		✓	
Ln (average pumping head * total water input to distribution system)		✓	
Ln (proportion of water input from river abstractions)		✓	✓
Ln (proportion of water input from reservoirs)		✓	✓
Ln (number of new meters installed in year as a proportion of metered customers)		✓	
Ln (length of new mains laid in year / total length of mains at year end)		✓	
Ln (length of mains relined and renewed / total length of mains at year end)		✓	
Ln (number of properties below reference pressure level/total properties connected)		✓	
Ln (volume of leakage / total water input to distribution system)		✓	
Ln (number of properties affected by unplanned interruptions > 3 hrs / total properties connected)		✓	
Ln (number of properties affected by planned interruptions > 3 hrs / total properties connected)		✓	
Ln (potable water delivered to billed metered households / total potable water delivered)		✓	
Ln (potable water delivered to billed metered non-households / total potable water delivered)		✓	

Source: CMA analysis of CEPA (March 2014), *Cost assessment – advanced econometric model*.

Estimation technique and specification of the error term

30. Having specified the dependent variable, functional form and explanatory variables, CEPA faced some further decisions on model specification and estimation.

31. CEPA used two different approaches:

(a) The pooled OLS estimation technique (CEPA used the term 'corrected OLS',[8] or COLS).

(b) A random effects model, which it estimated through the generalised least squares technique (GLS).

32. As an approximate explanation, the OLS technique is based on the idea of a line of best fit across the data in the sample. Unlike a best fit line drawn in two dimensions on a piece of paper, which may capture a relationship between two variables, the OLS technique can construct a line of best fit but in multiple dimensions (the estimated regression line) which can capture a relationship between more than two variables. In more technical terms, the OLS technique produces a set of estimated coefficients (one for each explanatory variable in the model) that, taken together, are calculated so as to minimise the square of the distance between each data point in the data set and the corresponding point on the estimated regression line. The smaller those differences are, the better the estimated model fits the data.

33. Applying pooled OLS to the data set treated all 90 observations in the same way, as if they were independent observations (ie no explicit account is taken of the fact that there were five observations from each company, which may have correlations between them over time).

34. The GLS (random effects) approach involved a more complex model specification and estimation process than OLS. Under this approach, the estimation is made under the assumption that there were additional factors (random effects) that affected or explained each company's costs in each year of the time period which were not captured by the explanatory variables in the model. These additional factors were assumed to have the same impact on the company's costs in each of the five years of the data period (ie they were time-invariant). Furthermore, these factors were assumed to be distributed across companies according to a normal probability distribution. CEPA and Ofwat treated the estimated random effect for each company as part of the overall residual for each company and attributed it to potential relative efficiency differences between companies rather than company-specific cost drivers. Because CEPA treated the time-invariant random effects as part of relative efficiency, CEPA preferred to use a short data period (five

[8] This is essentially OLS as far as model specification and estimation is concerned, but with an adjustment to the predicted level of expenditure derived from the model to apply what Ofwat treated as an upper quartile efficiency adjustment.

years) instead of a longer panel (eg ten years) for the GLS (random effects) approach.

35. CEPA also discussed the use of a fixed-effects estimation technique. Under this approach, there would be a company-specific explanatory variable (or fixed effect) for all but one company. Compared with the random effects approach, the fixed-effects approach involves no assumption that the company-specific effects were distributed across companies according to a normal probability distribution. Instead, the company-specific effect was a separate estimated coefficient for each company.

36. CEPA said that the true distinction between fixed and random effects was whether the effects were correlated with the other explanatory variable or not and that in the case of random effects the effects were assumed to be uncorrelated with the explanatory variable, whereas in fixed effects the effects were permitted to be correlated with the explanatory variable.[9]

37. CEPA preferred the random effects approach to the fixed effects approach. CEPA reported that it used the Hausman test to choose between GLS (random effects) and fixed effects models. CEPA considered that results from the Hausman test indicated that the assumption of the random effects model, that there is no correlation between the random effect and the explanatory variables in the model, was reasonable.[10]

38. None of the OLS, random effects or fixed effects model specifications produced results that decomposed the estimated residuals from the model between efficiency and 'noise' (eg modelling or measurement error).

39. An alternative approach that purports to decompose the estimated residuals from the model between efficiency and noise is stochastic frontier analysis (SFA). CEPA considered several different SFA approaches as candidates for its model estimation, but decided against these. CEPA considered that its OLS and GLS (random effects) models produced more stable and robust results than the SFA models it tried; it also found that some of the SFA models were not possible to estimate for technical reasons.[11] Furthermore, CEPA was concerned about the ability of the SFA models to reliably achieve what they were purported to do: split the error term between efficiency and noise. CEPA considered the theoretical assumptions about the probability distribution of inefficiency and noise, on which the SFA models rested, and stated that these assumptions may be considered arbitrary.[12] CEPA preferred

[9] CEPA (March 2014), Cost assessment – advanced econometric model, page iii.
[10] CEPA (March 2014), Cost assessment – advanced econometric model, p24.
[11] CEPA (March 2014), Cost assessment – advanced econometric model, pp10–11.
[12] CEPA (March 2014), Cost assessment – advanced econometric model, p102.

alternative approaches (ie OLS and GLS random effects) which did not rely on those assumptions.

CEPA's model selection process

40. CEPA applied a model selection process to identify preferred models from its initial long list. CEPA reported that it used five evaluation criteria, which were:

    (a) theoretical correctness;

    (b) statistical performance;

    (c) practical implementation issues;

    (d) robustness testing; and

    (e) regulatory best practice.

41. Having obtained an initial long list of ten models, CEPA applied a 'traffic light' approach to evaluate these ten models, in light of both model specification and estimation results. Under this approach, green indicated a good model; amber a model that was acceptable but with a few issues; and red a model that CEPA considered flawed. CEPA applied its traffic light approach to three of its evaluation criteria: theoretical correctness, statistical performance, and robustness checks.

42. CEPA attended first to both the statistical performance and the robustness checks. In each case where these criteria were met (at least amber or green) CEPA looked at the theoretical correctness. When one of the ten candidate models received a red (only for statistical performance or robustness check) it was not taken further. The table below summarises aspects of the traffic light approach that CEPA applied to the ten models.

Table 2: Summary of CEPA's traffic light model selection approach

	Theoretical correctness	*Statistical performance*	*Robustness check*
RED	N/A	The estimated coefficients for the subset of explanatory variables that CEPA considered 'core' were substantially outside CEPA's ex ante expectations.	Overall range of efficiency scores and predictions is not plausible. Pooling tests suggest significant and material differences in coefficients for key variables in different time periods.
AMBER/ GREEN	1. CEPA prefer translog over CD functional form (based on theory and statistical analysis). 2. Are all core theoretical drivers included? If not, given amber.	1. Coefficient estimates largely in line with CEPA's expectations and elasticities relatively sensible. If not, given amber. 2. How refined is the model? (Statistically significant parameter estimates while including as much of the value chain drivers as possible.) Is N-K >5 for RE? The most refined models given green. 3. Statistical results: goodness of fit/statistical preference for GLS random effect over fixed effects. If fixed effects preferred, given amber.	1. Sensitivity to dropping observations/ variables. If efficiency scores or predictions are sensitive, given amber. 2. Are model rankings outliers with respect to other CEPA models at same level of expenditure and value chain disaggregation? If so, given amber.

Source: CMA analysis of CEPA Cost assessment – advanced econometric model, March 2014.

43. Of the ten estimated models, CEPA recommended five models to Ofwat. CEPA grouped these into three categories:

(a) One full totex model (model WM3) with all candidate explanatory variables included except the BCIS variable.

(b) Two 'refined' totex models (model WM5 and model WM6) for which some of the variables from the full totex model were dropped. These two models were the same except one is pooled OLS and the other GLS random effects.

(c) Two refined base expenditure models (model WM9 and model WM10). These two models were the same except one is pooled OLS and the other GLS random effects.

44. CEPA described its refined models as including only the explanatory variables which it found to be statistically significant or were important cost drivers from a theoretical perspective.[13]

45. These five models were used as part of Ofwat's overall cost assessment for its final determinations.

[13] CEPA (March 2014), Cost assessment – advanced econometric model, page viii.

Estimated coefficients from Ofwat's econometric models

46. This section sets out and briefly comments on the estimated coefficients from Ofwat's econometric models. These are the general results from the models that are applied to all companies.

47. CEPA estimated the coefficients for the explanatory variables in each of its five selected models, using its historical data set spanning five years.

48. In its published report, CEPA reported estimated coefficients for models that used 'normalised' versions of the explanatory variables for the various translog terms of these models. It applied normalisation to its three scale variables (total length of mains, density and usage) and, in turn, the explanatory variables based on these terms. The normalised variables were calculated by dividing the variable by its sample mean. CEPA considered that the normalisation process made it easier to understand the magnitude of the implied effect of each explanatory variable on estimated expenditure. For example, CEPA used the normalised results to examine whether the estimated coefficients were in line with its initial hypotheses. CEPA said that for the explanatory variables other than the translog terms, the estimated coefficients should be the same for the normalised and non-normalised versions.[14]

49. Table 3 presents the estimated coefficients for the five models, estimated for the normalised explanatory variables. The list of explanatory variables in the first column of the table uses CEPA's short-form variable names (see Table 2 above). Ofwat told us that the standard errors that were used for the measures of statistical significance of estimate coefficients, which are indicated in Table 3, were estimated using the cluster robust approach to estimation of the standard errors in the case of the OLS models and that unadjusted standard errors were used for the GLS random effects models.

[14] CEPA (March 2014), Cost assessment – advanced econometric model, p110.

Table 3: Estimation results: estimation results of models WM3, WM5, WM6, WM9 and WM10

Model	*WM3: translog; OLS*	*WM5: translog; OLS*	*WM6: translog; GLS (RE)*	*WM9: translog; OLS*	*WM10: translog; GLS (RE)*
	Full totex	Refined totex	Refined totex	Refined base expenditure	Refined base expenditure
Dependent variable	Log totex	Log totex	Log totex	Log base expenditure	Log base expenditure
Independent variables	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Constant	–0.96128	2.88752*	2.51229†	2.9165	1.71338*
Length of mains	0.90456‡	1.07182‡	1.07838‡	1.03714‡	1.03225‡
Density	–0.27601	0.21036	0.28066	0.27499	0.40509†
Usage	–0.03222	-	-	-	-
Length^2	–0.03077	–0.02259	–0.01917	0.01439	0.01912
Density^2	1.15405‡	1.06674†	0.94174*	0.23994	0.35379
Usage^2	–0.24695	-	-	-	-
Length x Density	0.64729‡	0.51222‡	0.55717‡	0.35875*	0.44863‡
Length x Usage	-0.00603	-	-	-	-
Density x Usage	-0.06318	-	-	-	-
Time trend	0.01193	–0.00675	–0.00319	-0.00077	0.00941*
Average regional wage	1.49168‡	0.71957	0.95771‡	0.28008	0.90116‡
Population density	–0.56056	0.98924	0.49497	2.03158†	1.05336†
Proportion of metered properties	–0.77579	-	-	-	-
Sources	–.29272‡	-	-	-	-
Pumping head	0.12203	-	-	-	-
Proportion of water input from river abstractions	0.00224	0.02014‡	0.01182	0.00477	0.00388
Proportion of water input from reservoirs	–0.01501	–0.01397	–0.01229	–0.00654	0.00214
Proportion of new meters	0.02846	-	-	-	-
Proportion of new mains	–0.03075†	-	-	-	-
Proportion of mains restored/renovated	0.02901†	0.06502‡	0.05565‡	0.05994†	0.03764‡
Properties below reference pressure level	0.00295	-	-	-	-
Leakage volume	–0.20009	-	-	-	-
Properties affected by unplanned interruptions > 3 hrs	0.008	-	-	-	-
Properties affected by planned interruptions > 3 hrs	0.02661	-	-	-	-
Proportion of usage by metered household properties	0.5006	-	-	-	-
Proportion of usage by metered non-household properties	–0.17073	-	-	-	-
Adjusted R2	0.9955	0.9894	0.9886	0.9878	0.9856
N	90	90	90	90	90

Source: CEPA (March 2014), Cost assessment – advanced econometric model.
*Statistical significance at 10% level.
†Statistical significance at 5% level.
‡Statistical significance at 1% level.

50. The estimated coefficients can be interpreted as elasticities. A 1% increase in the explanatory variable would imply a percentage change in costs given by the estimated coefficient. For instance, a change on the length of mains by 1% would imply that totex in model WM3 increased by 0.905%, whereas in model WM6 the 1% increase would lead to a 1.0784% increase in totex.

51. The explanatory variables that, across all five models, CEPA found to be both statistically significant and to have a relatively large coefficient, are the length of mains and length * density variable. This suggested that, in these models at least, the effects of mains network size and the number of connected properties are very important in determining total estimated expenditure.

52. A number of other explanatory variables that were common across the five models showed significant variation in the magnitude of the estimated coefficients and sometimes even changes in sign between models (for example, see the results for population density).

53. Many of the estimated coefficients for the explanatory variables were not consistent with what CEPA had expected from a theoretical or economic perspective. For example, in
the full totex model WM3: *(a)* the estimated coefficient on usage (defined as average potable water delivered per connected property) was negative and not significant; and *(b)* the estimated coefficient on the proportion of new mains laid in the year was found to be statistically significant but to be negative rather than positive.

54. The impact of some of the other explanatory variables is difficult to interpret from the estimated coefficients. This is the case for the translog terms (eg 'length * usage').

55. We consider the results implied by Ofwat's models in more detail in the next section.

Analysis of cost relationships implied by Ofwat's models

56. Bristol Water argued that some of the estimated cost relationships implied by Ofwat's models were unexpected and contrary to engineering judgment. In addition, our own review further model of Ofwat's approach to model specification identified risks that the estimated coefficients from Ofwat's models may be spurious, because of the large number of explanatory variables relative to the sample size (see paragraphs 195 to 207).

57. In the first part of this section, we highlight the counter-intuitive results for estimated coefficients that Bristol Water identified in its SoC and Ofwat's response to these issues. We also identify some further results that are unexpected in terms of the estimated coefficients.

58. In the remainder of the section, we provide our own analysis of the relationships implied between costs and the explanatory variables in Ofwat's refined base expenditure model (OLS version). This analysis involves estimates of the level of expenditure that this model would imply for a hypothetical industry average company, which we use as a reference point to examine how changes in explanatory variables (or changes across several factors) affect estimated expenditure. This provides further insight on the cost relationships implied by Ofwat's models.

Counter-intuitive results for estimated coefficients

59. Bristol Water identified several cases where the estimated results from Ofwat's models seem counter-intuitive. These are cases where the relationship between costs and an explanatory variable go in the opposite way to what it would have expected. Bristol Water provided several examples of what it considered to be the unexpected cost relations from Ofwat's models:[15]

    (a) Each additional property would lead to predicted costs being £50 per year lower.

    (b) Each additional megalitre of water supplied to customers would result in predicted costs being £83 lower.

    (c) Each additional customer being metered would result in predicted costs being lower by £62 per year.

60. Bristol Water said that the specific translog model structure used in Ofwat's models introduced modelling errors that applied to Bristol Water but not necessarily to the majority of other companies. It said that this was because the complexities of the translog structure, combined with the estimated coefficients, meant that the overall relationship between costs and the explanatory variables varied between companies. Bristol Water said that some estimated coefficients had the wrong sign for Bristol Water, but not all companies, which contributed to its costs being underestimated.[16]

61. Ofwat told us that Bristol Water's view that the translog coefficients had the wrong sign for Bristol Water but not for other companies was not fully correct. Ofwat said that Bristol Water benefited from the translog model as it had an elasticity of costs with respect to length of mains greater than one in all models and also a positive elasticity of usage in the full model.

62. We identified some further issues beyond those highlighted by Bristol Water. One example of particular significance is the regional wage measure.

63. Ofwat's full totex model (WM3) includes the logarithm of the regional wage measure as an explanatory variable. The estimated coefficient is around 1.5. The economic interpretation of this is that a 1% difference in the regional wage rate between two companies would lead to a 1.5% difference in costs. Our starting point would be an expectation that the coefficient would be less than one. This is because wages are only part of a company's costs, and we

[15] Bristol Water SoC, paragraph 1475.
[16] Bristol Water SoC, pp396–403.

would expect other significant costs (eg materials costs) to vary less (if at all) between regions than wages. Similarly CEPA reported an expectation that this coefficient would be 'relatively high and positive, circa 0.6-0.7, but below 1.0'.[17]

64. It is possible that there is an economic explanation for this aspect of the results from Ofwat's full totex model (eg perhaps there is more acute variation between regions in the wages/salaries of water company employees than there is variation in the wider categories of occupations covered by the regional wage measure used in Ofwat's models). But it is also possible that the results reflect other correlations in the data and therefore do not provide a reliable estimate of the extent to which differences in wage rates between regions lead to differences in companies' expenditure requirements.

65. We note that the estimated coefficient for regional wages varied substantially across Ofwat's models, which mitigates the effect from WM3, but it also serves to highlight the potential inaccuracy in these types of models.

66. In its response to Bristol Water's SoC, Ofwat said that it was important to focus on 'overall model performance and robustness' and highlighted a number of arguments, in particular the following:[18]

    (a) Ofwat argued that an 'un-intuitive' sign of a single coefficient estimate need not undermine the credibility of a model's prediction. Ofwat said that its estimates were based on the OLS and random effects estimators, both of which were unbiased and consistent under certain conditions (notably, that the errors were uncorrelated with the explanatory variables). Ofwat identified that multi-collinearity between two explanatory variables may harm the accuracy of estimated coefficients for these factors but that jointly these factors would remain unbiased.

    (b) Ofwat said that the accuracy of a model depended on the collective set of estimated coefficients across the full set of explanatory variables in the model. Ofwat argued that, in its view, it was not particularly insightful to argue that an increase in a single variable was forecasted to reduce costs because this was not how Ofwat used these models in forecasting – Ofwat moved all the variables together.

[17] Bristol Water SoC, p20.
[18] Ofwat response, pp58–59.

67. CEPA had made similar arguments in its explanation of multi-collinearity:[19]

> An exact linear relationship between two or more explanatory variables characterises the extreme case of perfect collinearity (approximate linear relationships between variables are more common in practice). In the former case (perfect collinearity) the OLS procedure cannot be implemented. The latter case (approximate linear relationships) results in high standard errors. Whilst the parameter estimates and estimates of the standard errors are not biased as such, the problem is that it will be hard to draw conclusions on the impact of individual variables on the dependent variable. The overall predictive power of the model is not reduced (only the ability to use the coefficients individually).

68. Similarly, CEPA stated that:[20] 'The unexpected results for statistical significance and size/signs of the parameters may be due to multi-collinearity, which would not pose issues for the overall predictive power of the model.'

69. Ofwat's references to statistical concepts of 'unbiased' and 'consistent' estimators did not address the concern that we had with the models and their use to estimate companies' expenditure requirements. It is not sufficient that an estimator has the statistical property of being unbiased 'under certain assumptions', particularly where estimated coefficients have high estimated standard errors, are sensitive to model specification or imply surprising results. Furthermore, the concept of consistency in an estimate is that, as the sample size tends to infinity, the probability of the estimate being accurate converges to one. CEPA's sample size is 90 and therefore the asymptotic properties of estimators seem to be of limited relevance.

70. Ofwat identified multi-collinearity between its explanatory variables as a possible reason for the unexpected estimates for specific coefficients (though it is not the only reason). We note it is possible that, where inaccuracy in estimated coefficients stems from correlations between them, the inaccuracy in the overall model prediction may be lower than the inaccuracy suggested by looking at any coefficient in isolation (the effects may offset each other to some degree). Nonetheless, any inaccuracy in estimated coefficients that arises from multi-collinearity between explanatory variables may still be a material problem. The estimated expenditure requirements for any particular company could be distorted by counter-intuitive estimated coefficients that are affected by multi-collinearity.

---

[19] Ofwat response, page ii.
[20] Ofwat response, p33.

71. We did not accept Ofwat's argument that it was not particularly insightful to look at the increase in costs arising from a single variable because this was not how Ofwat used these models in forecasting. We did not consider that this argument could address the concern that the expenditure estimate for any particular company was adversely affected by counter-intuitive estimated coefficients that are affected by multi-collinearity. Furthermore, Ofwat's approach did not move all the variables together as Ofwat had suggested. Ofwat's estimated expenditure requirements for each company are based on a series of forecast explanatory variables for that company. The forecasted explanatory variables are not the same as those from the historical data set and the overall correlations across Ofwat's data set will not be the same as the correlations between explanatory variables for any one company.

72. It was not clear what CEPA meant by the 'overall predictive power of the model'. However, we would disagree with the proposition that multi-collinearity does not raise concerns about the accuracy of predictions of the expenditure of any single company – or for the accuracy of Ofwat's cost assessment.

73. We note that CEPA had identified that its results differed from what it had expected, in terms of both the sign (positive or negative) and magnitude of many of the estimated coefficients.

Further analysis of Ofwat's refined base expenditure OLS model

74. In the remainder of this section, we examine the results from Ofwat's modelling in more detail.

75. For this further analysis, we focused on Ofwat's refined base expenditure modelling. The refined base expenditure models seem the most important element of Ofwat's three econometric modelling workstreams in terms of their impact on Ofwat's overall cost assessment for Bristol Water. This is because: *(a)* Ofwat effectively disregarded the results from the refined totex models in the case of Bristol Water; and *(b)* Ofwat's review and interpretation of the results from its full totex model for Bristol Water was dependent on the results it had obtained for Bristol Water from the refined base expenditure model (which Ofwat used to split the results from the full totex model between base and enhancements).

76. For Bristol Water, the differences in Ofwat's model results between pooled OLS and GLS (random effects) are relatively small and we focused our analysis on the refined OLS model. However, we recognise that the analysis below may not be representative of the results for the random effects version of the refined base expenditure model.

77. One way to seek to examine and interpret the results from Ofwat's econometric models is to assess whether the estimated coefficients from these models seem reasonable from an engineering and economic perspective.

78. If both the dependent variable and a cost driver are expressed as a natural logarithm, a 1% increase in the cost driver (holding all other explanatory variables constant) would imply a percentage change in expenditure given by the estimated coefficient for that cost driver.

79. We identified issues in using such an approach to review the estimated coefficients for each of the explanatory variables in the models used by Ofwat. The coefficient on an explanatory variable might be interpreted as an indication of the effect on expenditure of a change in that explanatory variable, holding all other explanatory variables constant. However, the translog functional form used in Ofwat's models makes it difficult to interpret the coefficients on some explanatory variables in this way, because there are relationships between them. It is not possible to consider the impact of one explanatory variable whilst holding other explanatory variables constant if these are mathematically linked to each other.

80. For example, we might be interested in what the model implies for the relationship between mains length and expenditure. However, this is complicated because mains length features in several different explanatory variables (eg the explanatory variables in the refined base expenditure models include: *(a)* the natural logarithm of mains length; *(b)* the square of the natural logarithm of mains length; and *(c)* the product of: (i) the natural logarithm of mains length; and (ii) the natural logarithm of the number of customers divided by mains length).

81. In addition, since the dependent variable in Ofwat's models is the natural logarithm of expenditure, the estimated coefficients for the explanatory variables are estimates of the proportionate effect of each explanatory variable on expenditure. This in itself creates interdependencies between explanatory variables as the effect in £ million of a given change in one explanatory variable will depend on the other explanatory variables.

82. We identified an alternative approach. We defined a hypothetical average water company as a point of comparison. This is a hypothetical company that has characteristics and outputs which are the simple averages across the companies in our data sample. More specifically, we took each of the explanatory variables used in our econometric models and calculated the average value over the 18 companies over the five-year period from 2008/09

to 2012/13. Table 4 shows the assumed characteristics for our hypothetical average company.

83. We were then in a position to examine the relationships between expenditure and the explanatory variables implied by Ofwat's refined OLS model by examining the effect on the estimated annual expenditure requirements of varying specific characteristics of the hypothetical average company, whilst holding others constant.

Table 4: Specification of hypothetical average company

Explanatory variable or characteristic	*Hypothetical average company*
Total number of connected properties (million)	1.38
Total mains length (km)	18,870
Total connected properties divided by total mains length (persons per km)	73
Average consumption per property (m^3/year)	176
Population supplied in winter (million persons)	3.08
Total population supplied divided by total connected property	2.24
Regional wage measure (2012/2013)	16.3
Average pumping head (m.hd)	135
Distribution input (average across year) (Ml/day)	804
Proportion of distribution input from rivers	37%
Proportion of distribution input from reservoirs	22%
Proportion of distribution input from boreholes	41%
Mains length relined or renewed (km)	108
Mains length relined or renewed as proportion total mains length	0.57%

Source: CMA analysis.

84. By combining the assumed features of the hypothetical average company with the estimated coefficients from Ofwat's refined base expenditure OLS model (WM9) we obtained an estimated base expenditure for the hypothetical company in 2015/16 of £156.5 million or £109 per connected property.

85. The figure of £109 is an estimate for an averagely efficient hypothetical average company. If we apply the same 6.53% downward adjustment for upper quartile efficiency as Ofwat, we obtain an estimate of the efficient base expenditure requirements for our hypothetical average company of £102 per property.[21]

86. We used the estimate after adjustment for upper quartile efficiency (£102 per property) as a baseline.[22] We then examined a number of scenarios for how a hypothetical company may differ to that hypothetical average company and used Ofwat's estimated coefficients to calculate the implied efficient base expenditure requirements for each of these scenarios.

[21] Ofwat's approach to cost assessment was based on estimates for a company which had 6.53% lower costs than an averagely efficient hypothetical company. Ofwat had found that a company at the upper quartile in efficiency performance would have costs that were 6.53% lower than an averagely-efficient hypothetical company.
[22] In this exercise we did not include the 'alpha adjustment' used by Ofwat and CEPA. This had a small effect.

Summary of results from analysis based on hypothetical average company

87. Table 5 shows the results from the exercise described above. The rows in the table show the estimated efficient base expenditure requirements for each scenario. In each case the estimates apply to a company that is identical to the average hypothetical company except for the specific differences specified in the scenario column. The table shows both the estimated efficient base expenditure for the hypothetical company and the estimated efficient expenditure per customer (connected property).

Table 5: Efficient costs implied by model WM9 for hypothetical companies

Scenario	*Estimated efficient base expenditure (£ million, 2012/13 prices)*	*Estimated efficient base expenditure per customer (£, 2012/13 prices)*	*Difference in base expenditure per customer compared to hypothetical average company*
Hypothetical industry average company	140.69	102.13	N/A
(1) Company with twice the number of customers, twice the population and twice the total length of mains	290.51	105.44	3.2% higher
(2) Company with half the number of customers, half the population and half the length of mains	69.08	100.30	1.8% lower
(3) Company with 10% greater population	170.75	123.95	21.4% higher
(4) Company with 10% less mains in total	129.68	94.13	7.8% lower
(5) Company with 10% greater average pumping head	140.69	102.13	No change*
(6) Company that takes 10% less of its total distribution input from rivers and 10% more from boreholes than the hypothetical company	140.48	101.97	0.2% lower
(7) Company that takes 10% less of its total distribution input from impounding reservoirs and 10% more from boreholes than the hypothetical average company	141.25	102.54	0.4% higher
(8) Company with 10% higher value for regional wage measure than the hypothetical average company	144.50	104.89	2.7% greater
(9) Company with rate of mains replacement and relining (per km of main) that is 50% greater than the hypothetical average company	144.15	£104.64	2.5% greater

Source: CMA analysis.
*Pumping head not in refined models.

88. This analysis raised some issues. We highlight below four aspects of the results from the table above:

(a) Estimated coefficients that, taken together, imply a form of diseconomies of scale with respect to the number of connected properties and

population that a company supplies (taking length of mains per property and other explanatory variables as constant).

(b) The implied relationship between population density (population supplied divided by number of connected properties) and expenditure was of an unexpectedly high magnitude.

(c) The implied relationship between length of mains and expenditure (holding customer numbers constant) and expenditure was of an unexpectedly high magnitude.

(d) The model seems to imply limited effect of variations in a company's use of different raw water sources (eg rivers, reservoirs and boreholes) on costs.

89. We take these issues in turn. Overall, we consider that this analysis provides evidence of the limitations and inaccuracies arising from Ofwat's models. This was relevant to our views on the extent to which Ofwat's models (and other models of this nature) were likely to provide accurate estimates of Bristol Water's efficient expenditure requirements.

90. The implications that we drew from this review were not simply that we should consider alternative econometric models, but also that we should recognise the limitations of econometric benchmarking analysis of base expenditure more generally.

Diseconomies of scale with respect to company size

91. The refined base expenditure model implies a form of diseconomies of scale that we did not consider plausible. A company that is twice the size of our hypothetical average company, in terms of number of connections, population and total length of mains, would have an expenditure per property served that is 3.2% higher than our hypothetical average company (see result for scenario (1) in Table 5). Similarly, a company that is half the size of our hypothetical average company, in terms of number of connections, population and length of mains, would have a cost per property served that is 1.8% lower than our hypothetical average company (scenario (2)).

92. This would suggest that simply taking a water company and breaking it up into two separate companies would reduce the total costs across the two companies. Repeating the process would further reduce total costs across these companies.

93. For example, if we had a company that was double the size of the hypothetical average company and we separated it into two companies of

equal size, the model results suggest that (excluding divestment costs), across the two companies, base expenditure would reduce by around £10 million per year.[23] This seemed counter-intuitive.

94. We were concerned about the consequences of using an econometric model to estimate water companies' efficient expenditure requirements that involved an assumption of this type of diseconomies of scale.

95. Ofwat provided some comments in response to our analysis on the potential implication of diseconomies of scale in the refined base expenditure OLS model. Ofwat said that there were valid reasons for diseconomies of scale to exist, such as sourcing sufficient water for a large number of customers or establishing sufficient capacity for growth which may not yet be fully utilised.

96. We did not consider these to be valid explanations for the feature of Ofwat's models that we were concerned with. We did not understand why companies that supply a large number of customers would face higher costs because of the need to source sufficient water for them. This might be an issue for companies that have a relatively high number of customers relative to the geographic area that they supply, but that is a separate matter relating to population density. Similarly, we did not understand why establishing capacity for growth would mean that larger companies that supply more customers will have higher costs: both large and small companies may face increased costs to accommodate growth in customer numbers and consumption levels.

97. Ofwat also said that it thought that Bristol Water benefited from the diseconomies of scale with 1.15 elasticity of cost to length in the refined base expenditure OLS model and did not consider that the model's economies of scale specification adversely affect Bristol Water. The view that Bristol Water benefited did not seem correct (though the complexity of Ofwat's models make it difficult to interpret them precisely). We used a similar type of analysis to that above and found that the refined base expenditure OLS model predicted lower costs for a company with Bristol Water's size and length of mains relative to customer numbers and population, than for the hypothetical average company.

Counter-intuitive results for effect of variations in population density

98. The results for scenario (3) above indicate that a company that supplies the same number of properties as the hypothetical average company, and has the same length of mains, but serves a population that is 10% higher, would have

[23] This is calculated as (£105.44–£102.13) * (2*1,377,589 properties), using data from Tables 4 and 5.

an estimated level of efficient base expenditure that is 21.4% greater than the hypothetical average company (all else equal).

99. We can see this as an implied relationship between population density (average number of persons per property supplied) and expenditure. We assumed an industry-average company that has an average population density of 2.24 persons per property supplied. We found that Ofwat's refined model implied that such a company would have an efficient base expenditure of £102.13, whereas a company with a population density of 2.46 would have an efficient base expenditure of £123.95.

100. We considered a 21% increase in base expenditure for a 10% increase in population (all else equal) to be unlikely.

101. The population density is a potential driver of the expenditure requirements per property supplied. This is especially relevant if there is no measure of average consumption per property (usage in Ofwat's terminology) in the model, as is the case for Ofwat's refined base expenditure models. If a company supplies a larger population relative to the number of connected properties, then it seems likely that the volume of water that it is required to abstract, treat, produce and distribute will be greater (all else equal) which would increase its costs. However, if the relationship between population density and expenditure requirements was driven by variations in average consumption per property we would not expect such a large effect. For instance, even if all costs were proportionate to the volume of water produced and distributed, we would expect an effect in this scenario of around 10%.

102. CEPA's explanation of the inclusion of the population density explanatory variable in the models was that it 'approximates average consumer size (domestic vs. I&C) and can be used to take some of the variation away from usage'.[24] We did not understand this and did not consider that it explained the result above.

103. In its report, CEPA singled out the estimated coefficient on population density from its model WM9 as a reason to give the model an amber rating rather than a green rating under its statistical performance criterion. CEPA stated that the coefficient for population density was 'slightly high, possibly due to multi-collinearity'.[25]

104. It is conceivable that the population density explanatory variable is picking up some more subtle underlying relationship. For example, some of the areas of

[24] CEPA (March 2014), Cost assessment – advanced econometric model, p45.
[25] CEPA (March 2014), Cost assessment – advanced econometric model, p78.

England and Wales that have a relatively high population relative to the number of connected properties may also be areas that require greater use of relatively high-cost water resources, as the lower cost resources are insufficient to meet demand. This would tend to increase the average expenditure requirements per customer. However, it is also possible that the estimated coefficient on the population density variable is reflecting correlations in the data that are not reflective of causal cost drivers.

105. Ofwat told us that the population density issue was an isolated case in the base expenditure OLS model, and that the base expenditure random effects models had a lower coefficient for population density (10.5%) and that since Ofwat's approach included triangulation, it did not consider this to be an issue overall. Furthermore, it said that Bristol Water was an average company in terms of population density and was not adversely affected. We recognise that the population density issue seems more acute for the OLS base expenditure model and that this issue may not have adversely affected Bristol Water. Nonetheless, we considered our analysis of the population density effects in the OLS base expenditure model to be relevant to our wider review of Ofwat's models.

Counter-intuitive results for effect of variations in mains length

106. The results from scenario (4) above are that a company that has 10% less mains in total than the hypothetical average company would have 7.8% lower costs per connected property.

107. The positive relationship between length of mains and expenditure requirements (holding all else equal) seems plausible. If a company's customers are relatively diversely spread across the geographic area that it serves, such that it requires a relatively large amount of water mains to serve them, we would expect, all else equal, its costs to be greater than those of a company that can serve the same customer base with less water mains infrastructure.

108. However, the implied scale of the effect seemed high. This was for two reasons:

    (a) While the length of a water company's distribution mains seems a relevant cost driver for the costs of parts of its water distribution system, there is a substantial part of its assets and activities for which we would not expect the length of mains to be an important cost driver (eg water abstraction and treatment processes or service reservoirs). We would expect the overall effects of mains length on base expenditure to be diluted by the areas of base expenditure for which mains length has limited effect on expenditure.

(b) Even in areas where mains length affects costs, there may be partially offsetting factors. For example, as the length of mains per connected property increases then, all else equal, we would expect smaller volumes of water flowing through these mains, on average. This would tend to allow for smaller diameter pipes as mains length increases, and doubling mains length would not necessarily double the total costs associated with water mains. The PR09 cost base (a database of unit cost estimates for water industry capex projects) indicated that the diameter of water mains had a material effect on the costs of laying or rehabilitating (through pipe insertion) water mains, with higher diameter mains being associated with higher costs per metre.

109. To illustrate the first point, suppose a water company's costs were made up of two parts, A and B, and that these were of equal size in terms of costs. Suppose that there was a proportionate relationship between total mains length and the costs of part A such that doubling mains length doubled costs, and no relationship between total mains length and the costs of part B. In this example, we would expect to find that a 10% increase in mains length would increase costs by only 5%.

110. Bristol Water's regulatory accounts indicate that treated water distribution is approximately half of its total wholesale costs.[26] Of the treated water distribution costs, a significant part will be for assets and activities not driven by mains length. In this context, a 7.8% increase in costs for a 10% increase in mains length seemed high.

Limited effect from variations in raw water inputs

111. Two explanatory variables of CEPA's refined base expenditure model concern the raw water inputs that companies draw on:

(a) The proportion of distribution input from rivers (expressed as a natural logarithm).

(b) The proportion of distribution input from impounding reservoirs (expressed as a natural logarithm).

112. Our analysis of the hypothetical company indicated that these factors had a relatively limited effect on the estimated efficient level of base expenditure.

113. In scenario (6) we considered a company that takes 10% less of its total distribution input from rivers and 10% more from boreholes than the

[26] CMA analysis of Bristol Water's regulatory accounts 2014.

hypothetical average company. We found that its base expenditure would be 0.2% lower than those of the hypothetical average company. This translated as 15 pence per customer per year.

114. We carried out some further calculations using information on the industry average company and found that the implied cost difference between river water and water from sources other than rivers and impounding reservoirs (eg borehole abstraction) worked out at around 0.7 pence per cubic metre.[27]

115. Bristol Water's view was that this figure of 0.7 pence per cubic metre was not reasonable and far too low, and referred to estimates from Ofwat's PR09 opex econometric models which Bristol Water considered to predict a difference between surface water and groundwater of 8.3 pence per cubic metre in terms of opex (2007/08 prices).

116. In addition, the results from our scenario (7) implied that taking a greater proportion of water from reservoirs rather than boreholes would slightly increase costs. This would run counter to a view that reservoir water is more costly. CEPA stated that 'water from reservoirs is expected to lead to higher costs than water from boreholes'.[28] However, the effect is quite small.

Review of Ofwat's modelling approach

117. This section provides a review of a number of elements of the top-down econometric models used by Ofwat. We identified a number of concerns, which raised further questions about the accuracy of these models, in addition to those from our review of the model estimation results in the previous section.

118. The fact that we identified concerns with Ofwat's models does not, on its own, dictate whether or not these models should be used for cost assessment. No benchmarking analysis will be perfect and there will always be vulnerabilities and limitations in any approach. The appropriate approach overall should be considered in the light of the potential contribution and limitations of the various approaches that are feasible.

119. Furthermore, the development of econometric models of the nature that Ofwat used for its cost assessment involves (or reflects) choices over a great many aspects of model specification and estimation. It is not practical to take every conceivable aspect and dimension of model specification and critically

[27] We obtained this figure by taking the difference in costs per customer (£0.15), multiplying by the number of customers of the hypothetical average company, and dividing by 10% of the total annual volume of distribution of the hypothetical average company.
[28] CEPA (March 2014), Cost assessment – advanced econometric model, p21.

examine all reasonable options and alternatives. As a consequence any model development and selection process will be affected by judgement on which aspects of model characteristics and performance are most important. It is perhaps inevitable that the models resulting from such a process will overlook or give insufficient weight to issues that other parties may consider important.

120. Our discussion below focuses on the econometric models themselves. We recognise that Ofwat's special cost factor process provided companies with opportunities to mitigate, to some degree, the effect on them of possible limitations or inaccuracies in Ofwat's econometric models. The special cost factor process was an important part of Ofwat's overall approach to cost assessment, which we considered separately in Appendix 3.1.

121. We organise our discussion and review of Ofwat's models into three broad areas:

(a) the use of totex models (paragraphs 123 to 152);

(b) model specification (paragraphs 153 to 193); and

(c) statistical and model estimation issues (paragraphs 194 to 223).

122. These areas are interrelated (eg the statistical issues we identified had implications for model specification), but we have sought to give some structure to the discussion that follows.

The use of totex models

123. The subsections below discuss four aspects of Ofwat's use of totex models:

(a) The timing of investment needs (paragraphs 124 to 133).

(b) The inclusion of enhancement expenditure (paragraphs 134 to 138).

(c) No disaggregation of models into parts of the value chain below wholesale water (paragraphs 139 to 147).

(d) Lack of more granular benchmarking analysis (paragraphs 148 to 152).

The timing of investment needs

124. Ofwat's models involved comparisons across companies and over time of measures of companies' totex and base expenditure, covering both opex and capex. This reflects Ofwat's decision to take a totex approach to cost assessment and other parts of its price control framework.

125. Making comparisons across companies of totex raises an immediate problem. Capex concerns investment and companies' investment requirements will vary over time. Differences between companies in their level of total cash expenditure, in a given year or five-year period, may be reflective of differences in their investment requirements at a point in time and not indicative of their relative efficiency. For example, two different companies may have the same level of efficiency but different expenditure if they are at different points in their asset replacement cycles.

126. Accounting practice has long recognised that looking at a company's costs in a given year on a cash basis may provide a misleading indication of its financial position or performance. Companies' profit and loss statements do not report revenues minus totex as a measure of profit. Instead, capex enters the profit and loss statement through depreciation charges or amortisation. Ofwat's models do not use any measures of depreciation or amortisation: comparisons between companies and over time are on a cash basis.

127. Furthermore, Ofwat's econometric models did not include any explanatory variables that measure differences between companies, or over time, in companies' investment needs or the condition or quality of companies' capital stock.[29] Ofwat told us that including variables relating to the condition or quality of capital stock would create perverse incentives to reward companies with poor quality asset stock and that companies had ongoing responsibilities for serviceability. We agreed that there may be such a risk to incentives (though this depends on other aspects of the price control framework), but this does not detract from the risks of inaccuracy in the results from such models: the estimated expenditure from Ofwat's models may be too high for some companies and too low for others because they fail to account for the relative condition or quality of companies' capital stock and the timing of investment needs.

128. There are two risks to accuracy of the model results:

    (a) The estimates derived from totex models for a particular company may provide an inaccurate guide to its expenditure requirements over a five-year period because they may take insufficient account of the extent to which its investment requirements in that period differ from those that applied on average across all companies in the historical data period used

[29] Each of the five models used by Ofwat included a measure of the volume of mains replaced and relined as an explanatory variable. In addition, the full totex model included explanatory variables for the proportion of new meters installed and the proportion of new mains laid in the year. However, these measures of companies' levels of activity are not necessarily indicative of their investment requirements; the activity levels reflect management choices and working practices and do not cover all aspects of water companies' investment requirements (they focus on water mains and metering assets).

for these models. The timing of a company's investment needs may mean that it has relatively high expenditure requirements in the next five-year period compared with the results implied by the modelling, and vice versa.

(b) Variations over time and between companies in capex, which are driven by variations in investment needs, may give add noise to the data and distort the estimated coefficients from the econometric model and worsen the accuracy of the estimated expenditure for each company that is derived from the model. This is because variations in capex may, by chance, be correlated in the historical data with one or more of the explanatory variables in the model. This would tend to distort the estimates of the coefficient for these explanatory variables.

129. Ofwat told us that dealing with different investment needs was an issue in any comparative assessment and that it considered that its approach of smoothing capex in the econometric models and its broader approach involving special cost factor claims mitigated this issue. On special cost factors, Ofwat said that where companies considered that Ofwat's modelling results did not capture their large capital investment project they could submit a special cost factor claim for consideration.

130. We agreed that smoothing capex helps to reduce the problem above, but we had no reason to think that smoothing over five years was sufficient to address this issue given the much longer asset lives in the water industry.

131. We reviewed the special cost factor adjustments that Ofwat made for base expenditure across all companies and did not consider that Ofwat had developed a reliable method for taking full account of differences between companies in the timing of investment needs. The issue might not be a single 'large capital investment' project. It could instead be the cumulative effect, across different assets, which means that one company's investment needs are significantly higher or lower than the industry average. It seemed difficult to assess the case for special cost factor adjustments relating to the timing of investment needs for a specific company without looking at expenditure requirements across the whole of its wholesale business.

132. We recognised that Ofwat's decision to develop and use totex models for cost assessment reflected concerns that the previously regulatory framework provided companies with an undue bias towards capex and distorted their decisions away from finding ways to deliver services to customers at least cost (without compromising quality). The Gray review of Ofwat and consumer representation in the water sector had found the evidence of a bias towards

capital investment to be convincing.[30] The assessment of the Gray review team was that the bias towards capital investment was both real and important, and that the approach set out in Ofgem's RIIO framework for energy network companies appeared to have considerable attractions.[31]

133. Ofwat's specific implementation of a totex approach is not the same as that used by Ofgem. Ofwat's approach to cost assessment for PR14 placed more weight on top-down benchmarking of totex than implied by Ofgem's RIIO framework and by Ofgem's subsequent implementation of that framework for electricity and gas distribution network companies. The specific aspects of Ofgem's approach that the Gray review identified as a potential means to address the capital investment bias concerned equalising marginal incentive rates across operating and capex and capitalising a fixed percentage of totex for the purposes of calculating the RCV.[32] The Gray review did not comment explicitly on the totex approach to benchmarking analysis or cost assessment.

Inclusion of enhancement expenditure

134. Ofwat's totex econometric models included base service and enhancement expenditure. There are likely to be substantial differences between companies (and over time) in enhancement expenditure requirements. For example, enhancement will reflect whether increases in (forecast) demand for water can be met through existing capacity or require new capacity to be built (eg some companies may have excess capacity in water resources and water treatment at a particular point in time, reflecting historical investment decisions and changes in population and industry over time in their regions).

135. Furthermore, where companies need to increase water resource capacity, the costs of doing so may vary substantially between companies depending on local and regional ecological and environmental factors that determine the feasible options for additional water resources. Enhancement requirements may also be driven by environmental concerns, such as over-abstraction from particular sources, which will vary across different companies' regions.

136. Despite the number of explanatory variables in Ofwat's models, the models seemed limited in the explanatory variables that take account of differences between companies in their enhancement expenditure requirements.[33]

---

[30] Defra (2011), Review of Ofwat and consumer representation in the water sector, p42.
[31] Defra (2011), Review of Ofwat and consumer representation in the water sector, p43.
[32] Defra (2011), Review of Ofwat and consumer representation in the water sector, p43.
[33] The unit cost models that Ofwat used for enhancement expenditure used additional cost drivers, such as forecasts of the water supply deficits from companies' WRMPs that seem relevant to enhancement expenditure. But these did not feature in the totex and base expenditure models that are the focus of the review in this appendix.

137. We considered that this reflected a general difficulty in seeking to include enhancement expenditure in the econometric models, rather than omissions in the explanatory variables selected for Ofwat's models. We did not identify a set of alternative explanatory variables that seemed likely to capture the material differences between companies in their enhancement needs.

138. We recognised that there are potential benefits of including enhancement expenditure in the econometric models. In particular, the split between enhancements and base expenditure is not clear-cut, and separate analyses for base and enhancements are vulnerable to risks from imperfect and inconsistent cost allocations. But these cost allocation issues did not detract from the problems arising from the inclusion of enhancement expenditure in Ofwat's totex benchmarking models.

No disaggregation of models into parts of the value chain below wholesale water

139. Compared with its previous approach to price control reviews, Ofwat has moved towards more aggregated and high-level forms of benchmarking analysis. In addition to the aggregation of opex and capex into single models, Ofwat's approach took the whole of wholesale water supply together, without considering different parts of the value chain or different wholesale water activities separately.

140. Ofwat's models specified the dependent variable as the logarithm of measures of totex, or base expenditure, across companies' wholesale activities. This is one reasonable type of model specification to consider.

141. However, Ofwat could also have considered models that take different parts of the value chain separately. Ofwat could still have taken opex and capex together, but used separate models for different parts of the value chain. For example, Ofwat's previous price control reviews adopted the principle of using separate models for different parts of the water value chain, distinguishing between:

    (a) raw water abstraction, transportation, storage and treatment;

    (b) treated water distribution; and

    (c) power costs (which were stripped out of *(a)* and *(b)* above).

142. The categorisation would probably require refinement, but this type of approach could allow for more accurate estimates of the relationships between costs and cost drivers. This is for two main reasons:

(a) Models that focus on specific parts of the value chain may allow the set of explanatory factors to be tailored to each model, reducing risks of inaccuracy in estimated coefficients from the small sample size (and limited variation within the sample) relative to the number of cost drivers that are material for wholesale water supply. For example, a model of treated water distribution expenditure might benefit from the exclusion of variables relating to raw water quality and a focus on explanatory variables that are more important to treated water distribution costs.

(b) Under Ofwat's approach there are risks that the estimated coefficients for some cost drivers are adversely affected by non-causal correlations between the cost driver and expenditure in parts of the value chain that are not significantly affected by the cost driver. In contrast, a disaggregated approach allows a greater focus on the areas of expenditure that specific cost drivers relate to.

143. There are potential downsides from such models (eg vulnerabilities to differences between companies in cost allocation) but these did not seem so great as to override the contribution that such models could make to the estimation of coefficients on explanatory variables in the model.

144. Ofwat told us that consideration of the different sections of the value chain for wholesale water supply reinforced rather than undermined the advantages of totex modelling because of the complex trade-offs and interactions between activities in the value chain. It set out the following argument:

> A company may choose a water source further from the main area of demand because it has low treatment costs, which it uses to offset some of the extra transport costs of raw or treated water. Alternately it may choose multiple sources of raw water closer to centres of demand that are more expensive to treat but reduce its water transport costs. The investment in transport and treatment capacity can also impact on distribution costs by reducing the need for investment in the local storage of treated water. Taken together these issues significantly undermine the case for disaggregated benchmarking and would create substantial difficulty in implementing such a scheme.

145. We agreed with the first part of the extract above, which relates to: *(a)* the possible choices a water company may face as to how to organise its water

supply to customers; and *(b)* potential differences between companies in the extent to which they use different activities and asset types within the overall value chain. However, we disagreed with the inference that these features of the industry undermine the case for disaggregated benchmarking or create substantial difficulties. While there are risks with the development and use of disaggregated models (as there are with totex models), we did not believe that a well-designed disaggregated benchmarking approach would be undermined by these features.

146. For example, a bad approach to disaggregated benchmarking would involve running a series of separate models for different parts of the value chain, calculating an upper quartile efficiency benchmark for each model, and then producing an upper quartile efficiency benchmark for wholesale water as the sum of these separate upper quartile benchmarks from each model. This would be vulnerable to the criticism that it provides an unrealistic and unachievable cost benchmark by ignoring the interactions and trade-offs across different parts of the value chain. This specific problem can be addressed by summing the estimated costs (or cost per customer) across different disaggregated models before calculating any efficiency benchmark.

147. Ofwat also said that partitioning the value chain also exposed any benchmarking analysis to the distortions caused by cost allocation and attribution issues. We recognise that there are risks to the accuracy from costs allocation issues but these risks did not seem so great as to provide a reason for excluding disaggregated models from the assessment, particularly where they may bring benefits in terms of the estimation of relationships between expenditure requirements and the cost drivers.

Lack of more granular benchmarking analysis

148. Besides the possibility of benchmarking models that take different parts of the water supply value chain separately (eg separating water treated from treated water distribution), another approach is to carry out relatively granular or disaggregated forms of benchmarking analysis. This could provide an additional perspective, to complement more aggregated benchmarking models.

149. In its regulation of electricity distribution companies in Great Britain, Ofgem has complemented relatively aggregated top-down benchmarking analysis with far more granular benchmarking analysis. Ofgem's final approach in its most recent review of the price controls for the electricity distribution companies gave a 50% weight to totex modelling and a 50% weight to disaggregated modelling. The disaggregated modelling was built up from many different streams of benchmarking analysis at the level of individual

activities that companies carry out (eg tree-cutting, or inspections and maintenance) or for specific categories of investment (eg 33kV transformers). Ofgem explained as follows:[34]

> Totex models internalise operational expenditure (opex) and capital expenditure (capex) trade-offs and are relatively immune to cost categorisation issues. They give an aggregate view of efficiency. The bottom-up, activity-level analysis has activity drivers that can more closely match the costs being considered.

150. We recognised that there are differences between the water companies in England and Wales and the regional electricity distribution companies regulated by Ofwat (for example, there is a larger sample of independent water companies in water industry). However, we saw merit in Ofgem's view that there are significant benefits from more granular benchmarking analysis despite the existence of trade-offs between opex and capex and cost allocation issues.[35]

151. The CC's 2014 price control determination for Northern Ireland Electricity Ltd (NIE) drew on more granular forms of benchmarking than used by Ofwat. The CC made extensive use of the detailed data sets that Ofgem had collected for electricity distribution network operators (DNOs) in Great Britain. This data fed into the CC's analysis of NIE's network investment plan and also the benchmarking of NIE's 'indirect' costs.[36]

152. More granular benchmarking analysis would require more detailed data than Ofwat used for its totex and base expenditure models. The data collected by Ofwat for the PR14 price control review, and its approach to benchmarking analysis and cost assessment, reflects, in part, the outcome of the Gray review.[37] That review was critical of the data burden that Ofwat placed on companies and the review's recommendations included for Ofwat to 'set clear targets and timescales for a reduction in the burden of the price control and compliance processes'.

---

[34] Ofgem RIIO-ED1: Final determinations for the slow-track electricity distribution companies: business plan expenditure assessment, 28 November 2014, p28.
[35] Ofgem has developed a very detailed set of regulatory reporting arrangements for annual data submissions from regulated electricity distribution companies. Ofgem provides detailed definitions of activities and assets to reduce risks that companies report on an inconsistent basis.
[36] Northern Ireland Electricity Limited price determination (2014).
[37] D Gray (2011), Review of Ofwat and consumer representation in the water sector, p28.

Model specification

153. We take the following aspects of model specification in turn:

(a) The use of the translog functional form (paragraphs 154 to 163).

(b) The assumed relationship between expenditure and the cost drivers (paragraphs 164 to 174).

(c) Inclusion of inputs in the explanatory variables (paragraph 175 to 186).

(d) Potential missing cost drivers (paragraphs 187 to 193).

The use of the translog functional form

154. For the purposes of our assessment, we did not focus on the general question of whether a translog functional form was a useful model for econometric analysis of costs or efficiency. Instead, our focus was on the specific translog implementation used in Ofwat's models, within the specific context of our determination for Bristol Water.

155. We found it difficult to rationalise and interpret the specific explanatory variables that Ofwat included in its econometric models for the purposes of implementing the translog approach (eg the natural logarithm of mains length multiplied by the natural logarithm of the number of connected properties divided by the total length of mains).

156. In explaining its use of the translog form, CEPA stated as follows:[38]

> We tested both [Cobb-Douglas and translog] functional forms in our modelling as previous literature indicated that there is evidence of varying economies of scale in the water and sewerage industry. For example, work commissioned and published by Ofwat (Stone and Webster 2004) suggested the presence of variable returns in the water industry, with evidence of diseconomies of scale for water and sewerage companies (WaSCs), but possible economies of scale for WoCs. Although, Stone and Webster could not reject the presence of constant returns to scale for water-only companies (WoCs). In addition, Saal et al (2011) found that, for WoCs, the average sample firm was subject to diseconomies of scale. However, it concluded that vertically integrated firms gained significant benefits from economies of scope and scale. We discussed the theoretical

[38] CEPA (March 2014), *Cost assessment – advanced econometric model*, p7.

implications of the translog with Ofwat staff and we agreed with them that a translog form was viable.

157. It seemed that CEPA and Ofwat used the translog function form because they thought that there may be significant economies or diseconomies of scale across our sample of water companies. CEPA's reports did not, however, explain why, from an economic or engineering perspective, there would be such economies or diseconomies of scale.

158. We did not consider that CEPA had fully explained the use of models that allowed for economies or diseconomies of scale through its references to past studies. Any statistical analysis is vulnerable to potential unreliable results or inaccurate inferences. For instance, any study that seeks to draw conclusions about the presence of economies or diseconomies of scale by considering the statistical significance of estimated coefficients may be found to be vulnerable on further review. We saw from both Ofwat's models and our own work on alternative models, that the estimated coefficients from econometric models of the expenditure of English and Welsh water companies can be highly sensitive to model specification, and relatively minor changes to aspects of a model may change the estimated coefficients. Furthermore, the standard errors may be underestimated (eg if the estimation of standard errors ignores possible correlations over time in companies' costs), and hence the significance of estimated coefficients can be overstated. These are things that one would need to investigate before giving weight to the results from the studies referred to by Ofwat and CEPA.

159. In the context of a small sample size relative to the number of explanatory variables in the econometric model, it may be unsafe to rely on statistical analysis to reveal how the econometric models should be specified. Our analysis above of Ofwat's refined base expenditure model (OLS), which features a translog functional form, found that this implied diseconomies of scale. We could not think of an economic or engineering reason why the cost per connected property should be higher simply because a company supplies a greater number of connected properties (assuming what CEPA terms the density and usage remain constant).

160. If a statistical analysis suggested some form of economies of scale or diseconomies of scale, we would not necessarily consider it appropriate to take account of this in the models used for cost assessment for Bristol Water's price control. Even if it was the case that smaller companies had lower costs than larger companies, on the basis of cost per customer or cost per cubic metre supplied, it does not follow that we would want to provide for relatively higher expenditure allowances (eg per customer) for the larger companies and lower allowances for smaller companies. The relationship in

the data could be due to non-causal factors, such as in the following examples:

(a) A correlation between company size and unit cost measures could be driven by correlations in efficiency: small companies may happen to have had more efficient working practices (on average) over the sample period. This would not necessarily mean that all small companies would be lower cost in the future.

(b) It could be due to factors that enable some of the smaller companies to operate at lower costs, or that raise some of the larger companies' costs, which are not captured by the explanatory variables in the model and which do not necessarily apply to all small companies.

161. Because statistical analysis on a small sample cannot be entirely accurate, we would consider it important to have an explanation of the rationale for treating diseconomies of scale as a causal factor that the regulatory cost assessment should allow for, if such models are to be used.

162. In response to our initial comments on Ofwat's use of the translog models, Ofwat said that there were a number of economic and engineering reasons why the cost per connected property could be higher because a company supplied a greater number of connected properties. Ofwat said that the company may have needed to build a new treatment plant which was not running at capacity or that the treatment of raw water could be more complex given the greater number of properties.

163. We did not accept these attempts by Ofwat to rationalise the form of diseconomies of scale that we had expressed doubts over:

(a) The extent to which a company is making use of the capacity of its assets, rather than having a high degree of asset underutilisation, could affect the calculated cost per property. However, there seemed to be no reason to expect that companies that serve a relatively high number of customers would suffer from a larger degree of asset underutilisation than companies that serve a relatively low number of customers.

(b) The point made by Ofwat on raw water quality seems to confuse differences between companies in the total number of customers with differences in the density of customers within the area they serve. It seems possible that a company that serves a geographic area with a high density of customers may have higher costs per customer because, to meet water demand in its area, it needs to use some relatively inferior water resources that have higher water treatment costs. This would be an argument for including measures of customer density in the models (for

example, relating to the geographic area supplied relative to customer numbers, though this might already be captured by the variables for mains length relative to connected properties). However, our concern was not about customer density but about the idea that, holding the density of customers constant, supplying a greater number of customers will increase costs.

The assumed relationship between expenditure and the cost drivers

164. We reviewed the way that Ofwat's models incorporated potential cost drivers into the specification of explanatory variables. We found that, in some cases, the models impose assumptions on the relationship between expenditure and cost drivers that did not make sense.

165. The first issue that we discuss is the use of logarithms for the specification of explanatory variables that are calculated as proportions. An example concerns the explanatory variables relating to the nature of each company's water resources. These variables are: *(a)* the natural logarithm of the proportion of distribution input from rivers; and *(b)* the natural logarithm of the proportion of distribution input from impounding reservoirs.

166. We did not consider it sensible to take the logarithm of this proportion for the specification of the explanatory variable. Doing so would assume that a 10% increase in the *proportion* would lead to an X% increase in costs. This would imply, for example, that the effect on a company's costs of moving from 5% river water abstraction to 10% river water abstraction (a 100% increase in the proportion) would be the same in £ million as if that company moved from 40% to 80% river water abstraction (similarly, a 100% increase in the proportion).

167. This aspect of Ofwat's model specification followed from its general policy of taking the natural logarithm of the dependent variable and all explanatory variables in its models. The approach of expressing costs and cost drivers as a natural logarithm has support from the Cobb-Douglas functional forms (of which the translog form is an extension) used in some academic literature. However, this does not in itself justify taking the natural logarithm of a cost driver in the special case where that cost driver is expressed as a proportion. The classic Cobb-Douglas production function in the academic literature has inputs of capital and labour, neither of which are expressed as proportions.

168. There are further problems, beyond the use of explanatory variables of logarithms of variables that are proportions. These concern the use of explanatory variables that are defined as proportions or as one cost driver divided by another variable.

169. As an example of this second issue, we considered the explanatory variable for 'proportion of new meters'. This was defined as the number of new meters installed by the company in a year as a proportion of the number of the company's customers that were metered. CEPA identified this as a driver of enhancement costs. CEPA stated that, for the coefficient on this explanatory variable, it would expect a low positive number as the installation of new meters should drive up capital costs.[39]

170. Variations between companies in the number of new meters installed is a relevant cost driver to consider (at least if the expenditure measure includes enhancements). However, the exact specification of the explanatory variable used in Ofwat's models raised some questions. The explanatory variable in Ofwat's full totex model did not consider variations in the total volume of meters installed between companies, but rather variations in new meters expressed as a proportion of the existing base of metered customers. This model assumed that two companies would have the same costs of installing new meters, as a percentage of their totex, only if this proportion was the same. This did not seem to make sense.

171. We illustrate this by reference to an illustrative example in Table 6. In this example, we assume that companies A, B and C are the same in all ways except the factors in the table relating to metering. Companies A and B have a different existing base of metered customers and install a different number of meters, but the number of new meters as a proportion of existing metered customers is the same.

Table 6: Illustration of the problem with CEPA specification of proportion of new meters variable

	Total number of metered customers	*Number of new meters installed*	*Number of new meters as proportion of metered customers*
Company A	100,000	4,000	0.04
Company B	150,000	6,000	0.04
Company C	150,000	4,000	0.027

Source: CMA analysis.

172. The model specification used by Ofwat would make the same allowance for totex associated with new meters for companies A and B even though company B installs 50% more meters. Furthermore, if the model identifies a positive coefficient for this explanatory variable, the allowance for totex associated with new meters would be greater for company A than company C, even though they install the same number of meters.

[39] CEPA (March 2014), Cost assessment – advanced econometric model, p21.

173. This aspect of model specification was not explained in CEPA's reports. We did not identify any reason to think, as Ofwat's model specification implied, that the marginal costs of installing meters would be best represented as a function of the number of customers that already have meters.

174. A more plausible approximation, for the purposes of model specification, would be that the cost per meter was the same across companies. All econometric model specifications can only provide imperfect approximations of relationships between costs and cost drivers. But it seems more reasonable to assume that, in this example, companies A and C have similar meter installation costs and company B has higher meter installation costs, than to assume that companies A and B have similar meter installation costs and company C has low meter installation costs.

Inclusion of inputs in the explanatory variables

175. CEPA's and Ofwat's interpretation of the model results rests on the assumption that the estimated residuals from the econometric models – ie the cost differences between companies that are not explained by the estimated coefficients for the explanatory variables in the model – are a measure of efficiency differences between companies. If the explanatory variables themselves capture features of companies that reflect their efficiency in delivering services, this may distort the results (in statistical terms, there may be a problem of endogeneity).

176. To take an extreme example, an econometric comparison of costs could be specified to include number of employees (both own staff and contractors' staff) as an explanatory variable. The model might find this to be highly correlated with costs – that variations in levels of staff between companies have explanatory power (further to other variables in the model) in explaining differences in costs between companies. But we should not expect estimated residuals from such a model to be a good guide to efficiency differences.

177. A number of the explanatory variables in Ofwat's models seemed to relate to the inputs used by water companies to provide services to customers, over which companies have at least some degree of control. For example:

(a) the length of mains;

(b) the proportion of water abstracted from rivers;

(c) the proportion of water abstracted from reservoirs;

(d) the proportion of properties that are metered;

(e) the length of new mains laid in year divided by total length of mains;

(f) the length of mains relined and mains renewed divided by the total length of mains at year end; and

(g) the estimated volume of leakage divided by total water input to distribution system.

178. For several of these explanatory variables, it seems possible to argue that they are used to make an allowance in the model for an important underlying feature of companies' operating environment that has a significant effect on its expenditure requirements (if it operates efficiently) and which is not possible to capture directly.

179. For example, a water company will have some flexibility in both day-to-day operations and longer-term planning on the proportion of its water that it takes from different sources. However, the options and opportunities for raw water available will vary considerably across companies, due to both local environmental factors and investment decisions made in the past by the company or its predecessors (perhaps many years ago). Including explanatory variables for the proportion of water abstracted from rivers and reservoirs can make an allowance for these differences in the water sources available to a company, which reflect local environmental factors and historical decisions. This may be beneficial to the modelling even if there is a risk that the model overlooks or even distorts a company's efficiency in optimising across the different raw water options available to it.

180. Similarly, while a water company will face some asset management and system development choices that affect its length of mains, it faces duties to serve customers in its appointed area. Variations between companies in the dispersion of customers across that area will give rise to cost differences. Furthermore, a company's network design and infrastructure will be influenced by the pattern of customer demand that arose over time.

181. Our view was that, in some cases at least, including explanatory variables that are inputs and under management control may be better than a strict approach of excluding such factors. In principle, there would be merit in using alternative explanatory variables or data sources that could capture the same underlying factors with less of a link to a company's inputs and asset management approach, but such data sources may not be available.

182. There seems to be a different issue relating to leakage. CEPA's modelling treated leakage as an aspect of quality. This reflected more general aspects of Ofwat's regulation of the water industry, which treats companies' reported

leakage as a relevant measure of performance (eg with incentive schemes attached to leakage measures).

183. An alternative view is that leakage is not, in itself, a measure of quality or performance, and reflects instead the inputs to the production processes used to meet customer demand for water supplies. As part of their approach to asset management, companies will face cost trade-offs that relate to leakage (eg greater pipe replacement activity might reduce leakage and, in turn, the costs relating to water abstraction, treatment and pumping but these should be set against the costs of more pipe replacement work).

184. Including leakage as an explanatory variable in a model might increase the extent to which the model explains differences in costs between companies but may reduce the extent to which the model captures differences between companies in their efficiency of providing water services to customers. In particular, the model may predict higher levels of efficient costs for companies that have achieved lower levels of leakage, but this may overlook the possibility that maintaining lower levels of leakage may turn out to be more expensive overall for customers. There are wider environmental concerns relating to leakage which may be relevant to the determination of wholesale price controls, but these would tend to vary across different geographic areas.

185. Ofwat's view was that the potential concerns about endogeneity relate only to the full totex model (which includes leakage and quality variables) as the variables in the refined models such as network length cannot be substantially influenced by management in the short term and that, while inclusion of leakage in the full model may mean Ofwat understated the inefficiency of Bristol Water, there is no evidence that this has caused wider problems with its suite of models.[40]

186. Our concerns about endogeneity were more severe and important for Ofwat's full totex model. However, we did not agree with Ofwat's claim that these concerns related only to the full totex model. Ofwat's refined models included an explanatory variable for the proportion of a company's distribution mains that it renews each year. This variable is clearly under management control; indeed it reflects a company's choices about its approach to asset management.

[40] Ofwat response to our provisional findings, paragraph 260.

Potential missing cost drivers

187. CEPA's report presents its full totex model as covering all theoretical cost drivers. However, we were not persuaded that this was the case. For example, we considered the following:

(a) The number of connected properties seemed a relevant cost driver, but it was not included in Ofwat's models directly as an explanatory factor.

(b) Another potentially relevant cost driver concerns peak demand or measures of the variance between peak demand and average demand.

(c) The nature and quality of raw water sources seems an important cost driver, and it may not be adequately captured by the explanatory variables used by Ofwat relating to the proportion of water taken from river and reservoir sources. Bristol Water argued that a measure of the complexity of treatment processes required by companies was a relevant cost driver.

188. In respect of the second point, the costs of providing a water service are, in large part, costs required to provide and maintain the capacity needed to accommodate the demand for water services from customers. Demand is uncertain and varies both within the day (eg more consumption in the morning and evening and less in the middle of the night) and over the year (eg more consumption during hot summer periods).

189. The capacity that companies need to provide are not driven predominantly by average levels of consumption, but by the 'peakiness' of consumption patterns.

190. For instance, the capacity needed for water treatment might be driven by estimates of peak daily demand during a period of very high consumption during the summer. Similarly, the capacity needed for treated water distribution infrastructure may reflect not only the total volume of water distributed but also the extent to which consumption peaks at particular times of the day (eg this may affect the costs of service reservoirs and also pipe capacity).

191. If there are significant differences between companies in the peakiness of their customer's demand, this could lead to significant differences in costs. While Ofwat's econometric models include an explanatory variable for usage (a measure of water consumption per property) they do not include any variables which capture the peakiness of consumption: ie potential differences between companies in consumption at times of peak and average consumption.

192. Ofwat told us that it did not consider that the peak demand relative to average demand was an important consideration in the water econometric models because treated water could be stored in various parts of the network. We did not find this argument persuasive. Companies do deal with the peaks through different forms of storage, but storage itself carries costs.

193. Overall, we were not confident that Ofwat's models included all relevant theoretical cost drivers. This was not primarily a criticism of the model specification; with a limited sample size, we would not expect it to be practical to include all theoretical cost drivers. Instead, this point contributed to our overall view that there will be limitations in the types of totex and base expenditure models used by Ofwat.

Statistical and model estimation issues

194. The subsections below take the following issues in turn:

(a) Number of explanatory variables relative to sample size and variation (paragraphs 195 to 207).

(b) Relatively short data period (paragraphs 208 to 215).

(c) Pre-modelling adjustments as alternative to statistical estimation (paragraphs 216 to 223).

Number of explanatory variables relative to sample size and variation

195. We were concerned that the models used by Ofwat model might be 'over fitted' for a sample size of 90 observations (ie they include too many explanatory variables relative to the number of data points).

196. It is ambitious to take a data set spanning 18 companies over five years and attempt to use an econometric model to produce estimates that quantify the relationship between expenditure and up to 27 different explanatory variables.

197. Econometric models have limitations. To the extent that they can identify and estimate meaningful and usable estimates of the relationships between cost and the explanatory variables, this must come from inferences drawn from the correlations in the data sample. At a high level, there are two related problems to be aware of:

(a) There may be correlations in the data sample between the expenditure measure used for the dependent variable and an explanatory variable which are not reflective of causality (how cost drivers affect expenditure requirements). This would tend to distort the accuracy of the estimated

coefficient for that explanatory variable, at least for the purposes of treating the coefficient as an approximation of the causal relationship between that factor and companies' expenditure requirements.

(b) Where two explanatory variables are highly correlated, it may be difficult for the econometric model to isolate the causal effect of any one of them on costs. This could result in inaccurate estimates of the way that these two factors would, on their own, affect costs.

198. The second issue relates to the statistical concept of 'multi-collinearity'. Ofwat argued that multi-collinearity may explain some of the estimated coefficients from its models which, taken in isolation, look counter-intuitive. Ofwat and CEPA did not seem to treat multi-collinearity as a problem for the cost assessment that draws on the econometric modelling, but we had concerns. See the discussion in the subsection above on 'Ofwat's response to unexpected coefficients'.

199. The two problems above are a greater concern the smaller the sample size is and also where there is limited variation in the explanatory variables within a small sample. A smaller sample size presents greater risks of spurious (ie non-causal) correlations and less opportunity for the model to withstand correlations between explanatory variables.

200. Ofwat's data sample had 90 observations. We considered this insufficient to avoid the two problems above. Furthermore, the sample cannot be seen as 90 independent observations. Some of the explanatory variables explaining costs do not vary much across time (ie they are stable over time for each company) and the model estimation may, in effect, be relying on the variation across the 18 observations (18 companies) to estimate coefficients for these explanatory variables.

201. The R-squared in Ofwat's models are all very close to one (at least equal to 0.985) which is an indication that the model is over-fitted.

202. The probability that estimated coefficients reflect spurious rather than causal effects is greater when the sample size is small compared to the number of parameters.[41] Moreover, multivariate methods are problematic in this respect because such data are often high-dimensional and have an inherent complex

---

[41] Freedman, DA. (1983) 'A note on screening regression equations.' *The American Statistician*, p37, paragraphs 152–155.
Stauffer, DF, Garton, EO and Steinhorst, RK (1985) 'A comparison of principal component from real and random data'. *Ecology*, 66, pp1693–1698.
Flack, VF and Chang PC (1987), 'Frequency of selecting noise variables in subset regression'. *The American Statistician*, 41, pp84–86.

structure which is the case for many of the explanatory variables in the cost equation used by Ofwat (eg interaction terms or variables that are ratios of other parameters).[42]

203. Whether the model is over fitted is intrinsically related to lack of degrees of freedom (constraints on one variable after controlling for the rest of the parameters in the model). Furthermore, the relatively limited variation over time for some of the explanatory variables might reduce the effective sample size.

204. The very high correlations between some of the explanatory variables (eg correlation of 0.92 between proportion of usage by metered household properties and proportion of metered properties) might be an indication of more than a single variable capturing very similar effects on costs. This is related to the multi-collinearity problem that increases the standard errors of the estimators, making them less precise and potentially unreliable. The multi-collinearity problem seems particularly high in the full totex model.

205. Ofwat told us that, in relation to our comments on the number of explanatory variables, it considered that its refined models struck a reasonable balance between sample size and number of explanatory variables and were similar in this respect to some alternative models that we had proposed (see the alternative models in Section 4 of our provisional findings). Ofwat also said that it recognised the limitations of the full model but considered that the benefits of including one such a model in its triangulation (the model being less likely to suffer from omitted variable bias) outweighed the risks from over specification.

206. We agreed with Ofwat that the issue of the number of explanatory variables is more problematic for the full totex models than for the refined totex models. We were not persuaded that the full model brought net benefits. The ability of the full model to reduce risks of omitted variable bias is limited by the small sample size relative to the number of explanatory variables and several of the estimated coefficients were counter to what CEPA had expected.

207. We still had concerns about the number of explanatory variables in the refined model, especially given the lack of variation over time in many of the explanatory variables in the sample.

---

[42] Rextad, EA, Miller, DD, Flather, CH, Anderson, EM, Hupp, JW, and ANDERSON, DR (1988). 'Questionable multivariate statistical inference in wildlife habitat and community studies'. *Journal of Wildlife Management* 52, pp794–798.

Relatively short data period

208. Running the econometric models over a longer time period would increase the sample size and may allow for a more accurate analysis of the extent to which each explanatory variable affects costs. This would depend on the extent to which data is reported on a reasonably consistent basis over time and also whether the model specification is vulnerable to any significant changes in the relationship between an explanatory variable and costs over the sample period.

209. The final models recommended by CEPA and used by Ofwat for the water service used a panel data set covering 18 companies over the five-year period from 2008/09 to 2012/13. Ofwat's dependent variables, totex and base expenditure, are both constructed using a smoothed measure of capex, which took a moving average of capex over the last five years. As a result, Ofwat's models drew on capex data over a nine-year period from 2004/2005 to 2012/13 and opex data for the five-year period 2008/09 to 2012/13.

210. CEPA's earlier report for Ofwat in January 2013 had referred to a data set available for use in the econometric modelling that covered the five-year period from 2001/02. Ofwat told us that there were a number of differences between CEPA's initial data set and the final data set used by CEPA to produce the final models:

    (a) They cover different time periods. The initial data set used by CEPA actually covered the period 1996/97 to 2010/11, whereas the final data set covered 2008/09 to 2012/13.

    (b) The initial data set included more potential explanatory variables (ie explanatory variables that CEPA did not use for its final models).

    (c) The initial data set 'included relatively crude assumptions' to split opex between wholesale and retail. Ofwat said that it was able to use a more sophisticated approach for the final data set.

211. CEPA did not provide a full explanation of its decision to use a sample period of five years only for the water service. It highlighted the constraints of the random effects approach which it considered better to run using a short time period. This is because the assumption used by CEPA and Ofwat that the time-invariant random effect was attributable to relative efficiency would be less plausible the longer the time period over which the random effect model was run (we would not expect relative efficiency differences to persist unchanged over a lengthy period of time). That assumption would not be relevant to the OLS models (three of CEPA's final five models were OLS models).

212. CEPA said the following on the effects of using different time periods:[43]

> In general the long panel estimates were very similar to the short panel estimates. Where the model parameters were dissimilar, the long-panel estimates were within the short-panel confidence intervals.

213. We cannot be sure from this statement that the effects of using a longer data period would be immaterial for Bristol Water. The confidence intervals for the estimated coefficients in Ofwat's models are often wide, so CEPA's statement above does not mean that there would be no effect on the cost assessment for each company if a longer data period had been used.

214. The relatively short data period used by Ofwat is a potential concern. We recognised that using a longer time period would increase the risks of inaccuracy arising from the need to make an approximate split between wholesale and retail activities in the period before Ofwat's data reporting requirements provided for such a split. However, since retail costs are a small proportion of overall costs, the inaccuracy from cost allocation did not seem sufficiently large to rule out a longer time period.

215. Ofwat's view was that simply increasing the length of the data set may not improve the robustness of the model estimates due to limited variation in some of the explanatory variables. We did not consider this to be a strong point. Even if explanatory variables do not vary over time, the level of expenditure may do, and a longer time period may reduce risks that the results are affected by short-term non-causal correlations between expenditure and explanatory variables.

Pre-modelling adjustments as alternative to statistical estimation

216. Where we identify differences between companies' operating environment and circumstances, besides relative efficiency, that are likely to affect their costs, we can seek to take account of them through the benchmarking analysis. One way to do so is to include an explanatory variable in the econometric model that captures these differences and allows the econometric model to make an estimate of the extent to which that factor affects costs. This is the approach that Ofwat and CEPA took to the modelling.

217. There is an alternative approach which is to make a non-econometric adjustment to the cost data to take account of that factor before running the

[43] CEPA (March 2014), Cost assessment – advanced econometric model, p12.

econometric analysis (eg to normalise the cost data for assumed regional wage differentials between companies) and then to apply a corresponding adjustment for that factor to the cost estimates for each company (eg to re-introduce the assumed regional wage differences). This second approach requires an assumption on the extent to which the factor (eg regional wage differences) affects costs.

218. Where the sample size is small, there are significant risks that an econometric estimate of the extent to which a factor affects costs will be inaccurate, or that correlations between that factor and other parts of the model will be detrimental to the overall assessment. The pre-modelling adjustment approach may be an improvement in cases where we can form a reasonable view on the extent to which a factor affects costs, outside of the model.

219. This approach has previously been used to make adjustments to costs for differences in regional wage rates, drawing on regional wage data and estimates of the proportion of costs that is likely to reflect regional wage differences. This is the approach that Ofgem has taken in its price control cost assessment for electricity distribution companies, most recently for RIIO-ED1.[44] The CC also adopted this approach in its final determination for Northern Ireland Electricity Limited in 2014.

220. Besides wages, another area where pre-modelling adjustments might have a role, rather than econometric estimation, as a means to account for differences between companies is for differences in service levels. Differences in elements of the quality of service provided by companies may affect their costs, but the scale of effect on costs may be quite small as a proportion of totex and it may be difficult for the econometric models to make an accurate estimate of the relationship. It may be possible to use other data sources and information to make adjustments to 'normalise' costs of companies on aspects of service quality before the econometric modelling.

221. Ofwat's approach to cost assessment did not seem to consider alternative methods that involved this type of pre-modelling adjustment or to provide an evaluation of its relative merits in the context of the small sample size.

222. Ofwat told us that it did not believe that Ofgem's approach of making pre-modelling adjustments for wages offered clear benefits over Ofwat's econometric treatment of wages and Ofwat believed that Ofgem's approach

[44] Ofgem (28 November 2014), RIIO-ED1: Final determinations for the slow-track electricity distribution companies, p41.

was driven by the smaller sample size (number of companies) available to Ofgem.

223. Bristol Water said that it considered it preferable to use pre-modelling adjustments to adjust for factors such as regional wages, because there was a risk that the regional wage term was correlated with other variables in some of the models and therefore capturing more than the regional wage impact. Bristol Water said that that using a pre-modelling adjustment would address this issue.

Supporting information on alternative econometric models

Introduction

1. This appendix provides supporting information on the specification of the alternative econometric benchmarking models which we used in Section 4 of our determination. We provided an overview of these models in Section 4 (see Tables 4.4 and 4.5).

2. Our development of alternative models focused on models of base expenditure. We did not seek to identify alternative models of totex, which included enhancement expenditure, because we were particularly concerned about the difficulties of capturing differences in companies' enhancement requirements in the models.

3. This appendix is organised as follows:

   (a) The first section concerns the specification of the dependent variable, which is the measure of expenditure that the model compares across companies and over time (paragraphs 4 to 46).

   (b) The second section concerns the specification of the explanatory variables in the model (paragraphs 47 to 152).

   (c) The third section concerns the model estimation approach and, in particular, the choice between the pooled OLS and GLS random effects approaches used for Ofwat's models, as well as the potential use of SFA proposed by Bristol Water (paragraphs 153 to 168).

   (d) The fourth section discusses several issues arising from our review of the alternative models and from submissions that we received from Ofwat and Bristol Water as part of our model development process (paragraphs 169 to 223).

   (e) The final section presents model estimation results for the 18 models presented in Section 4 of our provisional findings (paragraphs 224 to 225).

Specification of the dependent variable

4. This section considers the specification of the dependent variable. We take three aspects of this specification in turn:

(a) Aggregate expenditure versus average expenditure per customer (paragraphs 5 to 21).

(b) Smoothed versus unsmoothed treatment of capex (paragraphs 22 to 32).

(c) Logarithmic versus non-logarithmic expenditure measures (paragraphs 33 to 46).

Aggregate expenditure versus average expenditure per customer

Our approach

5. Ofwat's econometric models used measures of totex and aggregate base expenditure as the dependent variables. As an alternative to Ofwat's approach, we explored models which made comparisons between companies' measures of expenditure per customer. More specifically, we used a measure of expenditure per connected property as the dependent variable in the econometric model.

6. We considered that benchmarking comparisons between companies in measures of expenditure per property supplied was a reasonable starting point for comparisons between water companies. Comparisons of aggregate expenditure were difficult to make at an intuitive level because of the variation in scale between companies in Ofwat's sample. Over the period of Ofwat's data, the companies ranged from serving around 120,000 properties (Dee Valley Water) to serving around 3.6 million properties (Thames Water). Making comparisons of expenditure per property supplied provided a way to make comparisons between water companies more intuitive and meaningful.

7. Using expenditure per connected property as the dependent variable also brought three benefits:

   (a) Our unit cost models reduced problems relating to the small size of the data sample (and limited variation over time for some variables) relative to the number of potential cost drivers. A unit cost model of the type we have used requires one less explanatory variable than aggregate expenditure models used by Ofwat because the measure of companies' scale (eg number of properties supplied or total length of mains) can be used in the dependent variable rather than required as an explanatory variable. In a small sample size, this may allow other more important cost drivers to be captured in the model.

   (b) There were correlations between many of the variables that we would consider cost drivers for totex (eg total length of mains, number of

customers, total water delivered), which reflected underlying differences between companies in the scale of their activities and services. Such correlations may make it difficult for the econometric estimation to produce reasonable estimates of the relationship between an explanatory variable and costs, because it will be difficult to isolate the effect of that factor on costs from the effect of other correlated factors. An approach of dividing both the dependent variable and potential explanatory variables by a measure of scale (such as the number of properties supplied) means that the explanatory variables are less likely to be correlated with each other and this reduces the problems from multi-collinearity. Bristol Water referred to this argument in favour of unit cost models as part of its work on models of IRE.[1]

(c) We considered that the unit cost model made greater sense from an intuitive perspective, in terms of understanding the implied relationship between costs and the cost driver. We found it difficult to interpret aspects of Ofwat's models, which combined a dependent variable of aggregate expenditure with a series of explanatory variables, some of which were based on aggregate figures (eg total length of mains) and some of which were proportions or ratios.

8. The second and third issues were, to some degree, related. We identify below that for a number of potential cost drivers, a linear or non-logarithmic relationship with expenditure seems more reasonable from an intuitive or theoretical perspective than a logarithmic relationship. The expenditure per connected property model structure that we used provided a way to specify models with linear relationships between cost drivers and expenditure (provided both the dependent variable and explanatory variable were normalised in a consistent way). Whilst it would be possible to specify a linear model with aggregate expenditure (rather than expenditure per customer) as the dependent variable, the explanatory variables that would be needed for such a model are likely to suffer from multi-collinearity.

9. One possible objection to the specification of expenditure per customer as the dependent variable is that it might imply an assumption that there are constant returns to scale in the relationship between expenditure and the number of customers. However, using cost per customer as the dependent variable does not, by itself, mean that the model must preclude allowances for economies of scale. The assumptions of the model specification in relation to economies of scale with respect to the number of customers depend on both the dependent variable and the explanatory variables. It would be possible to allow for

[1] Bristol Water SoC, paragraph 1037.

economies of scale in a unit cost model by adding an additional explanatory variable to the model that relates to the number of connected properties. For instance, the additional explanatory variable might be the number of connected properties or perhaps the inverse of this. In each case, this would allow the model estimation to identify potential relationships between the number of connected properties a company has and its average expenditure per connected property.

10. Nonetheless, we did not include in our unit cost models an explanatory variable for economies of scale with respect to the total number of properties that a water company supplies. We did not identify a good reason why a greater number of properties should, on its own, materially decrease expenditure requirements per property.

11. We recognised, instead, that having more properties located within a network of a given size (length) or geographic area may help to reduce costs per customer. We allowed for this by using an explanatory variable of length of network divided by connected properties in the unit cost models.

12. Furthermore, even if there was some degree of economies of scale with respect to customer numbers, there was still an argument in favour of unit cost models in that these require one less explanatory variable and, in a small sample size, may allow other more important cost drivers to be captured in the model.

13. Whilst we see value in unit cost models that compare measures of expenditure per property supplied between companies, we did not restrict our analysis to these unit cost models. We also considered models that compare aggregate expenditure between companies, in line with the approach taken by Ofwat.

Ofwat's submissions on unit cost models

14. Ofwat disagreed with the use of unit cost models. Ofwat considered it a major drawback that these unit cost models implied constant returns to scale in the relationship between expenditure and the number of properties supplied. Ofwat said that it was normal practice in econometrics to allow the model to determine the economies of scale rather than impose a strict structure on the effect of scale.

15. Our approach to model specification reflected the risks of misleading results from econometric model estimation using a data set with a small sample size and limited variation over time in some explanatory variables. We did not

consider it safe to rely on the statistical results in isolation to determine the model specification.

16. We had found that Ofwat's refined base expenditure model (OLS) implied a form of diseconomies of scale that was counter-intuitive. We thought that this result may be due to the inaccuracies in estimation results arising from the small sample size. As discussed in Appendix 4.1, Ofwat provided reasons why there might be diseconomies of scale with respect to the number of customers, but we found that Ofwat's arguments related to other issues (eg why costs per customer may increase as the number of customers per square kilometre increased) and did not explain the form of diseconomies of scale that we were concerned about.

17. We did not consider that it was unreasonable to use models that assumed constant returns to scale with respect to the number of customers. Neither Ofwat nor Bristol Water provided a good reason to consider that some of the smaller water companies in our data sample were operating at an inefficiently small scale or suffered from significantly higher levels of base expenditure per property as a consequence of smaller supplier areas and lower customer numbers.

18. Furthermore, as highlighted above (paragraph 7), we identified significant benefits from the unit cost models.

19. Ofwat also questioned our inclusion of linear unit cost models in which the dependent variable was not a logarithm. Ofwat said that the use of log-transformed equations in efficiency studies was the norm rather than the exception, and any deviation from this norm should be well-justified.

20. We provide further discussion of logarithmic and non-logarithmic models below (paragraphs 33 to 46). To summarise, decisions about whether the dependent variable and the explanatory variables are logarithms are decisions (explicit or implicit) about the relationship between costs and the cost drivers assumed for the purposes of the model. Assuming a linear relationship between costs and the cost driver was different to assuming a logarithmic relationship. All models will be approximations, but we found that a linear relationship between unit costs and the cost drivers was reasonable. We also found that Ofwat's use of logarithms for explanatory variables that were expressed as proportions implied untenable assumptions about the relationship between expenditure and cost drivers.

21. Overall, we considered there to be good reasons for using the linear unit cost models. However, we also recognised that all models involve imperfections and approximations and there was merit in considering a range of

approaches. In our model development work, we considered a range of models which included: models of aggregate expenditure as well as unit cost models; and models with the dependent variable, and some explanatory factors, in logs as well as linear (non-logarithmic) models.

Smoothed versus unsmoothed treatment of capital expenditure

22. In considering the use of smoothed and unsmoothed models, we found that it was important to distinguish between two parts of the overall methodology:

    (a) The specification of the econometric models to be applied to the historical data on water companies' expenditure.

    (b) The method used to take the results (estimated coefficients) from the econometric models from (a) and produce an estimate of Bristol Water's expenditure requirements in the period from 1 April 2015 to 31 March 2020.

23. Our focus in this subsection is point (a). We also gave detailed consideration to point (b), and this led to a refinement of our approach between our provisional findings and determination. We discussed point (b) in Section 4 (paragraphs 4.112 to 4.124).

24. Ofwat's models specify the dependent variable, for each year, as a measure of opex plus a measure of capex that was an average of capex over a five-year period: that year and the previous four years. Ofwat described this approach as smoothed capex. This can also be described as a moving average treatment of capex.

25. Variations in capex between companies, and over time, are driven, in part, by differences in the timing of companies' investment requirements and may also be significantly affected by companies' strategic decisions within the context of a five-year price control period. Such variations over time and between companies may distort the estimated relationship between expenditure and the explanatory variables in the model. In this context there are also risks of drawing misleading inferences about efficiency differences between companies at a point in time from benchmarking analysis of totex.

26. The approach of using average capex over a five-year period might reduce these problems by averaging out fluctuations over a five-year period. In particular, if there tends to be a five-year cycle in investment due to the price control period, the approach would reduce (or remove) the effect of the cycle on the dependent variable. However, the approach seems unlikely to eliminate the more general problem that companies' capex will show

variations due to differences in their investment needs at a given point in time: a five-year average appears to be too short to address this concern.

27. The smoothed approach also has other effects:

(a) It reduces the time period of the sample. If the measure of totex was defined to include capex from the past five years, then a nine-year period of raw data will only allow for a five-year period of data to use for estimation of the econometric model. Using a smaller sample period might lose useful information that could otherwise help improve the reliability of estimated relationships between expenditure and the explanatory variables.

(b) It introduces inconsistency between the period of time covered by the dependent variable and the period of time covered by the explanatory variables. For instance, the observation in the data set for a particular company in 2009/10 will reflect that company's expenditure over the period 2005/06 to 2009/10 but the explanatory variable data (eg average consumption per property or the regional wage measure) will apply only to 2009/10. This inconsistency could distort model estimation results and makes the interpretation of coefficients more difficult.

(c) It was not entirely consistent with the objective of carrying out benchmarking analysis on the basis of totex. The dependent variable for Ofwat's models was not, strictly speaking, a measure of a company's totex in a year, but rather a measure of the company's opex in the year plus average capex over the past five years. This introduces a different treatment of opex and capex into the benchmarking analysis, which may cause distortions to results.

28. For this reason, we explored two types of models:

(a) Following Ofwat's approach, using capex averaged over five years (the smoothed approach).

(b) Models that use the sum of opex and capex in a year for the expenditure measure, without averaging, and which made use of a longer period of available data for estimation and, therefore, a larger sample size.

29. The main data set that Ofwat provided to us used seven years of data, from 2006/07 to 2012/13. That data set was consistent with that which Ofwat used for its econometric analysis, and had undergone some quality assurance processes by Ofwat. We used this seven-year data set for the unsmoothed approach under (b) above. Whilst we could see benefits in exploring a longer

data period than seven years, neither Ofwat nor Bristol Water provided a comprehensive data set that could be used directly for our analysis.

30. Bristol Water said that it considered the unsmoothed approach superior to Ofwat's smoothed approach. It agreed that the unsmoothed approach has disadvantages in terms of: *(a)* reducing the time period for the assessment; *(b)* introducing an inconsistency between the time period of the dependent variable and the time period of the explanatory variable; and *(c)* giving rise to distortions in the results between opex and capex. Bristol Water highlighted that, whilst the unsmoothed approach had limitations, the smoothed approach suffered because the cost driver information in a particular year would not relate in a meaningful way to the capital maintenance expenditure over the previous five-year period.

31. We had initially considered both a five-year and seven-year version of the unsmoothed approach, and shared the results of some initial models on this basis with Bristol Water and Ofwat. Bristol Water argued in favour of the five-year unsmoothed approach. It said that for the purpose of providing an accurate assessment of its future expenditure needs it was important that the models were not influenced by the unrepresentative AMP4 period and that given the trend in investment expenditure between AMP4 and AMP5, there was a real risk that the results for Bristol Water would be distorted under both the smoothed approach and the seven-year unsmoothed approach.

32. In the initial analysis we had carried out, the results had been similar between the seven-year and five-year unsmoothed models, with an average difference of around 1% (the five-year smoothed model being higher) across two sets of comparable model specifications. Given the scale of this difference, and to keep the number of models under consideration manageable, we retained only the seven-year unsmoothed models for our determination. We saw merit in the longer sample period of the seven-year version. We did not agree with Bristol Water's arguments that we should use the five-year unsmoothed models. Bristol Water did not explain why we should give more weight to the more recent data, across the industry, for AMP5 than the data from AMP4. Bristol Water considered that the AMP4 data was unrepresentative but did not explain why this was so across the various water companies in our sample.

Logarithmic versus non-logarithmic expenditure measures

33. A further decision on the dependent variable to take was whether or not to specify the dependent variable as a natural logarithm of the expenditure measure.

34. CEPA said that a model specification in which both costs and explanatory variables were expressed as a natural logarithm 'is deemed superior to a linear model in the cost modelling literature as it does not require marginal costs to be constant as in the linear model'.[2] Ofwat also argued in favour of models that used natural logarithms for the dependent variable, stating that the use of log-transformed equations in efficiency studies was the norm rather than the exception and that any deviation from this norm should be well justified.

35. We recognised that there can be good reasons for a logarithmic specification. However, the application of cost modelling to the price controls for water companies in England and Wales, and the specific types of explanatory variables used, seemed sufficiently different to cost modelling in other economic literature that we did not consider it safe to rely on general inferences and views about normal practice.

36. In its model development for Ofwat, CEPA seems to have addressed the question of log versus linear models by focusing on the restrictive assumption of a linear model: that marginal costs (the impact on costs of a small change in the cost driver) are taken to be constant across companies. CEPA showed limited attention to the restrictive assumption involved in the type of logarithmic models that it favoured.

37. A model in which the dependent variable is expressed as the logarithm of expenditure implies that each cost driver has a proportionate effect on expenditure. In some cases, this assumption makes sense. However, this assumption may be problematic in other cases, especially for the type of model that Ofwat used. For example:

    (a) Ofwat's models cover the whole wholesale water service, yet a number of the cost drivers used by Ofwat relate only to costs in a specific activity or part of the value chain. For instance, differences between companies in pumping head are assumed in Ofwat's full totex model to have a proportionate effect on costs (ie a 1% greater pumping head would increase totex by X%, where X is taken to be the same across companies and over time). However, the relationship between pumping costs (both energy costs and capital maintenance of pumping stations) seem unlikely to be proportionate to totex. If a company has higher totex because it requires relatively complex water treatment processes, we would not expect this to affect the relationship between pumping head and its

[2] CEPA (March 2014), *Cost assessment – advanced econometric model*, pi.

pumping costs. There seems to be no reason why the impact on totex (in £ million) of an increase in pumping head would be proportionate to totex.

(b) For some of the cost drivers, the relationship with costs seems poorly approximated by a logarithmic relationship and a linear approximation makes more sense. For instance, if we had a model with the logarithm of water resource and treatment costs as the dependent variable (to avoid problem (a) above), which included the logarithm of the proportion of water from rivers as an explanatory variable (as Ofwat's models use), this would imply that the impact of a given increase in water from rivers, in Ml/day, would be proportionate to the company's total resource and treatment costs. A positive coefficient would imply that the impact on costs, in £ million, of taking an additional 5 Ml/day of water from rivers would be greater for a company that was taking a lot of water from other sources (and hence the proportion of water abstracted from rivers was low) than for a company that takes little water from other sources (and hence the proportion of water abstracted from rivers was high). Thus, the unit cost (£ per cubic metre) of abstracting more water from rivers was contingent on how much water the company takes from sources other than rivers. We have not identified a good basis for assuming such interdependencies in the model specification. A better approximation, which was available from a linear unit cost model, was that water from river sources has, on average across the industry, an additional cost of X pence per cubic metre than water from other (eg borehole) sources.

38. It was possible that the translog functional form favoured by Ofwat could, in some circumstances, mitigate the issues above to some degree by taking greater account of interactions between different cost drivers in explaining cost differences between companies. However, even if this were the case, the problem would remain unresolved for almost all of the cost drivers used by Ofwat. This was because Ofwat's models only applied its translog functional form to a subset of three cost drivers. More generally, we doubt that with a small sample size the estimation of coefficients on any translog terms will be sufficiently accurate to mitigate the issues above.

39. The choice of functional form of the model was not a choice between a functional form that involved a restrictive assumption on the relationship between costs and cost drivers and one that does not. The choice was between alternative functional forms that each involve different restrictive assumptions on these relationships. From this perspective, there was sense in considering which was the least bad restrictive assumption:

(a) **Non-logarithmic unit cost**. The restrictive assumption that the impact on totex (per property), from a given change in the cost driver, was the same

in £ across all companies and over time (holding other cost drivers constant).

(b) **Logarithmic unit costs**. The restrictive assumption that the impact on totex (per property), from a given change in the cost driver, was the same as a percentage of totex (per property), across companies and over time.

40. We considered the balance between (a) and (b) for a set of cost drivers we have identified for inclusion in our alternative set of models. Table 1 below presents our high-level assessment. Since both types of assumptions will be gross simplifications of the underlying factors that affect costs, it was difficult to make this assessment and it should be treated with caution (we add a question mark to denote areas that we were particularly uncertain about). Nonetheless, we found this to be a useful exercise, which raised questions about the logarithmic specification when applied to totex and base expenditure models.

Table 1: High-level assessment of functional form for dependent variable

Potential cost driver	*Assumption of non-logarithmic unit cost seems least bad*	*Assumption of logarithmic unit cost seems least bad*
Proportion of raw water from rivers	✓	
Proportion of raw water from reservoirs	✓	
Proportion of raw water subject to W3/W4 treatment	✓	
Regional wage measure (or proportionate change in wage measure)		✓
Average pumping head	✓	
Total length of mains divided by total properties supplied	✓ (?)	
Average water delivered per property	✓	
Proportion of consumption by metered non-household customers		✓ (?)

Source: CMA analysis.

41. The implication from the table above was that, at least for a model in which the dependent variable is expenditure per connected property, the non-logarithmic specification of the dependent variable seemed preferable for a number of cost drivers.

42. In the light of this, we took the following approach:

(a) We estimated models that follow Ofwat's approach of specifying the dependent variable as a logarithm of expenditure.

(b) We also estimated linear models that use expenditure per property as the dependent variable, without conversion to logs.

43. Neither is entirely satisfactory: it seemed that some cost drivers would call for approach *(a)* and others would call for approach *(b)*. It may have been possible to develop an alternative approach that addresses this issue through a more complex modelling strategy, but this was not a priority for our model development.

44. For the purposes of our alternative model development, we considered both functional forms (both of which seem imperfect). This had implications for the way that explanatory variables are specified. Because we used logarithmic and non-logarithmic models, we specified the explanatory variables slightly differently for each type. If the dependent variable in a model was expressed as a logarithm, it may also make sense for the explanatory variables to be expressed as logarithms. However, this was not always so. We considered a case-by-case review to be appropriate for each explanatory variable.

45. Note that if the dependent variable was an aggregate expenditure measure, rather than a unit cost measure, it does not make sense to use the non-logarithmic model. We use only the logarithmic approach to the dependent variable for our aggregate expenditure models.

46. Finally, we did not consider that we should make the decision on which functional form to use based solely on statistical results. We disagreed with the approach implied by Ofwat and CEPA on this issue. CEPA stated that with respect to the functional form of model, 'the choice is about how good a fit the form provides'.[3] We considered goodness of fit to be relevant, but we did not consider that the choice of functional form could be reduced to goodness of fit alone. There seemed to be no reason to believe that the functional form that provided the best fit of the data in statistical terms would necessarily provide the most reliable model for the purpose of estimating companies' future efficient expenditure requirements or for the purpose of comparing the relative efficiency of companies. Such a model might perform relatively well at attributing variations in costs between companies, and over time, to the explanatory variables included in the model. But that does not mean that the estimated coefficients are the most accurate or reliable estimates of the causal relationships between cost drivers and companies' expenditure requirements. This was particularly so given our small data sample which showed limited variation over time in some of the explanatory variables.

[3] CEPA (March 2014), *Cost assessment – advanced econometric model*, p7.

Specification of explanatory variables

47. This section considers the explanatory variables that can be included in the model specification. It takes the following in turn:

    (a) Use of Ofwat's explanatory variables as a starting point (paragraphs 48 to 61).

    (b) The explanatory variables relating to raw water quality (paragraphs 62 to 74).

    (c) The use of distribution mains age as an explanatory variable (paragraphs 75 to 81).

    (d) We provide a more detailed discussion of the explanatory variables used by Ofwat and Bristol Water (paragraphs 82 to 149).

    (e) We provide measures of correlation across explanatory variables (paragraphs 150 to 152).

Use of Ofwat's explanatory variables as a starting point

48. We took Ofwat's econometric models as a starting point for specification of explanatory variables for our alternative models. This reflected the extensive work done by CEPA and Ofwat and the data readily available for the purposes our inquiry.

49. We reviewed Ofwat's explanatory variables, with emphasis on two issues:

    (a) Whether the explanatory variable featured a cost driver that was likely to contribute positively to the model estimation, in the context of a small sample size.

    (b) Whether the way that the explanatory variable incorporated this cost driver was appropriate (eg whether the cost driver was expressed in absolute terms or as a proportion and whether it was in logs). In considering this second issue, it was relevant that in some cases our dependent variable was a measure of expenditure per customer, which differed from Ofwat's dependent variable.

50. We discuss these two issues below.

Explanatory variables that did not seem likely to contribute positively

51. We were concerned that the inclusion of some potential explanatory variables used by Ofwat could worsen the reliability or accuracy of the model, and

excluded them on this basis. For example, we excluded explanatory variables where we had concerns that CEPA's reports for Ofwat did not provide a good explanation of the economic (rather than statistical) case for including them (where it was not otherwise obvious), and also where we had concerns that the factor would be misleading for our intended purposes because of an ambiguous relationship with costs.

52. In an ideal world, with a large data set, it might be possible to include a large number of potential – or experimental – cost drivers as explanatory variables and take the view that if the cost driver is important it will show up in the estimated results. We did not consider this safe for our analysis.

53. With a small sample, every additional explanatory variable we add raises a risk of spurious (non-causal) correlations with the dependent variable and the other explanatory variables. If the additional explanatory variable was an important cost driver (or heavily correlated with an important cost driver that has been omitted) the inclusion of that variable may bring improvements to the model, despite those risks. However, in other cases, adding an additional explanatory variable may lead to model estimation results that worsen the accuracy of the cost estimates derived from them.

54. To take an extreme example, if there was a variable that we knew affected companies' costs but that had a maximum impact of 0.1% of totex it would, at best, add no material benefit to estimation results. But if the variable happened, by chance, to be correlated with companies' costs or relative efficiency – or with the other explanatory variables – it could worsen the accuracy of the model estimation results overall.[4]

55. There were risks of misleading results due to the small sample size relative to the range of factors that affect water companies' costs. These risks were compounded by the limited variation over time in some of the potential explanatory variables. We considered the counter-intuitive estimated coefficients from Ofwat's full totex model to be indicative of these risks.

56. We considered it preferable to use a smaller set of explanatory variables, which captured what seemed to be the most important cost drivers available from the data set.

57. In addition, we were concerned that some cost drivers would have an ambiguous effect on costs, which reflected in part the potential endogeneity in

[4] In considering accuracy, it is important to keep in mind that the estimated coefficients from the models are used to make an estimate of expenditure requirements for a specific water company. The point estimate for the coefficient could have a material effect on estimated expenditure requirements regardless of the size of the confidence interval for that estimated coefficient.

the explanatory variables. For instance, a measure of low quality service might be indicative of relatively low expenditure (lower costs are incurred in providing a lower quality service) or indicative of relatively high expenditure (higher expenditure was needed to address problems with service quality). In the absence of a way to disentangle these opposing effects (eg an instrumental variable approach that captured one effect only), we were concerned that any coefficient estimated for that explanatory variable would not make a reliable contribution to the estimation of companies' future efficient expenditure requirements.

58. As part of our work, we asked Bristol Water which (if any) of the explanatory variables from Ofwat's econometric models it considered – from an economic, engineering or business perspective – to be immaterial to differences in base expenditure between companies. We defined 1% of base expenditure as the materiality threshold. Bristol Water's response took each of the explanatory variables in Ofwat's models in turn, and considered both whether these were appropriate and whether they were material. Bristol Water identified the following subset of the variables used by Ofwat as both appropriate and material (we leave aside variables that were only relevant to models including enhancement expenditure):

    (a) Length of mains.

    (b) Regional wage.

    (c) The number of connected properties.

    (d) Proportion of usage by metered non-household properties.

    (e) Pumping head.

59. In many cases, Bristol Water's views were consistent with our own initial view of Ofwat's explanatory variables, but this was not always the case and we avoided placing undue reliance on Bristol Water's submissions.

Refinement of explanatory variables to better reflect cost drivers

60. We also reviewed the way that Ofwat's models incorporated potential cost drivers into the specification of explanatory variables. We found that these models imposed assumptions on the relationship between expenditure and cost drivers that did not always make sense. (See the discussion on the assumed relationship between expenditure and the cost drivers in our review of Ofwat's models in Appendix 4.1.)

61. To take an example, we considered that the proportion of raw water from river sources was a relevant cost driver to consider. But, on further analysis, it did not seem reasonable to incorporate this cost driver in any of our models by including an explanatory variable defined as the natural logarithm of the proportion of raw water from river sources.

The explanatory variables relating to raw water quality

62. The nature and quality of raw water available to a company was a potentially important cost driver. Ofwat's cost assessment process had revealed that this was a particularly important issue for Bristol Water.

63. The set of econometric models that CEPA developed for Ofwat included an explanatory variable relating to the proportion of a company's distribution input that comes from river sources and an explanatory variable relating to the proportion of a company's distribution input that comes from reservoir sources. This reflects the view that, on average, water from different types of source will have different costs for raw water abstraction, storage, transportation and treatment. These explanatory variables had been used in Ofwat's econometric models for opex at its previous price control reviews.

64. Bristol Water disagreed with this approach of using explanatory variables relating to the use of river and reservoir water sources. It favoured an explanatory variable which concerned the complexity of each water company's treatment processes. Specifically, Bristol Water proposed using a measure of the proportion of a water company's distribution input that was from water treatment works categorised as W3 or W4 works in terms of the complexity of their treatment processes (where these implied more complex processes than works categorised as either W1 or W2). The data on this categorisation was previously collected by Ofwat but was no longer collected.

65. Bristol Water argued as follows:

    (a) While water from rivers tended to be harder to treat than that from boreholes, there was a wide degree of variation. Some rivers such as upland sources or chalk streams could have relatively high-quality raw water and required little treatment. On the other hand, lowland rivers with hard water at the end of large catchments could be very difficult to treat (due to difficult-to-remove factors such as colour, nitrates and pesticides).

    (b) There was also a large variation in the costs of treating groundwater. Water from deep wells could be very high quality and need no treatment at all. Other groundwater sources might be closely tied to surface water and therefore exhibit wide variations in quality, often with poor quality

during wet weather (this was true of many of Bristol Water's ground water sources). As such these groundwater sources might require more complex treatment than some river sources.

(c) While raw water from reservoirs tended to be harder to treat than groundwater, there was a wide variability. Water from upland reservoirs tended to be much higher quality than water in lowland reservoirs. As a result, the treatment costs for United Utilities, which had a large number of upland reservoirs (in the Lake District and the Pennines), would be much lower than for Bristol Water, where Chew and Blagdon reservoirs in particular were effectively just impounding poor-quality lowland river water. In addition, factors such as algae can vary significantly from reservoir to reservoir leading to significant variation in treatment complexity and cost.

66. Bristol Water said that while the data on the W3/W4 variable was becoming out of date, as Ofwat discontinued collection of it in 2008/09, changes in raw water quality were likely to be slow, and it considered the data to be likely to be a reasonable proxy for raw water quality.[5]

67. Ofwat said that it had a number of reservations about using the W3/W4 variable in its benchmarking models:

(a) The water source type (eg river and reservoir sources) was already used in Ofwat's modelling, and this would reflect treatment complexity.

(b) Ofwat had concerns over the reliability of the data, as Ofwat stopped collecting W3/W4 data in 2008/09.

(c) If an adjustment to Ofwat's models was to be required for Bristol Water due to atypically complex treatment, Ofwat would expect to see a relatively high level of non-infrastructure spend for Bristol Water compared to the industry over time. Ofwat said that its analysis from 1999/2000 onwards showed that Bristol Water's non-infrastructure maintenance expenditure was consistently below the industry average.

68. Despite these concerns, Ofwat did take account of results from models using the W3/W4 treatment variable in making a special cost factor adjustment for Bristol Water for treatment complexity of £18.2 million.[6] Ofwat explained that this decision reflected a number of factors, including the evidence that Bristol Water had relatively complex treatment works, Ofwat's finding that the W3/W4

---

[5] Bristol Water SoC, paragraph 1500.
[6] For further explanation of this adjustment, see Appendix 4.3.

variable was statistically significant in explaining variations in wholesale water costs across companies when included in the base and refined totex models, and the relatively large gap between Ofwat's analysis of base expenditure and Bristol Water's business plan.[7]

69. We decided that we should consider models with the rivers and reservoirs variables as well as models with the treatment complexity variable. We considered that there were benefits and drawbacks of each approach.

70. Bristol Water's arguments on the differences in raw quality within source types suggested that it was not sufficient to use the rivers and reservoirs variables in isolation. The models with the W3/W4 variable brought a different perspective from the models that used the river and reservoir variables.

71. We were concerned about the W3/W4 data being out of date, but thought that the data would still have indicative value. The data on the W3/W4 variable provided to us by Bristol Water used companies' regulatory reporting up to 2008/09. There was no reported data from 2009/10 onwards. The Bristol Water data series for the W3/W4 variable involved an assumption that the proportion of water subject to the W3/W4 treatment processes was the same from 2009/10 onwards as it had been from 2008/09. From the data provided by Bristol Water, we could see that the data for the W3/W4 variable tended to be similar over time, and where there were changes these were more often increases over time than decreases. The assumption that it was the same from 2009/10 onwards as it had been from 2008/09 made some sense. However, the data limitations mean that there were significant risks of inaccuracy and we did not consider it appropriate to rely exclusively on models that used the W3/W4 variable.

72. The way that we specified the explanatory variables for water source type and the W3/W4 variable depended on whether the dependent variable in the model was in logarithmic or non-logarithmic form. For the logarithmic models we used the proportion of distribution input from rivers (or similarly from reservoirs, or subject to W3/W4 treatment). For the linear unit cost models we used the proportion of distribution input from rivers (or reservoirs, or subject to W3/W4 treatment) multiplied by average potable water delivered per property. We explain this aspect of our approach in Section 4 (paragraphs 4.125 to 4.136).

[7] Ofwat, Final determination cost threshold populated feeder models for Bristol Water.

73. We also considered the explanatory variables for water source type and treatment complexity further as part of the assessment of potential special cost factor adjustments in Appendix 4.3.

74. In addition to the points discussed above, there were some further issues with the use of either the W3/W4 variable or the rivers and reservoirs variables. Both were, to a limited degree, under the control of a company's management and long-term planning. Including them as explanatory variables may overlook potential efficiency differences between companies in their choice of water inputs, water resource planning and water treatment techniques and technologies. Nonetheless, we did not have alternative explanatory factors that could make allowances for differences between companies in available raw water inputs. We considered it better to take account of these issues in an imperfect way than to use models that did not capture them at all.

The use of distribution mains age as an explanatory variable

75. During the course of our model development work, we shared an initial set of models with Bristol Water and Ofwat. This initial set of alternative models included some models that included a measure of each company's average age of water mains as an explanatory variable. Bristol Water considered this variable to be an important cost driver, and we were keen to see the sensitivity of the results to this variable. For these initial models, which varied in several ways to those we used for our determination, we found that the mains age variable increased the estimated base expenditure level for Bristol Water by around £10–£20 million over the period 1 April 2015 to 31 March 2020 (this figure was sensitive to other aspects of model specification).

76. For our provisional findings and our determination we decided not to include any mains age explanatory variable in our models. Instead, we saw an opportunity to take account of the potential for Bristol Water to have relatively high expenditure due to its mains renewal needs through special cost factor adjustments (see Appendix 4.3), drawing on the findings from our review of Bristol Water's business plan forecasts for IRE (Section 5).

77. We identified two concerns with the mains age explanatory variable:

    (a) We were unsure whether, from an engineering and asset management perspective, a simple measure of the average age of a water company's distribution mains should be treated as a cost driver for the purposes of the econometric models of base expenditure. Bristol Water argued that it should be included, but Ofwat took the opposing view.

(b) There were serious limitations with the data available for distribution mains age.

78. We discuss the link between mains age and mains renewal expenditure requirements further in Section 5.

79. There seemed to be no up-to-date data on mains age that we could use for the econometric models. The data provided to us by Bristol Water relied on combining data reported by companies to Ofwat in the past with assumptions to fill in data for missing years. A range of possible assumptions were suggested to us by both Ofwat and Bristol Water, and these highlighted the deficiencies in the available mains age data.

80. For example, for one series that Bristol Water provided to us, which had been used by its consultants, the starting point was reported data for 2010/11 and data for the preceding years was created on the assumption that the average age of mains reduced by one year per year for each year before this; similarly, data for the subsequent years was created on the assumption that the average age of mains grew by one year per year from this date. However, Bristol Water told us that the assumption that the average age of the mains in the data set was increasing by one year per year was unlikely to be valid, and that a more likely ageing rate was around 0.4 years per year. Ofwat had also carried out some analysis that assumed that the average ageing rate was 0.8 years per year. We identified further inconsistencies between the various data series on mains age beyond these assumptions.

81. Because of these issues, the potential contribution to the econometric analysis from the mains age variable seemed low compared with the risks of misleading results, given our small sample size. We considered that it would be more appropriate to exclude the mains age variable from our models and to make a separate assessment of the case for a special cost factor adjustment for Bristol Water's mains renewal requirements (see Appendix 4.3).

Further discussion of Ofwat's and Bristol Water's explanatory variables

82. This section provides further information on our approach to the explanatory variables used by Ofwat. We take each of these in turn and summarise briefly whether and how we used these in our alternative models. We also consider two further variables proposed by Bristol Water (other than the W3/W4 and mains age variables discussed above).

83. For each explanatory variable, there was a question of whether it should be expressed as a logarithm or not. This depended in part on whether the dependent variable was expressed as a logarithm, but it was not always

appropriate to specify the explanatory variable as a logarithm just because the dependent variable was a logarithm. This may be the case, for example, where the explanatory variable was a proportion.

Ofwat variable: ln (total length of mains)

84. For the aggregate expenditure models, we included the natural logarithm of the total length of mains as an explanatory variable, following Ofwat's approach.

85. For models that use cost per connected property as the dependent variable it makes sense to include length of mains divided by number of connected properties as an explanatory variable.

Ofwat variable: ln (number of connected properties / length of main)

86. This variable was the inverse of the total length of mains divided by number of connected properties, which was included as above. For the unit cost models, there did not seem to be a case for including this as a variable in our models in addition to the length of mains divided by number of connected properties; they capture the same thing.

87. For the aggregate expenditure models, we included the natural logarithm of the total number of connected properties divided by the total length of mains as an explanatory variable, following Ofwat's approach. An alternative approach for the aggregate expenditure models would have been to use the total number of connected properties, but there was a high degree of correlation between the total number of connected properties and the total mains length variable (discussed above) which could introduce problems from multi-collinearity.

Ofwat variable: ln (potable water delivered / number of connected properties)

88. Potable water delivered divided by number of connected properties was a measure of average water consumption per property and seemed a potentially important cost driver. We included this in our models.

Ofwat translog variables:

89. The following variables were included in Ofwat's models for the purposes of its translog specification:

    (a) [ln (total length of mains (km)]^2.

    (b) [ln(number of connected properties/length of main (properties/km)]^2.

(c) [Ln(potable water delivered/number of connected properties)]^2.

(d) ln (total length of mains) * ln (number of connected properties / length of main).

(e) ln (total length of mains) * ln (potable water delivered / number of connected properties).

(f) ln (number of connected properties / length of main) * ln (potable water delivered / number of connected properties).

90. These variables were not included in our set of alternative models, which focus on a simpler model structure.

Ofwat variable: time trend

91. We considered that a series of time dummy variables for each year (time dummies) would be better, especially over a short sample period.

92. There may be year-to-year fluctuations in costs across the industry, associated with the price control periods or input price movements, which do not fit well with an upward or downward time trend and which may be better accommodated through a model specification using time dummies.

Ofwat variable: ln (average regional wage)

93. We included this as a potentially important explanatory variable.

94. We also identified some concerns about the regional wage data used as an input to the econometric model. We discuss these in paragraphs 186 to 196 below and in our assessment of special cost factors for Bristol Water in Appendix 4.3.

Ofwat candidate variable: ln (regional construction price index)

95. We recognised the problems Ofwat faced due to correlations between this variable and the regional wage measure, which led to its exclusion from Ofwat's models. We did not include it in our alternative models. We thought that there might be ways to incorporate this variable whilst limiting the risks from multi-collinearity (eg by taking the ratio of the construction index to the wage measure) but we did not consider this to be a priority for our modelling.

Ofwat variable: ln (population supplied / number of connected properties)

96. We did not include this variable in our models.

97. We did not identify an economic or engineering basis for this variable being included in addition to an explanatory variable for the average water delivered per connected property.

98. CEPA stated that this variable approximated 'average consumer size (domestic vs. I&C)' and could be used 'to take some of the variation away from usage'.[8] We did not understand this statement. This variable seemed to take no account of the level of consumption by non-household customers so we did not identify how it could approximate average customer size. The alternative measure of average water delivered per connected property seemed a more direct and relevant measure of the average customer's size.

Ofwat variable: ln (proportion of properties that are metered)

99. We did not include this variable in our models.

100. Wholesale costs exclude meter reading. There will be some incremental wholesale base expenditure costs associated with metered customers, as meters will require replacement from time to time (or perhaps repair). We would expect these costs to be a relatively small element of (wholesale) base expenditure. These did not seem material for inclusion in the models. Bristol Water told us that, for a 20% difference in meter penetration between companies, it would expect the costs to periodically replace meters, and maintain the meter space, to account for less than a 0.5% difference in base costs between companies.

101. Furthermore, the number of metered customers was positively correlated with consumption per property which presents risks of affecting the results for this consumption variable.

Ofwat variable: ln (potable water delivered to billed metered households / total potable water delivered)

102. We did not include this variable in our analysis. The two CEPA reports for Ofwat did not seem to provide an explanation for including this variable, which was highly correlated with the proportion of properties that are metered.

103. We did not identify a reason to include this variable, for similar reasons as above for the explanatory variable based on the proportion of properties that are metered.

[8] CEPA (January 2013), Cost assessment, p11.

Ofwat variable: ln (potable water delivered to billed metered non-households / total potable water delivered)

104. We included this variable in our analysis as a potentially relevant explanatory variable to consider, particularly when used in a model that also included the average consumption per property as the dependent variable.

105. Bristol Water told us that it considered this variable to be an appropriate and material cost driver. It explained that:

> Larger non-household customers tend to be supplied from larger mains and therefore avoid costs associated with the smaller diameter mains that make up the majority of the network. These lower costs are reflected in lower tariffs. Consequently, a higher proportion of water delivered to non-household customers would be expected to reduce costs.

106. It was also possible that a greater usage from non-households would lead to less peaky water consumption patterns across the year, which would tend to reduce costs.

107. We included this variable in some of our alternative models.

Ofwat variable: ln (total number of sources / total water input to distribution system)

108. We did not include this variable in our alternative models.

109. CEPA stated that 'it is a safe assumption that there are economies of scale in the resource and raw water distribution part of the business',[9] but did not provide any information to back up this view.

110. Without any explanation, we are unsure why there should necessarily be a strong relationship between the size of water resources and costs.

111. Even if there were economies of scale in relation to the average size of a company's water sources, it was problematic to include this variable. There was a negative correlation between average size of a company's water source and the proportion of its water from other sources (besides rivers and reservoirs) such as boreholes, which may tend to be significantly lower-cost than river and reservoir sources. Companies that take a relatively large proportion of their water from other sources tend to have a relatively small size of each source.

[9] CEPA (March 2014), *Cost assessment – advanced econometric model*, p46.

112. The results from Ofwat's full totex model showed a negative coefficient for this explanatory variable, which implied that producing a given amount of input from a greater number of sources reduced costs. This result runs counter to the theory of economies of scale that CEPA had identified as a safe assumption. It could be explained by the correlation between the number of sources and the usage of water from boreholes, in a context where borehole sources tend to be cheaper than reservoirs and rivers.

113. With a large enough sample of companies and years, it might be possible to disentangle the effects above. However, for our analysis, we did not include this variable, given the absence of a good explanation from CEPA's reports of the economies of scale argument for including the variable in the first place, and the risks to estimation results from correlations between the number of sources and the proportion of water from boreholes.

*Ofwat variable: ln (average pumping head * total water input to distribution system)*

114. For the logarithmic unit cost models, we used the measure of average pumping head as an explanatory variable.

115. For the logarithmic aggregate cost model, we also used measure of average pumping head as an explanatory variable. To limit risks from multi-collinearity, we did not adopt Ofwat's alternative approach of using average pumping head multiplied by total water input to distribution system as the explanatory variable.

116. For the linear unit cost models, we used average pumping head multiplied by potable water delivered per property as the explanatory variable. This was because greater water consumption per customer would tend to increase pumping costs. These interactions are more important to capture in the specification of explanatory variables in a linear unit cost model than for a logarithmic model.

Ofwat variable: ln (proportion of water input from river abstractions)

117. We included a measure of the amount or proportion of water input from river abstractions as a potentially important cost driver.

118. We did not consider it sensible to follow Ofwat's approach of taking the logarithm of this proportion for the specification of the explanatory variable, even if our dependent variable was the logarithm of an expenditure measure. Doing so would assume that a 10% increase in the proportion would lead to an X% increase in costs. This would imply, for example, that the effect on a company's costs of moving from 5% to 10% river water abstraction (a 100%

increase in the proportion) would be the same in £ million as if the company moved from 40% to 80% river water abstraction (similarly, a 100% increase in the proportion).

119. For the logarithmic unit cost models and the logarithmic aggregate cost models, we considered that a more reasonable approximation was to use the proportion of water from rivers without taking a logarithm. This would imply that a change in the proportion of water from rivers from 5% to 10% would have the same proportionate effect on base expenditure as a change in the proportion of water from rivers from 10% to 15%, or similarly from 75% to 80%.

120. As explained in Section 4 (paragraphs 4.125 to 4.136), we used a different specification for this explanatory variable for the linear unit cost models. We used the proportion of water from river sources multiplied by average potable water delivered per property.

Ofwat variable: ln (proportion of water input from reservoirs)

121. We considered that the amount or proportion of water input from reservoir abstraction was a potentially important cost driver. See comments for water from river abstraction above.

Ofwat variable: ln (number of new meters installed in year as a proportion of metered customers)

122. The number of new meters was a potentially relevant cost driver for enhancement expenditure. Our alternative models focused on base expenditure so we did not include this variable.

Ofwat variable: ln (length of new mains laid in year / total length of mains at year end)

123. The length of new mains was a potentially relevant cost driver for enhancement expenditure. Our alternative models focused on base expenditure so we did not include this variable.

Ofwat variable: ln (length of mains relined and mains renewed / total length of mains at year end)

124. We considered the length of mains relined and mains renewed as a potentially relevant cost driver but have not included it in our alternative models. A top-down econometric model that seeks to explain totex by reference to the volume of investment that a company has chosen to carry out carries risks of

misinterpreting efficiency differences between companies that reflect asset management choices about how much mains to renew.

125. Furthermore, the length of mains renewed seemed a narrow aspect of capital maintenance to pick out and treat differently for econometric modelling purposes.

Ofwat variable: ln (number of properties below reference pressure level / total properties connected)

126. We did not include this variable.

127. CEPA explained this variable as follows: 'Quality measure: the lower the proportion of properties with inadequate water pressure, the higher the costs because companies have spent or are spending money to improve quality but relationship was unclear in the models.'[10]

128. A concern with this variable is that it has an ambiguous relationship with costs:

(a) A company that performs relatively well on this quality measure will, all else equal, have higher costs than a company that performs relatively badly, since it will (all else equal) cost more to provide a higher quality service.

(b) A company that performs relatively badly on this quality measure at a given point in time may have higher costs because it needs to take action (including investment) to address the quality problem.

129. These two effects are distinct. Including this variable in the regression analysis will, at best, produce a coefficient that reflects which of these two forces dominates across the industry on average over the sample period. The balance of this average effect may not be relevant for any particular company.

130. Furthermore, differences between companies in their performance against this quality measure may reflect wider differences between companies in their relative performance or quality of management which also affect relative efficiency. There is a risk that the model estimation would suffer from endogeneity problems between the level of expenditure and the level of quality.

131. Given these issues, it seemed safer to exclude this variable altogether than to include it in the econometric analysis.

---

[10] CEPA (March 2014), *Cost assessment – advanced econometric model*, p46.

Ofwat variable: ln (volume of leakage / total water input to distribution system)

132. We did not include this variable.

133. Ofwat and CEPA treated leakage as a measure of quality of service.

134. The same concerns apply as above for the variable related to the number of properties below reference pressure level.

135. In addition, there is an argument that leakage is not itself a measure of quality or output of the water company, but rather a factor that reflects asset management decisions that companies face in providing a water service to customers (eg trade-offs between pipe replacement and maintenance to reduce leakage and the costs of abstracting and treating the water lost through leakage). The optimal level of leakage could vary substantially across companies.

136. Including leakage as an explanatory variable in a model might increase the extent to which the model 'explains' differences in costs between companies but may reduce the extent to which the model captures differences between companies in their efficiency of providing water services to customers. In particular, the model may predict higher levels of efficient costs for companies that have achieved lower levels of leakage, but this may overlook the possibility that maintaining lower levels of leakage may turn out to be more expensive overall for customers.

137. We were not persuaded of the need to adjust the estimate of a company's (efficient) expenditure requirements over the price control period according to whether its leakage was relatively high or low compared to other companies.

Ofwat variable: ln (number of properties affected by unplanned interruptions > 3 hrs / total properties connected)

138. We did not include this variable. The same concerns apply as above for the variable related to the number of properties below reference pressure level.

Ofwat variable: ln (number of properties affected by planned interruptions > 3 hrs / total properties connected)

139. We did not include this variable.

140. We had similar concerns as for other quality variables.

141. CEPA described this variable as follows: 'Service quality measure: the more interruptions, the lower the quality; thus if interruptions decrease, this might be associated with service enhancement and thus higher costs; planned

interruptions however may be correlated with maintenance works and may result in positive sign'.[11]

142. We have not identified a way to disentangle the following effects:

(a) A company that has relatively few planned interruptions greater than 3 hours may have higher costs because it provides a better service (eg it may incur costs to make arrangements that restore supplies, or allow supplies to be continued, while work on the system was carried out).

(b) A company that carries out a relatively large amount of capex may have a high level of planned interruptions, to enable work on the system to be done.

143. The second effect means that there are risks that the econometric model suffers from endogeneity, seeking to explain expenditure by a variable that reflects a company's chosen level of expenditure. In turn, there are risks that companies with inefficiently high expenditure are perceived as efficient (and that efficient companies with low interruptions are perceived as inefficient).

144. CEPA's reports did not provide any evidence that the first effect above has a sufficiently material effect to warrant the risks from the second effect.

Bristol Water variable: proportion of GMEAV of water distribution infrastructure in condition 4 or 5

145. We did not include this variable in our alternative models.

146. We could see some logic for an explanatory variable of this nature being included as a cost driver. A limitation of Ofwat's models of totex (and our alternative models) was that they did not allow for asset condition at the start of the period as a relevant driver of (capital) expenditure in that period.

147. However, the data Bristol Water used, and provided, for this variable was based on Ofwat data from 1997/98, which had not been updated. We would not expect differences in asset condition between companies to be stable over such a long period of time. We were concerned about the data for this variable being out of date and potentially unreliable.

[11] CEPA (March 2014), *Cost assessment – advanced econometric model*, pp46–47.

Bristol Water variable: proportion of upstream assets by GMEAV

148. We did not include this variable in our alternative models. We had a number of concerns. In particular:

(a) We preferred to focus on variables that related more directly to underlying economic or engineering reasons why a water company's expenditure requirements may be relatively high or low, than to rely on variables that explained expenditure requirements by reference to estimates of the replacement costs each company's assets;

(b) a high proportion of upstream assets by GMEAV may be indicative of a company having a low-cost distribution system, rather than higher-than-average upstream costs; and

(c) the MEAV data may not be sufficiently comparable across companies to use for econometric benchmarking analysis. GMEAV data may be vulnerable to significant estimation error or variance, especially for long-life infrastructure assets. Ofwat raised further concerns with the latest available GMEAV data.[12]

149. Although we did not include an explanatory variable for upstream infra-structure assets in our econometric models, we considered the arguments raised by Bristol Water in relation to its upstream infrastructure maintenance requirements as part of our assessment of potential special cost factor adjustments in Appendix 4.3.

Measures of correlation across explanatory variables

150. Our modelling approach, given the relative small sample size of the data, has favoured more parsimonious model specifications to avoid problems associated with overfitting the model.

151. We have taken further steps to reduce the risks associated with multi-collinearity. These steps included the use of unit cost models and specifying explanatory variables in a way that limited, where practical, the correlations between the explanatory variables in each model.

152. Table 2 below presents the correlation coefficients between pairs of variables that have been used in our alternative models. It provides a guide to the degree of correlation between the explanatory variables which might cause problems in the inference and prediction performance of our models. The

[12] See Appendix 4.3, paragraph 245.

greater the correlation between variables, the closer the correlation coefficient will be to one (in the case of positive correlations) or minus one (in the case of negative correlations). The variables shown in the table are either variables used directly in the models or variables which are used in the models after being expressed as a natural logarithm (for reasons of space the table does not show the logarithms as well).

Table 2: Correlation matrix

Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*
Mains length (1)	1.00													
Mains length per property (2)	0.05	1.00												
Average potable water delivered per property (3)	(0.35)	(0.26)	1.00											
Number of customers divided by total length of mains (4)	(0.02)	(0.96)	0.30	1.00										
Regional wage measure (5)	(0.18)	(0.56)	0.45	0.63	1.00									
Proportion of distribution input from rivers (6)	(0.07)	(0.21)	0.32	0.23	(0.11)	1.00								
Proportion of distribution input from reservoirs (7)	0.48	0.51	(0.46)	(0.51)	(0.68)	(0.12)	1.00							
Proportion of distribution input from rivers multiplied by potable water delivered per property (8)	(0.13)	(0.25)	0.53	0.28	(0.01)	0.97	(0.21)	1.00						
Proportion of distribution input from reservoirs multiplied by potable water delivered per property (9)	0.46	0.51	(0.42)	(0.51)	(0.66)	(0.13)	1.00	(0.21)	1.00					
Average pumping head (10)	(0.18)	0.29	(0.14)	(0.32)	(0.02)	(0.32)	0.02	(0.30)	0.02	1.00				
Average pumping head multiplied by potable water delivered per property (11)	(0.33)	0.17	0.31	(0.19)	0.18	(0.16)	(0.18)	(0.06)	(0.16)	0.89	1.00			
Proportion of distribution input subject to W3 or W4 treatment (12)	0.26	(0.18)	(0.04)	0.14	(0.10)	0.62	0.26	0.54	0.25	0.09	0.08	1.00		
Proportion of distribution input subject to W3 or W4 treatment multiplied by potable water delivered per property (13)	0.02	(0.31)	0.53	0.29	0.17	0.70	(0.04)	0.76	(0.03)	0.01	0.25	0.83	1.00	
Proportion of water consumption by metered non-household customers (14)	(0.15)	0.24	0.47	(0.26)	(0.33)	0.49	0.00	0.59	0.00	(0.23)	(0.01)	0.02	0.28	1.00

Source: CMA analysis.

Model estimation and assumptions on the error term

153. Ofwat's analysis used two different approaches to model estimation:

(a) pooled OLS; and

(b) using GLS to estimate a model with an assumed random effects error term.

154. In addition, Bristol Water suggested the SFA approach used by its consultants, Oxera.

155. For our development of alternative models, we focused on the pooled OLS technique. We explain below why we took this approach.

Random effects models

156. We did not consider there to be a clear case in favour of the GLS random effects approach. The GLS random effects approach that Ofwat used was more complicated than OLS and the estimation of the coefficients for the explanatory variables in the random effects model requires more restrictive assumptions than the pooled OLS technique.[13]

157. The results from Ofwat's models suggested that, for Bristol Water at least, the choice between OLS and GLS random effects had a small effect on the estimated efficient level of expenditure from the models. Whilst this finding may not necessarily hold for all possible alternative models, it suggested that this was not one of the most important aspects of model specification that we should prioritise for our development of alternative models.

158. One difference between the GLS random effects and pooled OLS approaches is that the random effects model specification includes some allowance for correlations over time, for each company, in the element of expenditure that is not explained by the explanatory variables in the model. We recognised that such correlations may be important and sought to allow for them under the OLS approach using the 'cluster robust' approach for the estimation of the variance or standard errors for the coefficients.[14]

[13] Ofwat's GLS random effects approach required assumptions about the probability distribution of the error term and the random effect term. No similar assumptions are required to obtain the estimated coefficients using the OLS technique (such assumptions were used for the estimation of the variance for these coefficients).
[14] See paragraph 225 below.

159. For our development of alternative models, we considered it more important to examine other aspects of model specification than the choice between random effects and OLS models, and focused on the simpler OLS approach.

Stochastic frontier analysis

160. Bristol Water suggested the use of SFA as an estimation technique for the econometric benchmarking models. The SFA approach seeks to decompose the 'error' term in the model (ie the element of expenditure not explained by the explanatory variables) between *(a)* random noise (eg modelling and measurement error) and *(b)* inefficiency.

161. Bristol Water identified that there was regulatory precedent for the use of SFA and referred us to the results from SFA models developed by its consultants, Oxera, which Bristol Water considered should form part of the evidence base for our cost assessment. Oxera's SFA models produced significantly different results from the pooled OLS and GLS random effects models used by Ofwat.

162. In order to achieve the decomposition between noise and inefficiency, the SFA model requires an assumption that the probability distribution (across companies) for the noise element is significantly different to the probability distribution (across companies) of the efficiency/inefficiency element. This is a major assumption of the SFA approach.

163. Oxera's SFA approach made an assumption that the probability distribution (across companies and over time) for the noise element is a normal distribution while the probability distribution (across companies) for inefficiency is a half-normal distribution. Bristol Water told us that Oxera's models were 'based on a half-normal form for inefficiency as it is a relatively simple distribution and one that is commonly employed in the literature'.

164. Bristol Water provided a note from its consultants, Oxera, which expanded on the assumption of the half-normal distribution for inefficiency:

> For the inefficiency component, the distribution has to be one-sided, by definition (ie, $u \geq 0$ for a cost function model). This is because a company is either fully efficient (ie on the cost frontier) or it is inefficient, in which case the inefficiency term, u, is positive, so that the company's costs are higher, all other things being equal. Thus, u cannot be normal because the normal distribution cannot preclude negative values. To progress any further, a decision needs to be made with respect to what one-sided distribution to use for the inefficiency component.

165. We did not consider there to be obvious *a priori* reasons for expecting a high proportion of companies to be operating just below the 'efficiency frontier', as assumed if the half-normal distribution is adopted. For example, in the context of the regulated water industry in England and Wales, it might be reasonable to expect that a few companies would be at the frontier, most companies would have a moderate level of inefficiency and a small number of companies would be more inefficient.

166. Ofwat told us that it did not have much confidence in the results of the SFA models. It said that these models required a lot of data and were based on strong distributional assumptions regarding the components of the composite error term.[15] In its model development work for Ofwat, CEPA had considered the theoretical assumptions for the probability distribution of inefficiency and noise that were required for SFA models and stated that these assumptions might be arbitrary.[16]

167. Bristol Water provided some analysis of the distribution of operating cost efficiency as assessed by Ofwat at PR04 and PR09. Bristol Water said that this appeared to give some empirical support for a higher density of companies being closer to the frontier as would be expected in the case for a half-normal distribution. Bristol Water said that this showed that a half-normal distribution for opex efficiency was plausible. However, Ofwat's approach to selection of the frontier company at PR04 and P409 meant that some companies were more efficient than the frontier company and Bristol Water's calculations did not seem to take this into account. We did not consider Bristol Water's analysis to provide strong evidence in favour of adopting the half-normal distribution for inefficiency.

168. In the light of the issues above, and in the absence of evidence to indicate an appropriate assumption for the distribution of inefficiency, we decided not to prioritise investigation of the potential use of SFA analysis in our development of alternative models.

Further review and discussion of alternative models

169. As part of the development of the set of models and estimates that we used for our determination, we drew on feedback from Bristol Water and Ofwat on an initial set of alternative models we had shared with these parties and also on the responses to our provisional findings. We also carried out our own sensitivity testing and exploration of alternative models.

---

[15] Ofwat response, paragraph 255.
[16] CEPA (March 2014), *Cost assessment – advanced econometric model*, p102.

170. In Section 4 of our determination, we explained how we used the estimates from our econometric models to produce an overall estimate for Bristol Water's base expenditure requirements over the period 1 April 2015 to 31 March 2020.

171. In addition to the explanation in Section 4, we discuss below a number of further issues that we considered:

(a) Estimates from unsmoothed models used for our provisional findings (paragraphs 172 to 180).

(b) Instability in estimated coefficients across models (paragraphs 181 to 185).

(c) The wage variable used for the econometric models (paragraphs 186 to 196).

(d) Ofwat's statistical tests for the alternative models (paragraphs 197 to 205).

(e) Statistical significance of estimated coefficients (paragraphs 206 to 216).

(f) Potential use of 2013/14 data (paragraphs 217 to 223).

Estimates from unsmoothed models used for our provisional findings

172. This subsection provides some further analysis which was relevant to our decision to make a change, following our provisional findings, to the way that we used the results from the unsmoothed econometric models to produce estimates for Bristol Water's expenditure requirements. For an explanation of this change, see Section 4 (paragraphs 4.112 to 4.124).

173. In our provisional findings, we used an average of the estimates for Bristol Water from a set of ten preferred econometric models.[17] Six of these models used the smoothed approach to capex in the calculation of the dependent variable and four models used the unsmoothed approach.[18] We had seen in our provisional findings that the estimates from the unsmoothed models were systematically higher for Bristol Water than the estimates from the corresponding smoothed models.

174. Following publication of our provisional findings, we carried out further analysis to compare the estimates produced by this set of models for the

[17] Provisional findings, p89.
[18] For explanation of the differences between the smoothed and unsmoothed approach, see paragraphs 22–32 above.

other 17 water companies in our sample. We made comparisons against the estimates from Ofwat's upper-quartile models and also between our smoothed and unsmoothed models.

175. Table 3 shows, for each water company in our sample, the base expenditure forecast for the period 1 April 2015 to 31 March 2020 for the average of the two refined base expenditure models (OLS and GLS random effects) used by Ofwat. It also shows the estimated base expenditure for the smoothed models from our provisional findings and the unsmoothed models. The estimate shown for the smoothed approach was the average estimate across the six smoothed models from the set of ten preferred models used for our provisional findings. The estimate shown for the unsmoothed approach was the average from the four unsmoothed models from the set of ten preferred models used for our provisional findings. In all cases, these estimates:

(a) are based on the model specification used for our provisional findings;

(b) use the Ofwat forecasts of the explanatory variables over the 2015-2020 period;

(c) apply Ofwat's 6.53% upper-quartile efficiency adjustment;

(d) are before inclusion of policy additions (eg cumulo rates); and

(e) are before any adjustments for special cost factors.

176. The figures in Table 3 allow for comparisons between the different modelling approaches but represent neither the final approach that we used for Bristol Water for our determination nor the final figures that Ofwat used for FD14.

Table 3: Estimates for base expenditure from Ofwat's models and our models from provisional findings

	£m (2012/13 prices)			%	
Company	*Ofwat base expenditure estimate*	*CMA base expenditure estimate from provisional findings smoothed models*	*CMA base expenditure estimate from provisional findings unsmoothed models*	*Difference CMA smoothed model compared to Ofwat*	*Difference CMA unsmoothed models compared to Ofwat*
Anglian Water Services	1140	1228	1310	8	15
Dŵr Cymru Cyfyngedig (Welsh)	826	910	1011	10	22
Northumbrian Water Ltd	988	1052	1172	6	19
Severn Trent Water Ltd	1976	1728	1867	–13	–6
South West Water Ltd	456	485	531	6	16
Southern Water Services Ltd	528	580	645	10	22
Thames Water Utilities Ltd	2474	1939	2228	–22	–10
United Utilities Water Plc	1628	1614	1800	–1	11
Wessex Water Services Ltd	369	319	353	–14	–4
Yorkshire Water Services Ltd	1107	1234	1360	12	23
Affinity Water	828	770	843	–7	2
Bristol Water plc	261	286	316	10	21
Dee Valley Water Plc	69	69	75	-1	9
Portsmouth Water Ltd	118	119	133	1	12
Sembcorp Bournemouth Water	103	107	112	4	9
South East Water Ltd	547	519	574	–5	5
South Staffordshire Cambridge	327	353	397	8	21
Sutton & East Surrey Water Ltd	146	164	176	12	20
Simple average across sample	-	-	-	1	12

Source: CMA analysis.

177. Table 3 shows that, for each of the 18 water companies in the sample, the estimate from the unsmoothed models used for our provisional findings was higher than the estimate from the smoothed models.

178. The differences between the estimates used for our provisional findings and Ofwat's estimates are greater for the unsmoothed approach. The last row in Table 3 shows the simple average of the differences between the estimates from the smoothed (and unsmoothed) models from our provisional findings and those from Ofwat's base expenditure models. On average, the smoothed models produced estimates that were 1% greater than the estimates from Ofwat's base expenditure models. On average, the unsmoothed models produced estimates that were 12% greater than the estimates from Ofwat's base expenditure models.

179. We would not necessarily expect the smoothed models and unsmoothed models to produce the same estimates of companies' expenditure requirements. Nonetheless, the scale of differences, and the findings that the estimates from unsmoothed models were systematically higher than those from the smoothed models, called for further investigation. In addition, in response to our provisional findings, Ofwat identified our use of unsmoothed models as one of three main reasons for differences between Ofwat's

assessment and the assessment in our provisional findings, and criticised our use of unsmoothed models.[19]

180. We set out in Section 4 (paragraphs 4.112 to 4.124) how we responded to these issues for the purposes of our determination, including our analysis of the likely reasons for the higher estimates from the unsmoothed models from our provisional findings.

Instability in estimated coefficients across models

181. Ofwat identified that some of the estimated coefficients from the initial set of alternative models that we shared with the parties were unstable, in that they varied substantially following relatively small changes in model specification.

182. We found the estimation results for the regional wage variable and the average consumption per property variable to be particularly sensitive to model specification. As explained in Section 4, we excluded from our preferred set of models the models for which the estimated coefficients for the regional wage and average consumption per property variables were counter-intuitive.

183. Furthermore, if we take an average of estimates across a number of preferred models, the effects of variability and estimation error for the coefficients for these two variables will tend to be diluted across this set.

184. Nonetheless, we considered the treatment of regional wages and average consumption per property to be one of the weaknesses of the models. Both these variables make sense to include from an economic perspective, but the statistical results suggested that the effects of these variables are not well captured by the models. There were similar issues for Ofwat's econometric models.

185. We commented further on the average consumption per property variable in Section 4 (paragraphs 4.146 to 4.154). We discuss the wage variable further in the subsection below.

The wage variable used for the econometric models

186. In our provisional findings, our econometric models followed the approach used by Ofwat of including a measure of regional wages as an explanatory variable. We would expect companies that operate in parts of the country with

[19] Ofwat said that the difference in the final cost allowance for Bristol Water appeared to be driven by: seven-year unsmoothed data alongside the five-year data set used for the Ofwat modelling; a special cost factor adjustment for regional wages; and a further special cost factor adjustment for mains renewal (Ofwat response to our provisional findings, paragraph 36).

relatively high wages (for similar occupations) to face higher costs than companies that operate in parts of the country with relatively low wages.

187. We used the data series on regional wages that Ofwat had prepared for the 18 water companies in the sample, drawing on regional wage data from the Annual Survey of Hours and Earnings (ASHE) from the Office for National Statistics (ONS). Ofwat's wage variable used a weighted average of ASHE data on regional weekly wages (excluding overtime) for two specific occupational categories:[20]

(a) Science, research, engineering and technology professionals. This is the two-digit standard occupational classification (SOC) 21.

(b) Skilled construction and building trades (60% weight). This is the two-digit SOC 53.

188. Ofwat gave a 40% weight to reported wage rates from category (a) and a 60% weight to wage rates from category (b). Ofwat used a mapping or allocation of each water company's area of appointment to the regions used for the ONS wage data. Some companies, such as Bristol Water, only operated in a single region covered by the ONS wage data. Other companies had service areas that spanned several regions used by the ONS and Ofwat's wage measure for these companies was a weighted average of these regions.

189. Ofwat calculated the wage variable separately for each year, adjusted to 2012/13 prices using the RPI as the price base. For each regulatory financial year ending 31 March in year 't' Ofwat used the ONS ASHE data reported for year 't' (which was, more specifically, a measure of wage rates in the April of year 't'). The exception was the final year 2012/13 for which Ofwat had lacked the latest wage variable and had instead used the wage variables for 2011/12 as a proxy. Some of the data that Ofwat used was the ONS provisional data.

190. We identified four main issues with the regional wage variable:

(a) The wage measure used by Ofwat was calculated using wage data for two relatively high-level or aggregate occupational categories. It was possible that differences in wages between regions reflect, in part, differences in the mix of job types in each region rather than reflecting only the differences in wages for like-for-like occupations that are relevant to water companies.

[20] CEPA (March 2014), *Cost assessment – advanced econometric model*, pp56–58.

(b) The ONS wage data that Ofwat had used was not fully up to date and there appeared to be a timing inconsistency between using ONS data reported for the April of year 't' for a regulatory financial year running from 1 April of year 't-1' to 31 March of year 't'.

(c) The wage variable for Bristol Water was based on wage data from the ONS ASHE that applied to a large area of the South West of England. The same regional wage measure used for Bristol Water was also used for South West Water and Wessex Water. We were concerned that this may not be representative of the level of wages faced by Bristol Water.

(d) The estimated coefficients for the regional wage measure varied considerably between the different model specifications we explored and, in some cases, the estimated coefficients were counter-intuitive. It seemed possible that this was, at least in part, a consequence of (a), (b) and (c) above.

191. At the same time, we recognised that the regional wage variable could only provide a proxy for the differences in wage conditions faced by each water company.

192. Following our provisional findings, we carried out some exploratory analysis of potential alternative wage measures to use for the econometric analysis, using more granular regional wage data from the ONS ASHE, in response to issues (a), (b) and (d) above. This was a relatively limited exercise: we did not seek to carry out a full-ranging review of how we could specify the wage variable. We started with Ofwat's wage measure but considered more granular SOC three-digit occupational categories within the weighted average.[21] We tried a version of the Ofwat wage variable updated to use the latest available ONS data and amended to bring greater consistency between regulatory financial year and the time period covered by the regional wage measure.[22] In addition, we tried an alternative approach of excluding the wage measure from the econometric models and instead making a pre-modelling adjustment using the alternative wage measures and an assumption on the

[21] We constructed one alternative variable which replaced the two-digit SOC 21 used by Ofwat (science, research, engineering and technology professionals) with the more granular three-digit SOC 212 'engineering professionals' (Ofwat's SOC 212). We constructed another alternative variable which made this change and also replaced Ofwat's two-digit SOC 53 (skilled construction and building trades) with the average across the following three-digit categories: SOC 112 (production managers and directors, which includes production mangers for water supplies); SOC 521 (meter forming, welding and related trades, which includes maintenance and repair of water supply pipes); SOC 812 (plant and machine operatives, which includes water and sewerage plant operatives); and SOC 814 (construction operatives, which includes construction work on water supply systems).
[22] We calculated a wage measure for the regulatory financial year ending 31 March of year 't' as an average of the ONW wage data reported for April in year 't' and April in year 't-1'.

approximate scale of effect of differences in wages on base expenditure requirements.[23]

193. The estimates for Bristol Water from our alternative approaches were generally similar to those under the approach we had used for our provisional findings. In terms of the average estimate for Bristol Water calculated across our preferred set of seven models, we found that the impact of the alternative approaches to the wage measure that we tried ranged from +2% to –2%.

194. We did not identify an alternative approach to the regional wage measure that worked entirely satisfactorily or which produced a step-change improvement in model estimation results. We identified possible alternative approaches that seemed better in some respects to the approach that we had used for our provisional findings, but there remained significant issues.

195. We decided that there were not sufficient grounds to justify a change to the wage variable in our econometric models from that which we had used for the public consultation in our provisional findings.

196. The issue highlighted in paragraph 190(c) above reflects the data available from the ASHE data set. The ASHE does provide wage data at a more local level than the regions of England and Wales that Ofwat used for its wage variable (eg data was available for local authority areas), but the more local data was only available for wage measures that cover all occupations. We considered it reasonable to use the available data on wages by occupation, at least as a first approximation for the econometric models. We decided to address the specific issue at point (c) through consideration of the case for a special cost factor adjustment for Bristol Water: see our assessment in Appendix 4.3.

Ofwat's statistical tests for the alternative models

197. In response to an initial set of models that we shared with the main parties, Ofwat carried out some further analysis of these models which included running a series of statistical tests on them.[24]

---

[23] For this approach we made a pre-modelling adjustment to water company expenditure data before running the econometric models. We made adjustments to water companies' expenditure in year 't' to 'normalise' them with respect to the wage variable for Bristol Water in year 't'. To do so, we assumed that an X% difference in wage rates would have an effect on expenditure of approximately 0.5*X%. The figure of 0.5 was based on Bristol Water's estimate for the effect of regional wage differences on costs: see Bristol Water response to our provisional findings, paragraph 174.

[24] Ofwat summarised these tests as the Ramsey RESET test; the Link test for model specification; a heteroskedasticity test; the Shapiro Wilk test for residual normality; the Breusch-Pagan test for heteroskedasticity; and a time fixed effects test.

198. We make some preliminary observations. First, the specific results from a statistical test vary by model, and Ofwat's comments related to the initial set of models which we subsequently refined. Second, as with any aspect of model estimation, the statistical tests are themselves based on assumptions and may be subject to error and uncertainty. Indeed, some of Ofwat's test results were based on an assumption that the error term in the models followed a normal distribution but Ofwat's own test results challenged that assumption.

199. In our view, Ofwat's statistical tests suggested four main points:

(a) Ofwat found that, for all models, it could not reject the hypothesis that the coefficients for the time dummy variables were jointly equal to zero.

(b) Possible additional explanatory variables, based on the squares of the explanatory variables (eg Var1^2) in our models and/or their cross-products (eg Var1*Var2) could be relevant to 'explaining' variations in expenditure over time and between companies.

(c) Ofwat found that, for some models, it could reject the hypothesis that the error term in the model was normally distributed.

(d) There were strong correlations over time, within a company, in the error term of our models.

200. We consider the implications below.

201. The first point concerned the approach we took for our alternative models of including time dummy variables rather than a time trend. Our models included each year as a separate potential explanatory variable. In contrast, Ofwat's models assumed a steady upward or downward growth in costs over time (relative to the RPI). The logic for our approach was that there may be year-to-year fluctuations in costs (eg due to the price control cycle or volatility in input prices such as construction tender prices) that are not well approximated by a steady time trend. Furthermore, the estimation results from Ofwat's models did not strongly support Ofwat's approach. The estimated coefficients on its time trend were sensitive to model specification, and were positive for some models and negative for others.

202. Ofwat said that its test results showed that none of the alternative models required time dummies and that these models should be re-run without time dummies. We disagreed with Ofwat's premise that whether or not a potential explanatory variable should be included in a model could be determined exclusively from statistical tests. We used the time dummy variables to try to

control, as far as possible, for industry-wide changes in costs over time. We were not seeking to test any hypothesis.

203. We considered the statistical test results reported by Ofwat that relate to the squares of existing explanatory variables (eg Var1^2) and/or their cross-products. We did not consider these results conclusive in their implications for how the alternative models should be specified. They might suggest some support for some specific aspects of the translog model specification used by Ofwat, since Ofwat's model specification used the squares and cross-products of a small subset of Ofwat's explanatory variables. However, there remains a risk that the values of estimated coefficients reflect non-causal correlations in our data set between expenditure and the squares and cross-products of some explanatory variables, particularly given the small sample size and limited variation over time in some explanatory variables. We identified a choice between:

(a) the simpler alternative models that make sense intuitively but fail some statistical tests relating to square and cross-product terms; and

(b) Ofwat's translog model specification that may fit the data better statistically, but makes less sense intuitively.

204. We considered it reasonable to use approach (a).

205. Ofwat's statistical test results on the normal distribution for the error term and correlations in the error term over time, for each company, have implications for estimation of the standard errors for the coefficients in the models. Our approach had already taken account of these issues to some degree. In particular, we sought to allow for correlations over time by reporting standard errors estimated using the 'cluster robust' technique,[25] and we did not place great weight, overall, on the estimated standard errors as we recognised the uncertainty in these estimates.

Statistical significance of estimated coefficients

206. In its response to our provisional findings, Ofwat said that our assessment of econometric models was 'unbalanced' and that this was best illustrated by considering the extent to which the modelling process had reasonably identified statistically significant explanatory variables.[26]

[25] See paragraph 225 below.
[26] Ofwat response to our provisional findings, paragraph 28.

207. Ofwat presented a table which compared the four smoothed logarithmic and linear unit costs models that we had used for our provisional findings against Ofwat's two base expenditure models (the OLS and GLS random effects variants). The table reported that, at the 95% confidence level, three of our unit cost models had no statistically significant variables (besides the constant term) and the other model had just one statistically significant variable (mains length per property). In contrast, Ofwat's OLS model had three statistically significant explanatory variables at the 95% confidence level and the GLS random effects model had six statistically significant explanatory variables.[27]

208. Ofwat also showed that our logarithmic aggregate expenditure models performed better in terms of statistical significance than our unit cost models, and argued that only the logarithmic aggregate expenditure models produced credible results.[28]

209. At the outset, we did not consider that the difference between Ofwat's models and our models in terms of statistical significance was as stark as Ofwat's comparisons indicated:

(a) Ofwat's random effects model was shown to have six statistically significant variables. However, we were not confident that the comparison of the statistical significance measures between this random effects model and our OLS models was a fair one to make. Ofwat's method for calculating statistical significance for the OLS models was not the same as that for GLS random effects models. The fact that Ofwat's OLS model only had three statistically significant variables, whereas the random effects model had six, suggested that the measures of statistical significance may not be on a consistent basis. We asked Ofwat about this comparison. Ofwat said that it considered it reasonable to compare its OLS models with our OLS models, but that it was hard to be sure that the standard errors calculated for the random effects models were on an exactly equivalent basis to those for the OLS models.

(b) Ofwat's models were aggregate expenditure models, whereas our models for provisional findings included both aggregate expenditure models and unit cost models. We did not consider that the number of statistically significant variables in a unit cost model could be compared directly against the number in an aggregate expenditure model. There are very large differences between companies in the level of aggregate expenditure, which reflect the scale of companies' supply area and customer numbers. The aggregate expenditure models identified a

[27] Ofwat response to our provisional findings, Table 1.
[28] Ofwat response to our provisional findings, paragraph 31.

statistically significant scale variable (total length of mains), whereas the scale variable we used for the unit cost models (number of properties) was already applied in the specification of the dependent variable, rather than treated as a potential explanatory factor.

(c) If we used the 90% confidence level, rather than the 95% confidence level, the unit costs models from our provisional findings had two or three statistically significant explanatory variables (aside from the constant term) and the aggregate expenditure models had between three and five statistically explanatory significant variables.

210. Furthermore, care is needed in drawing implications for our determination from measures of statistical significance. Statistical significance is a statistical concept that is dependent on model specification and does not translate directly into conclusions about the relationship between potential cost drivers and water companies' costs.

211. If variable X is found not to be statistically significant at the 95% confidence level, it means that, if we were to accept the econometric model specification as a precise representation of the underlying cost structure in the water industry, we could not, on the data used for the analysis, reject the hypothesis (with a 95% chance of being correct) that variable X does not affect companies' costs in the way specified in the model. This is quite a narrow implication. It does not provide proof that a particular explanatory variable affects (or does not affect) water companies' costs or a test of whether the variable ought to be included in the econometric models.

212. The indicators of statistical significance for an explanatory variable reflect the estimated variance or standard deviation for the estimated coefficient of that variable. One interpretation is that, the higher is the variance relative to the estimated coefficient, the greater is the extent to which we would expect the estimated coefficient to vary (differ) if the same model was re-estimated using another sample of data (from a hypothetical similar set of companies and years).

213. For the purposes of our determination, and in the context of the specific econometric models and data sample that we considered, our views were as follows:

(a) It was not a surprise that the estimation results from our econometric models did not produce statistically significant estimated coefficients, at the 95% confidence level, for all (or even the majority) of the explanatory variables relating to plausible cost drivers for water companies in England

and Wales. This outcome is likely to reflect the small sample size and the complexity of the factors affecting water companies' costs.

(b) The findings on the statistical significance of explanatory variables reflect the estimated variance for each coefficient in the econometric models. The estimated variance for a coefficient provides a measure of the precision of the estimated value for that coefficient. However, the estimated variance is itself subject to estimation problems arising in a small sample. Furthermore, the estimated variance applies to the estimated value of a coefficient taking the model specification as given; the variance may differ for alternative model specifications.

(c) We had decided towards the start of our model development work that we would focus on models with a smaller number of key explanatory variables than used by Ofwat and which made more sense from an economic or engineering perspective, rather than prioritising statistical significance in the development or selection of models. We did not consider that we could rely on statistical significance alone, especially given the small sample size. We remained confident that this approach was appropriate despite Ofwat's submissions on statistical significance.

(d) It would not be appropriate to restrict the econometric models to those for which all (or the majority) of the explanatory variables are found to be statistically significant. Indeed, that was not the approach taken by Ofwat (eg for Ofwat's refined OLS model of base expenditure, only three out of 11 of the explanatory variables were statistically significant at the 95% confidence level).

214. We considered it important to keep in mind that the purpose of the econometric model was as a means to estimate a water company's base expenditure requirements. Rather than focusing on the estimated variance for specific coefficients, we also calculated the variance (or confidence interval) for the estimate of expenditure derived from these models. This reflects the combined effect of the variance of each of the estimated coefficients in a model on the prediction derived from them. The 95% confidence interval for Bristol Water's base expenditure requirements from our alternative models varied but, on average across the seven preferred models used for our determination, it was a range of –13.1% to +14.1% around the central estimate. In comparison, the 95% confidence interval for Bristol Water's expenditure requirements from Ofwat's base expenditure OLS model was a range of –16.7% to +17.1% around the central estimate. These calculated confidence intervals are subject to the same qualifications as measures of statistical significance; in particular they are contingent on the model specification. Nonetheless, this comparison indicated that, despite a greater

number of statistically significant variables (at the 95% confidence level), the estimated precision of the expenditure estimates from Ofwat's OLS base expenditure model was no better than that from our preferred set of alternative models.

215. In addition, we provide an example to help illustrate the practical issues relating to statistical significance and the choice of approach. Ofwat's econometric models of base expenditure included an explanatory variable relating to the total population supplied by each company divided by the company's total number of connected properties. In both the OLS and GLS random effects versions of these models, this variable was found to be statistically significant at the 95% confidence level. We found that if we included this variable in our econometric models, in place of the variable for consumption per property, this led to several more statistically significant variables in our models. However, we were reluctant to include this variable in our models as we did not understand the economic rationale for this variable, either as a complement or alternative to the water delivered per property variable.[29] For instance, under Ofwat's forecasts, Bristol Water had a lower-than-average consumption per property but above-average population per property. It is possible that Ofwat's population per property variable picks up some underling causal relationship with water companies' costs, but it was hard to be sure that this was the case and the estimated coefficient had a relatively large effect. We were concerned that the results for this variable reflected the limitations of econometric modelling given our small sample size, and that its use could be misleading.[30]

216. Overall, we reconsidered our approach in the light of Ofwat's comments on statistical significance in response to our provisional findings but did not consider that it was appropriate to change our models or to use the estimates from Ofwat's models instead.

[29] A higher population would (all else equal) lead to greater consumption, but this variable seemed a less direct measure of consumption than the estimates of potable water delivered that we had used, and did not take sufficient account of non-household consumption. Alternatively, we could also see potential logic for a population density variable expressed in terms of the number of people per square kilometre of each water company's supply area, but this is quite different to the population variable used by Ofwat.
[30] Ofwat's OLS model of base expenditure had a statistically significant coefficient of more than 2 for the population per property variable (Ofwat's refined base expenditure models did not include the usage / water delivered per property variable). This coefficient would imply that if company X supplies the same number of properties as company Y, but the population in the area supplied by company X is 10% greater, then company X would have 20% higher costs than company Y. We found the scale of this effect counter-intuitive.

Potential use of 2013/14 data

217. The econometric models that we used for our provisional findings, and which Ofwat used for FD14, used data up to and including the financial year 2012/13.

218. In response to Ofwat's comments on the use of unsmoothed models in its response to our provisional findings, Bristol Water suggested that we investigate the sensitivity of the results to extension of the data used for the econometric analysis to cover the financial year 2013/14. As a consequence, we carried out some further analysis to examine the feasibility and effects of using more recent data.

219. Ofwat told us that there was not a complete set of available data that would allow us to extend the models that we had used for our provisional findings for 2013/14 data. Ofwat did not collect data annually from water companies on all of the explanatory variables that we had used. Ofwat also confirmed that while it had received expenditure data from companies for 2014/15, it had not completed its internal checks of this data and, in any event, there was very limited data on the explanatory variables for 2014/15.

220. We decided to investigate the effects of including 2013/14 data, albeit with some approximations. In particular:

(a) For the measures of base capex and opex (which feed into the measures of smoothed and unsmoothed base expenditure) we used data provided by Ofwat, which was on the same basis as that used for its econometric modelling for FD14.

(b) Ofwat provided updated data for 2013/14 in respect of the explanatory variables relating to length of mains, number of properties supplied, potable water delivered, the proportion of distribution input from rivers, and the proportion of distribution input from reservoirs.

(c) There was no data available for 2013/14 for average pumping head or the proportion of consumption from metered non-household customers. For these variables we used the corresponding figures from 2012/13.

(d) For the W3/W4 variable, the data had not been updated since 2008/09 and for our provisional findings we had relied on data from previous years. We adopted the same figures for the W3/W4 variable for 2013/14 as we had for 2012/13.

(e) We obtained provisional data from the ONS which allowed us to calculate an updated version of the Ofwat regional wage variable for 2013/14. We

also updated the Ofwat wage variable for updated data for previous years (some of Ofwat's data had been ONS provisional data and the final data was now available to us).

221. We found that, on average across our set of seven preferred models from Section 4, the effect of these updates would be to increase the estimate for Bristol Water's expenditure requirements by less than 1%. This provided some comfort that our estimates were not heavily contingent on using data up to 2012/13.

222. We also carried out further sensitivity analysis considering both an update for 2013/14 data and alternative potential changes to the approach to the regional wage variable (discussed in paragraphs 186 to 196 above). We considered a range of alternative approaches and these produced variations in the average of the estimate for Bristol Water from the seven preferred models that were within the range +2% to –1%.

223. Given the relatively small scale of these differences, the variation in the direction of the impact, the significant limitations in the available data for 2013/14, and the fact that our public consultation for provisional findings had used data to 2012/13, we considered that it was appropriate to retain the approach from our provisional findings of using the original Ofwat data set that provided data to 2012/13.

Estimation results for alternative models

224. This section sets out results from the estimation of the 18 alternative econometric models.

225. We first comment on the issue of estimated standard errors which was material to the results we present. We used the statistical software package Stata for our analysis. Stata provides functionality that seeks to control for heteroskedasticity and autocorrelation of the error terms in the estimation of the standard errors.[31] We used the 'vce (cluster robust)' command in Stata to take account of both the possible heteroskedasticity and possible autocorrelation (correlations over time for each company) in the estimation of

[31] Heteroskedasticity exists where the variance of the error term is not constant across the observations of the sample. When heteroskedasticity is not tackled and it is instead assumed that the error terms are homoskedastic (constant variance), the estimated standard errors for the coefficients on the explanatory variables in the model may be inaccurate. This imposes risks in determining the relevance we should give to each explanatory variable. An additional problem that also affects the size of standard errors for the estimated coefficients emerges when the error terms in the model are correlated for different observations (eg over time). This means that the covariance between the error terms for different observations is not equal to zero. Particularly in models using panel data, it is more likely that this problem arises since the error terms for the study period and corresponding to each specific 'entity' (in our case each water company) possibly exhibit similar patterns (eg over time). If this issue is not taken into account in the estimation of standard errors, these again could be inaccurate.

the standard errors. We clustered by company as there may be correlations, for each company, over time in the modelled error term.

Table 4: Estimated coefficients from logarithmic unit cost models

	Base expenditure smoothed (5-year data sample)			*Base expenditure unsmoothed (7-year data sample)*		
Explanatory variables groups	*EV1*	*EV2*	*EV3*	*EV1*	*EV2*	*EV3*
Ln (water delivered per property)	0.06745	0.40857	0.55917*	0.08432	0.55357*	0.7052**
Ln (regional wage measure)	1.1877	0.613	0.05398	1.1912	0.45485	(0.14187)
Ln (mains length per property)	0.32298	0.39959	0.42931**	0.28906	0.38489	0.40785*
Proportion of DI from rivers	0.27698	0.33325*		0.27453	0.35037	
Proportion of DI from reservoirs	0.37497*	0.272		0.41259	0.28872	
Ln (average pumping head)	0.28984**	0.24867*	0.13771	0.30337**	0.24656*	0.13916
Prop. consumption by metered NHHs		(0.99791)	(0.82419)*		(1.3926)**	(1.2114)**
Proportion of DI subject to W3/W4 treatment			0.44088			0.45225
Time dummy variable (2006/07)				(0.07072)	(0.05535)	(0.03467)
Time dummy variable (2007/08)				(0.08586)	(0.05367)	(0.03723)
Time dummy variable (2008/09)	(0.0418)	(0.0226)	(0.0149)	(0.10634)*	(0.08226)	(0.07293)
Time dummy variable (2009/10)	(0.02615)	(0.00786)	0.00745	(0.15337)**	(0.13075)**	(0.11362)*
Time dummy variable (2010/11)	(0.03007)	(0.01795)	(0.00583)	(0.13751)**	(0.12299)**	(0.10944)*
Time dummy variable (2011/12)	(0.00101)	(0.01382)	(0.01946)	(0.01543)	(0.03276)	(0.03867)
Constant	(7.9009)***	(5.7924)**	(3.9092)**	(7.8086)**	(5.0302)*	(3.0432)
R^2	0.45539	0.50205	0.46691	0.32384	0.38291	0.35127
R^2 Adjusted	0.38645	0.43182	0.39943	0.25204	0.31128	0.28238
Number of observations	90	90	90	126	126	126

Source: CMA analysis.
Note: Statistical significance indicated at *10%, ** 5%, ***1% levels, based on cluster robust standard errors.

Table 5: Estimated coefficients from linear unit cost models

	Base expenditure smoothed (5-year data sample)			*Base expenditure unsmoothed (7-year data sample)*		
Explanatory variables groups	*EV1*	*EV2*	*EV3*	*EV1*	*EV2*	*EV3*
Potable water delivered per property	(0.08072)	0.01139	0.01642	(0.08384)	0.03448	0.03962
Regional wage measure	0.00762*	0.00309	0.00097	0.00814	0.00265	0.00029
Mains length per property	0.00289*	0.00356*	0.00393**	0.00286	0.00365*	0.00399**
Proportion of DI from rivers multiplied by average potable water delivered per property	0.0531	0.06863*		0.05436	0.07415	
Proportion of DI from reservoirs multiplied by potable water delivered per property	0.07403	0.04716		0.08187	0.05125	
Average pumping head multiplied by potable water delivered per property	0.00043*	0.00035	0.00015	0.00042*	0.00032	0.00012
Prop. consumption by metered NHHs		(0.13413)	(0.10337)*		(0.17838)**	(0.14438)**
Proportion of DI subject to W3/W4 treatment multiplied by average potable water delivered per property			0.09555			0.09999
Time dummy variable (2006/07)				(0.0078)	(0.00517)	(0.00399)
Time dummy variable (2007/08)				(0.00878)	(0.00415)	(0.00372)
Time dummy variable (2008/09)	(0.00418)	(0.00134)	(0.00162)	(0.01269)**	(0.00923)	(0.00944)
Time dummy variable (2009/10)	(0.00217)	0.00043	0.00088	(0.01757)**	(0.01444)*	(0.01387)*
Time dummy variable (2010/11)	(0.00299	(0.00109)	(0.00071)	(0.01603)**	(0.01375)*	(0.01331)*
Time dummy variable (2011/12)	(0.000021)	(0.00138)	(0.00168)	(0.00133)	(0.00304)	(0.00341)
Constant		0.0003	0.00983	(0.05618)	0.01705	0.02904
R^2	0.43752	0.50013	0.48524	0.28295	0.34662	0.32867
R^2 Adjusted	0.36633	0.42964	0.42008	0.20681	0.27078	0.25738
Number of observations	90	90	90	126	126	126

Source: CMA analysis.
Note: Statistical significance indicated at *10%, ** 5%, ***1% levels, based on cluster robust standard errors.

Table 6: Estimated coefficients from logarithmic aggregate cost models

	Base expenditure smoothed (5-year data sample)			*Base expenditure unsmoothed (7-year data sample)*		
Explanatory variables groups	*EV1*	*EV2*	*EV3*	*EV1*	*EV2*	*EV3*
Ln (number of properties / total mains)	0.67683***	0.60064**	0.58735***	0.71568***	0.61957**	0.61173***
Ln (water delivered per property)	0.10373	0.44092	0.57812*	0.1148	0.57526*	0.7287**
Ln (regional wage measure)	1.0734	0.50839	0.05825	1.0817	0.3708	(0.14799)
Ln (total mains length)	1.0153***	1.0144***	1.0152***	1.0137***	1.0111***	1.016***
Proportion of DI from rivers	0.27511	0.33119*		0.2707	0.34677	
Proportion of DI from reservoirs	0.31586	0.21687		0.3595	0.24645	
Ln (average pumping head)	0.29508**	0.25383*	0.1527	0.30785**	0.25057*	0.15569
Prop. consumption by metered NHHs		(0.99255)	(0.74272)		(1.3836)**	(1.132)**
Proportion of DI subject to W3/W4 treatment			0.42041			0.43038
Time dummy variable (2006/07)				(0.06984)	(0.05473)	(0.03825)
Time dummy variable (2007/08)				(0.08226)	(0.05096)	(0.04033)
Time dummy variable (2008/09)	(0.03794)	(0.01907)	(0.01663)	(0.10242)*	(0.07923)	(0.07434)
Time dummy variable (2009/10)	(0.02234)	(0.00437)	0.00573	(0.14943)**	(0.1277)*	(0.11499)*
Time dummy variable (2010/11)	(0.02757)	(0.01567)	(0.00788)	(0.1348)**	(0.12089)*	(0.11128)*
Time dummy variable (2011/12)	(0.00333)	(0.01593)	(0.02076)	(0.0174)	(0.03424)	(0.04019)
Constant	(7.7151)***	(5.6288)**	(4.0833)*	(7.6089)**	(4.8862)*	(3.1908)
R^2	0.98498	0.98626	0.98534	0.97246	0.97484	0.97367
R^2 Adjusted	0.98286	0.98412	0.98327	0.96927	0.97167	0.97061
Number of observations	90	90	90	126	126	126

Source: CMA analysis.
Note: Statistical significance indicated at *10%, ** 5%, ***1% levels, based on cluster robust standard errors.

Assessment of special cost factors

Introduction

1. This appendix provides our detailed assessment of special cost factor adjustments to apply to the estimates from our econometric models of Bristol Water's base expenditure requirements, as set out in Section 4 of our final determination.

2. The purpose of special cost factors in Ofwat's approach was to take account of specific characteristics or circumstances of a water company which affect its efficient level of expenditure requirements but may not be adequately captured by the econometric benchmarking analysis. In our approach we considered those factors which were potentially relevant to Bristol Water.

3. Our assessment covers the following issues, which relate only to base expenditure:

   (a) Canal and River Trust payments (paragraphs 12 to 29);

   (b) treatment complexity: W3/W4 treatment processes (paragraphs 30 to 66);

   (c) additional water treatment costs at Purton and Littleton (paragraphs 67 to 116);

   (d) congestion in Bristol (paragraphs 117 to 152);

   (e) regional wage data for Bristol Water (paragraphs 153 to 189);

   (f) mains renewal programme (paragraphs 190 to 223);

   (g) upstream maintenance expenditure (paragraphs 224 to 262263); and

   (h) Bedminster reservoir (paragraphs 263 to 273).

4. Before turning to these issues, we first comment briefly on the relevance of regulatory precedent, which Bristol Water raised as part of its response to our provisional findings.

Regulatory precedent for special cost factors

5. In its response to our provisional findings, Bristol Water highlighted that in its final determinations for the 2010-2015 price controls, Ofwat allowed Bristol Water special cost factors for its operating costs of £30.3 million (in 2012/13

prices). Bristol Water said that this was also accepted by the CC in its 2010 determination. Furthermore, Ofwat allowed £33.1 million of special cost factors for operating costs in its final determinations for the 2005-2010 price controls. Bristol Water said that these figures were greater than the allowance of £25.6 million that it sought for the special cost factors relating to its opex for the 2015-2020 price control period. Bristol Water identified Canal and River Trust payments, treatment complexity, additional costs at Purton and Littleton and congestion in Bristol as special cost factors relating to opex.[1]

6. Bristol Water said that the allowance we had made in our provisional findings for special cost factors relating to opex represented only a quarter of the allowance for opex special cost factors made by the CC in its 2010 determination.[2]

7. Bristol Water also said that, specifically in respect of the additional costs of Purton and Littleton treatment works, our approach was not consistent with regulatory precedent. This was because we had not made a special cost factor allowance for these additional costs in our provisional findings, whereas there was an adjustment of £13.3 million for these costs made by Ofwat and the CC at PR09 and an adjustment of £10.3 million for these costs made by Ofwat at PR04.[3]

8. Bristol Water subsequently told us that it had referred to regulatory precedent not as an argument to say we should allow the amount allowed five or ten years ago, but to provide additional confidence that the special cost factor adjustments that it had estimated and proposed for this price control review were reasonable.

9. We agreed with the general principle from the regulatory precedent of considering special cost factors as potential adjustments to the results from econometric models. We also recognised the importance of special cost factors in the previous price control determinations for Bristol Water.

10. We gave weight to the regulatory precedent for special cost factors through:

    (a) the specification of our econometric models: we sought to include the W3/W4 water treatment complexity variable in our original econometric models, rather than treating this as a special cost factor as Ofwat had done; and

[1] Bristol Water response to our provisional findings, paragraph 199 & Table 5.
[2] Bristol Water response to our provisional findings, paragraph 199.
[3] Bristol Water response to our provisional findings, paragraphs 125–128.

(b) our detailed assessment of the various special cost factor adjustments proposed by Bristol Water: this included review of claims relating to the three specific special factors allowed at the PR09 periodic review for Bristol Water, which were for treatment complexity, the Purton and Littleton treatment works and congestion in Bristol.

11. We did not consider that it would be appropriate to be bound by the specific financial value of adjustments applied at previous price control reviews. This was for two reasons. First, the cost assessment models to which special cost factors were to be applied were different for our determination compared to those used in the past. Second, and more fundamentally, it was common practice at price control reviews to make a fresh, forward-looking, assessment of costs in the light of the available evidence.

Canal and River Trust payments

Summary of the claim and our provisional findings

12. Bristol Water obtains around 45% of its raw water from river sources. Over 99% of its river water is from the River Severn, which Bristol Water receives via the Sharpness Canal. The River Severn is located outside Bristol Water's area of appointment.[4]

13. The Canal and River Trust has a statutory responsibility to maintain the Sharpness Canal. Bristol Water told us that, under a long-term bulk supply agreement, Bristol Water was contractually obliged to pay an annual maintenance fee of £1.67 million to the Canal and River Trust, which it expected to continue until the end of AMP6 in real terms. This charge was to support the structural maintenance of the Sharpness Canal. This charge was intended to cover:

(a) the purchase of water that could otherwise be used in the canal network;

(b) necessary works on the canal's system to ensure that abstraction could take place, such as maintenance and dredging; and

(c) provisions to deal with emergency situations preventing abstraction.[5]

[4] Bristol Water SoC, pp89–90.
[5] Bristol Water SoC, p90.

14. Bristol Water submitted a special cost factor claim to Ofwat in relation to the payments it made to the Canal and River Trust. The claim was for £8.1 million over the five-year period.[6]

15. In its final determinations, Ofwat accepted the need for the claim and made an adjustment of £6.3 million. This figure for the adjustment reflected a deduction for the implicit allowance that Ofwat considered to be already allowed for in its basic cost threshold, in respect of the payments to the Canal and River Trust. It also reflected an adjustment for upper quartile efficiency, because Ofwat was concerned that the level of payments may not be efficient.[7]

16. Ofwat's assessment of the need for the claim treated Bristol Water's payments to the Canal and River Trust as comparable to the abstraction charges that water companies pay to the EA for abstraction of water. Ofwat found that Bristol Water was at the industry average in terms of its EA abstraction charges as a proportion of totex (3.6%), but that taking abstraction charges and the payments to the Canal and River Trust together, Bristol Water's charges were well above average as a proportion of totex (5.5% vs 3.5%). Ofwat considered that this suggested its models did not include enough of an allowance for Bristol Water's payments to the Canal and River Trust.[8]

17. In our provisional findings, we made an adjustment of £8.1 million, which was the full value of Bristol Water's claim. This figure reflected the payments that Bristol Water expected to make to the Canal and River Trust under the long-term supply agreement.

18. We found that that our econometric models were not likely to make an allowance for Bristol Water's payments to the Canal and River Trust. We said that the analysis and evidence of Bristol Water and Ofwat suggested that Bristol Water was required to make additional payments, compared with other companies, for the water that it abstracted from the environment.

19. We considered whether there were any closely associated offsetting factors that should be taken into consideration. For instance, if a company takes water from a third party (eg bulk supply from another water company or from a canal) this might enable it to avoid some costs that other companies in the industry incur, such as maintenance costs for abstraction and raw water transportation and water treatment costs.

---

[6] Bristol Water SoC, Table 107, p404.
[7] Ofwat, Final determination cost threshold populated feeder models for Bristol Water.
[8] Ofwat, Final determination cost threshold populated feeder models for Bristol Water.

20. In the case of the water from the Sharpness Canal, we did not consider that there were factors that were likely to offset the payments to the Canal and River Trust. The water that Bristol Water abstracts from the Sharpness Canal requires treatment by Bristol Water, and Bristol Water's submissions argued that the quality of raw water from the canal was worse than was typical for river sources. From a high-level review, abstraction from the Sharpness Canal did not seem a significant benefit to Bristol Water in terms of raw water transportation costs: the abstraction point from the canal at Purton is outside Bristol Water's area of appointment, and did not seem to be in a particularly convenient location; it is not close to Bristol and is further from the main areas of demand than other water sources used by Bristol Water.[9] Our wider review of Bristol Water's water treatment costs (see paragraphs 30 to 116 below) did not identify significant factors that were likely to offset the additional costs relating to Canal and River Trust payments.

21. We found no basis to use a figure for the adjustment that differed from Bristol Water's claim of £8.1 million. In particular, we did not agree with Ofwat's calculation of an adjustment of £6.3 million for this claim. Ofwat used two approaches which it found to give similar results:

    (a) Its main approach involved a deduction of its calculated implicit allowance from Bristol Water's claim.

    (b) Ofwat's second approach applied the 2% difference (5.5% vs 3.5%, referred to in paragraph 16 above) to Ofwat's basic cost threshold for Bristol Water.

22. On approach *(a)*, we did not consider that Ofwat's calculation method for the implicit allowance was likely to provide a good estimate of the extent to which the expenditure estimates from Ofwat's models (or our alternative models) took specific account of the additional costs relating to payments to the Canal and River Trust. Ofwat's calculation of the implicit allowance seemed unrelated to this question; it seemed to be based instead on a *pro rata* allocation of the difference between Bristol Water's base expenditure forecast and Ofwat's modelled estimate for base expenditure, across Bristol Water's various base expenditure special cost factor claims. We did not identify a logical basis for the *pro rata* allocation.

23. Ofwat's approach under *(b)* had the effect of scaling down the allowance for payments to the Canal and River Trust according to differences between Bristol Water's base expenditure and Ofwat's view of an efficient level of Bristol Water's base expenditure. We did not consider that this approach

[9] CMA indicative analysis of diagram of image 1 of Bristol Water SoC, p81.

provided a reasonable way to estimate an efficient level for the payments that Bristol Water needed to make to the Canal and River Trust.

Further submissions following our provisional findings

24. Bristol Water agreed with the allowance we had made for Canal and River Trust payments in our provisional findings.

25. Ofwat made further submissions on the special cost factor for Canal and River Trust payments following our provisional findings. Ofwat said that, as far as it was aware, Bristol Water had not provided evidence that these costs were efficiently incurred and represented best value for money in terms of strategic options appraisal.

26. Ofwat also argued that other water companies had unique costs associated with their different circumstances (including water treatment complexity) and that these would be reflected in the model coefficients, so that some of these unique costs were already reflected in the modelled allowances. Ofwat said that a full adjustment for the costs arising from Bristol Water's payments to the Canal and River Trust would not be appropriate and suggested allowing between one-half and two-thirds of these costs.

Our assessment

27. We considered that it was appropriate to make an adjustment of £8.1 million for the Canal and River Trust payments, for the same reasons set out in our provisional findings and reproduced above.

28. We did not identify grounds to adopt Ofwat's proposed approach of making only a partial adjustment in this case. We recognised that the costs arising from the use of resources from the Canal and River Trust were partly within Bristol Water's control, but we did not have any evidence that the level of costs forecast by Bristol Water were inefficiently high. We did not consider that it would be appropriate to adopt the approach advocated by Ofwat of assuming that the efficient level of these costs was significantly below Bristol Water's actual level of these costs. We did not have a reason to expect that the costs related to the Canal and River Trust payments were likely to be reflected already in the estimated model coefficients.

29. The adjustment of £8.1 million did not include any allowance for Bristol Water's claim of additional costs arising from the quality of water from the Sharpness Canal, which we consider in the following two subsections.

Treatment complexity: W3/W4 treatment processes

Summary of the claim and our provisional findings

30. In its representations on Ofwat's draft determinations, Bristol Water made two types of argument in relation to treatment complexity:

    (a) Ofwat's econometric models did not take adequate account of the additional costs that Bristol Water faced as a result of needing to treat a relatively high proportion of water with the treatment processes that Ofwat had previously categorised as W3 or W4.

    (b) The nature of the water treated at Purton and Littleton was such that the complexity and costs of treating it were much higher than the costs of treating water from a more typical river abstraction that would require a W3 or W4 level of treatment complexity.

31. For its final determination, Ofwat's assessment against its special cost factor criteria failed both of these claims for Bristol Water.

32. On the first element, Ofwat said that the claim failed due to insufficient evidence of need and because Bristol Water's estimated adjustment was based on out-of-date data (the W3/W4 variable) and ignored the treatment complexity drivers already in the model. On the second element, Ofwat said that there was a lack of evidence that both the water treated was of unusually poor quality and the type of treatment was unusually complex for the industry.[10]

33. However, Ofwat did include a special cost factor adjustment of £18.2 million for Bristol Water in its final determinations, following what Ofwat described as its more holistic assessment of the base expenditure allowance for Bristol Water. Ofwat's adjustment was calculated by comparing the estimated costs for Bristol Water from its models with estimates from alternative models that included the W3/W4 treatment complexity variable.[11]

34. We considered whether it would be appropriate to make any special cost factor adjustments to the results from our alternative models. We take the two issues at (a) and (b) above separately. We consider the W3/W4 treatment variable below, and the claim for additional costs at Purton and Littleton treatment works in the following subsection.

---

[10] Ofwat, Final determination cost threshold populated feeder models for Bristol Water.
[11] Ofwat, Final determination cost threshold populated feeder models for Bristol Water.

Summary of our provisional findings

35. The econometric models of totex and base expenditure that Ofwat used for its PR14 triangulation process did not include the W3/W4 treatment complexity variable. Ofwat only considered this variable as a potential special cost factor adjustment. Furthermore, although Ofwat's models included explanatory variables for water source type (rivers and reservoirs), the estimated coefficients for these variables were relatively small.

36. Our approach to the econometric models has differed substantially to Ofwat's models in relation to treatment complexity:

    (a) Because of differences in various aspects of model specification, the estimated coefficients for the rivers and reservoirs variables in our models implied a greater effect of water source type on expenditure requirements than Ofwat's models.

    (b) Despite some concerns that the data series was not up to date, we also included models with the W3/W4 variable in our set of preferred econometric models. We discuss this aspect of model specification further in Appendix 4.2.

37. The estimates from our econometric models for Bristol Water included a greater additional allowance than Ofwat's econometric models for the additional costs that Bristol Water faces due to its mix of water sources and the complexity of its water treatment processes.[12]

38. We found that the models that used the W3/W4 variable provided lower estimates of Bristol Water's expenditure requirements than comparable models that used the proportion of distribution input from rivers and reservoirs as a proxy for raw water quality and treatment complexity.

39. The models that we used for our provisional findings made an allowance of around £12.7 million over AMP6 in respect of Bristol Water's raw water sources and treatment complexity. We noted in our provisional findings that the models and analysis suggested that there were two important effects to consider for Bristol Water:

    (a) Bristol Water's raw water sources might mean that it had relatively high water abstraction and treatment costs, in pounds per cubic metre of treated water produced, relative to the average across the industry.

[12] This comparison with Ofwat's estimates is before consideration of the special cost factor adjustment for treatment complexity that Ofwat applied to the results of its main econometric models.

(b) Bristol Water had relatively low distribution input per property compared with the industry average (in part because of relatively low leakage), which meant that it needed to abstract and treat less water than the average company to meet the same level of demand per property.

40. In our provisional findings, we did not identify grounds to make any further adjustment to the results from our alternative econometric models to take greater account of the proportion of Bristol Water's treatment work that involved W3/W4 treatment processes.

The use of distribution input in the explanatory variables for linear unit cost models

41. For our provisional findings, we used a range of different econometric models. For the linear unit cost models, we specified the explanatory variables that related to water sources (rivers and reservoirs) and treatment processes (the W3/W4 treatment variable) as measures of the total volumes of distribution input (per property supplied) from river sources, from reservoirs, or subject to W3/W4 treatment processes.

42. In its response to our provisional findings, Bristol Water questioned the use of distribution input as a volume measure in the specification of these explanatory variables. Bristol Water argued that we had not taken into account the additional ongoing costs that Bristol Water incurred to achieve lower levels of leakage, and in turn, lower levels of distribution input. Bristol Water said that our models penalised Bristol Water in the cost assessment because these models allowed for the benefits to Bristol Water from a lower volume (distribution input) but not the additional costs to achieve lower leakage (and hence lower distribution input).[13]

43. As explained in Section 4 (paragraphs 4.125 to 4.136), we revised our econometric models to address the issues raised by Bristol Water. Our revised approach took account of the effects of differences in demand or consumption patterns between companies in the estimation of the additional costs (if any) associated with different water source types or treatment requirements. It did not overlook the additional costs of achieving lower levels of leakage, which was the concern raised by Bristol Water with the models used for our provisional findings.

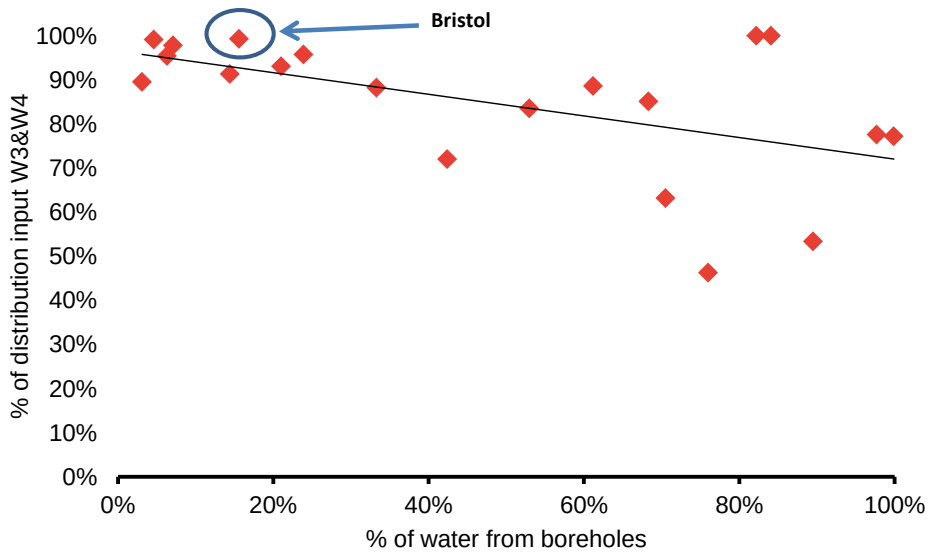
[13] Bristol Water response to our provisional findings, paragraphs 116–118.

Lower estimates from models with W3/W4 explanatory factor

44. In our provisional findings, we found that the models that used the W3/W4 variable provided lower estimates of Bristol Water's expenditure requirements than comparable models that used the proportion of distribution input from rivers and reservoirs as a proxy for raw water quality and treatment complexity.

45. In its response to our provisional findings, Bristol Water provided a chart which compared each company's percentage of distribution input from W3/W4 against its percentage of distribution input from boreholes (which it said was effectively the inverse of the proportion of water from rivers and reservoirs. We have reproduced that chart in Figure 1 below.

Figure 1: Relationship between abstraction of water from boreholes and W3/W4 treatment complexity



Source: Bristol Water response to our provisional findings, Figure 1.

46. Bristol Water argued that its proportion of water treatment in the most complex and expensive treatment works (W3/W4) was higher than would be expected on the basis of its mix of water source type. Bristol Water said that, as a result, it would expect the econometric models that used the W3/W4 variable to result in a higher level of predicted cost for Bristol Water than the models which used the river source and reservoir source variables. Bristol Water said that the fact that the models with the W3/W4 variable did not produce a higher level of predicted costs for Bristol Water than the models with the rivers and

reservoir source variables reflected a concern with that aspect of the modelling.[14]

47. Bristol Water's argument was effectively that it was in a more extreme (adverse) position in terms of the W3/W4 variable than it was in terms of the water source type variables, and that this should be reflected in a higher expenditure estimate from the models that used the W3/W4 variable than the models that used the rivers and reservoirs variables.

48. We did not accept that Bristol Water's analysis and arguments on this issue demonstrated a concern or problem with the results from our econometric models that required a special cost factor adjustment.

49. We can see from Figure 1 that the correlation between the percentage of water from boreholes and the percentage of water requiring W3/W4 treatment was far from perfect. This indicates that treatment complexity (or at least treatment complexity as measured by the W3/W4 variable) was not simply a reflection of water source type. Indeed, Bristol Water made that same point to us in other submissions.[15] This means that we should not necessarily expect the results from the models with the rivers and reservoirs variables to be directly comparable with the results from models with the W3/W4 variable.

50. There are reasons why variations in water source type may have a larger effect on costs than variations in measures of treatment complexity. For example, Bristol Water argued that it had relatively high costs for maintaining upstream reservoir assets (see paragraphs 224 to 262). Any additional infrastructure maintenance costs associated with reservoir assets seemed more likely to be reflected in the results from models that included the reservoirs explanatory variable than from the models that use the W3/W4 variable instead of the rivers and reservoirs variables.

51. Bristol Water's response to our provisional findings did not seem to recognise the role that the reservoirs variables might play in capturing both the effects of water treatment complexity and reservoir maintenance costs. However, it seemed possible to us that the W3/W4 models might underestimate Bristol Water's costs by only taking account of treatment complexity and not capturing other costs that arose from the use of reservoirs. We carried out some further analysis to investigate this issue.

52. Bristol Water's submissions to us had emphasised that the W3/W4 variable was a better means to capture treatment complexity than the rivers and

[14] Bristol water response to provisional findings, paragraph 115.
[15] See Appendix 4.2, paragraph 65.

reservoirs variable. On that logic, and taking into account Bristol Water's views on the importance of upstream reservoir maintenance, it could be argued that, rather than using our original EV3 models (which included the W3/W4 variable instead of the rivers and reservoirs variables), it would be more appropriate to use a model which included the W3/W4 variable and the reservoirs variable (but not the rivers variable).

53. We carried out some sensitivity analysis to consider alternative models which included the W3/W4 variable and the reservoirs variable (but not the rivers variable). The estimates for Bristol Water from these alternative models were:

    (a) similar (plus or minus 1%) to the estimates from the original EV3 models with the W3/W4 variable only; and

    (b) lower than the estimates from the original EV2 models, which included the rivers and reservoirs variable but not the W3/W4 variable.

54. There would not be a significant difference to our estimates for Bristol Water's expenditure requirements if we had replaced the models with the W3/W4 variable with corresponding models that included both the W3/W4 variable and the reservoir variable.

55. We might have expected the estimates from the models including the W3/W4 variable and the reservoir variable to have been higher than the estimates from the models with just the W3/W4 variable, and closer to the estimates from the models with the rivers and reservoirs variables (but not the W3/W4 variable). This was not the case. It was possible that the various models with the W3/W4 variable underestimated Bristol Water's costs by not taking sufficient account of either the costs of reservoir maintenance or treatment complexity or both. But it was also possible that the models that included the rivers and reservoirs variables (but not the W3/W4 variable) overestimated Bristol Water's costs by giving an additional allowance to Bristol Water that was not explained by either treatment complexity (as would be measured by the W3/W4 variable) or upstream infrastructure maintenance (as would be measured by the reservoir variable).

56. The uncertainty in this area reflected the limitations to estimation accuracy from the econometric models. With a small sample size, it was difficult to take full and accurate account of the varying effects of treatment complexity and source type on each company's costs. This was particularly so given the correlations between the W3/W4 variable and the source type variables which made it more difficult to disentangle their effects. Furthermore, there were limitations with the available W3/W4 data, not least that it was not up to date.

57. On the evidence available, our further analysis of the W3/W4 variable and the issues related to upstream infrastructure maintenance did not demonstrate that the estimates we had used for our preferred set of models were too low (or too high). We did not consider that there was evidence to favour one type of model over another or to amend the mix of different models that we had used in our analysis.

Bristol Water's argument for using Ofwat's special cost factor adjustment

58. In its response to our provisional findings, and in the light of the issues discussed above, Bristol Water said that we should allow an additional special cost factor of £5.5 million to make up the difference between the implied allowance for treatment complexity from our provisional findings (£12.7 million) and the special cost factor adjustment for treatment complexity that Ofwat had made in its final determination (£18.2 million).[16]

59. We asked Ofwat to provide further information on how it calculated its £18.2 million adjustment for treatment complexity. Ofwat's approach was as follows:

(a) Ofwat produced a variant of its two refined totex models and its two refined base expenditure models which included the W3/W4 variable as an additional explanatory factor; there were no other changes to the specification of these models. Ofwat also tested a variant of its full totex model but the addition of the W3/W4 variable did not make a significant difference to the coefficients of this model and so it did not consider that a special cost factor adjustment for treatment complexity was appropriate for this model.

(b) Ofwat used the four new econometric models from (a) to produce estimates of Bristol Water's expenditure requirements (before upper quartile efficiency adjustment) over the historical period from 2008/09 to 2012/13.

(c) Ofwat compared the estimates for Bristol Water from each of the four models with the corresponding estimate for the historical period from 2008/09 to 2012/13 from Ofwat's original refined totex and refined base expenditure models (ie models that did not include the W3/W4 treatment complexity variable).

[16] Bristol Water response to our provisional findings, paragraph 120.

(d) Ofwat found that each of the models with the W3/W4 variable produced a higher estimate for Bristol Water and calculated this as a percentage uplift on each of the original Ofwat models.

(e) Ofwat applied the percentage uplift to its estimated expenditure for Bristol Water from its refined totex and refined base expenditure models. This produced an uplift of £30.1 million for the refined totex models and £27.7 million for its base expenditure models.

(f) Ofwat applied its approach to triangulation, which gave a weight of one-third to the uplift for the refined totex models and one-third to the uplift for the refined base expenditure models (as noted under (a) above, Ofwat did not make an adjustment in relation to its full totex model). This produced £19.5 million.

(g) Ofwat applied its 6.53% upper-quartile efficiency adjustment to the figure from (f) above. This led Ofwat to an overall special cost factor adjustment of £18.2 million.

60. The description above shows that Ofwat's special cost factor adjustment for treatment complexity was obtained from detailed calculations using the results of Ofwat's original econometric models and the results from alternative versions of those models. We did not consider it appropriate to simply take Ofwat's figure and apply it to the results from our econometric models, which differed from Ofwat's models in a number of significant ways.

61. Bristol Water was very critical of many aspects of Ofwat's original econometric models (see Appendix 4.1). We did not consider it consistent for Bristol Water to reject Ofwat's econometric models on a number of grounds unrelated to treatment complexity, and then to consider that versions of Ofwat's models which included the W3/W4 treatment complexity variable provided a reliable way to estimate the appropriate special cost factor for treatment complexity.

62. The treatment complexity adjustment made by Ofwat was relevant to our assessment. Indeed we took this adjustment into account in our model development, where we included models with the W3/W4 variable. However, we did not consider that the level of the adjustment calculated by Ofwat using its econometric models provided a good estimate of the appropriate adjustment to expect from (or apply to) our econometric models.

63. Furthermore, Ofwat disagreed with the proposal from Bristol Water that we should make a special factor adjustment to reflect the differences between the allowances from our models and the special cost factor adjustment for treatment complexity that Ofwat allowed. Ofwat's view was that, because our econometric models produced a slightly higher level of costs and included

water treatment explanatory variables, there was 'clearly no case for an extra allowance on the basis of a comparison with the results of Ofwat's analysis'.

Our assessment

64. We considered that changes to the specification of the econometric models that we used for our final determination addressed Bristol Water's submissions on the use of distribution input in explanatory variables for these models and the risks of overlooking the costs of achieving relatively low levels of leakage.

65. We did not find grounds to adopt Bristol Water's proposal of allowing a special cost factor to make up the difference between the allowances for Bristol Water's water source type and treatment complexity from our econometric models and the special cost factor for treatment complexity that Ofwat had made for FD14.

66. We recognised that there was uncertainty as to whether the estimates from our econometric models took full account of differences in Bristol Water's expenditure requirements, relative to the rest of the industry, arising from its mix of water sources (eg its relatively high use of rivers and reservoirs) and the quality of its raw water. However, we did not find clear evidence that the models disadvantaged Bristol Water and required an adjustment.

Additional water treatment costs at Purton and Littleton

Summary of the claim and our provisional findings

67. Bristol Water argued that the nature of the water that it took from the Sharpness Canal was such that the complexity and costs of treating it at Purton and Littleton were much higher than the costs of treating water from a more typical river abstraction that would require a W3 or W4 level of treatment complexity.

68. Bristol Water's submissions indicated that water treatment at Purton and Littleton involved numerous complex processes. It seemed possible that our econometric models – both those using raw water sources as explanatory variables and those using the W3/W4 variable as an explanatory variable – might understate Bristol Water's efficient expenditure requirements by giving insufficient allowance for the costs that would be efficiently incurred to manage and treat the water abstracted from the Sharpness Canal.

69. In our provisional findings, we considered the evidence provided by Bristol Water (and available to us) to be insufficient to make any special cost factor

adjustment. We also recognised that there was some uncertainty about whether to make an adjustment and that there were limitations in the publicly available information on the costs of water treatment works that impeded the analysis (eg Ofwat's regulatory reporting requirements did not produce comparable cost data at the level of individual treatment works).

Bristol Water's comparisons with Hampton Loade

70. Bristol Water said that higher costs at Purton and Littleton arose from *(a)* increased costs for common treatment processes, and *(b)* the need for extra treatment processes. Bristol Water identified issues at Purton and Littleton relating to factors such as zebra mussels and chlorination by-products, pesticides and raw water cryptosporidium risk.

71. In its SoC, Bristol Water sought a special cost factor adjustment for the additional treatment complexity at Purton and Littleton of £1.67 million per year, or £8.35 million over the five-year period. This figure was based on estimated additional costs compared with a reference site, Hampton Loade, operated by South Staffordshire Water. Bristol Water selected this site because:

    (a) Ofwat's models predicted that it should have similar costs to Purton (both are non-ground water treatment works which had been categorised as W4); and

    (b) water is abstracted from the same underlying source, the River Severn.

72. Bristol Water's comparisons of Purton and Littleton treatment works against Hampton Loade treatment works included a summary of the treatment processes used at these sites. Bristol Water identified that Purton and Littleton needed a number of additional processes that were not required at Hampton Loade. Bristol Water discussed the reasons for the differences in the processes required, and made estimates of the additional annual costs of the processes needed at Purton and Littleton which were not required at Hampton Loade. It added these together to calculate an annual cost difference compared with Hampton Loade of £1.67 million, which gave its proposed adjustment of £8.35 million over the five-year period. This calculation did not make any allowance for indirect costs.

73. We considered that Bristol Water's analysis provided some evidence that the expenditure requirements for treatment at Purton and Littleton may be relatively high, even for a site categorised with W3/W4 processes. However, this evidence was limited because the comparison was against a single reference site.

74. Even if Bristol Water's costs for Purton and Littleton treatment works were materially higher than the treatment costs faced by South Staffordshire Water for the Hampton Loade treatment works, this would not provide strong evidence of the need for an adjustment to the results from our econometric benchmarking models. In particular, a comparison against a single site could not show that:

(a) Bristol Water's efficient costs for abstracting and treating water at Purton are high (eg on a pound per cubic metre basis) relative to the costs of the average river water source; nor that

(b) Bristol Water's efficient costs for abstracting and treating water at Purton were high (eg on a pound per cubic metre basis) relative to the average treatment works with W3/W4 treatment processes.

Bristol Water's response to our provisional findings

75. In its response to our provisional findings, Bristol Water said that the treatment works at Purton and Littleton were significantly more complex than typical W3/W4 treatment works and that together they typically represented 45% of Bristol Water's water into supply.[17]

76. Bristol Water highlighted that at the PR09 periodic review, Ofwat and the CC allowed a special cost factor of £13.3 million for the additional costs arising at Purton and Littleton treatment works. This was in addition to a special cost factor allowance of £6.9 million related to Bristol Water's use of W3/W4 treatment works.[18]

77. Bristol Water's response to our provisional findings[19] presented a chart which showed that its direct costs of water treatment in the period 2008/09 to 2010/11 was the highest out of 18 companies. Bristol Water calculated that if its costs were in line with the industry average of 5.1 pence per cubic metre, its direct costs of water treatment would be £4.7 million per year lower, which equated to £23.6 million over the five-year price control period.[20]

78. Bristol Water said that, in addition, it had higher indirect costs of resources and treatment, as a result of central factors relating to the higher direct costs (eg greater allocation of HR and finance costs, additional process science and DWI reporting costs). Bristol Water said that at PR09 Ofwat allowed 33% of the additional indirect costs as part of the Purton and Littleton special cost

---

[17] Bristol Water response to our provisional findings, paragraph 122.
[18] Bristol Water response to our provisional findings, paragraphs 125 & 126.
[19] Bristol Water response to our provisional findings, Figure 2.
[20] Bristol Water response to our provisional findings, paragraph 130.

factor. It said that its claim for PR14 of £8.35 million did not include any indirect costs and that allowing 33% for indirect costs would result in additional costs of £4.5 million over five years.[21]

79. Bristol Water presented calculations which compared its estimate of the additional direct costs that it faced for water resource and treatment compared with the average company in the industry (£23.6 million) against: *(a)* the allowances in our provisional findings for special cost factors relating to water resource and treatment (£8.1 million for Canal and River Trust payments); and *(b)* Bristol Water's views on appropriate special cost factor allowances. Bristol Water argued that these calculations showed that the approach in our provisional findings was equivalent to assuming that £15.5 million of Bristol Water's costs for water resources and treatment were inefficiently above average. It said that these costs represented over 30% of its actual costs and that assuming the difference was due to inefficiency was effectively assuming that Bristol Water spent 46% more than it needed to on resources and treatment, which would not be a reasonable assumption. Bristol Water said that, in contrast, its calculations showed that allowing for the special cost factors it had proposed in its response to the provisional findings, its costs would be slightly above average, which demonstrated that the special cost factors it estimated were conservative.[22]

80. Bristol Water's response to our provisional findings also provided and discussed a series of charts that showed how water companies' direct costs for water resources and treatment (between 2008/09 and 2010/11) varied according to: *(a)* the proportion of distribution input from river sources; *(b)* the proportion of distribution input not from boreholes; and *(c)* the proportion of distribution input from W3/W4 treatment works. Bristol Water provided this analysis in response to the comments we had made in our provisional findings about the limitations of comparisons against a single site, Hampton Loade (see paragraph 74 above).[23]

81. Bristol Water said that its analysis showed that Bristol Water's direct costs of resources and treatment were higher than would be expected simply from the proportion of water derived from river sources, or derived from river and reservoir sources, and that this demonstrated that its costs overall were high relative to these factors. Since Purton and Littleton were Bristol Water's most expensive treatment works, Bristol Water considered that this demonstrated

[21] Bristol Water response to our provisional findings, paragraph 131.
[22] Bristol Water response to our provisional findings, Table 4 & paragraphs 133 & 134.
[23] Bristol Water response to our provisional findings, paragraphs 136–146 & Figures 3–5.

that the costs of Purton and Littleton were high relative to the average treatment works with a river water source.[24]

82. Bristol Water said that its analysis showed that the relationship between resources and treatment direct costs and the proportion of water treated at W3/W4 treatment works was much stronger than the relationship between resources and treatment direct costs and the proportion of water from rivers or boreholes. In addition, Bristol Water said that the analysis showed that Bristol Water's costs were higher than those of an average company with the same proportion of W3 and W4 works. It said that this demonstrated that its costs overall were high relative to the typical costs associated with the proportion of W3 and W4 works. Since Purton and Littleton were Bristol Water's most expensive treatment works, it considered that this demonstrated that the costs of Purton and Littleton were high relative to the average treatment works with W3/W4 treatment processes.[25]

83. Finally, Bristol Water referred to the limitations in the information available for it to make comparisons. It said that, apart from the detailed comparison it provided with Hampton Loade, it did not have information on the costs of treatment for other companies. Bristol Water argued that the fact that such data was not available should not be, in itself, a sufficient reason for rejecting the special factor claim. In any event, Bristol Water said that the available data on direct resources and treatment costs could partially answer this question. Bristol Water also noted that Ofwat was satisfied at both PR04 and PR09 that the comparison of these direct costs between companies was an appropriate and reasonable comparison.[26]

Bristol Water's comparisons of its resource and treatment costs

84. Bristol Water's response argued that the approach taken in our provisional findings implied that it spent 46% more than it needed to on resources and treatment, which was not a reasonable assumption. Bristol Water's calculation was as follows:

    (a) It estimated the extent to which its direct costs of water resources and treatment were above the level that would apply if it had industry-average costs (on a pence per cubic metre basis). Its estimate was £23.6 million over a five-year period.

[24] Bristol Water response to our provisional findings, paragraph 141.
[25] Bristol Water response to our provisional findings, paragraphs 145 & 146.
[26] Bristol Water response to our provisional findings, paragraph 143.

(b) Bristol Water stated that, under our provisional findings, £15.5 million of this was 'additional costs assumed to be inefficiency'. It calculated this by subtracting the £8.1 special cost factor allowance we had made for the Canal and River Trust payments from the figure of £23.6 million from (a).

(c) Bristol Water estimated what its total level of water resources and treatment direct costs would be if it were not for these additional costs assumed to be inefficiency. It subtracted £15.5 million from its reported actual costs for the five-year period of 49.3 million, to obtain a figure of £33.8 million.

(d) Bristol Water calculated that £15.5 million of costs assumed to be inefficiency out of a total direct costs of £33.8 million would represent 46% of those total direct costs.

85. We did not accept this calculation and the implications drawn by Bristol Water.

86. Bristol Water's analysis ignored the fact that the econometric models that we used for our provisional findings made allowances for Bristol Water requiring higher expenditure for its water resources and treatment activities. These allowances arose from the coefficients on the explanatory variables in our econometric models for source type (rivers and reservoirs) and treatment complexity (the W3/W4 variable).

87. The models we used for our provisional findings made an allowance of £12.7 million for water source type and treatment complexity. Bristol Water's calculation did not take any account of this allowance and therefore presented a misleading impression of the approach we used for our provisional findings.

88. We produced a revised version of Bristol Water's calculation. We found that only £2.8 million of the additional direct costs for water resources and treatment of £23.6 million that Bristol Water had identified (additional costs compared to the industry-average costs) would not be explained by the combination of the special cost factor for Canal and River Trust payments (£8.1 million) and the allowances in the econometric models for Bristol Water's source type and treatment complexity being different to the average company (£12.7 million). Repeating steps (c) and (d) from Bristol Water's calculation (see paragraph 84) would indicate an implied inefficiency (or at least unexplained cost differential) of 6%.

89. Following our provisional findings, we refined our preferred set of econometric models in several ways. We estimated that, for the refined models, the allowance for water source type and treatment complexity was £12.3 million. This would also imply, under the approach above, an implied inefficiency for direct costs (or at least unexplained cost differential) of 7%.

90. Some caution is needed in the interpretation of these calculations. Our econometric models, and special cost factor assessment, concerns Bristol Water's base expenditure, across opex and capital maintenance, which differs from Bristol Water's analysis of direct costs preventing a like-for-like comparison. Furthermore, Bristol Water's calculations used comparative data from a three-year period 2008/09 to 2010/11 which may be out of date and not entirely accurate for the 2015-2020 price control period.

91. We can bring a further perspective to Bristol Water's claims that our approach to Bristol Water's special cost factor claims in our provisional findings implied that it had a level of inefficiency that was implausibly high. Section 4 of our provisional findings produced an overall assessment of Bristol Water's base expenditure requirements of £346 million over the five-year price control period, drawing on the estimates from the econometric models and our special cost factor assessment. This figure was around 90% of the amount for base expenditure in Bristol Water's business plan (the corresponding figure when compared against our final determination for base expenditure was 88%). We did not consider that there was evidence that our approach to the econometric models and special cost factors in our provisional findings (or our final determination) implied anything implausible about Bristol Water's relative efficiency.

92. We did not consider that Bristol Water's charts comparing water companies' direct costs against the proportion of distribution input from rivers, from boreholes and against the proportion subject to W3/W4 treatment added to the available evidence relating to Purton and Littleton. This further analysis by Bristol Water did not differentiate the costs of abstracting and treating water at Purton and Littleton from the costs at Bristol Water's other sites. Some analysis to distinguish between Bristol Water's various treatment sites seemed important for a special cost factor that specifically concerned the additional costs at Purton and Littleton relative to other sites.

Ofwat's further submissions

93. Ofwat provided submissions in response to Bristol Water's response to our provisional findings on the additional costs of treatment at Purton and Littleton.

94. Ofwat said that it did not consider that (relatively) out-of-date information that only explained cost levels rather than efficiency should have any significant bearing on the determination of price levels for the period 2015-2020. Ofwat said that during the PR14 cost assessment, Bristol Water failed to demonstrate that the raw water used by Purton and Littleton was an outlier in

terms of quality or that it had considered an optimal range of solutions for treating raw water.

95. Ofwat referred to an extract from its final determination feeder model, which summarised the conclusions of its analysis:

> Bristol Water does not discuss any alternative solutions to its current high opex requirements - such as resilience, bankside storage or developing monitoring technology. We suggest that there may be a link to the Southern Resilience scheme, which will provide resilience from 2019 if Purton and Littleton are unavailable. However, there is no information on the impact of the resilience scheme on the operation and costs of treatment in the Purton and Littleton supply area. There was no independent assurance on alternatives to managing the poor water quality - resilience or other. Overall, we do not consider that there is sufficient evidence that the raw water at Purton and Littleton is of worse quality than that at other W3/W4 sites, or that increased costs are unavoidable. Some independent engineering assurance could have been provided on how complex these works actually are compared to other treatment works in the industry.

96. Ofwat said that, given the lack of evidence in relation to raw water quality and cost efficiency, it was clear that Bristol Water had not provided sufficiently robust evidence to justify its special cost factor claim. Ofwat also argued that Bristol Water appeared to be double counting its special cost claims, because it received an allowance for its relatively high level of W3/W4 water treatment complexity and yet calculated its special cost factor claim on the basis that it received an average allowance.

Further analysis of treatment costs

97. We did not identify available data at the level of treatment works on a comparable basis across the water companies in England and Wales. In this context, we saw merit in making comparisons between Bristol Water's treatment works.

98. As part of our analysis following Bristol Water's response to our provisional findings, we asked Bristol Water for cost information separated for each of its treatment works.

99. Bristol Water said that because of the dependency of the Littleton treatment works on water provided from Purton, the allocation of costs between these two sites was difficult. It said that the costs of running only Littleton (without

using Purton) would most likely be higher than those it had reported for Littleton as some Purton costs would still be incurred. Bristol Water therefore presented costs for Purton and Littleton combined as well as separately. Since the special cost factor claim concerned differences between Purton and Littleton compared with other sites, it seemed reasonable for us to take Purton and Littleton together in the analysis.

100. Bristol Water provided information on its direct water treatment costs for different treatment works over AMP5. Table 1 provides a summary, which compares the direct costs, on unit cost basis (pence per Ml of treated water), for Purton and Littleton (taken together) with the average costs excluding Purton and Littleton. These figures exclude some costs which Bristol Water was not able to able between sites (eg production management and operation room costs).

Table 1: Average water treatment direct costs, AMP5, per cubic metre

Pence per m^3

	Purton and Littleton combined	*Average excluding Purton and Littleton*	*Difference*
Power	4.5	2.1	2.4
Chemicals	3.2	1.5	1.7
Labour and other costs	2.8	4.5	–1.7
Total unit cost	10.5	8.1	2.4

Source: CMA analysis of Bristol Water data.

101. We can see that the direct unit costs reported for Purton and Littleton were around 30% higher than for the average of other sites. The main difference was for power costs, with chemicals costs also higher for Purton and Littleton. However, direct costs reported as 'labour and other' were less for Purton and Littleton. If power costs were to be excluded, the costs of Purton and Littleton would be similar to that for other sites.

102. The costs in Table 1 do not include capital maintenance needed for treatment works and focus only on water treatment, which did not account for other costs relating to the type and nature of water sources such as abstraction costs. We also asked Bristol Water to provide estimates of costs on a totex basis (ie covering opex and capital maintenance) for abstracting and treating raw water at each of its sites.

103. Bristol Water provided estimates of its average totex unit costs for its various treatment works. The opex element used Bristol Water's opex from 2012/13. It calculated the capital maintenance element of the totex unit cost using ten-year averages using AMP5 costs and its AMP6 forecasts. It said that because capex on a site-by-site basis was lumpy, comparisons over a shorter period could be misleading. It calculated unit costs using data on the average output from each treatment works during AMP5.

104. Table 2 presents estimates of Bristol Water's totex unit costs for abstraction, raw water distribution and water treatment, in pence per cubic metre, using the data provided by Bristol Water. Bristol Water presented a single figure for Cheddar and Stowey treatment works because some of the costs for these works were not separately identified in its accounting system. Similarly, Bristol Water said that its accounting system did not identify separately some of the costs for its various groundwater sources, so it reported combined figures for these. We combined the costs for Purton and Littleton given Bristol Water's view that the allocation of costs between these two sites was difficult.

Table 2: Totex unit cost, per cubic metre, for Bristol Water treatment works

					Pence per m^3
	Purton & Littleton	*Barrow*	*Cheddar and Stowey*	*Banwell*	*Groundwater sources*
Totex unit cost	24.7	14.3	22.3	17.4	21.8
Totex unit cost excluding Canal and River Trust payments	21.2	14.3	22.3	17.4	21.8
Totex unit cost excluding Canal and River Trust payments and power costs	14.6	12.8	14.2	15.0	15.2

Source: CMA analysis.

105. Table 2 shows that one part of the difference in unit costs between Purton and Littleton and Bristol Water's other sites was accounted for by the Canal and River Trust payments. These relate specifically to Purton and Littleton and we have considered these as a separate special cost factor above. The unit costs excluding the Canal and River Trust payments were the relevant point of comparison here, so avoid the risk of double counting.

106. We can see that, having excluded the costs of Canal and River Trust payments, the estimated totex per cubic metre for Purton and Littleton was not an outlier compared with Bristol Water's other sites. The estimated unit totex for Purton and Littleton was above the average unit cost from the sites that Bristol Water provided data for, but below the unit totex for *(a)* Barrow and *(b)* Cheddar and Stowey.

107. Furthermore, if power costs were also excluded from the comparison, the average unit totex for Purton and Littleton was no higher than the average for the other sites and was below the costs for Bristol Water's groundwater sources. Bristol Water told us that the reported power costs primarily reflected the pumping costs of moving water to and from the treatment works and that treated water from Purton was pumped south into Bristol Water's distribution system. Bristol Water said that power costs for water treatment (eg UV) would be less significant. The indication from this analysis was that the higher costs

at Purton and Littleton were driven in large part by additional power costs, which were primarily due to pumping water to and from the treatment works.

Our assessment

108. We considered the regulatory precedent for a special factor adjustment relating to the Purton and Littleton treatment works to be relevant to our assessment but not determinative. We considered that a fresh assessment in the light of the available evidence was appropriate. Furthermore, the main focus of the review of special cost factors in the CC10 determination was whether to accept Bristol Water's case for a higher adjustment, rather than a full reconsideration of the allowance that Ofwat had made.

109. Bristol Water's analysis established that its water resource and treatment costs were relatively high compared with other companies, at least on the basis of the 2008/09 to 2010/11 direct cost measure of opex that Bristol Water's analysis focused on.

110. The comparisons of costs provided by Bristol Water was relevant background information. But we did not consider that it would be appropriate to make a special factor adjustment simply because *(a)* Bristol Water argued that its raw water quality was worse at Purton and Littleton and *(b)* Bristol Water's overall water resource and treatment costs were higher than those of other companies. This was because there were other possible explanations for the higher reported costs for Bristol Water, such as the following:

    (a) Bristol Water's higher costs may reflect efficiency differences compared to other companies.

    (b) Bristol Water's higher direct costs for water resources and treatment may reflect differences in cost allocation and working practices between companies which were not necessarily reflective of higher costs overall. For example, if Bristol Water allocated more of its costs to opex than other companies, or if Bristol Water used working practices that involved a greater proportion of opex compared with capital maintenance, then Bristol Water's reported direct costs could be relatively high even if its overall costs were not.

111. We disagreed with Bristol Water's calculation that our provisional findings had implied that it was 46% inefficient. Bristol Water seemed to have overlooked the allowances relating to water treatment costs from our econometric models. If these were included, the figure used by Bristol Water would change to 6%.

112. Bristol Water provided some qualitative evidence that the necessary costs of treating the water abstracted from the Sharpness Canal at the Purton and

Littleton treatment works may be relatively high and that this may not be taken account of sufficiently in our econometric models of base expenditure.

113. Bristol Water's detailed comparisons with Hampton Loade provided some relevant quantitative evidence that the expenditure requirements for treatment at Purton and Littleton may be relatively high, even for a site categorised with W3/W4 processes. However, this evidence was limited because the comparison was against a single reference site.

114. One of the main difficulties with the assessment of the special cost factor claim for Purton and Littleton was a lack of data that would allow benchmarking of Purton and Littleton against a wider sample of treatment works operated by other companies, and an examination of how factors relating to raw water quality affected the costs for specific water sources and treatment works.

115. In the absence of such data, we saw merit in comparisons of Purton and Littleton against Bristol Water's other water sources and treatment works. The costs at Purton and Littleton did not appear to be out of line with those of Bristol Water's other sites, at least when we considered both opex and capital maintenance and excluded the Canal and River Trust payments. Our further analysis cast doubt on Bristol Water's argument that there should be a special cost factor adjustment due to the additional costs arising from the complexity of treatment processes required at Purton and Littleton. At the very least, it suggested that any additional costs at Purton and Littleton due to treatment complexity were offset by other factors.

116. Overall, we did not identify grounds to make a special cost factor adjustment for any additional costs at Purton and Littleton treatment works.

Congestion in Bristol

Summary of the claim and our provisional findings

117. In its SoC, Bristol Water argued that the congestion in the city of Bristol led to it facing higher costs than other companies:[27]

> Bristol as a city has considerable problems with congestion. The Department of Transport found that Bristol has the third lowest travel speed of all urban areas in England, with only Reading and inner London being lower. This is particularly evident during the morning peak, when Bristol's average speed of 14.9mph is

[27] Bristol Water SoC, paragraph 235.

10mph less than the average in England of 24.9mph, and 1.8mph less than in London. This impacts on Bristol Water as the lower traffic speeds in Bristol, where over half of its customer properties are located, result in greater travel time between jobs compared to other cities and water companies, thereby resulting in additional costs.

118. Ofwat had originally rejected Bristol Water's special cost factor claim for the effects of congestion. Between Ofwat's draft and final determinations, Bristol Water submitted a series of revised special cost factor claims, responding in part to Ofwat's feedback on its original claims.

119. Bristol Water estimated that the monetary impact of the relatively high congestion – and hence lower traffic speeds – in its area of appointment was £0.73 million annually, equating to £3.65 million over the five years. Bristol Water said that this was a conservative estimate in that it did not include the additional fuel costs arising from congestion, nor the additional insurance premiums and accidents that arose from operating in an area of high traffic density. Bristol Water said that its claim for congestion related to both opex and capex, as it affected staff attending both capital and operational jobs.

120. This figure was calculated by comparing a measure of the average morning peak speed for Bristol with a measure of the average morning peak speed across five other major cities in England, using data from the Department for Transport (DfT). Bristol Water found that the average morning peak speed was 14.9mph in Bristol compared with an average of 18.1mph in these other cities. Bristol Water used the difference between these speeds to calculate the additional hours required of its staff and contractors for work in Bristol. It combined the estimated additional hours with estimates of the hourly costs for different types of worker to produce an estimate of the additional cost arising from the slower morning average speed in Bristol compared with other cities.

121. Bristol Water also used three other calculation methods as part of its analysis and found its main calculation to be towards the lower end of its estimates.

122. Our provisional findings did not make any special cost factor adjustment for congestion. We identified that our econometric models were likely to already take some account of the effects of congestion, through the explanatory variables relating to the total length of water mains relative to the number of properties supplied. We recognised that there was uncertainty in this area, but considered that the evidence from Bristol Water's submissions was not sufficient to show that an adjustment to the estimates from these models was needed for congestion.

Bristol Water's further submissions in response to our provisional findings

123. In its response to our provisional findings, Bristol Water made some further points which were relevant to our assessment.

124. Bristol Water identified that a key reason that we had not made an adjustment was that our econometric models may already allow for congestion through the explanatory variables in the models relating to the density of water connections in a company's areas (mains length per property supplied or total properties divided by total mains length). It said that two cities with equal density could have quite different traffic conditions and costs. It argued that our econometric models would underestimate the costs of companies operating in areas where congestion was higher than average for a particular density of customers.[28]

125. Bristol Water said that its proposed adjustment was based on a comparison of traffic speeds in Bristol with an average of those in Leeds, Birmingham, Liverpool, London and Manchester and it argued that these other cities were likely to have similar connection densities to Bristol Water. It said that the quantum of its claim arose from a comparison of the costs of operating in Bristol compared with operating in an average major city with similar density.[29]

126. Bristol Water also sought to further justify its use of the DfT traffic speed data in its analysis, which was for weekday morning peaks, defined as 7am to 10am on days outside of August and other school holiday periods.[30]

127. Bristol Water also said that it was possible that the use of company-wide averages in the econometric models could underestimate the costs of a particular company. It said that this could be illustrated by considering an underlying industry cost function that had higher costs for high-density areas and for low-density areas, and lower costs for medium-density areas. A company that consisted of a high-density area and a low-density area would have relatively high costs, but it would appear, on average, to be medium density and may then be treated as a lower-cost company. Bristol Water said that its area consisted of a high-density area in Bristol and a low-density area (Somerset and the Mendips). It said that this feature contributed to its own estimate of the financial effect of the congestion it faced as being conservative.[31]

---

[28] Bristol Water response to our provisional findings, paragraphs 150–154.
[29] Bristol Water response to our provisional findings, paragraphs 155–157.
[30] Bristol Water response to our provisional findings, paragraphs 160 & 164.
[31] Bristol Water response to our provisional findings, paragraphs 158–160.

Ofwat's assessment for its final determinations

128. For its final determination, Ofwat included an additional allowance of £3 million for Bristol Water's special cost factor claim relating to congestion. The adjustment reflected Bristol Water's claim minus Ofwat's calculation of the implicit allowance.[32]

129. Ofwat had originally found that the evidence provided by Bristol Water was not sufficiently strong to warrant an adjustment. Ofwat's assessment failed the claim on the need criterion. Ofwat said that Bristol Water had not demonstrated that serving a congested city meant that its costs at a company level were materially higher, and that it was not clear whether there were any offsetting cost savings compared with other companies (eg the scheduling of jobs more efficiently because a large proportion of the area was urban and densely populated). Ofwat said that although DfT statistics showed that Bristol had low average traffic speeds, Bristol Water did not provide evidence that its total journey times were substantively different from other companies and that this led to higher costs overall, and that it did not demonstrate why the density and regional cost variables in its econometric models did not take account of the impact of congestion.[33]

130. However, after a more holistic review of its initial modelling allowance for Bristol Water, Ofwat decided to make an adjustment for congestion of £3 million. Ofwat told us that the special cost factor adjustment for congestion in Bristol was an area where it gave Bristol Water the benefit of the doubt.[34]

Ofwat's further submissions

131. Ofwat supported the approach taken to the congestion special cost factor in our provisional findings, particularly the view that congestion costs would largely be taken into account by the use of a density cost driver in the econometric models. Ofwat did not agree with Bristol Water that its mix of urban and rural areas made it different, as the majority of water companies served a mixture of urban and rural areas.

132. Ofwat said that its own analysis showed that the average speed in the comparator cities (Leeds, London, Manchester, Birmingham and Liverpool) was 17.2mph in 2012, which was lower than the figure of 18.1mph used by Bristol Water, and that the speed for Bristol was 15.2mph which was slightly higher than that used by Bristol Water. Ofwat said that it did not consider that

[32] Ofwat, Final determination cost threshold populated feeder models for Bristol Water.
[33] Ofwat, Final determination cost threshold populated feeder models for Bristol Water.
[34] Ofwat response, paragraph 23.

a 2mph differential in average traffic speeds was likely to be a significant driver of the efficient level of costs, particularly as Bristol Water's operational sites were predominantly on the outskirts of or in rural areas surrounding Bristol.

133. We clarified the source of this difference between the figures for traffic speeds reported by Ofwat and Bristol Water. The figures used by Bristol Water were based on data for flow-weighted traffic speeds for locally managed 'A' roads in 2012/13 (these flow-weighted average speeds would give greater weight to roads that were used more). The figures used by Ofwat were based on unweighted average tariff speeds for locally managed 'A' roads in 2011/12.

Further analysis of relative traffic speeds for Bristol Water

134. We reconsidered the case for a special cost factor for congestion in the light of the responses to our provisional findings and some further quantitative analysis.

135. Bristol Water's claim on congestion concerned the potentially higher costs of supplying customers in a densely-populated urban area, due to the effects of traffic congestion on the time required by its workforce to complete tasks.

136. Supplying customers in a geographic area with a relatively high population density (persons per square mile) compared to a geographic area with a relatively low population density may have effects on costs that work in opposite directions:

    (a) There may be higher costs per customer supplied because of factors that make work more difficult (eg traffic management and safety issues and reinstatement costs related to work on underground pipes in urban areas) or more time-consuming (eg to travel between different locations) in geographic areas with a relatively high number of people.

    (b) There may be lower costs per customer supplied because customers tend to be closer to each other if the population density was higher, and so customers can be supplied using less infrastructure (eg a lower length of mains relative to the number of properties supplied) and with shorter journeys, on average, between the premises of different customers.

137. The assessment of Bristol Water's claim for congestion needs to take account of the explanatory variables in our alternative econometric models and the extent to which they may capture the effects under *(a)* and *(b)* above.

138. Our econometric models were likely to make some allowance for the net effects at *(a)* and *(b)* above, through the explanatory variables relating to the

length of water mains relative to the number of customers. The length of water mains per customer was likely to be negatively correlated with the degree of congestion a company faces. Densely-populated urban areas will tend to have lower length of mains per property and face greater congestion than less densely-populated areas.

139. The results from our alternative econometric models suggest that the effect under *(b)* above dominates the effect under *(a)*, at least on average across the 18 companies over the sample period. For example, in our preferred base expenditure models from Section 4 the coefficient on the explanatory variable for the length of mains per customer was positive. On average, across the seven preferred models, the estimate for Bristol Water's base expenditure was 4% lower than it would have been had it had a total length of mains per customer, in line with the industry average. We would expect this figure to reflect some allowance for the effect under *(a)*, including congestion.

140. We would consider a special cost factor adjustment for congestion to be appropriate if we considered that, given the congestion faced by Bristol Water, the net effect of *(a)* and *(b)* above was likely to be significantly less favourable for Bristol Water in practice than the results implied for Bristol Water by our alternative econometric models.

141. We did not consider that Bristol Water's response to our provisional findings had shown this to be the case. For example, Bristol Water asserted that Leeds, Birmingham, Liverpool, London and Manchester were likely to have similar connection densities to Bristol Water, but did not provide or refer to evidence to support this.

142. We carried out some further analysis of the DfT data that Bristol Water had used in its submissions,[35] and combined this with data from the Office of National Statistics (ONS) on the population density of the cities and areas in the traffic speed data set.

143. Our analysis showed that, as we would expect, traffic speeds tend to be negatively correlated with population density. Table 3 below shows how the average traffic speeds from the DfT data vary according to the population density of the areas the speeds relate to. We followed Bristol Water's approach of using the 2012/13 flow-weighted average traffic speeds, which seemed more appropriate than the 2011/12 unweighted average traffic speeds that Ofwat had referred to.

[35] DfT, Average vehicle speeds (flow-weighted) during the weekday morning peak on locally managed 'A' roads.

Table 3: Relationship between population density and average traffic speeds

	Average population density (individuals per km^2)	*Morning peak speed 2012/13 (miles per hour)*	*Speed versus City of Bristol (%)*
City of Bristol	3,997	14.9	–
All observations in DfT traffic speed data set	2,731	23.4	+57
All observations with pop. density over 1,000	4,281	19.0	+28
All observations with pop. density over 2,000	5,001	18.0	+21
All observations with pop. density over 3,000	6,106	16.8	+13
All observations with pop. density between 3,000 and 5,000	4,014	18.1	+21

Source: CMA analysis.

144. Our analysis indicated that, across a range of comparisons, traffic speeds in the city of Bristol[36] seem to be significantly slower on average than for other local authorities with a similar population density.

145. We considered this analysis to be superior to that used by Bristol Water because it analyses traffic speeds together with population density and provides for a larger sample size for comparisons compared with Bristol Water's comparisons against a small number of cities.

146. Bristol Water's proposed special cost factor adjustment of £3.65 million was calculated by comparing the speed in the city of Bristol with the speed of 18.1 mph which it had calculated as the average speed across a number of other cities in England. We can see from Table 3 that the average traffic speeds for all observations with a population density of between 3,000 and 5,000 people per square kilometre was also 18.1mph. The average population density for these observations was 4,014 individuals per square kilometre, which was very close to the reported figure of 3,977 for the city of Bristol. Therefore, despite differences in the comparisons used, we considered 18.1mph to be a reasonable figure to use in the calculation of speed differentials compared with the city of Bristol.

147. Our analysis of the DfT and ONS data did not indicate that the traffic speeds in areas supplied by Bristol Water outside the city of Bristol were any faster than the average of other places with similar population density.[37]

[36] This data relates to the entire area of the local authority and is not limited to Bristol city centre.
[37] We considered the three unitary authorities that surround the city of Bristol (and which Bristol Water's supply area at least partially overlaps). North Somerset had a population density of 551 individuals per km^2 and an average speed of 29.8mph, South Gloucestershire had a population density of 541 and an average speed of 24.1mph and Bath and North East Somerset had a population density of 521 and an average speed of 22mph. All three had an average speed below 29.9mph, the average speed for all local authorities with a population density less than 1,000 individuals per km^2 (with an average population density of 429).

Our assessment

148. The further analysis set out above indicated that, on the reasonable assumption that population density was highly correlated with the mains length per property variables used in our econometric models:

(a) our models would make some allowance for the costs of congestion arising from the higher population density within the city of Bristol;

(b) our models would not take account of the reported traffic speeds in the city of Bristol being slower than we would expect for an area with a similar population density (and density of water supply connections).

149. We recognised that, on the information available, there was some uncertainty about the extent of any differences between the congestion faced by Bristol Water and that faced by other companies.

150. For example, Bristol Water's analysis, and the further analysis above, was based on the available data on differences in the relative speeds in the morning peak, which might not be representative of relative speeds across the working day. We did not consider that Bristol Water had shown that relative speeds in the morning peak were necessarily representative of relative speeds across the day. However, we did not identify a reason why the use of the morning peak would be unrepresentative or would produce biased results. Furthermore, the morning peak data seemed to be the only available data to allow traffic speed comparisons across different areas. We considered that, in the absence of other data, it was reasonable to base the analysis on the morning peak data.

151. We would expect Bristol Water to have some scope to mitigate slower traffic speeds through its working arrangements, but we had no reason to expect that this scope would be sufficient to mean that the apparently slower traffic speeds in the city of Bristol would have no material effect on its costs.

152. On balance, we considered that a special cost factor adjustment was appropriate. We considered that Bristol Water's calculation of the adjustment (see paragraphs 119 to 120) was reasonable and consistent with the outcome of our own further analysis of the DfT traffic spend data. We therefore made an adjustment of £3.65 million.

Regional wage data for Bristol Water

Summary of our provisional findings

153. Our alternative econometric models follow the approach used by Ofwat of including a measure of regional wages as an explanatory variable. We would expect companies that operate in parts of the country with relatively high wages (for similar occupations) to face higher costs than companies that operate in parts of the country with relatively low wages. We used the data series on regional wages that Ofwat had prepared for the 18 water companies in the sample, drawing on regional wage data from the ONS.

154. We identified that the econometric models did not seem to work particularly well for the regional wage variable.[38] The estimated coefficients varied significantly between models and in some cases implied counter-intuitive results.

155. The issues with the estimated coefficients for the regional wage variable may reflect, at least in part, issues with the data. The regional wage data that Ofwat used can only be taken as an approximate guide to the prevailing wage rates that companies operating in different regions face. The data relates to the wages of two categories of occupation*: (a)* science, research, engineering and technology professionals; and *(b)* skilled construction and building trades.[39] These two categories may not be fully representative of the range and mix of employees used by water companies (and their contractors). Furthermore, the wage data for different regions across England and Wales may not be fully representative of the wage rates that a water company operating in one part of a region may face.

156. We identified a specific issue for Bristol Water. The data series that we used provided a regional wage measure for Bristol Water based on regional data for the South West region of England. The same regional wage measure used for Bristol Water was also used for South West Water and Wessex Water. We considered that this may not be representative of the level of wages faced by Bristol Water. We considered it possible that the wages faced by Bristol Water were significantly higher than those across the South West region as whole.

157. In its submissions to us, Bristol Water said that the use of the South West regional wage factor unfairly penalised Bristol Water in the cost assessment. Bristol Water considered that the level of wages that it faced in the area it

[38] See Appendix 4.2, paragraphs 186–196.
[39] CEPA (March 2014), Cost assessment – advanced econometric model, p57.

served, and recruited from, was materially higher than the average for the South West as a whole.

158. Bristol Water presented some analysis using data from the ONS at a more granular level than the South West region. Bristol Water reported that the weighted average (based on population weights) across the four unitary authority areas that relate most closely to its supply area gives an hourly wage rate in 2013 of £14.89. Bristol Water reported that this was 7.4% higher than the figure for the South West region, much closer to the England and Wales average of £15.29, and higher than the average of England and Wales excluding London (£14.19).

159. These more granular wage estimates quoted by Bristol Water were not directly transferable to the wage data from Ofwat that we have used for the econometric models. Ofwat's regional data used wage statistics for two specific categories of labour, whereas the more local regional wage data covers all occupations.

160. For our provisional findings we considered that, on balance, the regional wage data for Bristol Water in the econometric models was likely to overstate the extent to which Bristol Water benefited from lower wage rates, and that an adjustment was warranted.

161. We made a special cost factor adjustment of £6.7 million in Bristol Water's favour. We calculated this adjustment by first taking the 7.4% difference quoted above and applying it to the wage data series that we had used to estimate Bristol Water's expenditure requirements in the period from 1 April 2015 to 31 March 2020. Our adjusted wage measure for Bristol Water for 2012/2013 was:

(a) 3.7% higher than the unweighted average across the 18 water companies in our sample for 2012/13;

(b) 2.1% less than the regional wage measure for Southern Water, Portsmouth Water and South East Water for 2012/13; and

(c) 11.7% less than the regional wage measure for Thames Water for 2012/13.

162. We recalculated our estimates using this adjusted wage rate for Bristol Water and found a difference of £6.7 million in the estimate over the five-year period from 1 April 2015.

163. We could see an argument that this adjustment may be too high for Bristol Water, since the higher reported wage rates in the city of Bristol compared

with the South West region were likely to reflect differences in the mix of occupations and differences in the wage rates for equivalent occupations. However, the ONS data from the 'Annual Survey of Hours and Earnings' was not sufficiently detailed to allow us to investigate this specific issue. It did not provide wage data for different categories of occupations within the geographic areas that Bristol Water operates in.

Bristol Water's argument for a greater adjustment

164. In its response to our provisional findings, Bristol Water supported the approach of making a special cost factor adjustment for regional wages but considered the value of the adjustment in the provisional findings to be underestimated.[40] It said that the regional wage adjustment should be £11.4 million.[41]

165. Bristol Water identified that our set of ten preferred econometric models from provisional findings implied than an increase in the regional wage variable for Bristol Water of 7.4% led to an increase of £6.7 million in our original cost estimate for Bristol Water of £307 million. Bristol Water inferred that these models would imply that a 1% increase in wages would lead to a 0.29% increase in base expenditure.[42]

166. Bristol Water argued that the key parameter that affected the magnitude of the effect of regional wage data on costs was the weight of regional salaries in overall costs. Bristol Water said that for its costs, across opex and capex, its estimated weight for wages should be 0.5. Bristol Water also referred to CEPA's view that the weighting should be around 0.6 to 0.7.[43]

167. Bristol Water's alternative figure of £11.4 million was obtained as follows:

(a) Bristol Water used its proposed weighting of 0.5 to estimate that a 7.4% increase in wages would lead to a 3.7% increase in costs.

(b) A 3.7% increase on £307 million was £11.4 million.

168. We did not accept Bristol Water's calculation because it seemed to be internally inconsistent. Bristol Water took the figure of £307 million as an input to its calculation. However, that figure of £307 million was calculated using the wage coefficients estimated from the econometric models and did not seem

[40] Bristol Water response to our provisional findings, paragraph 172.
[41] Bristol Water response to our provisional findings, paragraph 174.
[42] Bristol Water response to our provisional findings, paragraphs 173–175.
[43] Bristol Water response to our provisional findings, paragraphs 173 & 174.

compatible with assuming an alternative value of 0.5 for these wage coefficients.

169. If the wage coefficients from the econometric models had implied that a 1% increase in wages would lead to a 0.5% increase in costs then, all else equal, the estimate for Bristol Water would have been around £303 million and not £307 million (higher coefficients for wages would have decreased the estimated figure for Bristol Water). This would mean that the higher special cost factor of around £11 million proposed by Bristol Water would be added to a lower cost estimate from the econometric models of £303 million), with the net effect around £314 million. This was very similar to the net effect of the econometric estimate from our provisional findings models (£307 million) and a special cost factor of £6.7 million.

170. We found that there was no basis for applying Bristol Water's calculated figure of £11.4 million as a special cost factor to the results from our econometric models.

Bristol Water's further submissions on the mix of occupations

171. In its response to our provisional findings,[44] Bristol Water provided comments on the potential concern we had identified that data on higher wage rates in the city of Bristol may reflect, in part, differences in the mix of occupations and not necessarily the wage rates for the types of employees that Bristol Water needed. Bristol Water said that it considered this risk minimal because:

(a) potential staff had scope to switch between occupations within the area to some degree;

(b) wage rates in Bristol affected some living costs (eg housing) and this had a knock-on effect on wage rates in other occupations;

(c) the mix of Bristol Water staff was representative of the employment in the area; and

(d) people living within and close to Bristol could (and did) easily commute to locations within the Thames corridor where wages were even higher.

172. We did not consider that these further submissions from Bristol Water demonstrated that there was a 'minimal risk' that differences in the reported wage data for the city of Bristol compared with the South West region would

[44] Bristol Water response to our provisional findings, paragraph 176.

reflect differences in the mix of occupations rather than simply higher wage rates for the types of employees that Bristol Water needed.

173. Bristol Water's points (a) and (b) provided reasons why wage rates in Bristol for some types of occupations may have effects on wage rates in Bristol for other types of occupations. These points help to show the relevance of the local wage data, even if it was not focused on the most relevant occupational categories. However, it did not follow that wage rates across occupations would be equalised or that the concerns we identified do not stand at all.

174. We saw no evidence or basis to treat Bristol Water's point (c) as correct. We did not consider point (d) to be relevant because the wage data we had used for our provisional findings concerned wages by place of work rather than place of residence of the employee.

175. Bristol Water also argued that there was a risk that local factors meant that the costs of the mix of occupations employed by Bristol Water were likely to be underestimated by the overall wage data. Bristol Water highlighted the number of major engineering companies (eg British Aerospace, Rolls Royce and GKN Aerospace) in Bristol and that Bristol housed the regional offices of a number of major engineering contractors (eg Arup, Atkins and Mott Macdonald). It said that an additional potential factor that would impact on local wages was the construction of Hinkley Point C nuclear power station, which was in commuting distance of Bristol, and which it would expect to have a significant local impact on wage costs for technical staff.[45]

176. We did not accept the argument implied by Bristol Water's submissions that the existence of a number of engineering companies meant that Bristol Water's wages would tend to increase the wages faced by Bristol Water beyond that reflected in the wage data. Overall, we considered it difficult to make inferences about the effects of these factors. For example, a potential counterargument to that made by Bristol Water was that the existence of a number of engineering companies may provide a wider pool of labour with relevant skills that helps to reduce wages compared with a situation where a company was more reliant on its existing employees. We also noted that there was uncertainty about the timing of construction of Hinkley Point C nuclear power station.

Ofwat's response to our provisional findings

177. Ofwat did not agree with the special cost factor adjustment for regional wages that we made as part of our provisional findings. Ofwat made a number of

[45] Bristol Water response to our provisional findings, paragraph 177.

arguments which it said, taken together, comprehensively undermined the case for a special cost factor adjustment for wages:[46]

(a) Ofwat's view was that the estimated coefficients for the regional wage variable from some of our econometric models were already very low and that these models almost certainly understated the benefit that Bristol Water derived from the relatively low wage costs in the South West. Ofwat said that for these models, the special cost factor adjustment should be reversed, leading to a reduction rather than increase in the allowed totex for Bristol Water.

(b) Companies were not restricted to sourcing workforce from the area/ county of operation and Ofwat said that this was particularly true for relatively small water companies.

(c) Ofwat said that, on balance, there was no persuasive evidence that Bristol Water was required to pay wages that were significantly higher than those of the South West as a whole. Ofwat identified that within the city of Bristol, two of the four parliamentary constituency areas had lower wages than the South West average and that North Somerset (which was in Bristol Water's area) was not significantly different from the South West average. Ofwat also said that the lower wage rates away from the centre of Bristol were important as Bristol Water had its headquarters and operational sites on the very edge of the city or in the surrounding rural areas.

(d) Ofwat said that it was highly likely that differences in the more granular ONS wage data between closely located parliamentary constituencies or local/unitary authority areas were in part driven by occupational mix and that this data did not form a robust basis for a special cost factor adjustment. Ofwat said that to accurately adjust for regional wage differences, it was necessary to take account of the mix of occupations (as done for the wage variable used in Ofwat's econometric analysis) otherwise estimates of wage differences that included the centre of Bristol might distort the comparisons.

178. We did not accept Ofwat's argument that we should make a downward special cost factor adjustment to the totex allowance for Bristol Water rather than an upward adjustment. The estimated coefficients for the regional wage variable were sensitive to model specification and indicative of the difficulties of seeking to adjust for differences across water companies in the wage rates that they face using the available ONS data and econometric models.

---

[46] Ofwat response to our provisional findings, paragraphs 59 & 60.

Furthermore, a low estimated coefficient may suggest that the regional wage variable used in the models was an imperfect proxy for the wage differences between companies. In this context, we did not consider it reasonable to make a negative adjustment for Bristol Water to give greater effect to the fact that Ofwat's regional wage variable was significantly lower for Bristol Water than for the average company in the industry.

179. The regional wage variable used for the models may overstate the differences in wage rates between regions. For example, Ofwat's regional wage data implied that the wage rate applicable to Thames Water was, on average, around 30% higher in 2012/13 than the wage rate applicable to Dŵr Cymru Welsh Water. This scale of regional wage differential seemed higher than we would have expected for a measure relating to wages across water companies' workforce and their contractors' labour. We considered that low estimated coefficients might be compensating for differences between companies in Ofwat's regional wage measures that were overestimated.

180. We did not see the relevance of Ofwat's argument that water companies were not restricted to sourcing workforce from the area/county of operation. The wage data used in the econometric models and the additional wage measures that Bristol Water had referred us to, and which we used for the adjustment in our provisional findings, concerned the wages of employees by place of work (not by place of residence of the employee). We would expect that data to already reflect the ability of employers to use staff that who live in areas outside their immediate place of work or area of operation.

181. We discuss the issues relating to the overall evidence and occupational mix below.

Our assessment

182. To recap, there were limitations in the available data on the differences in wage rates faced by the water companies used for our econometric benchmarking analysis:

(a) The ASHE data used for the wage variable in the econometric models provides wage data for different occupational categories, across ten broad regions of England and Wales. It did not provide data for the specific geographic areas that water companies serve.

(b) There was a separate set of ASHE data that allows for a more granular comparisons or wage rates in different local authority areas, rather than for broad regions, but this wage data did not differentiate between different categories of occupation.

183. As a starting point, if a variable for wages was to be used in the econometric models, it seemed more of a priority that this variable was based on wage data for relevant occupations than on local data that related precisely to each water company's supply area but covered all occupations.[47]

184. Nonetheless, we were concerned about scale of downward adjustment to Bristol Water's costs implied by the results of our models (which we estimated to be £5.93 million over the five-year price control period)[48] in the context of the following:

(a) The estimated coefficients from our models using Ofwat's regional wage variable were sensitive to model specification, had relatively wide confidence intervals and sometimes produced counter-intuitive results. This could be indicative of limitations in the wage data taken as an input to the econometric models.

(b) The two occupational categories used for the Ofwat regional wage variable were not closely aligned with the specific types of labour used by water companies. Ofwat used relatively aggregated two-digit SOC categories and these included a range of different occupations. Differences between water companies in the calculated regional wage variable may reflect, in part, differences between regions in the mix of occupations within the categories used by Ofwat.

(c) We would not expect the wage rates in Bristol Water's area of appointment to necessarily match the average across the whole South West region. Bristol Water serves an area of around 2,400 sq kilometres.[49] This was around 10% of the South West area used for the ONS wage statistics.[50]

(d) The local wage data provided by Bristol Water showed that the average wage rates (across all occupational categories) in the areas it serves were about 7.4% higher than the wage rates for the South West as a whole. The local wage data provided by Bristol Water showed that the average wage rates (across all occupational categories) in the areas it serves were 4.9% higher than the average for England and Wales excluding London.

---

[47] As part of our work following our provisional findings, we carried out some preliminary analysis to try to develop an alternative regional wage based on the regional ASHE data, using different occupational categories and/or weights. We did not identify an alternative wage measure that brought a significant improvement to the results. See Appendix 4.2 paragraphs 186–196 for further discussion and sensitivity analysis.
[48] See Section 4, Table 4.10; figure given to two decimal places here for consistency with other special cost factors (eg congestion).
[49] Bristol Water website: The company today, retrieved on 1 September 2015.
[50] CMA analysis of ONS data for Region and Country Profiles - Key Statistics Tables, 17 October 2013, retrieved 1 September 2015.

185. Ofwat's submissions in response to our provisional findings did not address our underlying concern that the downward adjustment for Bristol Water implied by the econometric models did not reflect the specific wage conditions faced by Bristol Water.

186. We decided that, in the light of the considerations set out above, it was appropriate to make a special cost factor adjustment for Bristol Water to account for likely differences in wages between Bristol Water's area of appointment and the South West region as a whole.

187. We remained concerned that the more granular ONS data that Bristol Water referred to (and which we used in our provisional findings) would be affected by differences between local areas in the mix of occupations. For example, the reported hourly wage rate (excluding overtime) for the city of Bristol in 2013 was around 9% higher than the corresponding wage rate for the neighbouring areas of South Gloucestershire and North Somerset (also served by Bristol Water). We considered it likely that these differences reflected, in part, differences in the mix of occupations across these neighbouring areas (eg a greater proportion of higher-paid occupations within the city of Bristol). However, we also recognised that the Ofwat wage variable used for the econometrics would be vulnerable to differences between regions in the mix of occupations within the relatively broad two-digit occupational categories used by Ofwat.

188. We considered that an appropriate approach would be to make a special cost factor adjustment for Bristol Water that effectively cancelled out the negative adjustment for regional wages of £5.93 million from our econometric models.

189. This approach was around £0.8 million less favourable to Bristol Water than the approach we used for our provisional findings. We considered that a slightly lower adjustment was appropriate given the possibility that some of the differences between the local wage measure proposed by Bristol Water and the Ofwat regional wage measure used in our econometric models reflected differences in the mix of occupations rather than differences in wage rates for equivalent occupations. The effect of cancelling out the downward adjustment from the econometric models was to treat Bristol Water as facing similar wages to an industry-average water company in the data sample used for the econometric analysis, which seemed reasonable in the light of the range of evidence we reviewed.

Mains renewal programme

Summary of our provisional findings

190. As part of our development of possible econometric models, we considered the use of mains age as an explanatory variable, which Bristol Water had advocated. We explained in Appendix 4.2 that, rather than including mains age in the econometric models, we would consider Bristol Water's mains renewal programme as a possible special cost factor adjustment.[51]

191. Our econometric models did not include explanatory variables relating directly to differences between companies in the rates of mains renewal (length of mains renewed relative to total length of mains). We identified that Bristol Water's planned levels of mains renewal were significantly higher than the levels of mains renewal across the industry in the historical data we had used for our econometric benchmarking analysis. We considered Bristol Water's relatively high level of planned mains renewal to be reasonable. Mains renewal was a large part of water companies' investment programmes and we were concerned that the estimates from our econometric models would understate Bristol Water's base expenditure requirements.

192. In our provisional findings, we made an adjustment of £10.6 million for Bristol Water's mains renewal programme. We also recognised that there was uncertainty about whether an adjustment should be made and, if so, its size.

Bristol Water's response to our provisional findings

193. Bristol Water said that it was concerned that the special cost factor for mains renewal in our provisional findings was not sufficient, and said that there were a number of factors that resulted in the amount being underestimated. Bristol Water's arguments covered two main points:[52]

    (a) Bristol Water argued that the unit cost figure that we had used for the calculation of the special cost factor was not appropriate, and that we should use a higher figure which would have the effect of increasing the calculated adjustment for Bristol Water's main renewal programme.

    (b) Bristol Water argued that we should also consider the estimates derived from econometric models that included mains age as an explanatory factor. It said that there was a range of evidence from different

[51] Appendix 4.2, paragraphs 75–81.
[52] Bristol Water response to our provisional findings, paragraphs 179–183.

econometric models that network age had an impact on expenditure. It said that this would support a higher special cost factor of £15 million.

194. We consider (a) in more detail in the subsection below on the unit cost assumption. In relation to Bristol Water's point (b), we considered the results from Bristol Water's econometric models to be relevant to our overall assessment of the case for a special cost factor. But we had significant concerns with the mains age data used for these models and, more generally, with the ability of the econometric model to estimate an appropriate adjustment, given the small sample size.[53] We did not consider that the econometric estimates provided by Bristol Water were likely to provide a better guide to the scale of any special cost factor adjustment than the approach we had used for our provisional findings.

Ofwat's response to our provisional findings

195. In its response to our provisional findings, Ofwat said that our analysis had a number of limitations and significantly overstated the adjustment (if any) that should be made in relation to mains renewal. Ofwat made the following points:[54]

(a) Ofwat said that our consultants, Aqua, had revealed serious flaws in Bristol Water's model of mains replacement. Ofwat's view was that this suggested that Bristol Water was overstating the volume of mains replacement and that using Bristol Water's planned volumes to calculate a special cost factor adjustment would overstate the appropriate level of any adjustment.

(b) Ofwat said that the fact that Bristol Water's mains renewal in previous periods was lower than the industry average did not itself justify a requirement to do more in AMP6. Ofwat said that, furthermore, if Bristol Water's historical levels reflected a degree of neglect this would be a strong reason for not making additional allowances as these costs should be borne by shareholders and not customers.

(c) Ofwat referred to the limited evidence to make a judgement on the efficient level of mains replacement for Bristol Water. Ofwat said that given that Bristol Water was meant to have completed a robust business plan in December 2013, Ofwat considered it a clear failing of its business processes that it had not provided such evidence by July 2015. Ofwat

[53] Appendix 4.2, paragraphs 75–81.
[54] Ofwat response to our provisional findings, paragraph 62.

argued that Bristol Water should not receive the benefit of the doubt in respect of mains replacement.

(d) Ofwat said that there did not appear to be a clear-cut case that a special cost factor adjustment was necessary. Ofwat argued that mains replacement was a typical activity for a water company, and while it might have slightly higher-than-average levels of activity in mains replacement there would be other aspects of its investment plans that would have lower-than-average levels of activity.

(e) Ofwat referred to the alternative analysis we provided in our provisional findings which indicated that if a different period was used to compare Bristol Water against other companies in the industry, the adjustment would be zero.

(f) Ofwat referred to results from its econometric models for base expenditure, which included an explanatory variable for mains replacement. Ofwat's allowance was based on a forecast of an efficient length of mains replacement for Bristol Water of 181km in AMP6. Ofwat said that if it were to increase the length of mains renewed to 233km in its models, this would increase the allowance for Bristol Water by £3 million, not £10.6 million.

196. We briefly set out our views on these comments from Ofwat.

197. First, we recognised in our provisional findings that there was uncertainty about the appropriate level of mains replacement by Bristol Water. However, we did not accept Ofwat's argument at point (a) that the analysis indicated that Bristol Water's planned volumes were overstated. Section 5 provides our assessment of the information available on Bristol Water's planned volumes for mains renewal.[55] Although our assessment had found some limitations with Bristol Water's models for forecasting the level of mains renewal requirements, we did not find that these limitations implied that the volumes were overestimated. While we did not necessarily fully endorse this aspect of Bristol Water's plan, we considered the process and planned volumes reasonable.

198. We did not identify a consequence of Ofwat's hypothetical statement about the neglect of assets at point (b). Ofwat did not seek to argue that there had in fact been any neglect by Bristol Water, so this point did not seem relevant to our determination. We have not assumed that lower levels of mains replacement in the past would necessarily lead to higher levels today, but we

[55] Paragraphs 5.101 to 5.124.

did consider that the levels of past mains renewal could be a factor that led to higher mains renewal in the future.

199. We agreed with Ofwat's point of principle at point (c) that we should not give Bristol Water the benefit of the doubt, especially given the uncertainty about planned volumes for a core part of Bristol Water's business plan. We did not consider that this precluded a special cost factor for mains renewal if we found that Bristol Water's planned volumes were reasonable.

200. We agreed with Ofwat's point (d). There were risks from seeking to make a special cost factor adjustment simply because *(a)* a company's planned level of expenditure or activity in a particular area was greater than the industry average for that area, and *(b)* that difference was not likely to be captured by the explanatory variables in the econometric models. The econometric models of base expenditure were not intended to provide an estimate of a company's expenditure requirements in each subcategory of expenditure; their focus is on base expenditure overall. Making a special cost factor adjustment for areas where expenditure was higher than average may be inappropriate without consideration of areas where expenditure was lower than average. We considered that this concern should be addressed by giving further consideration to the underlying reasons for any differences in expenditure between companies. In this case, it seemed important to consider why Bristol Water might have high levels of mains replacement requirements than other companies. We consider this further in our assessment below.

201. Ofwat's point (e) was a reference to an issue that we had identified, and taken account of, in our provisional findings. We recognised the uncertainty, but on further review we did not consider it appropriate to rely on the alternative calculation, which implied an adjustment of zero.

202. Ofwat's references to results from its econometric models at point (f) provide another relevant perspective on how differences in mains renewal rates may affect costs. However, given the limitations of the econometric modelling of water companies' base expenditure, we did not consider that an econometric estimate of the relationship should govern our special cost factor assessment. Furthermore, we had some specific concerns with the way that Ofwat's models incorporated mains renewal into explanatory variables.[56]

[56] These included the specification of an explanatory variable in terms of the proportion of total mains length renewed each year. We had concerns with Ofwat's approach of taking logarithms of explanatory variables, such as this, that were expressed as proportions. See Appendix 4.1, paragraphs 164–174.

Analysis of differences in mains renewal rates between companies

203. We discuss Bristol Water's mains renewal programme in paragraphs 5.101 to 5.124. Bristol Water's planned length of mains renewal, excluding trunk mains relining which we consider separately under enhancement expenditure in Section 6, was 233km over AMP6.

204. We carried out some analysis to compare Bristol Water's planned rates of mains renewal against the industry-average rates that would tend to be reflected in the estimates from our econometric models of base expenditure.

205. An indicative estimate of the amount of mains renewal allowed for in our econometric models can be obtained by looking at the average rates across the companies and time period used for our models. We used data provided by Ofwat to examine the average annual rate of mains renewal (and relining) across companies over the period of expenditure covered by our econometric models. The average rates of mains relining and renewal across water companies fell significantly between 2004/05 and 2012/13. The average rate across companies in 2004/05 was 1.40%; it was 0.57% in 2012/13.

206. We made an estimate of the industry-average rate of mains renewal and relining over the period of time that corresponded to that used in our econometric estimates of Bristol Water's expenditure requirements from 1 April 2015 to 31 March 2020. To calculate this figure, we considered the two different treatments of capex that we had used in our econometric models: the smoothed and unsmoothed approaches:

    (a) For the smoothed models, our estimates of Bristol Water's expenditure requirements were based on an extrapolation from the industry-level smoothed base expenditure (per property) data from 2012/13. The smoothed base expenditure data for 2012/13 included companies' average capital maintenance expenditure in the five-year period 2008/09 to 2012/13. The average rate across companies of mains renewal and relining in this period was 0.60%.

    (b) For the unsmoothed models, our estimates of Bristol Water's expenditure requirements were made using an approach that sought to give similar weight to industry-level expenditure in each of the five years from 2008/09 to 2012/13.[57] For the estimates for these models, it also seemed relevant to consider the average rate, across companies, of mains renewal and

[57] See Section 4, paragraphs 4.112–4.124.

relining in the period 2008/09 to 2012/13. This gave the same figure of 0.60% as (a) above.

207. We sought to compare this industry-average rate of 0.60% with the corresponding figure from Bristol Water's plans.

208. Bristol Water's planned volume of mains renewal was 233km within its base expenditure plan. This included a mix of work on different types of mains, including trunk mains. In addition, Bristol Water planned 30.5km of trunk mains relining specifically to reduce the level of discoloured water; this formed part of Bristol Water's planned enhancement expenditure (in the enhancement category 'improving taste / odour / colour'). The implied mains renewal rate in Bristol Water's base expenditure plan works out at an average rate of 0.69% per year, or 0.78% if the additional trunk mains relining was included.

209. Ideally, for our assessment of base expenditure, we would like to compare the 0.69% from Bristol Water's base expenditure plan with the corresponding rate of mains renewal feeding in to water companies' historical base expenditure. However, the industry-average rate of mains renewal of 0.60% that we calculated above includes all activity, whether for base expenditure or enhancements such as those aimed at improving taste, odour and colour.

210. We made the following comparison. We took the ratio between Bristol Water's base expenditure volumes (233km) and its volumes including the additional trunk mains relining, which was 88%. We scaled down the industry-average rate of mains renewal of by this amount to get an adjusted rate of industry-average base service mains renewal and relining of 0.53% (ie excluding enhancements). Bristol Water's planned rate of mains renewal (excluding the trunk mains relining for enhancement purposes) was 15 basis points higher than this amount.[58] For Bristol Water, this would translate into a difference of around 52km over AMP6, which represented around 22% of Bristol Water's planned volumes (excluding trunk mains relining treated as enhancements). This suggested that Bristol Water's planned volumes of mains renewal were significantly greater than would be allowed for in the estimates from the econometric models.

211. This estimated difference of 52km would be overstated (or understated) if the assumed ratio of 88% used in the calculation above were to be too low (or high). We did not have data to verify this, but considered it more likely that the

[58] This figure compares to a figure of 19% from our provisional findings. The difference reflects two changes. First, as a consequence of changes to the way that we made estimates from the unsmoothed models for our final determinations (Section 4, paragraphs 4.112–4.124) the applicable industry benchmark was higher. Second, given our focus in this section, we considered it more appropriate to adjust the estimated industry-average rate to relate to base expenditure than to make a comparison between the industry-average rate (including enhancement relining) and Bristol Water's rate (including enhancement relining).

52km was an overestimate than an underestimate. Bristol Water had told us that in AMP5 (which formed part of the data period on which our econometric estimates were based) the majority of companies had very little expenditure in this category for 'improving taste / odour / colour' (which would include trunk mains relining to address these water quality issues), though three companies had expenditure in this area of 5 to 10% of their total capex.

212. More generally, it was difficult to gauge the extent to which our estimates of Bristol Water's expenditure requirements from the econometric models includes or reflects allowances for mains renewal. The data we have used for the analysis above was subject to limitations and uncertainty (eg we did not have a breakdown between the renewal rates in different categories of water mains, but the mix of work in different categories could have significant implications for costs). The estimated differential of 15 basis points that we used in our calculations above was an approximate figure.

The unit cost assumption

213. In our provisional findings, we calculated an adjustment for Bristol Water by taking the difference between Bristol Water's planned volumes of mains renewal, and the estimated volume allowed for in the econometric models, and then multiplying this difference by an assumed average unit cost of £166 per metre (or £0.166 million per kilometre).

214. The figure of £166 per metre was based on information from our consultants, Aqua, who provided advice on the planned volumes and unit costs in Bristol Water's planned mains renewal programme.[59]

215. In its response to our provisional findings, Bristol Water objected to the unit cost figure provided by Aqua.[60] Bristol Water specifically suggested that the special cost factor adjustment could be £26.4 million, which it calculated by replacing the assumed average unit cost we had used for our provisional findings with an average industry expenditure figure of £412 per metre which Bristol Water reported as the average unit cost from industry-wide mains renewal data for 2009 to 2011.[61]

216. Following further consideration we considered that it remained reasonable to use the unit cost figure of £166 per metre. The unit cost figure to apply for our special cost factor adjustment can only be an approximation, not least because unit costs will differ according to factors such as surface types, mains

[59] See Section 5, paragraph 5.126.
[60] Bristol Water response to our provisional findings, paragraph 179.
[61] Bristol Water response to our provisional findings, paragraph 180.

renewal techniques and pipe diameter. We consider Bristol Water's various submissions on the mains renewal unit cost assumption further in Section 5.[62]

217. Multiplying the unit cost of £166 per metre by the estimated difference in volumes estimated above of 52km suggested a potential adjustment of £8.64 million.

Our assessment

218. In our review of Bristol Water's business plan (Section 5), we accepted Bristol Water's planned rates of mains renewal and relining as reasonable. We estimated above that these planned rates were higher than the industry-average mains renewal rates likely to feed into the estimate of Bristol Water's expenditure requirements from our econometric models.

219. On its own, a difference in planned expenditure in a particular category of activity, compared with the industry-wide benchmark, did not seem sufficient for a special cost factor adjustment. The estimates of base expenditure requirements for the econometric models were not intended to provide a detailed view of expenditure requirements in each different expenditure category; they apply to base expenditure overall.

220. In the case of Bristol Water's mains renewal programme, several further factors seemed important:

    (a) There was evidence that Bristol Water had renewed and relined a substantially lower proportion of its mains than other water companies in the recent past. For example, using data provided by Ofwat for the period between 2002/03 and 2012/13, the average rate of mains relined and renewed across the industry was 0.94% while Bristol Water's rate was 0.58%. This was a considerable difference over an 11-year period.

    (b) We did not identify evidence that the difference in (a) was because Bristol Water had neglected its assets. Nor did we have reason to believe that Bristol Water's customers had effectively paid for greater levels of mains renewal in the past that it had not carried out.

    (c) Bristol Water said that its water mains assets were relatively old and that this would tend to mean that its mains renewal expenditure requirements were relatively high (the older assets would partly reflect the difference identified in (a), but that was not the only factor). Ofwat had questioned the relevance of distribution mains age as a cost driver for mains renewal

[62] Paragraphs 5.126–5.153.

expenditure. We considered that mains age was relevant, particularly in the absence of information on condition and alongside other factors.[63]

(d) Bristol Water's mains renewal programme was a major area of its investment programme, representing around 30% of its planned capital maintenance expenditure.[64]

221. Whilst not a primary consideration on its own, we also took account of Bristol Water's submissions on the econometric models, which provided estimates that its expenditure requirements would be considerably higher than other companies (all else equal) due to its older water distribution mains.

222. Overall, we considered that an adjustment was appropriate and that our estimate of £8.64 million, as calculated above (paragraph 217), was reasonable.

223. This adjustment was lower than the corresponding figure of £10.6 million from our provisional findings. This was due to the effects of the refinements we made to our comparisons of Bristol Water's mains renewal rate against the industry average rate (see paragraph 210), which reduced the mains renewal volumes that we applied the unit cost assumption to.

Upstream maintenance expenditure

Summary of the claim and our provisional findings

224. In response to our provisional findings, Bristol Water proposed that we should include an additional special cost factor adjustment for upstream maintenance infrastructure. Its upstream assets include aqueducts, raw water mains and raw water reservoirs. Bristol Water argued that it had a greater number of these assets relative to the number of customers that it served and that it was therefore likely that it would incur higher maintenance costs per customer than other companies.[65] We had not considered Bristol Water's upstream infrastructure maintenance requirements as part of the special cost factor assessment for our provisional findings.

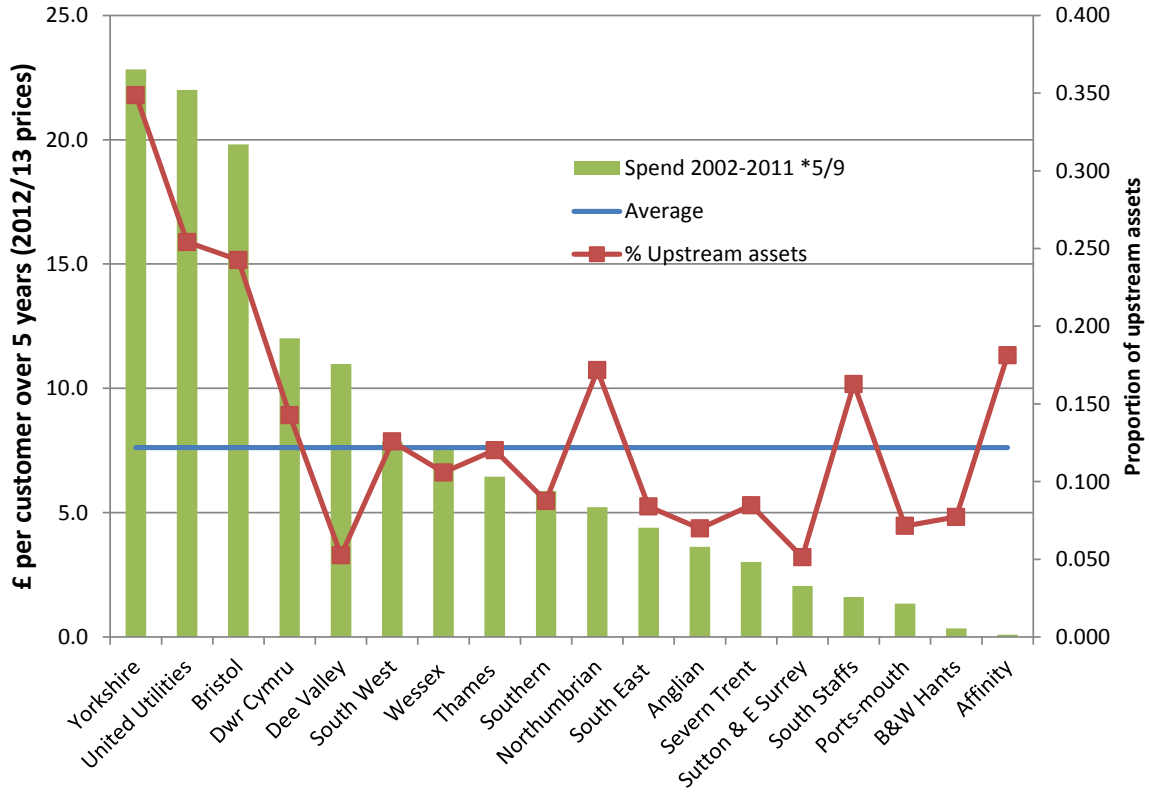
225. Bristol Water's response to our provisional findings provided a chart which compared a measure of the proportion of upstream assets (by GMEAV)

---

[63] We note the CH2M report for Bristol Water suggested that, whilst considering the Bristol Water model suitable for Bristol Water's need, the deterioration analysis should take into account factors such as materials, pipe type, diameter, soil type etc.
[64] CMA calculation based on information from Bristol Water SoC, Tables 2 & 59.
[65] Bristol Water response to our provisional findings, paragraph 185.

against infrastructure maintenance expenditure per customer. We reproduce this chart in Figure 2 below.

Figure 2: Bristol Water's comparisons of upstream maintenance expenditure



Source: Bristol Water analysis of June returns 2002/03 to 2010/11 (Bristol Water response to our provisional findings, Figure 6).

226. Bristol Water argued that the three companies with a significantly higher proportion of upstream assets tended to have significantly higher maintenance spend per customer on upstream assets.[66]

227. Bristol Water accepted that comparisons between companies of the **proportion** of upstream assets were not ideal, and said that it would have preferred to compare the MEAV of upstream assets between companies, but that data was not available to Bristol Water.

228. Bristol Water argued that the econometric modelling that we had undertaken for our provisional findings did not include any explanatory variable relating to upstream assets and that, in turn, the modelling would implicitly include an allowance for upstream expenditure equal to the average expenditure per company and that it would underestimate the expenditure requirements for companies with higher levels of upstream assets. Bristol Water proposed an adjustment for upstream infrastructure assets of £12.1 million, by comparing its planned expenditure on upstream infrastructure assets of £16.0 million with

[66] Bristol Water response to our provisional findings, paragraph 187.

its calculation of the allowance for upstream infrastructure maintenance of £3.9 million from our econometric models.[67]

229. Bristol Water also referred us to its own econometric analysis, which identified that its additional upstream assets would be expected to increase its costs by £19 million, and the econometric modelling carried out by its consultants, Oxera, which identified a range of between £0 million and £20 million. Bristol Water argued that this suggested that its proposed adjustment of £12.1 million was likely to be conservative.[68]

230. Bristol Water also calculated that its proposed expenditure of £16 million on upstream assets represented an effective replacement rate of 0.4% per year compared with the MEAV of these assets of 725 million. It argued that its level of proposed expenditure was likely to be below the long-term expectation.[69]

Submissions from Ofwat

231. Ofwat responded to the submissions that Bristol Water had made in response to our provisional findings.

232. Ofwat said that Bristol Water's submissions provided no evidence that its spending on capital maintenance for upstream assets was efficient and that Bristol Water simply highlighted its relatively high proportion of upstream assets and spending in 2010.

233. Ofwat highlighted that the historical figures for Bristol Water from Figure 2 of just under £20 per property would, when multiplied by 530,00 properties supplied, imply total costs of around £10 million and not the costs estimated by Bristol Water of £16 million.

234. Ofwat also argued that Figure 2 highlighted the extremely weak evidence on underlying cost drivers and efficiency. It said that Yorkshire Water and United Utilities had a relatively high proportion of upstream assets but did not request a special cost factor for upstream assets. Ofwat also noted that Northumbrian Water, South Staffordshire Water and Affinity Water had a relatively high proportion of upstream assets but very low upstream maintenance costs.

235. Ofwat also said that Bristol Water's MEAV was 'particularly high compared to the rest of the industry' and referred us to its analysis for its final determinations where it raised a number of concerns with the MEAV data for Bristol Water. Ofwat argued that as a result of using a high MEAV as a denominator

---

[67] Bristol Water response to our provisional findings, paragraphs 188 & 189.
[68] Bristol Water response to our provisional findings, paragraph 191.
[69] Bristol Water response to our provisional findings paragraphs 193.

Bristol Water may have understated its relative replacement rates and that, in any case, replacement rates tended to be relatively low across the water sector without jeopardising the quality of service to customers.

236. Ofwat's view was that, on balance, there was insufficient evidence to justify a special cost factor adjustment for upstream assets.

Further analysis of upstream infrastructure MEAV data

237. Bristol Water's arguments for an adjustment for upstream infrastructure maintenance were supported by analysis involving comparisons between companies of the proportion of upstream assets between companies.

238. We did not consider that Figure 2 provided strong evidence of the link between upstream assets and maintenance expenditure requirements.

239. Furthermore, we were concerned that comparisons of the **proportion** may be misleading. Differences in the proportion of upstream assets may not reflect differences in the amount of upstream assets. Mathematically, a company will have a higher proportion of upstream assets the lower the proportion of downstream assets that it has (all else equal). Looking at the proportion of upstream assets may not provide a reliable guide to whether a company's upstream infrastructure expenditure requirements were likely to be any different from other companies.

240. We were also concerned that Bristol Water's arguments focused on upstream assets categorised as 'infrastructure' assets without consideration of upstream assets categorised as 'non-infrastructure' assets. There were risks of drawing misleading inferences when making comparisons of companies' spend within specific expenditure categories without considering other, related areas of expenditure. For example, a company that takes a high proportion of its water source from reservoirs and a low proportion from groundwater sources would tend to have a relatively high amount of upstream **infrastructure** assets (reservoirs are categorised as infrastructure assets) and a relatively low amount of upstream **non-infrastructure** assets (eg pumping equipment needed for groundwater sources would be categorised as non-infrastructure). Having more assets in one category does not mean that a company requires more assets, or higher costs, overall.

241. Bristol Water had accepted limitations with comparisons of the **proportion** of upstream infrastructure assets, but explained that it did not have other data available.

242. More generally, we recognised that Bristol Water was somewhat constrained in the supporting analysis it could provide for its special cost factor claim by the data that was available.

243. To enable further investigation of the issues raised by Bristol Water, we obtained data from Ofwat on the reported GMEAV across a series of different asset categories, for each of the 18 water companies in our sample. The GMEAV is a measure of how much it would cost to replace assets with technically up-to-date new assets with the same service capability.

244. We found the following from our analysis of the water companies' reported 2012/13 GMEAV estimates:

(a) The GMEAV of Bristol Water's water mains and communication pipes, which are categorised as downstream assets, was around 20% lower, per property, than the average of other companies. As a result, comparisons of the proportion of upstream assets risk overstating the extent to which Bristol Water has more upstream assets than other companies.

(b) The GMEAV of Bristol Water's upstream infrastructure assets, per property supplied, was more than twice the average across all 18 water companies (£1,400 versus £645). Most of the difference (around 80%) was attributable to Bristol Water's GMEAV for 'dams and impounding reservoirs' being higher than average.

(c) Bristol Water's higher GMEAV for upstream infrastructure assets was offset to some degree by lower upstream non-infrastructure assets (eg raw water pumping), but its overall upstream assets were still around 75% higher than average.

(d) The [✂] companies with greater upstream infrastructure GMEAV per property than Bristol Water, [✂].

245. Ofwat told us that it had significant concerns with the 2012/13 GMEAV data and that it had not used this data in its wholesale cost assessment work. It said that the GMEAV data for Bristol Water was relatively high without a clear explanation of the factors driving this. Furthermore, the 2012/13 GMEAV data was not based on a full asset revaluation, but instead was calculated using data from the 2007/08 revaluation, with updates and adjustments (eg for the effects of capital investments in the intervening five years).

Treatment of upstream assets in our econometric models

246. We have shown above that Bristol Water's relatively high upstream asset GMEAV was primarily (if not fully) attributable to its dams and impounding

reservoirs. Furthermore, Bristol Water provided further clarification for the rational for its claim on upstream assets through the following example:

> If you had two companies that are exactly the same, apart from one had reservoir resources and the other had river abstractions, the company with the reservoirs is going to have big reservoirs that it is going to have to look at and they are going to have to incur maintenance costs that a sort of simple abstraction on the edge of a river would incur much, much less. Therefore, although everything else about those two companies may be the same, the one with the more upstream assets is going to have more maintenance costs.

247. In this context, Bristol Water was not correct to claim that our econometric models did not include any explanatory variables relating to upstream assets.

248. Six out of the ten preferred econometric models that we used for our provisional findings included an explanatory variable relating to the proportion or volume of distribution input from reservoirs (dams and impounding reservoirs). Furthermore, the reservoir explanatory variables made a positive contribution to the estimate of Bristol Water's expenditure requirements in the period from 1 April 2015 to 31 March 2020.

249. Bristol Water's response to our provisional findings did not explain why the inclusion of the reservoirs variables from our econometric models was insufficient.

250. Furthermore, because Bristol Water overlooked the role of the reservoirs variable in our models, we did not accept its calculation of the implied allowance for infrastructure maintenance from our models and, in turn, its calculation of a special cost factor adjustment.

251. The allowance for the reservoirs variables from our refined econometric models, across the seven preferred models from Section 4, was around £7.1 million (this reflected an average of around £12.4 million from the four models that included the reservoir variable and zero from the three models that did not). This allowance could be driven by a range of factors relating to the relative costs of reservoir sources, such as raw water quality and treatment complexity and the maintenance requirements for reservoir assets.

252. We recognised that this figure is below the forecast of £16 million provided by Bristol Water. However, we did not consider that it was appropriate to apply a special cost factor to make up the difference, as Bristol Water's approach would suggest:

(a) We did not accept the general principle of making special cost factor adjustments simply because a company's planned expenditure in a particular category of expenditure was higher than a calculation of the amount 'implied' by the econometric model (instead, we considered that special cost factor adjustments should be driven by objective differences between Bristol Water and other companies used for the benchmarking analysis, such as the use of reservoirs, discussed above). We used our econometric models to produce an estimate of each company's expenditure requirements in each specific category. The relevant question was whether the overall allowance from the models for base expenditure was too low or too high (something that we consider further in Section 7 using the outcome of the assessment in Section 5).

(b) As a specific (but not exhaustive) example of the more general point (a), Bristol Water's higher expenditure requirements for infrastructure assets may be offset to some degree by lower expenditure requirements for non-infrastructure assets. We found that Bristol Water had a lower-than-average GMEAV for upstream non-infrastructure assets. Bristol Water's submissions did not consider whether our econometric models may, under Bristol Water's approach to the implicit allowance, overestimate its expenditure requirements in respect of the maintenance of these non-infrastructure assets.

(c) As Ofwat argued, we did not know whether Bristol Water's figure of £16 million represented an efficient and necessary level of infrastructure maintenance for the AMP6 period. In our assessment of the base expenditure forecasts in Bristol Water's business plan, we did not review Bristol Water's proposed expenditure for upstream infrastructure assets in any detail, but identified significant concerns with other aspects of proposed expenditure on infrastructure assets. Both the upper and lower end of our range for Bristol Water's overall IRE requirements were below Bristol Water's forecasts.[70] This cast doubt on the case for making an adjustment to align the results from our econometric models with Bristol Water's forecast expenditure.

Bristol Water's alternative econometric models

253. Following Bristol Water's response to our provisional findings, we gave further consideration to the disaggregated econometric modelling carried out by Bristol Water and its consultants, Oxera.

[70] Paragraphs 5.146–5.148.

254. Bristol Water's SoC included some econometric modelling carried out by Bristol Water that focused on IRE. Bristol Water's model took a measure of IRE per head of population supplied as the dependent variable and included explanatory factors relating to the length of mains per head of population, measures of mains age and a measure of the proportion of upstream infrastructure. Bristol Water's model produced a central estimate for Bristol Water's IRE of £107.8 million over the five-year price control period and Bristol Water identified that its business plan proposal for IRE of £76 million was considerably less than this benchmark. Bristol Water's model estimated that it required an additional £19 million (compared with the industry average) specifically due to its relatively high proportion of upstream infrastructure assets.[71]

255. Bristol Water's SoC referred to a report by Oxera from October 2014 which considered Bristol Water's IRE model and the upstream infrastructure GMEAV variable.

256. Oxera's key conclusion was that 'modelling disaggregated data could be an important addition to Ofwat's top-down models'. Oxera also stated that Bristol Water's IRE modelling 'could be taken as a starting point and developed further'.

257. Oxera subsequently considered the upstream assets variable as part of further work to develop econometric models for Bristol Water, including models of base expenditure and models focused on IRE. Oxera reported that Bristol Water had informed it that the proportion of upstream assets could be an important cost driver, but Oxera found that in its IRE modelling, the estimated coefficient was not intuitive from an operational perspective. Similarly, in its base expenditure models, Oxera tried the upstream assets variable but found that the coefficients were not operationally intuitive and/or statistically significant. Oxera did not include the proportion of upstream assets variable, or any similar variable, in the models it produced for Bristol Water.

258. We considered that Bristol Water's IRE model was helpful in identifying that there may be differences between Bristol Water and other water companies that were relevant to its IRE requirements, including in relation to upstream assets.

259. However, we had a number of significant concerns about placing reliance on the results from Bristol Water's IRE model:

---

[71] Bristol Water SoC, Table 67 & paragraph 1040.

(a) Bristol Water's model took the proportion of upstream GMEAV as an explanatory variable. This variable was calculated using Bristol Water's estimates of the GMEAV of its upstream assets and of its downstream assets. If measures of the costs (GMEAV) of assets were used for an explanatory variable, there were risks of circularity and overlooking relative efficiency differences between companies. For example, a company with relatively high-cost assets may have relatively high costs to maintain and replace those assets, but this does not tell us whether the company's higher costs were necessary. As far as possible, we would prefer models that focus on underlying cost drivers or reasons why Bristol Water may need more upstream assets (eg the reservoirs variable in our model), rather than using measures of costs for explanatory variables.

(b) Ofwat highlighted concerns with the quality of the GMEAV data and, as explained above, we considered that the proportion of GMEAV comprised by upstream assets could be misleading (eg a higher proportion may reflect lower levels of downstream assets rather than higher levels of upstream assets).

(c) An econometric model that was focused on IRE was vulnerable to potential differences in cost allocation and asset management strategies between companies that affect the balance of expenditure between opex, IRE and MNI. We did not consider that this ruled out consideration of such models, especially as part of a wider investigation of specific issues further, but were aware that such models carried risks to accuracy from these issues.

(d) Bristol Water's model did not rely exclusively on reported historical expenditure data. It also included companies' forecast IRE for two years out of the five years of the 2010-2015 price control period. We were concerned that the forecasts may not have been an accurate reflection of actual expenditure requirements.

260. Furthermore, we found that Oxera's report for Bristol Water did not endorse Bristol Water's IRE econometric modelling as anything more than a starting point that would need further model development. Oxera did not include the proportion of upstream assets in the IRE models that it subsequently developed for Bristol Water.

Our assessment

261. Bristol Water's submissions and models did not provide a good explanation of the underlying reasons why it had or needed a higher amount of upstream assets. Our own analysis, together with some elaboration from Bristol Water,

indicated that this was primarily related to Bristol Water's relatively high use of reservoirs as a raw water source.

262. We sought to take account of any differences in water companies' expenditure requirements arising from differences in their use of reservoir source through the explanatory variables relating to reservoirs in our econometric models of base expenditure. Given the limitations of the econometric modelling, it was possible that the allowance provided for Bristol Water provided through the reservoir explanatory variables was not sufficient to cover the additional costs that Bristol Water faces in respect of its reservoirs. However, in light of the analysis and considerations set out above, we did not consider that there were grounds to apply a special cost factor adjustment to our modelling results.

Bedminster service reservoir

Summary of the claim and our provisional findings

263. In its response to our provisional findings, Bristol Water suggested a special cost factor adjustment for the Bedminster service reservoir. We had not considered the Bedminster service reservoir as part of the special cost factor assessment in our provisional findings.

264. Bristol Water argued that if we were to agree with its position that there was a need for the service reservoir in the AMP6 period, we should also make a special cost factor adjustment to allow for the expenditure on the service reservoir. Bristol Water said that its proposed expenditure for the Bedminster service reservoir should be treated as a lumpy item and that the expenditure would not be expected to be predicted by the econometric model.[72]

Our assessment

265. We consider Bristol Water's business plan proposals for the Bedminster service reservoir in Section 5. We decided that in making a forecast of Bristol Water's expenditure requirements for AMP6, based on Bristol Water's business plan, we should make an adjustment to remove the planned expenditure for refurbishment of the Bedminster service reservoir.

266. Furthermore, we considered that, regardless of whether we were to make an allowance for the Bedminster service reservoir in our assessment of Bristol Water's business plan for base expenditure, Bristol Water's response to our

[72] Bristol Water response to our provisional findings, paragraphs 194–196.

provisional findings would not provide grounds for a special cost factor adjustment.

267. It is the nature of water company investment that the expenditure on a single asset can be lumpy in nature, with significant upfront expenditure followed by periods of time when less expenditure is needed on the asset.

268. However, water companies use a large number and wide range of assets in their abstraction and treatment of water and in their treated water distribution systems. In any five-year price control period, we would expect some assets, or categories of assets to require a relatively high amount of expenditure and other assets, or categories of assets, to require less expenditure.

269. The identification of lumpy expenditure relating to one asset (eg a service reservoir) is insufficient to form a view on whether the timing of the company's expenditure requirements is such that its aggregate requirements for capex, across its wholesale activities, were materially higher in one price control period than they would be over a longer time horizon. This would depend on the net effect across all assets.

270. The relevant question for the special cost factor assessment was whether the aggregate estimate of Bristol Water's base expenditure requirements, derived from econometric models of historical data across 18 water companies, was reasonable.

271. We did not consider that it would be appropriate to infer anything about whether the estimate from the econometric models was reasonable or sufficient simply from an assessment of the need for expenditure on a single asset, such as a service reservoir. This was particularly so in the case where Bristol Water's proposed expenditure on the service reservoir (£6.1 million) represented a relatively small proportion (around 4%) of the base service capex from Bristol Water's business plan.

272. We did not consider it relevant to consider, as Bristol Water's submissions suggested, whether the specific expenditure on the service reservoir would be expected to be predicted by the econometric models of base expenditure. This was not what the models do: they take base expenditure in aggregate and do not produce predictions of expenditure requirements in particular categories or for specific assets.

273. Our approach above was consistent with that advocated in submissions from Ofwat. Ofwat said that the base expenditure models included all spending across the sector, including in relation to 'lumpy projects'. Ofwat argued that rebuilding a service reservoir was a routine activity undertaken from time to time by water companies and not an exceptional activity. Ofwat said that it

saw no basis for an adjustment for a project which constituted approximately 1% of business plan totex.