Annex S - Additional opex assessment reservoir inspections

Utility Regulator

29 March 2021

FINAL REPORT

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1. EXECUTIVE SUMMARY

The Utility Regulator has asked CEPA to assess the efficiency of Northern Ireland (NI) Water's request for £2.5 million of additional operating costs (opex) associated with reservoir inspection activities that were not included in its original PC21 business plan.

This request follows the latest round of reservoir inspections, which led to the All Reservoir Panel Engineers (ARPE) concluding that NI Water's overall reservoir inspection regime lags best practice. The ARPE recommended that site inspections should be undertaken at most of the sites a minimum of twice a week and at some of the larger sites at least 3 times a week[1].

Based on this recommendation, NI Water has estimated it will require 10 additional full-time equivalents (FTEs) to fulfil the recommended inspection requirements at a cost of £2.5 million over the PC21 control period. The additional opex request is set out in the table below.

Table 1.1: NI Water PC21 Reservoir Inspections Additional Opex Request Summary (£m, 2018-19 prices)

	Calculation	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	Total
(A) PC21 total opex request		0.410	0.541	0.541	0.541	0.541	0.541	3.116
(B) PC15 average annual opex		0.103	0.103	0.103	0.103	0.103	0.103	0.620
(C) PC21 additional opex	A - B	0.307	0.438	0.438	0.438	0.438	0.438	2.496

Source: NI Water

We evaluate the requested expenditure against the following criteria / gateways:

- **Need** – We ask whether NI Water has clearly demonstrated a need for the investment. The objective of this test is to ensure that the investment being proposed is genuinely necessary.
- **Additionality** – We assess whether NI Water has demonstrated that the proposed investment is not already captured in the opex baseline. Within this assessment, we apply twin sub-tests that are applied by the Utility Regulator – newness and exogeneity.
- **Cost efficiency** – The final test is an assessment of whether the amount estimated by NI Water can be considered cost-efficient.

Based on the evidence provided, we are satisfied that the need and additionality tests have been satisfied sufficiently. However, we have been provided insufficient information to be able to conclude that the proposed costs are entirely efficient. For this reason, we recommend applying the UR's baseline opex efficiency challenge to NI Water's requested additional reservoir inspections opex.

Table 1.2 sets out a summary of our assessment of NI Water's requested additional opex relating to reservoir inspection activities over the course of PC21.

Table 1.2: Summary of assessment, opex (£m, 2018/19)

Need	Additionality		Cost efficiency	Requested	Recommendation
	Newness	Exogeneity			
🟢	🟢	🟢	🟡	2.496	Fund as requested minus baseline opex efficiency challenge

Source: CEPA

[1] Source: NI Water, 2020. NI Water Response to the PC21 Draft Determination. Main Report. Paragraph 3.7.6.

2. INTRODUCTION

The Utility Regulator has asked CEPA to assess the efficiency of Northern Ireland (NI) Water's request for £2.5 million of additional operating costs (opex) associated with reservoir inspection activities that were not included in its original PC21 business plan. This short report documents our findings.

The Reservoirs Act (Northern Ireland) 2015 provides for the regulation of structures or areas, capable of holding 10,000 cubic metres or more of water above the natural level of the surrounding land (i.e., controlled reservoirs).[2] The Act aims to ensure that controlled reservoirs are managed and operated to minimise the risk of flooding due to an uncontrolled release of water resulting from dam failure in order to protect people, the environment, cultural heritage and economic activity. The Act anticipates industry best practice and is similar to the Reservoirs Act 1975 for England and Wales.[3] However, the sections of the 2015 Act that relate to inspection and supervisory requirements (sections 26 and 35) have not yet commenced. NI Water anticipates that these sections of the Act will come into force by the end of 2021 now that the Executive and NI Assembly have re-established.

Before the introduction of the Reservoirs Act (Northern Ireland) 2015, there was no regulation for the inspection or maintenance of reservoirs in Northern Ireland. But NI Water has historically managed its reservoirs in line with the Reservoirs Act 1975 that applies in England and Wales. As a result, the introduction of the Act did not have a major impact on NI Water[4] as it was already carrying out the following reservoir inspection activities:

- monthly, biannual, and annual inspections of its 45 controlled reservoirs.
- use of an independent inspecting engineer to carry out 10 yearly inspections and provide a comprehensive report on reservoir condition, including recommendations for any work that may be required.

However, following the latest round of inspections, the All Reservoir Panel Engineers (ARPE) found that NI Water's overall reservoir inspection regime lags best practice despite following the spirit of the UK legislation. The ARPE has recommended that site inspections should be undertaken at most of the sites a minimum of twice a week and at some of the larger sites at least 3 times a week[5]. Other recommendations include increased level and seepage monitoring, piezometer reading and testing of valves.

Based on this recommendation, NI Water has estimated it will require 10 additional full-time equivalents (FTEs) to fulfil the recommended inspection requirements at a cost of £2.5 million over the PC21 control period. The additional opex request is set out in the table below. We note that we do not assess existing reservoir inspections opex within this report as it is assessed as part of baseline opex (i.e., opex benchmarking).

Table 2.1: NI Water PC21 Reservoir Inspections Additional Opex Request Summary (£m, 2018-19 prices)

	Calculation	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	Total
(A) PC21 total opex request		0.410	0.541	0.541	0.541	0.541	0.541	3.116
(B) PC15 average annual opex		0.103	0.103	0.103	0.103	0.103	0.103	0.620
(C) PC21 additional opex	A - B	0.307	0.438	0.438	0.438	0.438	0.438	2.496

Source: NI Water

We evaluate the requested expenditure against the following criteria / gateways:

- **Need** – We ask whether NI Water has clearly demonstrated a need for the investment, taking into consideration legislative/policy requirements, benefits being delivered, and best practice from other water

[2] Source: Northern Ireland Department for Infrastructure. Regulating reservoir safety in Northern Ireland. Available here.

[3] Source: Reservoirs Act 1975. Available here.

[4] Source: Northern Ireland Assembly, Committee for Agriculture and Rural Development. Reservoirs Bill: Northern Ireland Water, February 2014. Available here.

[5] Source: NI Water, 2020. NI Water Response to the PC21 Draft Determination. Main Report. Paragraph 3.7.6.

companies and utilities. The objective of this test is to ensure that the investment being proposed is genuinely necessary either because it is in the interest of water consumers or because it is required by law or policy.

- **Additionality** – We assess whether NI Water has demonstrated that the proposed investment is not already captured in the opex baseline. Within this assessment, we apply twin sub-tests that are applied by the Utility Regulator – newness and exogeneity. The newness test considers whether the additional expenditure genuinely relates to a new obligation or specified improvement in service levels. The exogeneity test considers whether NI Water faces an exogenous (i.e., outside its management control) increase in cost in relation to current activities. If either or both of these two tests are passed, then the expenditure can be considered additional. The purpose of these two tests is to ensure that NI Water has not already been provided with an allowance for the investment, either explicitly or implicitly, within the opex baseline.
- **Cost efficiency** – The final test is an assessment of whether the amount estimated by NI Water can be considered cost-efficient. In other words, does the estimated expenditure reflect the costs that would be borne by a company operating in a competitive environment? A qualitative judgement may be required in cases where there is a lack of benchmarking data with which to assess cost efficiency. For example, the activity has been delivered by the licensee before and/or comparisons with comparators is not possible.

To assess the requested costs, we have had regard to the submission made by NI Water and a range of other sources of information, e.g., material available from England and Wales companies. Our information sources are inevitably imperfect, but we have sought to triangulate between multiple pieces of evidence to avoid over reliance on a single source. There remains however a degree of judgement in the conclusions we reach.

3. NEED

NI Water has indicated that the need for the investment is driven by the ARPE's recommendation that NI Water increase the frequency of its reservoir inspection activities to catch-up with industry best practice. More specifically, APRE recommended that reservoir site inspections occur at most of NI Water's sites a minimum of twice a week and at some of the larger sites at least 3 times a week.[6] This compares to NI Water's current reservoir inspection programme, which inspects each impounding reservoir once a month.

We understand that best practice reservoir management involves applying a risk-based approach, whereby the frequency of inspection activities is driven by the consequence of reservoir failure. APRE's recommendations appear to reflect current best practice, which dictates visits every 48 hours by trained staff to a reservoir where the predicted consequence of failure is high.[7]

NI Water has also informed us that the recommended number of inspections has been influenced by its reservoir risk categorisation, which provides further confidence that NI Water is adopting a risk-based approach. The categorisation of NI Water's impounding reservoirs is set out below, which is primarily based on the impact of an uncontrolled release of water due to dam failure.

Table 3.1: Risk categorization of NI Water's controlled impounding reservoirs

Risk category	Number of controlled impounding reservoirs
High	34
Medium	9
Low	2

[6] Source: NI Water, 2020. NI Water Response to the PC21 Draft Determination. Main Report. Paragraph 3.7.6.

[7] Source: Dams & Reservoirs Ltd, 2020. Report on the Nature and Root Cause of the Toddbrook Reservoir Auxiliary Spillway Failure on 1st August 2019. Available here.

Source: NI Water

The Reservoirs Act (Northern Ireland) 2015 also states that NI Water is required to carry out the instructions of the ARPE, to the satisfaction of the ARPE, and by the timescale that the ARPE specify.

Based on the evidence set out above, we consider a request for opex in relation to additional reservoir inspection activities passes the 'needs' test.

Table 3.2: Additional reservoir inspection activities opex request – 'need' gateway assessment

Additional reservoir inspection activities opex request – 'need' gateway assessment	
We consider the request for opex in relation to additional reservoir inspection activities passes the 'needs' test. The request has been driven by a recommendation made by the APRE, which is based on reservoir management best practice.	●

Source: CEPA

4. ADDITIONALITY

Newness

In assessing newness, we consider whether the opex baseline already implicitly or explicitly includes an allowance for reservoir inspection activities. This includes a consideration of the level of reservoir inspection activity undertaken by NI Water during PC15, as well as the level of reservoir inspection activity undertaken by water companies in England and Wales.

NI Water states that it has completed a detailed assessment to establish the total frontline estimated days required per year to complete the recommended reservoir inspections. The study estimated 3,482 annual visits and 2,519 person-days would be required, which equates to 11.3 full time equivalents (FTEs) based on 223 working days per year, plus an inspection supervisor to manage the additional staff and inspections. This results in a total of 12.3 FTEs being required to deliver the recommended level of reservoir inspections.

NI Water has recognised that some of these activities are already undertaken as part of the monthly visits. They currently conduct 540 visits per year or 15% of the 3,482 visits required to deliver the enhanced inspection regime, which equates to 1.7 FTEs. In addition, NI Water currently carries out levelling activities, which accounts for a further 0.6 FTEs. In total, this means that current staff can deliver around 19% of the recommended reservoir inspection activities.

NI Water have also assessed whether the existing team could take on additional duties to reduce the number of additional staff required. But they concluded there is no headroom within the current team as they are fully occupied in operating and maintaining water treatment works. As a result, NI Water considers that an additional 10 FTEs are required to deliver the additional inspection activities (12.3 FTEs minus 2.3 FTEs). Overall, the approach taken by NI Water gives us some confidence that they have considered 'additionality' when preparing the business case.

However, it is important to also consider 'newness' in the context of the top-down historical opex benchmarking analysis used to compared NI Water to water companies in England and Wales. We understand that companies in England and Wales already inspect their reservoirs in line with best practice. This may mean that NI Water had a competitive advantage in the opex benchmarking exercise because it is not currently delivering reservoir inspections to the same standard. All else being equal, this may lead to NI Water looking more efficient than its peers because the selected opex models do not capture differences in service quality.

There are two conflicting implications of this:

- **NI Water's baseline opex (2018-19 outturn opex) will be too low** as it reflects the current reservoir inspection regime (e.g., monthly inspections), and therefore does not include the additional opex required to deliver the enhanced reservoir inspection regime.

- **NI Water's catch-up opex efficiency challenge is lower than it would be if it had been inspecting the reservoirs in line with best practice** in the historical opex modelling period. A lower catch-up efficiency challenge results in a higher opex allowance based on the approach taken by the Utility Regulator at the Draft Determination.

It is relatively straightforward to assess the magnitude of the first issue by comparing historical reservoir inspection costs with forward looking reservoir inspection costs that are required to deliver the enhanced inspection regime. NI Water have set this out in the DD response, as described above.

But it is challenging to assess the magnitude of the second issue for several reasons:

- **NI Water manages relatively more impounding reservoirs than its peers**. As NI Water set out in its DD response[8], it has nearly twice as many controlled impounding reservoirs per head of population served compared to water companies in England and Wales. As a result, it may not be fair to suggest that NI Water has been operating at a cost advantage over companies in England and Wales (i.e., company / regional specific factor). NI Water ranked second in terms of the number of impounding reservoirs per million people from the twelve water companies it presented data on (See table below).

Table 4.1: Number of controlled impounding reservoirs per million people

Water company	Number of controlled impounding reservoirs	Population served	Impounding reservoirs per million people	Rank
NI Water	45	1,886,300	23.9	2
Anglian Water	35	4,771,324	7.3	9
Bristol Water	12	1,227,036	9.8	8
Northumbrian Water	53	4,568,986	11.6	7
Severn Trent Water	40	8,640,946	4.6	11
Southern Water	8	2,571,526	3.1	12
Thames Water	58	10,112,334	5.7	10
United Utilities	126	7,295,157	17.3	5
Dwr Cymru	85	3,071,030	27.7	1
Wessex Water	17	1,335,130	12.7	6
South West Water	40	2,214,820	18.1	4
Yorkshire Water	98	5,071,134	19.3	3
E&W average			12.5	

Source: NI Water

- **Water resources cost driver data reported by NI Water and companies in England and Wales includes only those that are used to supply a water treatment works,** and consequently excludes reservoirs that are 'out of service' but still require ongoing inspections and maintenance. As a result, the inclusion of an explanatory variable in the wholesale water opex models to estimate the impact of operating a relatively high number of reservoirs on opex (e.g., number of reservoirs per property; percentage of water input from reservoirs) is unlikely to produce precise results.
- **The impact of impounding reservoirs on wholesale water opex is ambiguous**. On one hand, companies with a relatively high number of controlled impounding reservoirs to manage, face higher reservoir inspection costs on a relative basis. But these companies may experience cost savings in other areas. For example, companies that abstract most of their water from other water sources (e.g., rivers and boreholes)

[8] Source: NI Water, 2020. NI Water Response to the PC21 Draft Determination. Annex 3.4 – Reservoir Inspection Regime – comparison with E&W.

are likely to incur relatively higher pumping costs (i.e., pumping from water resource to raw water / treated distribution network) and non-infrastructure asset maintenance costs because impounding reservoirs are filled via natural catchment and generally support water treatment works by gravity.

- **Costs associated with impounding reservoir inspections form a relatively modest component of wholesale water opex,** and therefore may get lost in the 'model noise'.

For the reasons set out above, we do not consider it is feasible to precisely estimate how much NI Water's wholesale water catch-up efficiency challenge would increase if it had been inspecting reservoirs in line with best practice.

This is demonstrated in Appendix A, which presents wholesale water opex model sensitivity results for models that include reservoir related explanatory variables – number of reservoirs per connected property and proportion of water input from impounding reservoirs.[9] The results show that the reservoir related explanatory variables are not statistically significant in the wholesale water opex models.

This result could be driven by any of the latter three issues described above and it is not possible to untangle the different effects based on the data available. We therefore take a conservative view that NI Water's wholesale water opex catch-up efficiency challenge would be unlikely to increase materially if it had been inspecting its reservoirs in line with best practice in the historical modelling period.

Overall, we consider that the opex baseline does not already capture the additional reservoir inspections expenditure requested by NI Water in its PC21 DD response.

Exogeneity

In assessing the exogeneity of NI Water's proposed investment in additional impounding reservoir inspections, we consider whether it is possible for management to control or absorb the additional costs.

The additional reservoir inspection requirements are driven by recommendations made by the APRE that it should increase the number of surveillance visits to reservoirs in line with best practice in the UK and the world, which NI Water has to abide by according to the Reservoirs Act (Northern Ireland) 2015; this is a factor outside of NI Water's control (i.e., exogenous). We therefore consider that additional costs for additional inspections are an exogenous cost.

Table 4.2: Additional reservoir inspection activities opex request – 'additionality' gateway assessment

Additional reservoir inspection activities opex request – 'need' gateway assessment		
We consider that a request for additional opex in relation to additional reservoir inspection activities passes the 'additionality' test from a 'newness' and 'exogeneity' perspective.	Newness	Exogeneity
The opex baseline reflects the current reservoir inspection regime rather than the APRE recommended 'best practice' reservoir inspection regime, which demands a higher frequency of inspections. The increase in expenditure has been driven by recommendations made by the APRE, which NI Water must abide by.	●	●
In addition, we consider it is unlikely that NI Water's wholesale water opex catch-up efficiency challenge would increase materially if it had been inspecting their reservoirs in line with best practice in the historical modelling period.		

Source: CEPA

However, NI Water does have control over **how** it delivers the recommended reservoir inspection regime, and some options may be more cost efficient than others. We assess the efficiency of NI Water's requested opex in relation to the additional reservoir inspection activities below.

[9] The data used excludes 'out of service' reservoirs.

5. COST EFFICIENCY

We consider the cost efficiency of NI Water's additional opex request from three perspectives:

- **Has NI Water considered a range of options** to deliver the reservoir inspection activities and selected the optimal solution?
- **Has NI Water arrived at an efficient number of FTEs** to deliver additional reservoir inspection activities?
- **Has NI Water arrived at an efficient FTE unit cost?**

We discuss each of these issues in turn below.

Have NI Water considered a range of options?

NI Water proposes to deliver the enhanced reservoir inspection regime programme using visual inspections performed by NI Water employees (existing and new). NI Water has informed us that the APRE stressed that visual inspections are a fundamental requirement and cannot be avoided. The rationale being that if the same person inspects the site on a consistent basis, they can establish what is normal and therefore notice any small changes in reservoir condition (e.g., new damp areas on the embankment). NI Water do not consider this can be replicated using technology, and they state that this is supported by other utility companies who have invested in monitoring technologies (e.g., satellite) but see this as a supporting tool rather than a replacement for visual replacement. As a result, NI Water consider that in-person visual reservoir inspections are the only feasible option available at present to meet the recommendations of the APRE.

NI Water state the only exception is in relation to the recording of seepage flows, where remote seepage monitoring is possible. But it concluded that the solutions at most sites would be complicated and expensive. NI Water's supervising engineer also recommended that manual monitoring would still be required even with remote monitors. For these reasons, NI Water does not consider remote seepage monitoring to be a feasible solution at this time.

We have assessed NI Water's arguments through desk-based research and engagement with a water company operating in England. Our desk-based research indicates that good practice with respect to dam safety includes having trained staff visit the sites several times a week and after 'extreme' events, and current best practice dictates visits every 48 hours by trained staff for a dam with high consequence of failure.[10] This evidence supports the arguments put forward by NI Water.

For additional reassurance, we also spoke with a water company in England that operates a relatively large number of reservoirs compared to the average water company. They also confirmed that advanced technologies to inspect reservoirs, such as the use of remote sensing to detect leakage (e.g., satellite or drone) and movement (e.g., via thermal mapping and light detection ranging (LiDAR)) [11], are not yet mature enough to perform well in poor weather, and do not have the level of spatial granularity and sensitivity to be able to emulate human inspection.[12]

Based on the evidence presented above, **we consider that NI Water has sufficiently demonstrated that in person inspection of reservoirs is currently the best option available at present.**

Have NI Water arrived at an efficient number of FTEs?

NI Water determined undertook a detailed assessment to determine that 11.3 FTEs will be required to deliver the enhanced inspection regime. This is based on an estimated 3,482 visits per year, which equates to approximately 308 visits per FTE per year. NI Water also considers than an additional reservoir inspection supervisor will be required to manage the additional staff and inspections, which leads to a total staff requirement of 12.3 FTEs.

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[10] Source: Dams & Reservoirs Ltd, 2020. Report on the Nature and Root Cause of the Toddbrook Reservoir Auxiliary Spillway Failure on 1st August 2019. Available here.

[11] Source: British Dams, 2017. The modern dam engineer. Available here.

[12] Following a discussion with a water company in England and Wales.

We concluded in the section above that NI Water had considered ‘additionality’ when estimating resourcing requirements. We therefore focus here on the reasonableness / efficiency of NI Water’s assumption that 12.3 FTEs are required to deliver the recommended reservoir inspection activities.

NI Water’s request implies that approximately 0.3 FTEs per controlled reservoir are required to deliver the enhanced reservoir inspection regime (12.3 FTEs in total for 45 controlled impounding reservoirs). We have assessed the efficiency of this assumption by comparing it with a water company in England that also operates many controlled reservoirs. ✂✂ ✂.

We have some reservations, however, on whether the additional reservoir inspection supervisor is necessary to manage the additional nine reservoir inspectors. It is not clear from NI Water’s evidence if it considered whether existing reservoir inspection supervisor/s could manage the additional staff to avoid the cost of a new staff member and deliver efficiency savings.

Based on this evidence, **we conclude that NI Water’s estimated number of FTEs is reasonable / efficient. But the additional reservoir inspection supervisor has not been fully justified.**

Have NI Water arrived at an efficient FTE unit cost?

NI Water has provided details of the assumed FTE unit costs via a query response, which are set out below:

- Nine grade 1 FTEs, who will deliver the additional inspection activity:
  - £43,544 per FTE, which includes national insurance contributions, pension contributions and the provision of an off-road vehicle given the upland and remote location of a number of the reservoirs.
- A level 5 FTE, who will manage the additional inspection staff:
  - £47,768 per FTE, reflecting the mid-point of the level 5 scale and including national insurance contributions and pension contributions.

NI Water informed us that the roles were benchmarked by its human resources department to ensure they are at the appropriate grade internally for the level of responsibility. The assumed costs were then based upon NI Water’s pay scales for the appropriate grade.

NI Water have not used any market evidence to ensure that the assumed costs are in line with current market conditions. It is therefore difficult for us to conclude based on the evidence provided that the assumed FTE unit costs are efficient. We have undertaken desk-based research to assess whether the assumed FTE unit costs are reasonable and efficient. Our research indicates that most companies’ budget for reservoir inspection and maintenance works is in the order of £15,000 per reservoir/per annum in England and Wales although this is a general estimate and costs are likely to vary with the characteristics of each reservoir. NI Water’s cost estimate equates to roundly £12,000 per reservoir/per annum. This is a simplistic comparison, that is not adjusted to take account of differences inactivity or factors such as input price differences between Great Britain and Northern Ireland, but it does give a degree of comfort that NI water’s estimate is reasonable.

Overall, we are reasonably satisfied that NI Water’s assumed FTE unit costs are approximately in line with industry benchmarks. But we cannot make a definitive conclusion as NI Water have not used market evidence to cross-check its internal salary benchmarking analysis. **We therefore recommend applying the UR’s baseline opex efficiency challenge to the requested additional inspection activity costs**.

Table 5.1: Additional reservoir inspection activities opex request – ‘cost efficiency’ gateway assessment

Additional reservoir inspection activities opex request – ‘cost efficiency’ gateway assessment	
We consider that NI Water have sufficiently demonstrated that human inspection of reservoirs is currently the only feasible option available based on the technology available. We also consider that NI Water’s estimated number of FTEs to deliver the enhanced reservoir inspection regime is reasonable / efficient.	●

Additional reservoir inspection activities opex request – 'cost efficiency' gateway assessment
But the additional reservoir inspection supervisor has not been fully justified and NI Water have not used the latest market evidence to ensure that its assumed FTE unit costs are efficient. We therefore recommend applying the UR's baseline opex efficiency challenge.

Source: CEPA assessment

6. RECOMMENDATION SUMMARY

We are satisfied that the need and additionality tests have been satisfied sufficiently. However, we have been provided insufficient information to be able to conclude that the proposed costs are entirely efficient. For this reason, we recommend applying the UR's baseline opex efficiency challenge to NI Water's requested additional reservoir inspections opex.

Table 6.1 sets out a summary of our assessment of NI Water's requested additional opex relating to reservoir inspection activities over the course of PC21.

Table 6.1: Summary of assessment, opex (£m, 2018/19)

Need	Additionality		Cost efficiency	Requested	Recommendation
	Newness	Exogeneity			
●	●	●	●	2.496	Fund as requested minus baseline opex efficiency challenge

Source: CEPA

Appendix A WHOLESALE WATER OPEX MODEL SENSITIVITIES: RESERVOIR INSPECTIONS

Table A.1: Reservoir inspections wholesale water opex model sensitivities - reservoirs per connected property

Variables	Wholesale water selected opex model results			Reservoir inspections sensitivities: reservoirs per connected property		
	Model 1	Model 2	Model 3	Model 1a	Model 2a	Model 3a
Length of mains	1.006***	0.970***	1.000***	1.004***	0.972***	1.000***
Number of booster pumping stations per length of mains	0.306**	0.290*	0.216	0.277*	0.270*	0.213
% of water treated in complexity bands 4 to 6	0.004***			0.004***		
Weighted average treatment complexity		0.396**			0.369**	
% of water input from pumped reservoirs			0.004***			0.004***
Connections per length of mains	-3.238*	-4.000**	-2.742**	-3.485**	-4.146**	-2.775**
Connections per length of mains squared	0.490**	0.586***	0.425**	0.525**	0.607***	0.430***
Post-2014/15 UK GAAP accounting treatment	0.187***	0.193***	0.196***	0.182***	0.186***	0.196***
Number of reservoirs per connected property				0.027	0.014	0.003
Constant	0.402	1.843	-0.647	0.64	1.984	-0.606
Overall predictive power	97.0%	96.8%	97.1%	97.0%	96.7%	97.0%
Number of observations	111	111	109	109	109	109

*Source: CEPA analysis. Note: Significant at the * 10% level, ** 5% level, *** 1% level.*

Table A.2: Reservoir inspections wholesale water opex model sensitivities – percentage of distribution input from impounding reservoirs

Variables	Wholesale water selected opex model results			Reservoir inspections sensitivities: reservoirs per connected property		
	Model 1	Model 2	Model 3	Model 1a	Model 2a	Model 3a
Length of mains	1.006***	0.970***	1.000***	0.989***	0.959***	0.983***
Number of booster pumping stations per length of mains	0.306**	0.290*	0.216	0.265*	0.257	0.186
% of water treated in complexity bands 4 to 6	0.004***			0.004***		
Weighted average treatment complexity		0.396**			0.379**	
% of water input from pumped reservoirs			0.004***			0.004***
Connections per length of mains	-3.238*	-4.000**	-2.742**	-3.134	-3.954**	-2.612*
Connections per length of mains squared	0.490**	0.586***	0.425**	0.484**	0.586***	0.414**
Post-2014/15 UK GAAP accounting treatment	0.187***	0.193***	0.196***	0.187***	0.191***	0.201***
% of water input from impounding reservoirs				0.003	0.002	0.002
Constant	0.402	1.843	-0.647	0.004	1.61	-1.013
Overall predictive power	97.0%	96.8%	97.1%	97.0%	96.8%	97.1%
Number of observations	111	111	109	109	109	109

*Source: CEPA analysis. Note: Significant at the * 10% level, ** 5% level, *** 1% level.*

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