TA 11.WN02 Nitrate
Business Case

September 2018
Version 1.0

Contents

1. Executive Summary

Name of technical annex	TA.11.WN02 Nitrate		
Context	The concentration of Nitrate in raw water has been increasing since the 1980s. During AMP6, 5 nitrate removal plants were installed. Concentrations are continuing to increase in AMP7, consequently we need to intervene to ensure treated water concentrations remain below the limit set by the Drinking Water Inspectorate (DWI).		
Customer and stakeholder views	Our customers have told us that we must supply high quality water. DWI has set a Prescribed Concentration Value (PCV). All water supplied to customers must have Nitrate concentrations below the PCV. We have recommended to the DWI that nitrate levels are likely to exceed the PCV at a number of sites and therefore interventions are required. The DWI have issued Final Decision Letters to confirm that they will issue Notices to ensure that we intervene to reduce Nitrate concentrations at all the proposed sites.		
Our aim	We will continue to ensure no breaches of the Nitrate PCV occur at customers' taps.		
Scope of this technical annex	Enhancement and capital maintenance expenditure for 14 sources to ensure that the nitrate PCV is not exceeded at customers' taps.		
	Botex	Enhancement	Total
Totex (£'m)	£20.4m	£59.4m	£79.8m[1]
Opex (£'m)	£0m	£4.0m	£4.0m
Capex (£'m)	£20.4m	£55.4m	£75.8m
Residual, post-AMP7 capex (£'m)	£0m	£0m	£0m
20 year Whole life totex (£'m)			
20 year cost benefit (3m)	£0m	£0m	-£77m
Materiality (% 5 year Totex for relevant price control)	-	-	WN+ 6.6% WR 5.0%
Relevant business plan table lines	WS1 line 13	WS2 line 13 & 52	-
Enhancement			
Need for enhancement / investment	The use of nitrate fertilisers during the 1980s is a major source of nitrate in ground and surface water. Nitrate is particularly long-lived in the chalk aquifers across our region. Our forecasts show		

[1] Our gross wholesale plan includes £5.436 million of enhancement Opex for AMP6 nitrate schemes, as required by WS2. To account for this we have reduced our Water Networks gross operating costs by £5.436 million. In order to align with our AMP7 delivery planning our technical annexes do not reflect these adjustments. Our Nitrate technical annex investment is therefore £85m - £5m = £80m, and our Water Networks technical annex investment is £255m + £5m = £260m.

	we will need to take action to control nitrate in water from 14 sources during AMP7. This has been reviewed and confirmed by the DWI. Mitigating nitrate levels from these 14 sources is now a statutory obligation.
Overview of AMP7 proposals	We first considered catchment management solutions as these are less costly in the long term, and more sustainable. These solutions rely on market mechanisms, predominantly in the form of payments to farmers and other land users to encourage different work and leisure practises. However, the benefits of catchment management will not be seen immediately. We then considered geographic clusters of sites to determine whether raw water blending options were available. Raw water blending solutions reduce the overall number of treatment works. This process aligns strongly with our Network 2030 approach whereby sites are combined to improve both resilience and operational efficiency. Where local sources of low nitrate treated water were identified, we considered network blending solutions. We also assessed provision of nitrate removal plant at each individual site. This approach ensures the lowest cost solutions are proposed. The hierarchy of applied solutions can be summarised as follows: Raw water blending – 2 sources Raw water blending and combined treatment – 9 sources Treated water blending – 1 source Treatment – 1 source Turn off during seasonal high nitrate period – 1 source Investment in this area is split between Water Resources and Water Networks+ price controls, with the majority of investment (£69m) in Water Networks+. We have also recognised that some of the costs in this area of investment would have been incurred in AMP7 if we did not need to mitigate these nitrate risks. We have therefore allocated these to botex, as shown above.
Why the proposals are the best programme-level option for customers	We have evaluated a range of programme level options and have used our Network 2030 approach to get the best long term costs for customers. We have considered and rejected the following options: Install treatment plant at all sites rather than blending – higher capital and operational costs. Expand Brighton East to include Falmer flows – higher cost in AMP7, no additional benefit in AMP7. Make no interventions to reduce nitrate in AMP7 – failure to meet customer expectations of high quality, safe water. We have selected the most cost beneficial options to address the water quality risk posed by rising raw water nitrate concentrations.
Customer and stakeholder support	The DWI has reviewed our proposals to control nitrate, they agree with our proposals and have issued final decision letters which support our proposals. Legal notices, that reflect the content of the final decision letters, will be issued by the DWI during 2018.

Need for a CAC (if relevant)	We have queried the need for a Cost Adjustment Claim (CAC) for nitrate with Ofwat (query ref 610b). Ofwat advised "this type of enhancement expenditure does not require a CAC".		
Extent of management control (if relevant)	The increase in nitrate levels has arisen from historical farming practises. We are implementing active catchment management to minimise future nitrate risk, however we are unable to address historic farming practise.		
Robustness and efficiency	In AMP6 our costs for nitrate removal per Megalitre (Ml) were roughly £800K. In AMP7 our enhancement costs at £700K/Ml are more efficient than those delivered in AMP6 and we are delivering additional resilience benefits due to alignment with our Network 2030 initiative.		
Customer protection (if relevant)	Customer protection is provided through the Compliance Risk Index (CRI) performance measure. If we do not deliver these enhancements our CRI score will be impacted which will lead to significant financial penalties.		
Affordability considerations	The spend is proposed in this technical annex will increase average customer bills by less than 1% over the course of AMP7.		
Board assurance (if relevant)	This enhancement technical annex has been externally reviewed by Jacobs, with no material exceptions identified.		
Performance Commitments supported by this technical annex			
PC	How relevant is this technical annex?	Comment	
Compliance Risk Index (CRI)	High	Failure of the nitrate PCV at these sites during AMP7 would have a significant impact on our CRI score.	
Schemes and scheme-level options			
Schemes over £10m	Options		
	Description	Cost	Selected option
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

2. Scope of Technical Annex

Our wholesale plan has been valued at £3.9 billion. This technical annex relates to the enhancement investment required to control nitrate in treated water within our supply network. Funding comes mainly under the Water Networks+ price control, with a small proportion funded from Water Resources.

Our gross wholesale plan (shown below) includes £5.436 million of enhancement Opex for AMP6 nitrate schemes, as required by WS2. To account for this we have reduced our Water Networks gross operating costs by £5.436 million. In order to align with our AMP7 delivery planning our technical annexes do not reflect these adjustments. Our Nitrate technical annex investment is therefore £85m - £5m = £80m, and our Water Networks technical annex investment is £255m + £5m = £260m.

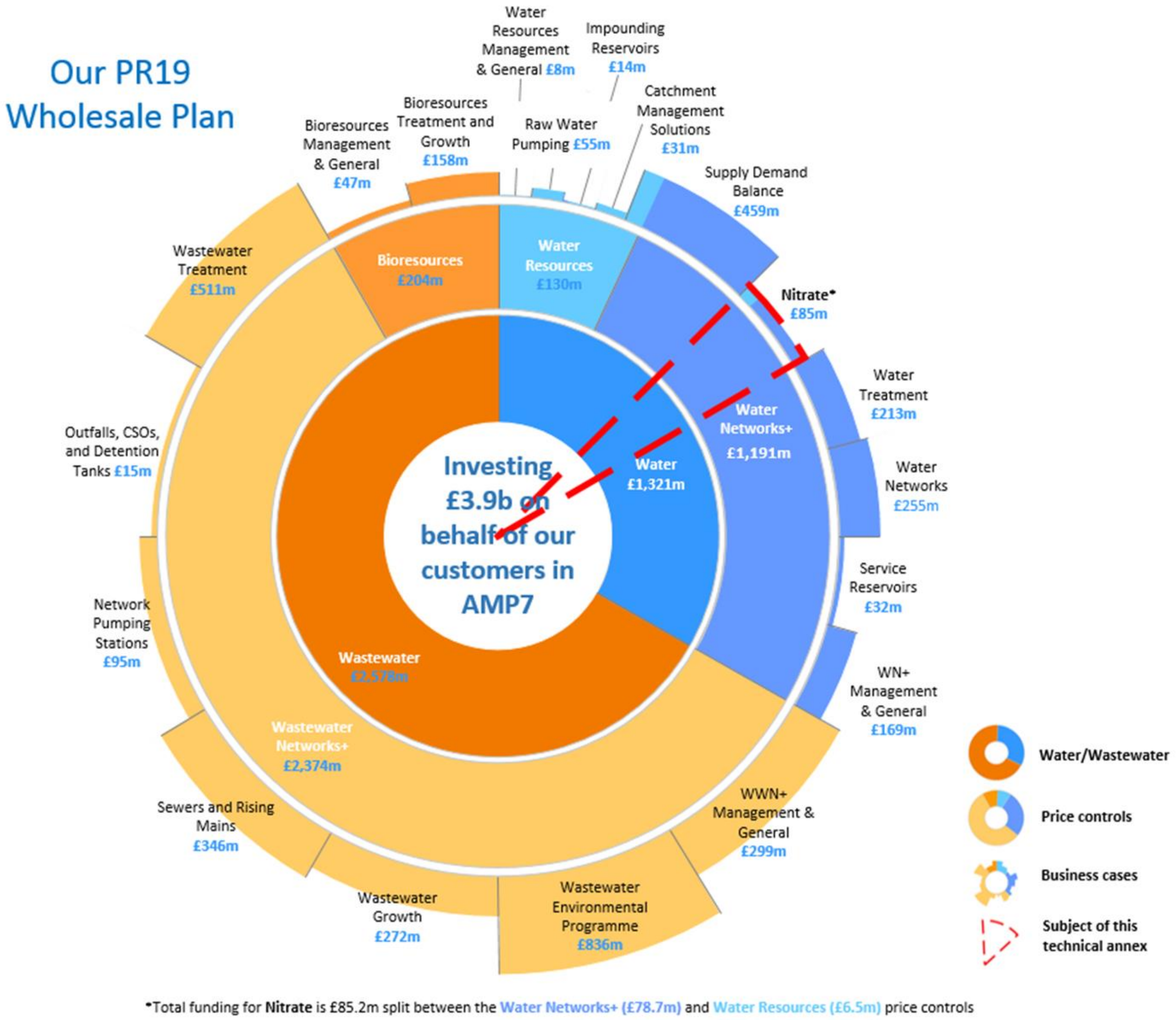


Figure 1

Nitrate is present in varying concentrations in both ground and surface water sources throughout our supply area. We identified several sites at risk of future nitrate prescribed concentration value (PCV) exceedance through our Drinking Water Safety Plans (DWSPs). Our proposals will resolve these public health risks.

Nitrate in water reduces to nitrite which inhibits oxygen transport in blood leading to Methemoglobinemia or ‘Blue Baby Disease’. This is particularly harmful to babies due to the relatively large proportion of their diet which can come from water. DWI therefore set a PCV for Nitrate in order to protect public health. We have worked with the DWI to determine the interventions required in AMP7 to ensure the nitrate PCV is not breached. The DWI have issued ‘Decision Letters’ supporting all the schemes within this investment area. These ‘Decision Letters’ form the basis for the legal notices we will develop with the DWI to ensure all necessary interventions are carried out. Our proposals reflect the interventions we expect to be in the DWI notices.

Investment in this area forms the bulk of the **Network 2030** initiative in AMP7 where a number of treatment works will be combined to improve operability, resilience and long-term cost efficiency. This will allow dilution of nitrate levels and reduce the amount of new treatment plant needing to be installed, operated and maintained.

Capital maintenance investment on treatment works, boreholes and the distribution network are excluded from this technical annex as is catchment management. However, these areas are interconnected and successful removal of nitrates relies on strong performance in them.

3. AMP6 Strategy

3.1. Investment Strategy

We actively monitor nitrate levels across our supply area. Where source levels already exceed the nitrate PCV (50 $mgNO_3/L$) we maintained existing blending and treatment systems to ensure customers' water is safe. Where levels were predicted to exceed the PCV within AMP6 we designed and installed treatment plant or blending solutions to ensure that the water reaching customers' taps is below the PCV.

In AMP6 the following work is planned:

[redacted]

Table 1 below shows our AMP6 spend for nitrate reduction. Our AMP6 spend equates to approximately £0.8m per megalitre.

Table 1 - Spend on Nitrate reduction in AMP6

£'m	AMP6 Actual					
	2015/16	2016/17	2017/18	2018/19	2019/20	AMP6 Total
TOTEX	4.692	8.836	10.460	6.002	3.332	**33.321**
CAPEX	4.692	8.836	10.460	6.002	3.332	**33.321**
Nitrate Schemes	4.692	8.836	10.460	6.002	3.332	**33.321**
OPEX						

3.2. Customer Benefits and Resilience

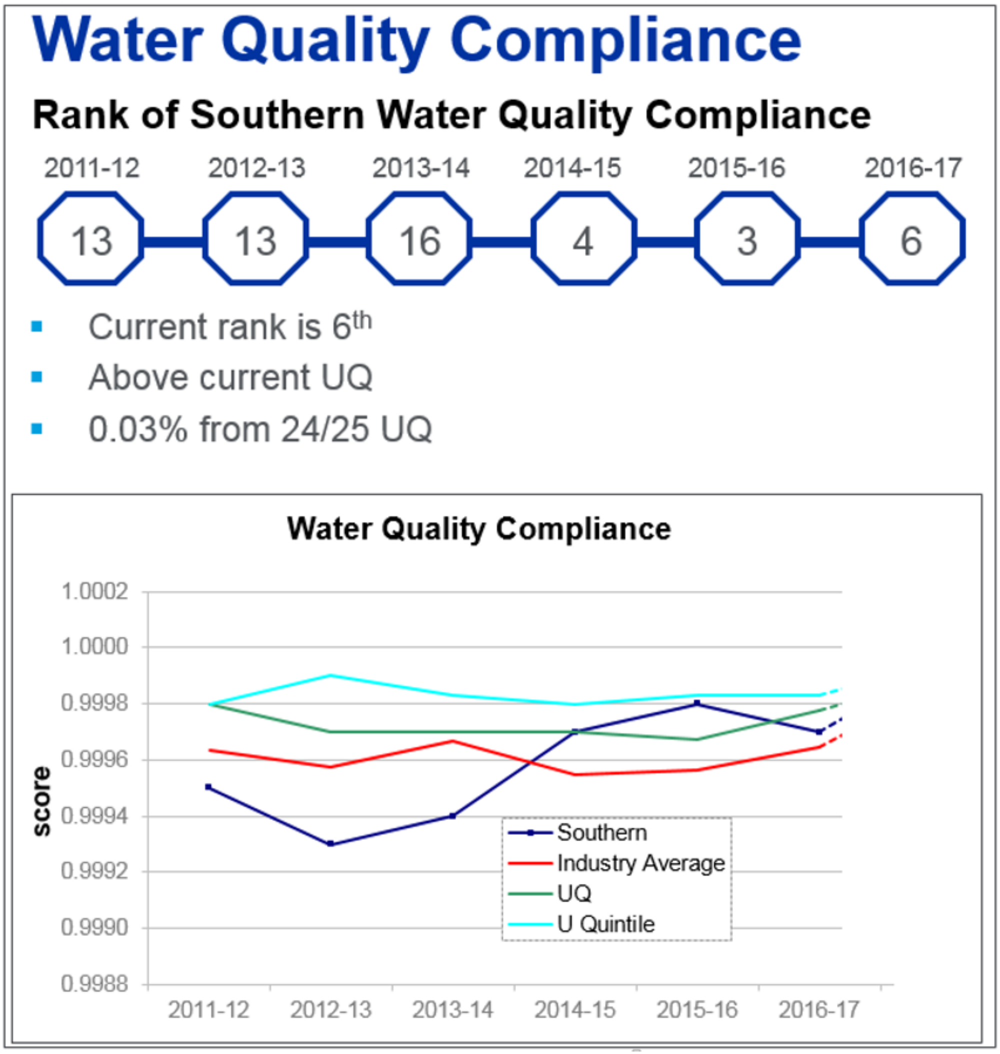


Figure 2 – Our improvement in water quality compliance

The measure currently used for water quality compliance is 'Mean Zonal Compliance (MZC) this will be replaced in AMP7 by CRI. Further details on CRI are in section 5.4.

Since 2011, both our performance and industry position has improved significantly – as shown in Figure 2.

Raw water nitrate levels are inconstant meaning mitigation, such as dilution by blending and direct removal, are not required at all times. When levels increase (predominantly in spring) our AMP6 interventions will ensure the quality of customers' supplies remain protected.

4. Drivers for change

4.1. Customer and Stakeholder insight

As outlined in **Chapter 4 – Customer and Stakeholder engagement**, we used insight from our extensive programme of customer and stakeholder engagement to develop a deep understanding of the views and priorities of our customers. All insight gathered from our customer and stakeholder engagement programme can be found in technical annex **TA.4.4 Customer and Stakeholder engagement deliverables**.

In general, customers view safe and high quality water as one of their top priorities. They want access to water that is as natural as possible and do not want too many added to their water supply. However, they acknowledge chemicals are sometimes necessary to ensure water safety. In particular, customers are concerned about the levels of nitrates in their drinking water as they understand that nitrates can have a big impact on human health, especially on babies.

On the other hand, stakeholders believe supplying safe and clean water should be a given and believe this is a lower priority. Customers of the future also take water quality for granted and tend to focus more on protecting and enhancing the environment. They, therefore, believe it is a medium priority.

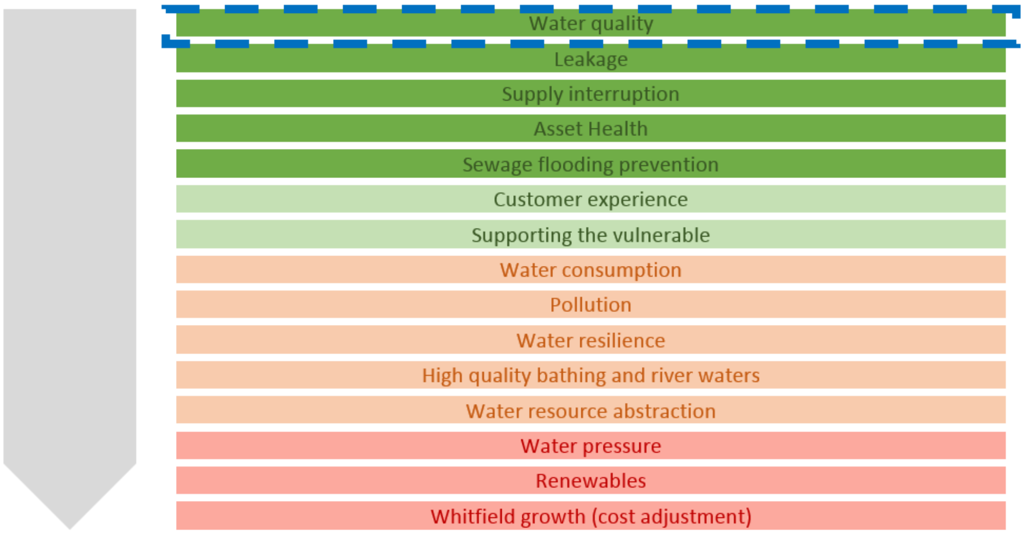


Figure 3: Relative priority of services according to our customers

We have used this understanding of our customers' priorities to define a set of performance commitments and investment proposals, which we validated and refined over the course of our programme of customer engagement. Our success at delivering on these priorities for our customers will be measured by the performance commitments outlined in this technical annex.

We have developed an AMP7 plan, based on customers views, to ensure nitrate levels in our customers' drinking water are safe both in the short and long-term. Customers asked us to deliver reduced nitrate levels in the following ways:

- **Keep water natural** –to ensure we do not add additional chemicals to their drinking water. Our response to this is to blend water as much as possible to dilute nitrate concentrations, only resorting to treatment when absolutely necessary.
- **Greater adoption of catchment management –** Both customers and stakeholders agreed that catchment managment was one of the preferred methods for

guaranteeing a high quality water supply for the future in an environmental manner. However, there was disagreement over who should take the lead. Many were supportive of the idea of us taking the lead role, but others felt this responsibility should fall on a government agency. The general consensus was that it was not our responsibility to fund any work in catchments that did not directly benefit our customers. Further detail on our catchment management solutions can be found in Technical Annex **TA.11.WR03 Catchment Management Solutions.**

4.2. Future Trends and Pressures

Nitrate levels in raw water vary by source according to various factors such as land use, contamination sources, topography and soil depth. Levels have been increasing over the last 30 years with this trend set to continue.

High use of nitrate fertilisers during the 1980s is a major source of nitrate contamination in both ground and surface water sources. Nitrate is particularly long-lasting in chalk aquifers – the principle type of aquifer we rely on for raw water[2].

Catchment management can reduce raw water nitrate levels. In the short term it is unlikely to alter the treatment solutions needed, however it will reduce the amount of treatment required in the long term.

The time it takes water to reach the borehole, the “age” of the water, and groundwater level fluctuations are important factors when considering the benefits of catchment management. Seasonal variations in nitrate trends are linked to groundwater level fluctuations, with peak concentrations usually occurring in winter. Further details of the proposed catchment management for control of nitrate is provided in technical annex **TA.11.WR03 Catchment Management Solutions**.

To determine the sources most likely to exceed the PCV between 2020 and 2025, we used historic data for each of our sources to calculate 90th percentile regression lines. More detailed catchment modelling was then carried out to improve future nitrate concentration forecasts.

Figure 3 shows the historic and modelled nitrate levels at our Sutton groundwater source. The light blue line shows the minimum long-term nitrate level and the orange line shows how nitrate concentrations vary according to rainfall, groundwater levels, topography and other catchment specific factors such as the presence and proximity of farmland, sewers and landfill sites.

[2] Drinking Water Quality – Problems and Solutions, Second Edition, 2008 – N.F Gray

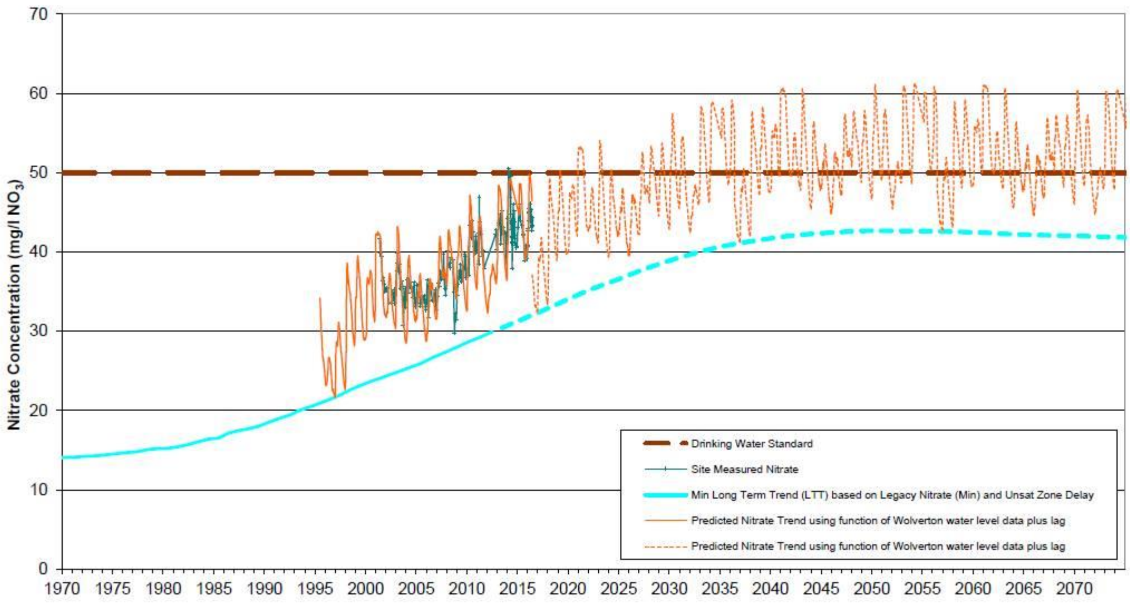


Figure 4 – Modelled raw water nitrate levels at Sutton source[3]

Although the timeframes and magnitude of fluctuations vary, the trend graph is typical for our chalk sources. Graphs for all of the sources considered for nitrate interventions in AMP7 are shown in Appendix 2 of this technical annex.

[3] SWS Drinking Water Protected Area NEP requirement report, February 2017 – Amec Foster Wheeler

5. AMP7 Strategy

5.1. Investment Strategy

Through the risk assessment and management processes applied to all our sites, we identified a large number at risk of exceeding the nitrate PCV. These are recorded in our DWSPs. As described in section 4.2 90th percentile regression trends of historic data and catchment modelling have been used to predict future nitrate concentrations until 2035.

In AMP7 we are seeing entire zones, such as Thanet in Kent, where the majority of sites will be at, or close to, the PCV. This has led us to consider broader, zonal level solutions.

For sites where the PCV for nitrate is predicted to fail, the following five main options (illustrated in Figure 5 below) have been considered. Each site has been investigated within a regional systems approach to balance medium to long-terms risks with the associated costs and overall network resilience.

Figure 5 – main options considered

Catchment Management

Catchment First means we consider catchment management solutions before traditional approaches. Catchment management interventions are more sustainable, more efficient, more environmentally friendly and can deliver wider social and natural capital benefits. The impacts of catchment management are slower to realise than traditional methods, typically showing after 5 to 10 years[4]. However these types of solutions are a priority for us and our customers, and we have a wide range of measures underway. Further details of our wide range of catchment proposals for AMP7 and beyond are included in TA.11 WR03 Catchment Management Solutions.

Maintain existing control / Abandon Source

For sites where an alternative supply is an option, we have considered using the alternative and abandoning the existing source. Taking no action has been considered if the existing mitigation is stable and exceedances are not predicted.

Raw Water Blending

Feasibility of blending low nitrate water sources with water from high nitrate sources to reduce reliance on nitrate treatment at supply works. Combining nearby sources for treatment has also been considered to rationalise the number of new nitrate plants required.

We also assessed the wider water quality risks for each site where raw water blending has been proposed to determine if other water quality benefits could be achieved.

Treated Water Blending

We have considered blending treated water from low nitrate sources within service reservoirs to dilute nitrate concentrations – this was preferred to mixing water within our

[4] See technical annex **TA.11.WR03 Catchment Management** for more detail

networks. Where available, water from other zones and neighbouring companies was also considered.

We also assessed the wider water quality risks for each site where treated water blending has been proposed to determine if other water quality benefits could be achieved.

Nitrate plant

To address short term risks, we considered installing nitrate treatment plant. The ion exchange plants we installed during AMP6 proved to be a suitable, cost-effective process to remove nitrate. We are also considering innovative solutions such as biological removal. The costs in this technical annex related to ion exchange treatment.

Other options, such as borehole re-drilling, have also been considered.

When implementing blending solutions, it is often necessary to reconfigure the water network. This can deliver increased network interconnectivity, improving overall resilience. Our resilience assessment framework calculates the number of properties at risk of supply interruptions, on both existing and proposed network configurations. This means we can maximise the resilience benefits of proposed solutions.

In addition to zonal level solutions, we are considering solutions for sites which do not currently require interventions but will in future AMPs. By considering all current and future sources requiring nitrate removal, we are able to optimally locate a smaller number of plants than otherwise necessary. This leads to lower whole life costs through reduced construction and operation expenditure – providing better long-term value for current and future customers.

As outlined in section 4.2, raw water nitrate levels are rising. We need to reduce the long-term rate of rise and hasten the decline of nitrate levels in raw water. To achieve these goals we will be implementing catchment management across our region to reduce and control nitrate levels. Additional details are in technical annex **TA.11.WR03 Catchment Management Solutions**.

From AMP8 onwards, catchment management will reduce both the time nitrate removal plants operate and required capacity of future plants, securing better long-term value for customers. An example is in Thanet, where a 60-year Whole Life Cost (WLC) analysis showed it is more efficient to blend raw water and only remove nitrate at strategic sites. Table 2 shows a breakdown of costs by site. A full list of the options considered for each source and a summary of their risks and benefits can be seen in Appendix 3.

Table 2 - Cost comparison between blended and individual treatment solutions in the Thanet zone

(£'m)[5]	Thanet blended solutions			Thanet individual nitrate plants		
	Capex	Opex	WLC (60yr)	Capex	Opex	WLC (60yr)
[redacted]	15.0	0.9	42.6	4.9	0.3	14.3
[redacted]				6.1	0.3	16.7
[redacted]				7.1	0.5	22.3
[redacted]	13.2	0.7	35.4	4.1	0.3	14.0
[redacted]				7.0	0.4	20.1
[redacted]	16.4	0.5	35.3	6.9	0.4	20.0

[5] Costs are pre-efficiency
[6] Costs for Lord of the Manor WSW upgrades are included in the 'Thanet Blended' costs but not the 'Thanet individual' costs these are an additional benefit for the 'blended' scheme

Sutton				8.0	0.4	20.4
Totals	**44.6**	**2.1**	**113.3**	**44.0**	**2.6**	**127.7**

Network 2030 is our transformational programme to rationalise, standardise and automate our water supply networks to improve connectivity and ensure a resilient system for future generations. We will rationalise smaller treatment works and service reservoirs, providing greater integration and increasing the use of smart networks. Addressing nitrate risk is an integral part of this.

Ambitious demand management measures, such as Target 100 and leakage reduction, will help control demand on our nitrate-rich sources. However, there is a risk demand from expected population growth will offset these reductions. See technical annex **TA.11.WN01 Supply Demand Balance** and **TA.11.WN04 Water Networks** for further details.

Table 3 – QBEG allocations and Ofwat tables for this area of investment 3 shows this investment falls within the Water networks+ and Water Resources price control and is allocated to both 'Quality' and 'Botex'.

Table 3 – QBEG allocations and Ofwat tables for this area of investment

£'m	AMP7			
	Price Control	**QBEG**	**Ofwat Table**	**AMP7 Total**
TOTEX				**79.743**
CAPEX				**75.783**
Nitrate Schemes (WN+ Quality)	Water networks +	Quality	WS2 13	**52.299**
Nitrate Schemes (WN+ Base)	Water networks +	Base Main - Non Infra	WS1 13	**16.958**
Nitrate Schemes (WR Quality)	Water Resource	Quality	WS2 13	**3.113**
Nitrate Schemes (WR Base)	Water Resource	Base Main - Non Infra	WS1 13	**3.413**
OPEX				**3.960**
Nitrate Schemes	Water networks +	Quality	WS2 47	**3.960**

To summarise our AMP7 proposals, Table 5 shows our forecast spend in AMP6 and a significant increase required in AMP7. This is due to the large number of sites requiring nitrate to be removed from raw water.

In AMP6 the combined Dry Year Critical Period (DYCP) yield for sites impacted by nitrate is 41 Ml/d, however in AMP7 the combined yield for the sites impacted by nitrate is 87 Ml/d. Additionally, we are forecasting whole areas, such as Thanet, being affected – reducing the opportunities for non-treatment solutions. As outlined in section 2.0, delivery of this programme is mandatory and will be enforced by the DWI.

Table 4 shows our AMP7 interventions enhance the water from a number of sites. The DYCP yield of these sites is around 87 Ml/d (1 in 200-year DYCP). The capital costs per megalitre are approximately £700K, which is more efficient than the £800K per Ml cost of AMP6 nitrate interventions. In addition, the AMP7 interventions will increase resilience due to the alignment with **Network 2030.**

Table 4 - Schemes considered for Nitrate interventions in AMP7

Source	Area	Solution	Source Yield, Dry Year Critical Period (DYCP)[7] (Ml/d)
[redacted]	Hampshire South	Investigation into use of remote sources for raw blending	10.8
[redacted]	Hampshire South	Continue monitoring – no investment required	
[redacted]	Hampshire South	Treated water blending	23.0
[redacted]	Worthing	Raw water blending	2.0
[redacted]	Worthing	Continue monitoring and turn off source during periods of high nitrate – no investment required	
[redacted]	Thanet Mid	Raw water blending then treatment at Flemings site	4.5
[redacted]	Thanet Mid		
[redacted]	Thanet Mid	Treatment	13.1
[redacted]	Thanet North	Raw water blending then treatment at New Treatment Works – Thanet North	6.5
[redacted]	Thanet North		
[redacted]	Thanet South	Raw water blending then treatment at Sutton	9.0
[redacted]	Thanet South		
[redacted]	Medway	Maintain existing treated water blending arrangements – no investment required	
[redacted]	Brighton North	Maintain existing raw water blending arrangements – no investment required	
[redacted]	Brighton East	Raw water blending then treatment at New Treatment Works – Brighton East	17.7
[redacted]	Brighton East		
[redacted]	Brighton East		
Total			**86.6**

The above yields are required within our WRMP19 to maintain supplies during AMP7 and beyond. Further information on WRMP19 is in Technical Annex **TA.11.WN01 Supply Demand Balance**.

As discussed in section 4.2, the nitrate challenge in AMP7 is greater than in previous AMPs, resulting in a significant increase in forecast costs. Table 5 shows required investment is forecast to be lower in AMP8. This is due to the relatively small number of sites with rising nitrate trends that won't already have mitigation in place by AMP8. In addition, catchment management measures implemented during AMP7 will start to impact peak nitrate levels during AMP8 and AMP9.

We will continue monitoring nitrate levels to inform planning and investment decisions for the remainder of this AMP and into future AMPs.

Table 5 – Comparison of current and future nitrate removal spend

	AMP6	AMP7	AMP8	AMP9

[7] WRMP document: Source DO Constraints v1.16

TOTEX	**33.321**	**79.743**	**32.00**	**0**
CAPEX	**33.321**	**75.783**	**30.00**	**0**
Nitrate Schemes (WN+ Quality)	33.321	52.299	30.00	0
Nitrate Schemes (WN+ Base)		16.958		0
Nitrate Schemes (WR Quality)	0	3.113		0
Nitrate Schemes (WR Base)	0	3.413		0
OPEX	0	3.960	2.00	0
Nitrate Schemes	0	3.960	0	0

5.2. Plan Options

As detailed in section 5.1, options to install treatment at every site have been considered alongside options to blend treated water or combine raw water for more centralised treatment.

We also considered not undertaking work during AMP7 and an option to carry out additional improvements. Capex, Opex and NPV for these options are shown below in Table 6 and Figure 6, alongside a customer willingness to pay NPV which includes customer benefits.

Table 6 - NPV costs for alternative options

Option	Brief Description	AMP7 Totex	20-year financial Whole Life Cost	20-year customer willingness to pay NPV	Willingness to Pay support	Ofwat priority	Regulator (DWI/EA) priority	Customer / CCG priority	Business Strategic Alignment
1 – Selected	[redacted]	£80m	+£140m	-£80m	●	●	●	●	●
2 – Increased spend	[redacted]	+£105m	+£165m	-£50m	●	●	●	●	●
3 – Do nothing	[redacted]	£0m	£0m	+£130m	●	●	●	●	●

● Major adverse impact
● Some adverse impact
● Minimal / no adverse impact

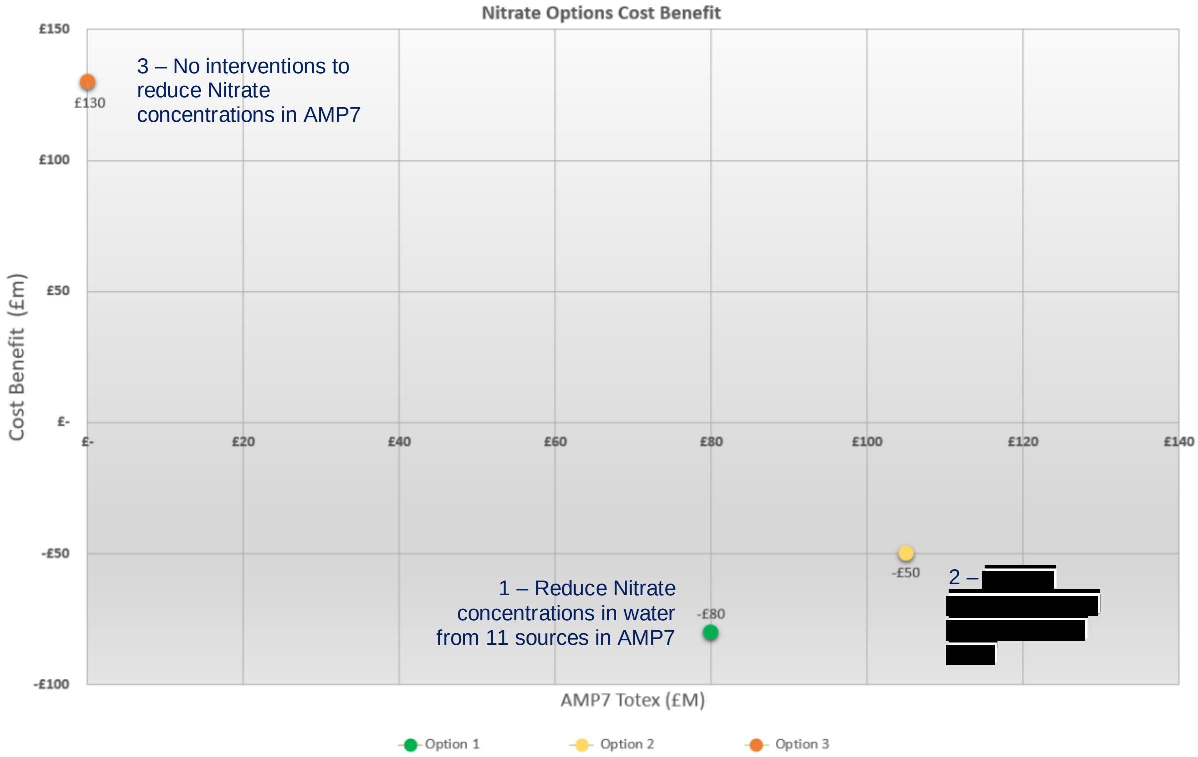


Figure 6 – Plan Options (Totex Vs CBA)

Option 1 to reduce nitrate concentrations in water from 13 sources and take Madehurst WSW offline during spring is the most cost beneficial option.

Option 2 was discounted because it is less cost beneficial and Option 3 was discounted as it was not supported by customer willingness to pay and, more importantly, would increase risk to public health.

5.3. Innovation

Innovation to support nitrate reduction is focussed on four key areas, outlined below. Using new methods and technology will reduce costs and improve resilience, measured through our resilience framework.

Zonal approach

To resolve the nitrate challenge for AMP7, we took a holistic view across entire supply zones in addition to individual sites. This innovative approach led to the development of several raw water blending solutions which reduce nitrate while simultaneously reducing other water quality challenges and improving resilience.

Long term approach

In addition to taking a zonal approach, we adopted a long-term perspective so sites with a predicted nitrate exceedance in future AMPs were considered when appraising raw water blending solutions. This approach is possible due to our industry-leading regression analysis and means our solutions will continue to be the most cost-effective solutions for AMP7 and beyond.

Catchment management

Catchment management will reduce both the time nitrate removal plants operate and required capacity of future plants. Catchment interventions will not only control nitrate but also reduce wider water quality challenges, such as pesticides. We have not previously used catchment methods to manage long term nitrate trends.

New technology

We are considering two new technologies to remove nitrate through a biological process, rather than traditional ion exchange processes, with the potential to reduce operating costs.

Evoqua currently have a two-stage process which has been given California State Water Resources Control Board's Department of Drinking Water conditional approval for use in drinking water. In addition Microvi Biotechnologies were recently a finalist in the 2018 water Industry awards with their Microvi MicroNiche Engineering Platform for Nitrate Removal.

5.4. Customer benefits and Resilience

The DWI's new CRI measures risk by considering the consequence of failures, any potential health risks, the population affected and how the company responds to generate a value. CRI can be calculated at national, company and supply system level – allowing comparison in mitigating risk to customers. Compliance with nitrate PCV is a key component of CRI performance. Our forecast performance is shown in Table 7 and Figure 6 below.

Table 7 – AMP6 and AMP7 CRI performance[8]

Performance commitment	Measure	End AMP 6 Performance	End AMP 7 Performance
Water quality compliance	CRI basket measure	2.65	0.95[9]

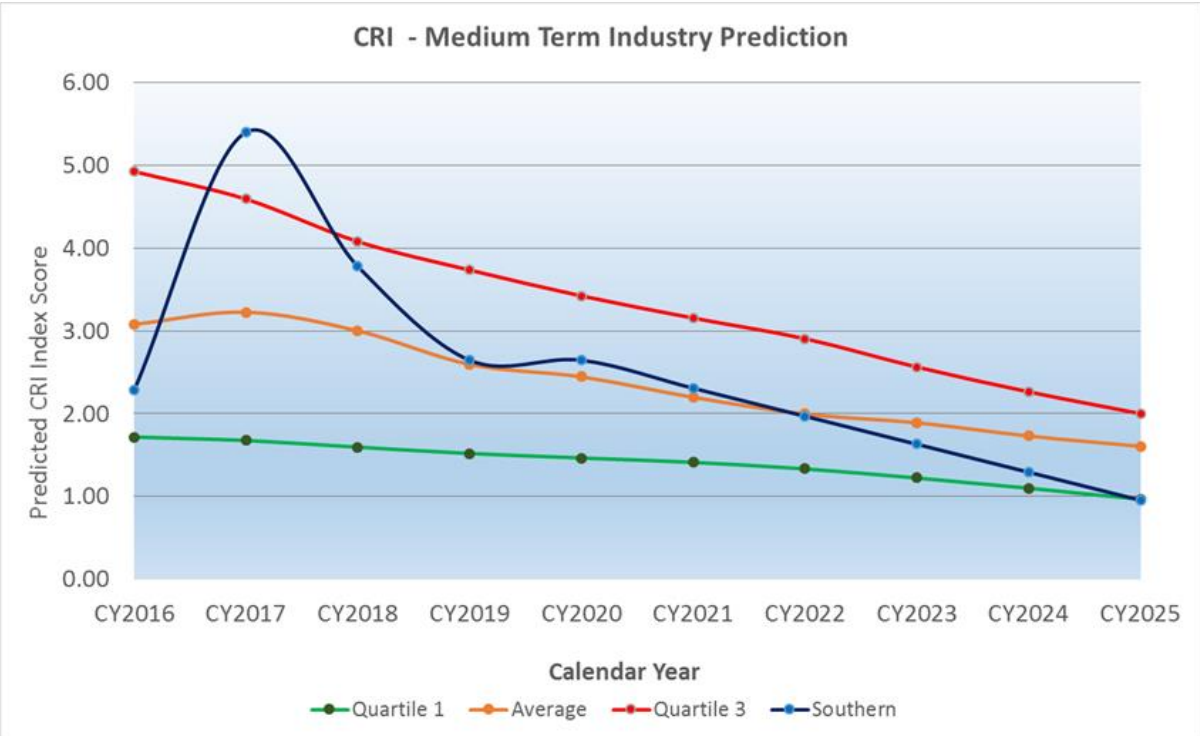


Figure 7 – AMP6 and AMP7 CRI performance[10]

[8] PR19 Data Table App1
[9] Target is zero
[10] Technical Annex TA.11.01 Water AMP7 Comparative Industry Performance Assessment

5.5. Value for Customers

Our additional ODI research into willingness to pay for service level improvements indicated that our customers are willing to invest on average £1.37 to ensure their drinking water quality meets the required compliance. Full detail on our customer engagement findings can be found in **Chapter 4 – Customer and Stakeholder engagement**.

Compliance with the nitrate PCV is crucial to protect public health. To ensure best value for money we sought supply zone level solutions which represent best whole life cost over multiple AMPs. Longer term, catchment management will control and reduce nitrate in raw water, reduce the need to operate nitrate removal plant, minimise the required capacity of future plant and deliver wider natural and social capital benefits.

Section 5.1 and Table 2 give an example of the NPV analysis carried out in Thanet.

Due to the widespread nature of the challenge, and to ensure public health is protected, our proposed blending and treatment measures must be implemented. This will ensure supplies are not interrupted during periods of high nitrate in raw water levels. Customers expect water to be safe to drink and supplies to be uninterrupted.

6. Costing Strategy

See cost efficiency and Optioneering technical annexes for information on our costing strategy.

7. Key Risks and Opportunities

7.1. Risks

- Raw water nitrate levels will increase at higher than the predicted rate, leading to the need for larger than anticipated removal plant being required. This will lead to large levels of expenditure above those levels included in our AMP7 proposals.
- New farming practices, or specific manure spreading/fertiliser spreading events cause unexpected contamination of groundwaters leading to raw water resource problems during AMP7. This could trigger an urgent need for us to invest in new nitrate removal plants at additional water treatment sites.

7.2. Opportunities

- There is an opportunity that raw water nitrate levels increase at lower than predicted rate at sites in plan which may allow us to defer investment into AMP8.

Appendix 1: Schemes in AMP7

The following is a list of the schemes within the Nitrate part of the business plan:

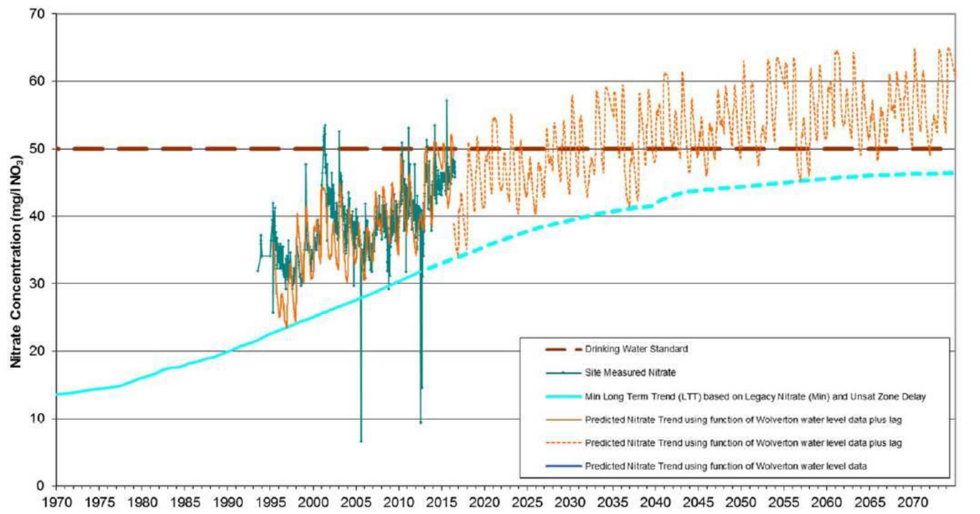
Source	Area	Solution	DWI provisional date[11]	Source Yield, Dry Year Critical Period (DYCP)[12] (Ml/d)	Scheme totex (£m)
[redacted]	Hampshire South	Investigation into use of remote sources for raw blending	Dec 2022	10.8	1.3
[redacted]	Hampshire South	Continue monitoring – no investment required	N/A		
[redacted]	Hampshire South	Treated water blending	Dec 2021	23.0	2.0
[redacted]	Worthing	Raw water blending	Dec 2022	2.0	3.7
[redacted]	Worthing	Continue monitoring and turn off source during periods of high nitrate – no investment required	Dec 2025		
[redacted]	Thanet Mid	Raw water blending then treatment at Flemings site	Dec 2025	4.5	8.3
[redacted]	Thanet Mid				
[redacted]	Thanet Mid	Treatment	Dec 2025	13.1	7.2
[redacted]	Thanet North	Raw water blending then treatment at new works – Thanet North	Dec 2022	6.5	15.5
[redacted]	Thanet North				
[redacted]	Thanet South	Raw water blending then treatment at Sutton	Dec 2022	9.0	13.4
[redacted]	Thanet South				
[redacted]	Medway	Maintain existing treated water blending arrangements – no investment required	N/A		
[redacted]	Brighton North	Maintain existing raw water blending arrangements – no investment required	Dec 2025		
[redacted]	Brighton East	Raw water blending then treatment at new works – Brighton East site	Dec 2025	17.7	28.3
[redacted]	Brighton East				
[redacted]	Brighton East				
Totals				**86.6**	**79.7**

[11] DWI PR19 Decision Letters 30.05.2018
[12] WRMP document: Source DO Constraints v1.16

Appendix 2: Modelled 60-year nitrate trend graphs

Below are the modelled 60-year nitrate trends for each of the sources requiring interventions. These graphs are taken from the Southern Water Drinking Water Protected Area NEP requirement report, February 2017 – Amec Foster Wheeler.

[redacted]



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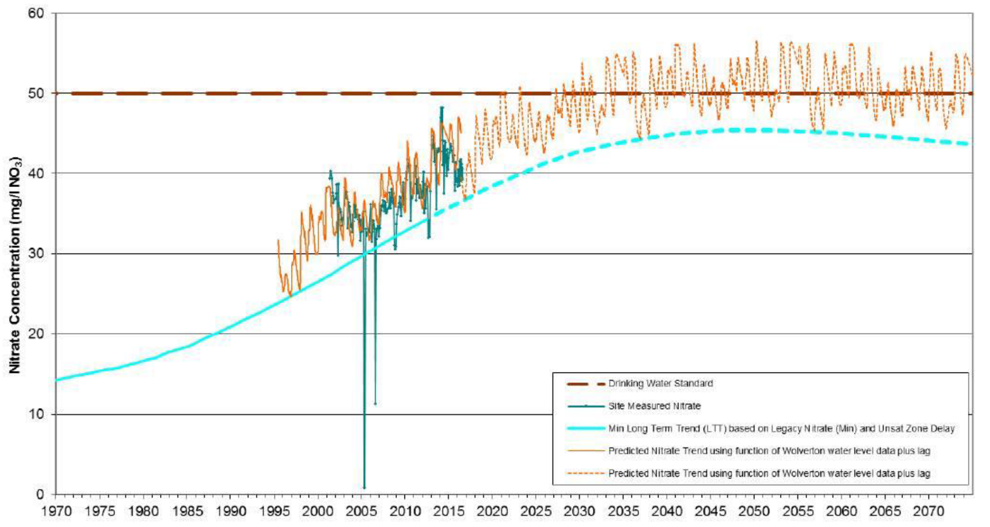

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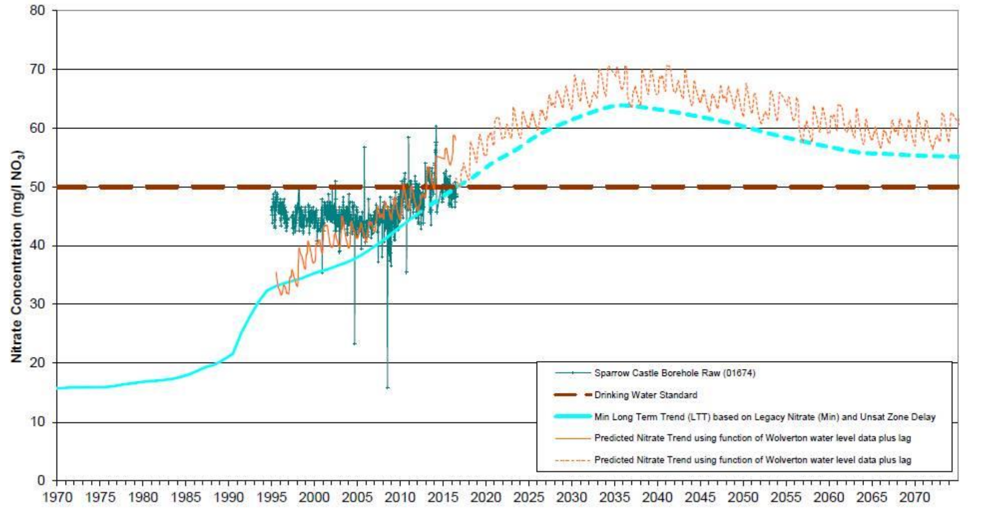

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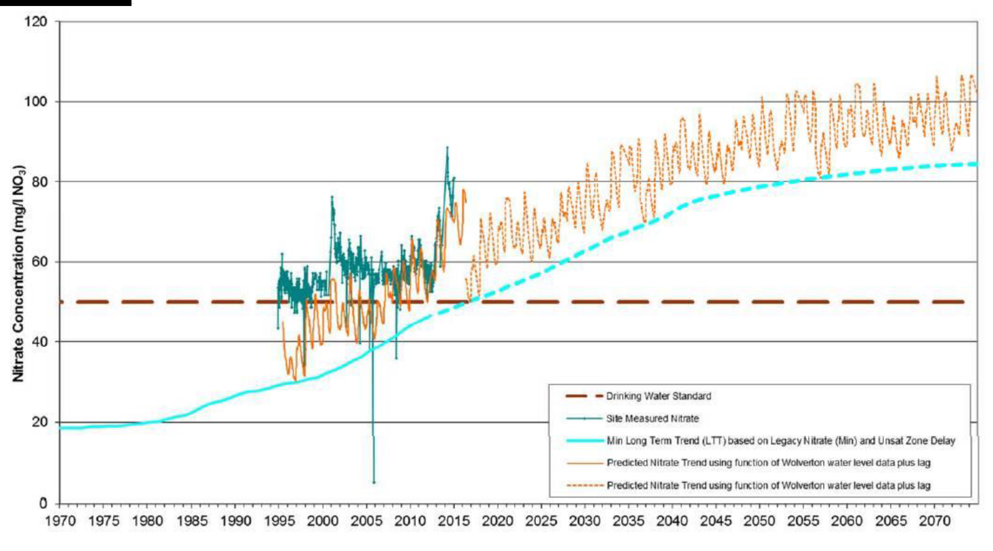

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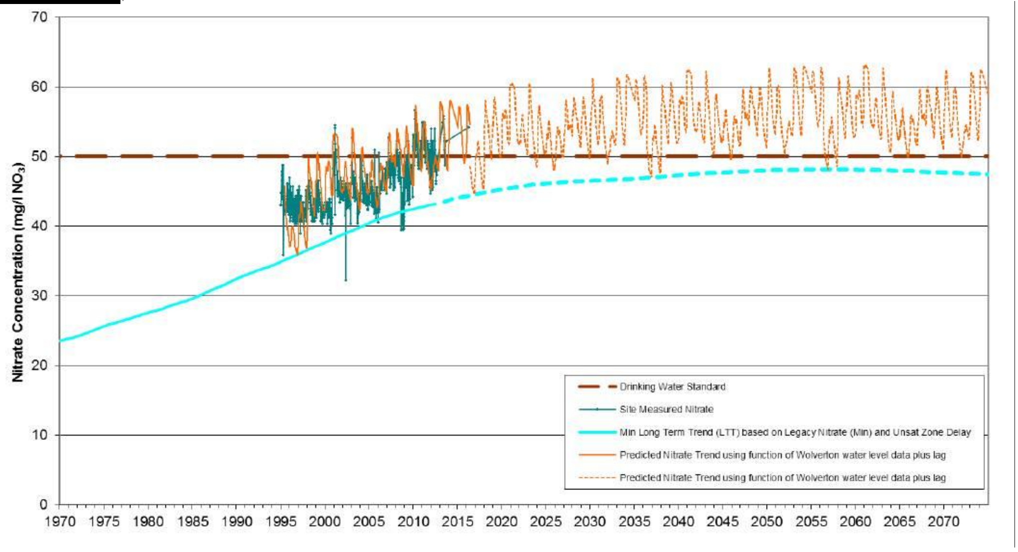

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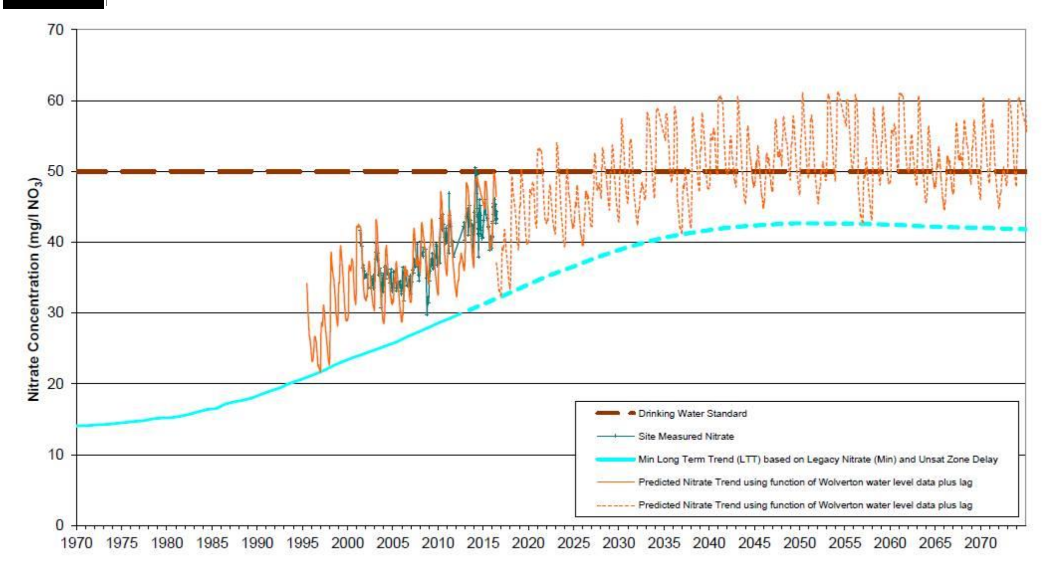

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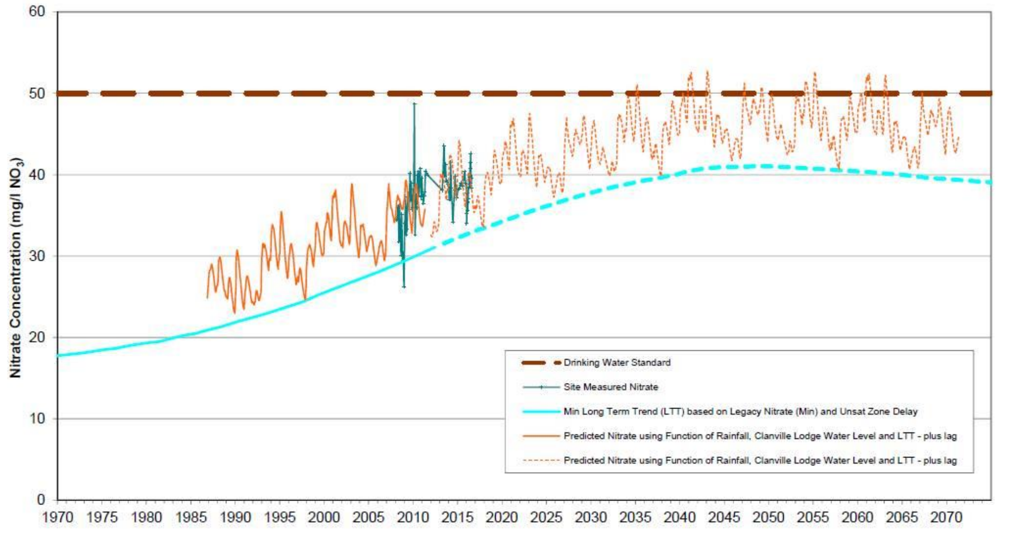
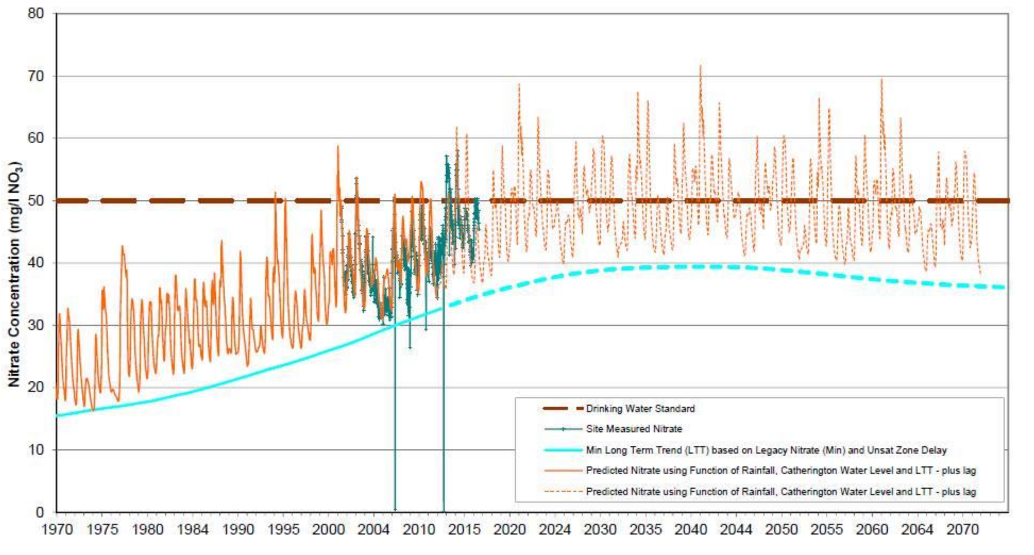
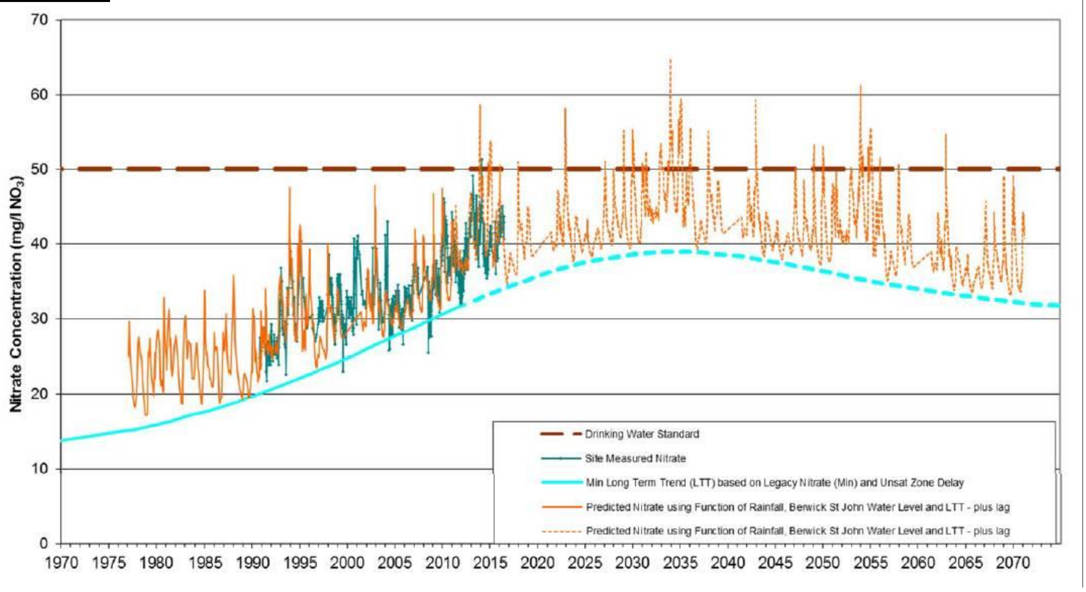


[redacted]



[redacted]



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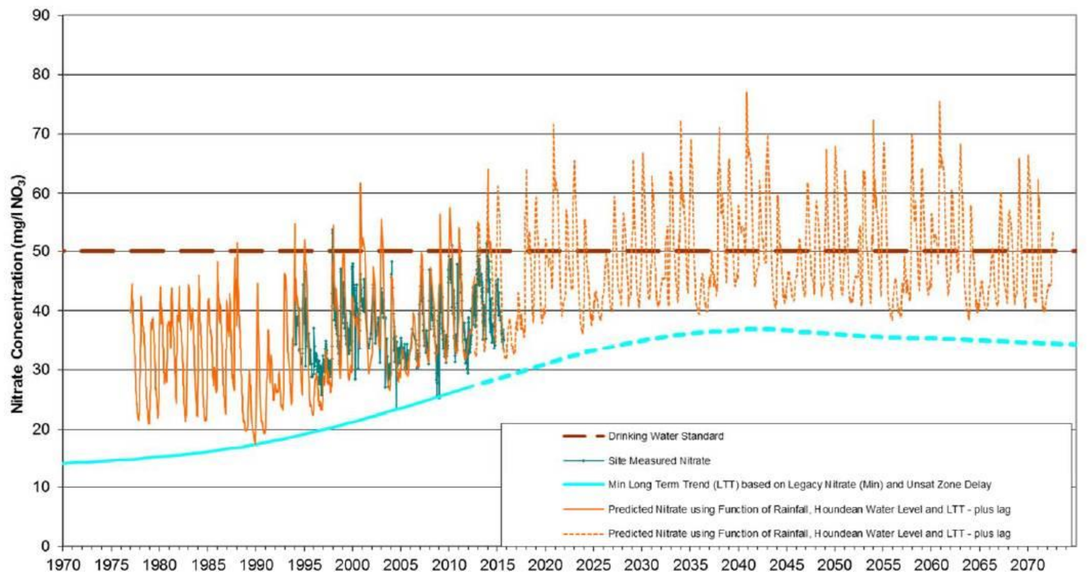
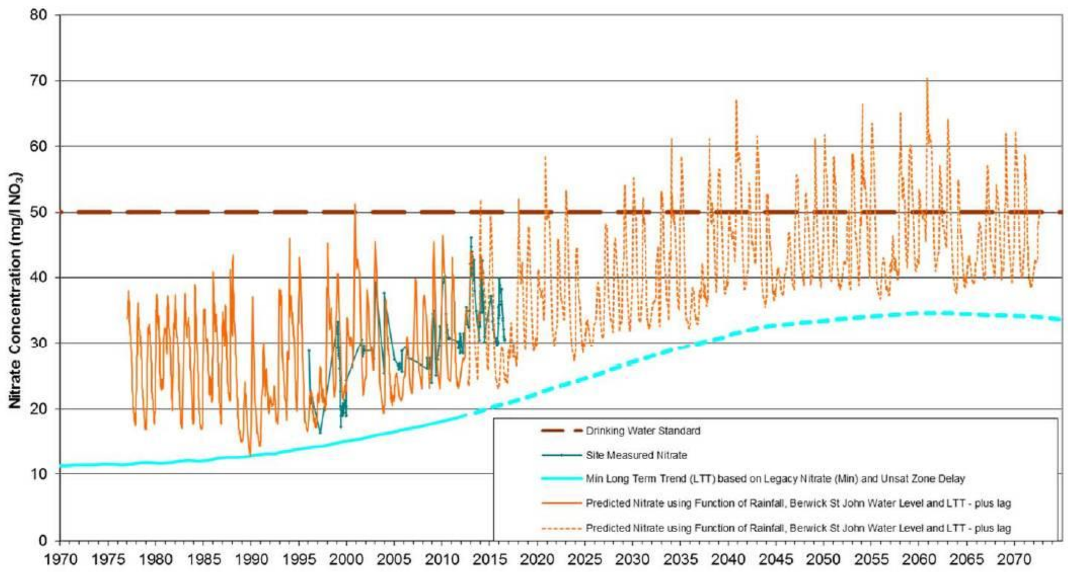


[redacted]



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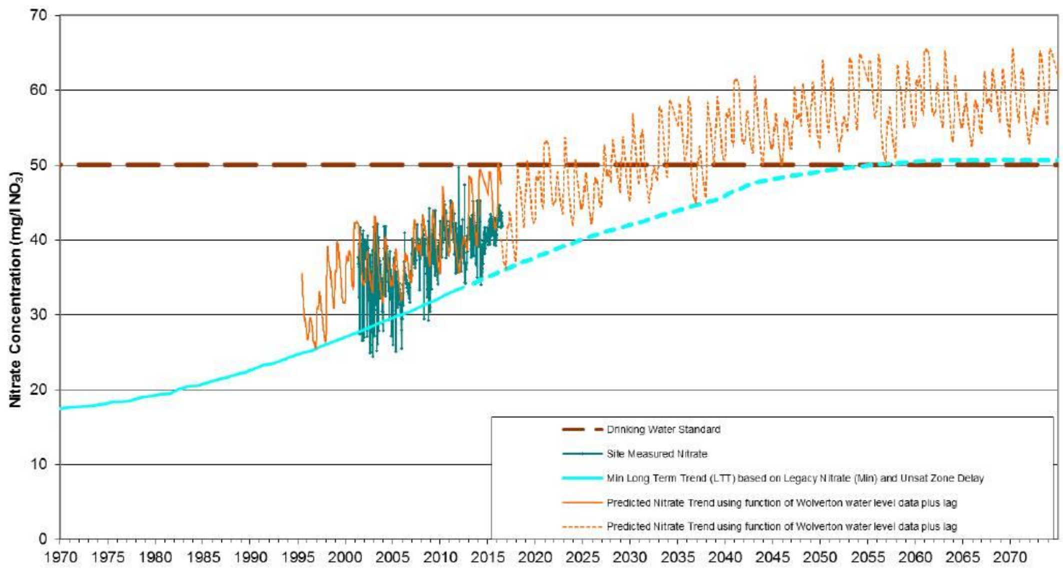

Appendix 3: Options summary

The below option costs are based on our December 2017 assessment and can be used to compare options. The preferred solutions have since been further developed and re-costed for use in our business plan.

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
	[redacted]	[redacted]	[redacted]	[redacted]			**1.5**	**N/A**	**1.4**
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
[redacted]	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipeline.	N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipeline (Horsebridge).	0	0	0

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	Environmental Impact	CAPEX (£m)	OPEX (£m/ annum)	WLC 60 Yr (£m)
				[redacted]	[redacted]				
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	7.2	0.44	23.9
	[redacted]			[redacted]	[redacted]	Sustainable approach to water quality; helps prevent deterioration in raw waters; provides wider benefits.	1.5	N/A	1.4
	[redacted]	[redacted]	[redacted]	[redacted]			0	0	0
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
[redacted]	[redacted]			[redacted]	[redacted]	Sustainable approach to water quality; provides wider resilience benefits.	0	0	0
	[redacted]			[redacted]	[redacted]	Construction impact of pipeline.	N/A	N/A	N/A

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
	[redacted]			[redacted]	[redacted]	Construction impact of pipeline.	N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	3.5	0.44	16.6
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			**2.2**	**0**	**2.0**
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipeline.	N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipeline - limited as adjacent to existing.	2.2	0	2.0

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
				[redacted]					
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	10.2	0.74	37.0
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			**5.6**	**0**	**5.13**
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipelines.	5.6	0	5.13
	[redacted]			[redacted]	[redacted]	Construction impact of pipelines.	N/A	N/A	N/A

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
				[redacted]	[redacted]				
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	5.9	0.36	19.27
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			**0**	**0**	**0**
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
	[redacted]			[redacted]	[redacted]	Zero environmental impact.	0	0	0
	[redacted]			[redacted]	[redacted]	Construction impact of pipelines.	N/A	N/A	N/A

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	Environmental Impact	CAPEX (£m)	OPEX (£m/ annum)	WLC 60 Yr (£m)
	[redacted]			[redacted]	[redacted]	Construction impact of pipelines.	N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	5.2	0.39	19.3
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			**0.11**	**See Flemings**	**See Flemings**
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
	[redacted]			[redacted]	[redacted]	Construction impact of pipelines.	1. £0.11M	See Flemings	See Flemings
	[redacted]			[redacted]	[redacted]	See Flemings	See Flemings	See Flemings	See Flemings
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	4.9	0.3	14.3 PLUS FLEMINGS
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]	[redacted]	[redacted]	[redacted]			**7.76**	**0.89**	**20.3**
[redacted]	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
	[redacted]			[redacted]	[redacted]	Construction impact of pipelines.	1. £7.76M Incl treatment costs at Flemings	1. £0.89M Incl treatment costs at Flemings	1. £20.3Mil ncl treatment costs at Flemings
	[redacted]			[redacted]	[redacted]	Construction impact of pipelines.	1. 18.0 2. 20.7 Incl treatment costs	1.1 Incl treatment costs	1. 53.2 2. 57.1 Incl reatment costs
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	Indiv. £6.05M Comb. SEE OPT 3	Indiv. £0.3M Comb. SEE OPT 3	Indiv. £16.7M PLUS BEACON LANE Comb. £20.3M SEE OPT 3
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			**7.085**	**0.49**	**22.3**
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
				[redacted]					
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipelines.	N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipeline.	N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	7.085	0.49	22.3
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]	[redacted]	[redacted]	[redacted]			**2.1**	**See Minster B**	**See Minster B**

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
[redacted]	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipelines.	2. £2.1M	See Minster B	See Minster B
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	4.06	0.33	13.99 PLUS MINSTER B & LOTM
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			**13.257**	**0.65**	**35.4**
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipelines.	2. £11.057M Incl treatment costs at Minster B	2. £0.65M Incl treatment costs at Minster B	2. £35.4M Incl treatment costs at Minster B
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	Indiv. £6.99M Comb. SEE OPTION 3	Indiv. £0.4M Comb. SEE OPTION 3	Indiv. £20.1M+ SPARROW & LOTM Comb. £35.4M

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
				[redacted]					SEE OPT 3
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]	[redacted]	[redacted]	[redacted]			**3.225**	**See Sutton**	**See Sutton**
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
[redacted]	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipelines.	3. £3.225M	See Sutton	See Sutton

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
	[redacted]			[redacted]	[redacted]				
	[redacted]			[redacted]	[redacted]		Indiv. 6.9	Indiv 0.35	20.0
	[redacted]			[redacted]	[redacted]				
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			**13.195**	**0.49**	**35.25**
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipelines.	3. £13.195M Incl treatment costs	3. £0.49M Incl treatment costs	3. £35.25M Incl treatment costs
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
				[redacted]	[redacted]				
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	Indiv. £7.98M Comb. SEE OPT 3	Indiv. £0.35M Comb. SEE OPT 3	Indiv. £20.38M PLUS DEAL Comb. £35.4M SEE OPT 3
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			**0**	**0**	**0**
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
	[redacted]			[redacted]	[redacted]	Zero environmental impact.	0	0	0
	[redacted]			[redacted]	[redacted]	Construction impact of pipeline.	N/A	N/A	N/A

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
	[redacted]			[redacted]	[redacted]	Zero environmental impact.	0	0	0
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	7.35	0.47	24.85
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			**1.4**	**See Newmark et**	**See Newmark et**
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipeline. Brighton East works would likely need land purchase for expansion within SDNP.	1.4	See Newmark et	See Newmark et

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	5.9	0.36	19.1 +NEWMARKET
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]	[redacted]	[redacted]	[redacted]			**21.265**	**0.39**	**51.5**
[redacted]	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
	[redacted]			[redacted]	[redacted]	Construction impact of pipeline. Brighton East works would likely need land purchase for expansion within SDNP.	21.265	0.39	51.5
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	Indiv. £2.7M Comb. SEE OPT 3	Indiv. £0.34M Comb. SEE OPT 3	Indiv. £13.1M HOUSED EAN Comb. £51.5M SEE OPT 3
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]	[redacted]	[redacted]	[redacted]			**0**	**0**	**0**
[redacted]	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
				[redacted]					
	[redacted]			[redacted]	[redacted]	Zero environmental impact.	0	0	0
	[redacted]			[redacted]	[redacted]	Construction impact of pipeline.	N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Construction impact of pipeline.	N/A	N/A	N/A
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	6.35	0.36	20.1

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A
	[redacted]	[redacted]	[redacted]	[redacted]			**0**	**0**	**0**
	[redacted]			[redacted]	[redacted]	No environmental impact - environmental improvement.	N/A	0.03	0.7
[redacted]	[redacted]			[redacted]	[redacted]	Zero environmental impact.	0	0	0
	[redacted]			[redacted]	[redacted]	Zero environmental impact.	0	0	0
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**Environmental Impact**	**CAPEX** (£m)	**OPEX** (£m/ annum)	**WLC 60 Yr** (£m)
	[redacted]			[redacted]	[redacted]	Salt use, process waste disposal.	5.8	0.22	10.4
	[redacted]			[redacted]	[redacted]		N/A	N/A	N/A