PRT07.03 RAW WATER DETERIORATION & DROUGHT CAPACITY ENHANCEMENTS

CONTENTS

1. SUMMARY

This proposal relates to two instances where the concentration of nitrate in the abstracted water has risen, and continues to rise, such that Portsmouth Water will not be able to supply drinking water below the prescribed and statutory limit of 50mg/l. The proposal also includes work at one of the related sites necessary to meet the requirements of the dWRMP24 during drought order conditions.

The first nitrate challenge relates to the '[redacted] site. [redacted] WTW comprises chalk boreholes, with Membrane ultra-filtration, with Chlorine (gas) and Orthophosphoric acid dosing. The site has an average production of 11.4Ml/d with a minimum deployable output (MDO) (from the dWRMP24 report) of 10.6Ml/d. Via booster pumps it supplies the [redacted] and [redacted] reservoirs.

The second nitrate challenge relates to the '[redacted] group of sites. This set comprises sites at [redacted] (chlorine gas), [redacted] (ultraviolet and Chlorine gas), [redacted] (ultra-violet and Chlorine gas), [redacted] (chlorine gas) and a small (2.9% vol.) transfer from [redacted] The sites feed the [redacted] service reservoir. All these sites are intimately related by the manual blending arrangements within the group to achieve acceptable Nitrate levels exiting the [redacted] reservoir.

In addition to nitrate, in order to meet the assumptions of the dWRMP24, the site at [redacted] is required to work at elevated flows during drought conditions. Enhancements to the [redacted] site are required to meet the higher flow conditions, which are only allowable under a drought order license.

The areas of work are considered together since the engineering works necessary to mitigate the conditions are most effectively carried out as a single coordinated program.

The work at [redacted] is included in this proposal since [redacted] is part of the '[redacted] Group' of sites and delivery efficiencies can be gained by joint consideration. It is recognised that the driver for the work at [redacted] is not related to nitrate mitigation. The proposal is hence also related to PRT07.02 since the costs for the proposed UV plant reactor (being inter-changeable with [redacted] at [redacted] are captured in that proposal. Investigations into the turbidity excursions at [redacted] are included in this paper for similar reasons.

Portsmouth Water proposed the initiatives to the DWI as part of the 'appendix B' proposals in March 2023. These proposals were submitted to the DWI in two papers: PRT 06, [redacted] Groups sites, and PRT07, for the [redacted] nitrate mitigation. Their letters of support are appended (PRT07.03.07 & 08).

2. NEEDS

1. Overview

This proposal is directed at achieving the following six objectives:

To mitigate the elevated and rising, and predicted to rise further, levels of nitrate exiting at the [redacted] site. In this paper we propose on-site nitrate treatment at the [redacted] site, with the objective of retaining compliant water exiting the [redacted] reservoir.

To reduce the reliance on [redacted] as a source of low nitrate water used for blending within the group. In this paper we propose that the on-site nitrate treatment at [redacted] mitigates against this single mode failure. Hence allowing routine and essential maintenance at [redacted]

To make the current manual arrangement, for blending water within the group (to achieve acceptable nitrate levels), more robust. In this paper we propose the provision of automated blending.

To investigate and potentially resolve turbidity challenges at [redacted] which preclude the use of the site following moderate to heavy rainfall. This in-turn adversely affects the output from the [redacted] group, increasing reliance on other members, and affects the blending strategy. In this paper we propose the further investigation work necessary to identify the cause and remedy it if it can be simply achieved.

To enable the use of [redacted] in drought conditions, to supply increased volumes of water into the group to maintain customer supplies in the 1-200-year drought scenario defined in the WRMP. In this paper we propose enhanced disinfection at [redacted] to meet CT requirements at the increased outputs including the installation of turbidity treatment to ensure raw water meets the specification for UV treatment and distribution during the [redacted] abstraction (drought condition).

To mitigate rising nitrate levels in water from [redacted] by blending with water from [redacted] WTW via the [redacted] service reservoir. Blending would take place at the [redacted] and [redacted] reservoirs.

All the proposals, along with all the supporting technical, risk, and microbiological data, were submitted to the DWI as ‘appendix B’ in March 2023. The proposals subsequently received their letters of support in August 2023 (Appendices PRT07.03.07 & 08).

2. Supporting Our ‘Vision’

1. The vision described by Portsmouth Water and supported by its customer comprises four key pillars. They are to:

   - Secure and deliver water supplies which are high quality, reliable and sustainable.
   - Be at the frontier of delivering high-quality, resilient, net zero services – for our customers, environment, and region.
   - Co-create solutions which deliver our customers communities and stakeholders priorities.
   - (Provide) affordable water for all. Always.

Figure 1: Our vision and priorities

This investment proposal supports the first, second and the final components of the Portsmouth Water vision. The proposal represents an ambitious plan to ensure the objectives summarised above are met, at the lowest possible cost to the customer.

Blending arrangements always introduce additional constraints and place additional reliability burdens on sites with low nitrate levels, to support sites with higher levels. However, the proposal contained in this paper reflects a balance between additional and costly treatment processes at each individual site and providing resilient services into the future.

By providing mitigation against observed and predicted rising nitrate levels, Portsmouth Water can secure its existing sites without the environmental consequences of obtaining further abstraction sources or installing more extensive water treatment at other sites.

By managing existing abstractions and treatments Portsmouth Water can avoid the additional carbon burden associated with developing new sources and providing further additional treatment sites.

By limiting the investment and by sharing assets between sites, and avoiding temporarily stranded assets, Portsmouth Water can meet the statutory obligations imposed on it, despite the observed and predicted deteriorations in raw water quality at these sources.

The need to provide resilient services is well understood. Customers expect high quality water to be available when they turn their tap. This investment proposal will maintain the high levels of quality and reliability that Portsmouth Waters customers rightfully expect.

3. Supporting Performance Commitments

Table 1 defines the linkages to common performance commitments and to additional commitments felt important to Portsmouth Water.

The relationships may be interpreted as follows:

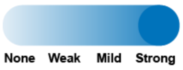
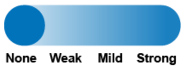
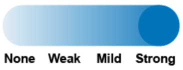
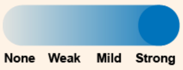
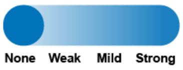
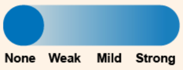
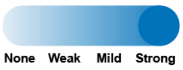
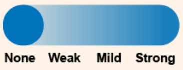
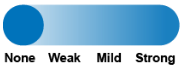
Strong	Weak	None
		
the proposal has the potential to directly and significantly impact the performance commitment or the corporate priorities. The impact will not, by itself, improve current performance, though may, if the risks surface, significantly and negatively affect current performance.	the proposal has very limited impact on the performance commitment or corporate priorities.	there is no perceived impact on the performance commitment or corporate priorities.

Table 1: Links to Performance Committments

Performance commitment	Relationship	Notes
Water Supply Interruptions		Inability to supply water below statutory levels will result in supply interruptions. The inability to achieve the elevated outputs at [redacted] to meet supply demands during drought could result in supply interruptions during times of demand stress.
Compliance Risk Index (CRI)		Though protected by monitoring systems elevated nitrates may cause parameter failures.
Per Capita Consumption (PCC)		There is no effect on PCC.
Leakage		There is no effect on Leakage.
Unplanned Outages		Failure of critical assets can directly lead to unplanned outages and undue reliance on single low Nitrate sources increases this risk. Reduction in unplanned outage from this enhancement case is set out in **PRT05: Delivering Outcomes for Our Customers.**
Mains Repairs		There is no effect on Mains Repairs.
Pollution incidents		There is no effect on the Pollution incidents measure.

CMex, DMex, BR-Mex	Strong	Customer Service is dependent on our ability to reliably supply water.
Customer Contacts WQ	Strong	Customer contacts are overwhelming high in supply interruption circumstances.
Greenhouse Gas emissions	Weak	Additional emissions are avoided by the proposal.
Biodiversity Index	None	There is no effect on biodiversity.
Carbon Footprint	Weak	Minimal increase achieved by minimising additional process plant running. The net effects are built into Portsmouth Water net-zero strategy.
Low customer bills	Strong	This proposal minimises costs to customer yet still mitigates against the deterioration in raw water quality.
Corporate responsibility	Strong	Strong belief in competent stewardship as is demonstrated by the Boards vision and alignment with customer priorities.
Electricity usage	Weak	Minimal increase achieved by minimising additional process plant running. The net effects are built into Portsmouth Water net-zero strategy.
Materials usage	Weak	Minimal increase achieved by minimising additional process plant procurement through active catchment management strategies and actions.
Community partnerships	None	The is no effect on community Partnerships.

4. Historical Perspective

Nitrates – [redacted] group of sites

Figure 2: [redacted] group sites – water supply system

[redacted]

Source: Portsmouth Water

Location	Type	Design capacity	Useage	Daily average output	Daily maximum output	
[redacted]	Borehole (chalk)	8	Continuous	6.3	7.5	
[redacted]	ditto	2.5	ditto	1.8	2.4	
[redacted]	ditto	22	ditto	8.3	12.8	
[redacted]	ditto	22	ditto	6.5	10.9	

Nitrate risks at abstraction, treatment, storage, and distribution stages within the Bognor Supply System have been carried downstream from the catchment stage.

Catchment walkovers are undertaken on a risk-based programme, a minimum of every 3 years across each individual Portsmouth Water catchment. These walkovers are undertaken by the Catchment Management team in collaboration with the Drinking Water Safety Plan (DWSP) team and local Environment Agency office. This programme allows greater catchment conceptualisation through documentation of land use practices that may result in application, run-off, and/or leaching of nitrate into Portsmouth Water's groundwater sources.

Document 302, Portsmouth Water Catchment Audit Procedure gives further details on the catchment walkover methodology and hazard identification process.

The [redacted] Group of sources (see fig.1 above), consisting of [redacted] and [redacted] WTWs, have their treated waters blended within [redacted] Reservoirs [redacted]). For resilience purposes this blending regime is supplemented by a reservoir transfer from an adjacent supply system ([redacted]), with lower nitrate water being transferred from the [redacted] reservoirs ([redacted]) to [redacted] reservoirs.

This blending regime has been undertaken historically as a Business as Usual (BAU) operation for supply resilience purposes. This BAU blending regime has always had the added benefit of nitrate mitigation during the high nitrate season, which is associated with elevated groundwater following the aquifer recharge period.

[redacted] and [redacted] are the high nitrate waters, with [redacted] and the [redacted] reservoir transfer being the low nitrate water inputs used for blending. The [redacted] contribution is small. This results in [redacted] being a critical abstraction during high nitrate period and an unplanned outage during this period increases the risk of a blending failure to control nitrate at [redacted] reservoirs. It also means that the Chichester supply system must also maintain a high level of resilience and have sufficient capacity.

An added pressure to this blending regime is the increasing nitrate trend at [redacted] WTW. The nitrate trend at [redacted] is very different to the other sources in the group. Where seasonal variations in nitrate concentration are observed at [redacted] and [redacted] the trend at [redacted] is linear in nature. Due to this difference in nitrate concentration behaviour in the aquifer, Portsmouth Water commissioned WSP (formerly Wood and AMEC Foster Wheeler) to undertake an investigation. It must be noted that the hydrogeological situation is very different at [redacted] when compared to the other sources in the group, with the [redacted] boreholes penetrating a significant confining Clay layer that is approximately 60m in thickness. Two hypotheses were modelled and tested by WSP, with the evidence suggesting the following hypothesis to be most likely.

The favoured hypothesis is that low nitrate is present beneath the confined zone but is being mixed with higher outcrop nitrate groundwater that is being pulled towards [redacted] by pumping, along with some denitrification in the confined zone. This is supported by the available evidence and scoping of mixing calculations can recreate the observed nitrate trend.

The new modelling by WSP, using the findings of the investigation, indicates that nitrate concentrations at [redacted] will stabilise at approximately 38mg/l, and will therefore remain a viable blending source.

However, a more recent study by Atkins, based on historical data and modelling, suggests that, due to rising nitrates elsewhere in the [redacted] group, nitrate levels will continue to rise at [redacted] reservoir. Despite blending, the study suggests that nitrate levels could approach the 50mg/l threshold as early as 2030 if nitrate treatment is not installed.

In addition to engaging external expertise to provide mitigation options, the consultants were asked to validate the nitrate models against the sampling data and ensure that the analysis, models and decisions were made according to best practice and with the best available data. Validation was confirmed and is included in the appended reports from Atkins (PRT07.03.05).

Locations where continuous nitrate monitoring is installed, and where routine sampling is being undertaken, are shown below. The '[redacted] group' of sites are shown circled.

Raw water online nitrate monitors are located at all [redacted] Group abstractions to provide real-time nitrate monitoring. Monthly monitor validation samples are taken at each source to confirm monitoring accuracy. However, this frequency increases to weekly once concentrations reach 45mg/l. In addition, raw water grab samples for lab analysis are taken monthly and treated water grab samples taken 8 times year. Appendices PRT07.03.01 & 02 define this methodology.

Figure 2: Nitrate monitoring

[redacted]

Source: 5220073-ATK-XX-XX-TR-PR-001 - Nitrate Resilience Strategy Optioneering Report.pdf

Average flows from 2022 were used to derive a base line of current day risk at the [redacted] reservoir (highlighted red below)

Figure 3: Average flows

[redacted]

Source: 5220073-ATK-XX-XX-TR-PR-001 - Nitrate Resilience Strategy Optioneering Report.pdf

The results, highlighted red in figure 4 (below), shows the 98% percentile values that were calculated from the model for predicted nitrate levels in 2022, using average recorded abstraction flows in 2022. For two sites, [redacted] and [redacted] the model suggests that these blending sites are at risk of breaching PCV for nitrate in the present day.

Figure 4: Calculated predicted nitrate values

[redacted]

Figure 5: Nitrate trend at [redacted] WTW

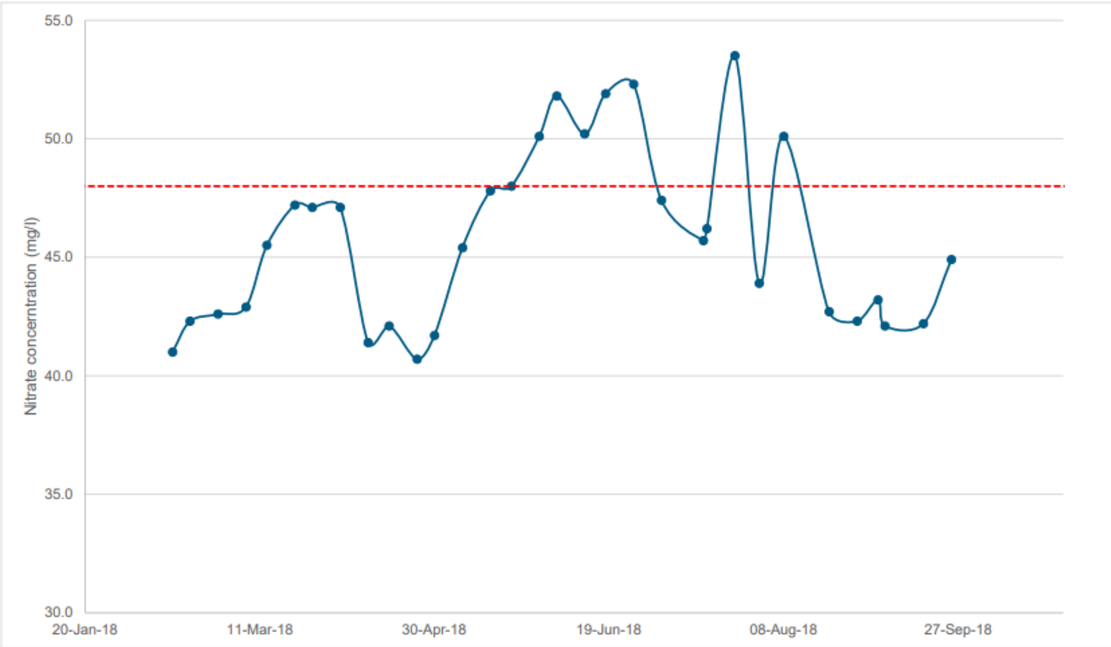
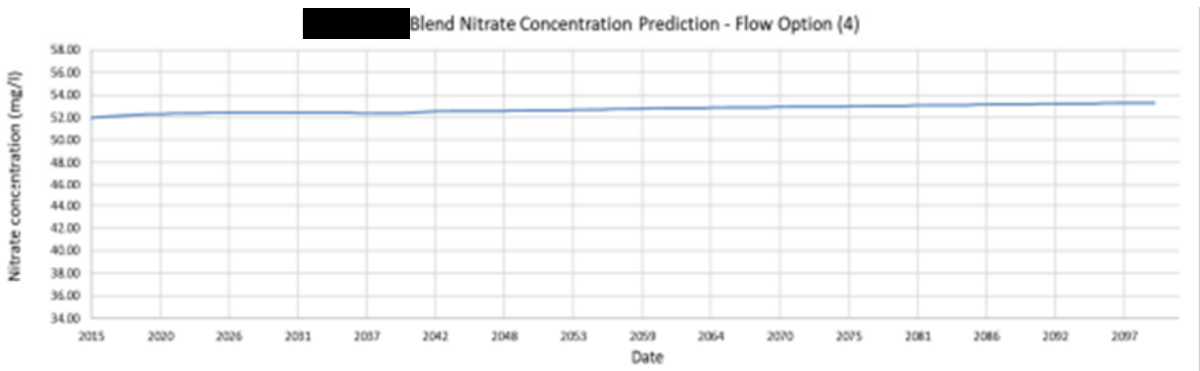


Figure 4-1 - Nitrate concentrations at [redacted] in 2018, showing elevated levels for large durations of summer months

Source: 5220073-ATK-XX-XX-TR-PR-001 - Nitrate Resilience Strategy Optioneering Report.pdf

The modelling suggests that unchecked, nitrate levels will continue to rise at [redacted] reservoir for the foreseeable future and beyond the limit of the LTDS (figure 6 below)

Figure 6: Predicted nitrate levels at [redacted] reservoir



The study by Atkins concludes that blending is unlikely to be able to maintain nitrate levels below 50mg/l and that treatment for nitrate at [redacted] should be implemented if the statutory threshold is to be maintained. This proposal includes nitrate treatment and the necessary automated blending control systems.

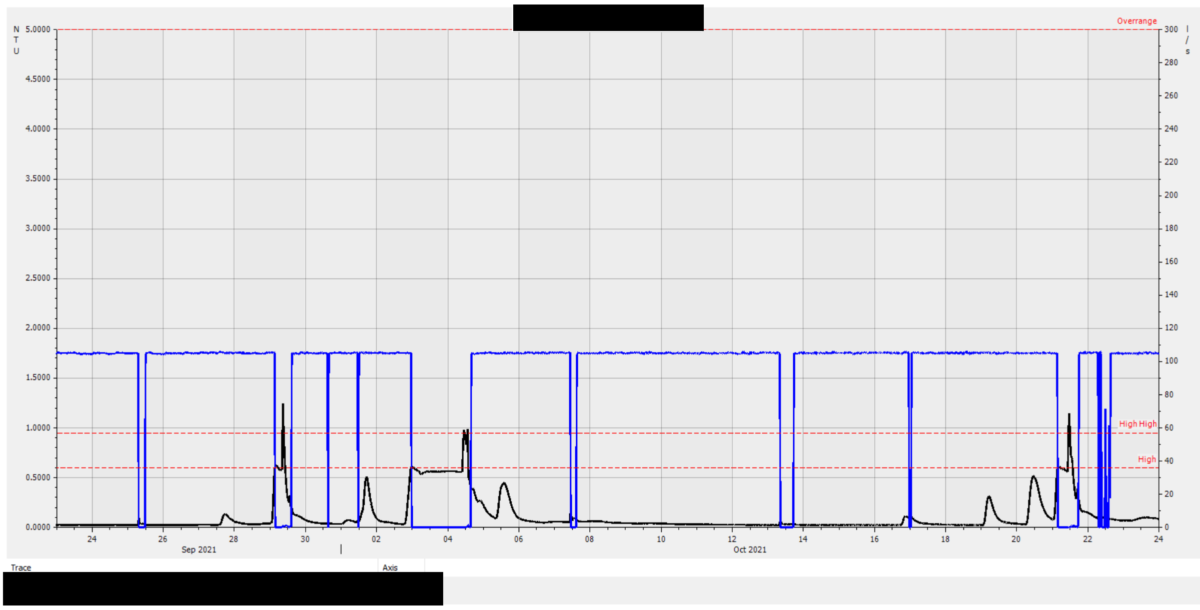
A possible solution may be a selective resin, ion-exchange system, deployed as side-stream treatment, and configured and controlled to minimally treat that component of [redacted] water necessary to maintain nitrate compliant water exiting the [redacted] reservoir and entering the distribution network. The process provides a robust mechanism to treat at the minimum level required, hence reducing operating costs.

To ensure and optimise the blending process, an automated control system is proposed for the [redacted] group of sites. Using the existing high integrity (Hach NITRATAX sc 2 mm) Nitrate monitors at all stations and a resilient and distributed PLC based control system to provide automatic control of site outputs according to their individual characteristics.

[redacted] turbidity

The [redacted] process sufferers from turbidity excursions shortly after the onset of moderate to heavy rainfall (see figure 7 below). These regularly and predictably exceed the threshold at which the site is taken out of supply (0.65ntu) (lower red line, upper trend). The mitigation measures required for the spike in turbidity are currently uncertain since the cause is unknown and requires further investigation.

Figure 7: turbidity at [redacted] WTW



[Source: 5200984-ATK-00-GEN-RE-Z-0005 [redacted] DO Recovery Solution Report Rev 2.0.pdf (appendix PRT07.03.06)]

[redacted] has been subject to a DWI notice pertaining to turbidity and cryptosporidium. A UV treatment plant was installed in 2016 to manage the cryptosporidium risk.

An attempt at mitigating the turbidity challenge was made by improving the run-to-waste facility at the time the UV plant was installed. However, this was not intended to address the cause and the turbidity excursions have increased in both severity and frequency in recent years and the site now frequently fails after moderate to heavy rain.

The current strategy is to maintain and manage the status-quo. Operations are increasingly active in manual intervention processes in order to maintain process and manage risk. This strategy necessitates: operating well below design outputs, and/or shutting down abstraction on frequent turbidity excursions.

The uncertainty surrounding the circumstances of the turbidity excursions, coupled with uncertainty surrounding the maximum, reliably and practically achievable, deployable output at [redacted] without mitigation, suggest regulatory support would not be forthcoming without further engineering evaluation and a better quantified understanding of the current circumstances. These investigations may involve ground works to better understand the subterranean conditions.

The turbidity challenges at [redacted] require further engineering evaluation before mitigation remedies can be proposed. Options range from local subterranean remedial works to permanently installed filtration. An investigation strategy is proposed for AMP 8.

[redacted] drought order operation.

The site at [redacted] is licensed to supply [redacted]. [redacted] contributes to the [redacted] Nitrate blending.

The site is required to achieve [redacted] to meet the dWRMP24 1-in-200-year drought condition, and the 'drought emergency' license arrangements can permit this increased flow for up to one year.

The higher flow rates required and licensed (on application) during drought conditions are currently precluded by its disinfection capability and turbidity.

In order to provide the required disinfection at [redacted] some additional disinfection is required to maintain eCT5. An Ultra-Violet (UV) system is proposed. Whilst solutions other than UV were considered in the Atkins report, all were more expensive, less cost effective and some required the purchase of additional land.

[redacted] and [redacted] are exclusively interoperable under drought condition. That is: [redacted] is only required to be operated at [redacted] when drought conditions do not permit the use of [redacted] This allows some interchangeability of UV disinfection equipment between the two sites.

For clarity, the cost of purchase for this proposed UV system is included PRT1301-03 (UV enhancements proposal). Whilst the costs of the on-site enabling infrastructure at [redacted] are contained within this paper.

Due to the operating regime of [redacted] and the infrequency of its elevated operation under drought conditions, there does remain some uncertainty surrounding the turbidity levels that would be witnessed during long periods of elevated drought operation. The provision of simple low-cost filtration (in service only during drought conditions), is a precautionary measure to ensure effective operation of the proposed UV plant. A graph illustrating the correlation of turbidity and borehole level changes is shown in figure 8 (below). Level data is inverted to provide borehole water level (Atkins, 2020).

Figure 8: [redacted] turbidity excursions at elevated flow rates.

Source: 5200984-ATK-00-GEN-RE-Z-0005 [redacted] DO Recovery Solution Report Rev 2.0.pdf (appendix PRT07.03.06)

Figure 8 demonstrates that [redacted] exceeds turbidity thresholds at elevated flows and provision of a low-cost cartridge filter arrangement is included in this proposal.

The existing borehole pumps also limits [redacted] output to [redacted] Providing suitable borehole pumps for the elevated flow conditions, and the electrical infrastructure to support them, are also included in this proposal.

[redacted] nitrate control

2. The [redacted] water supply system is shown in figure 9 (below).

Figure 9: [redacted] Water supply system

[redacted]

Source: Portsmouth Water

The Design capacity of [redacted] WTW is [redacted]. The site has an average production of [redacted] with an MDO (from the dWRMP24) of [redacted]. The site extracts water from a chalk borehole on a continuous use basis.

The site comprises Membrane filters, with chlorine (gas) and Orthophosphoric Acid dosing. The site feeds the [redacted] and [redacted] service reservoirs via two pairs of duty/standby booster pumps.

Nitrate risks at abstraction, treatment, storage, and distribution stages within the [redacted] Supply System have been carried downstream from the catchment stage.

High nitrate in the water source is resultant on historic land-use practices. Current levels of nitrate input are now better controlled by modern catchment management strategies. Catchment walkovers are undertaken on a risk-based programme, and a minimum of every 3 years across each individual Portsmouth Water catchment. These walkovers are undertaken by the Catchment Management team in collaboration with the DWSP team and local Environment Agency (EA) office. This programme allows greater catchment conceptualisation through documentation of land use practices that may result in application, run-off and/or leaching of nitrate into Portsmouth Waters groundwater sources. Document 302 'catchment audit procedure' (Appendix PRT07.03.03) defines the methodology.

Long term nitrate trend analysis undertaken by AMEC confirmed that the groundwater abstracted at [redacted] WTW experiences seasonal variations in nitrate concentrations. These elevated concentrations are intrinsically linked to high groundwater levels following the recharge period, with peak nitrate observed in spring (February to May) and typically lasts for 2-3 months. Peak nitrate typically occurs one week after peak groundwater.

If nitrate concentrations reach 48 mg/l the abstraction has to be turned off and the downstream reservoirs are then fed by an alternative supply system.

Online nitrate monitors are linked to an auto-shutdown system at [redacted] Monthly nitrate monitor validation sampling is carried out to confirm that these monitors are working correctly. The frequency increases to weekly once nitrate concentrations reach 45 mg/l. Appendices PRT07.03.01 & 02 define this methodology.

The set point of the [redacted] shutdown system is 48mg/l, hence preventing Drinking Water Safety (DWS) exceedances at the consumers tap. The difference between the shutdown level (48) and the absolute value of the parameter (50) being associated with measurement accuracy and instrument drift.

The downstream reservoirs ([redacted] Reservoir, [redacted] Reservoir No.1 and [redacted] Reservoir No.2) are then supplied by [redacted] Reservoir, which is part of the [redacted] system. The downstream Water Supply Zone ([redacted]) ([redacted]) is then fed by these reservoirs.

This removes the nitrate risk for consumers within [redacted], however the resilience of the [redacted] supply system is unacceptably reduced, risking water supplies to customers in this area.

The current controls for nitrate at this stage are, therefore, this alternative supply from [redacted] service reservoir ([redacted]) pre-[redacted] and [redacted] reservoir boosters.

Hydraulic restrictions currently prevent the blending of [redacted] Water with water from [redacted] and [redacted] must be shut down under these circumstances.

Shutting down [redacted] for such regular and extended periods is no longer considered a tenable option for reasons of water supply resilience.

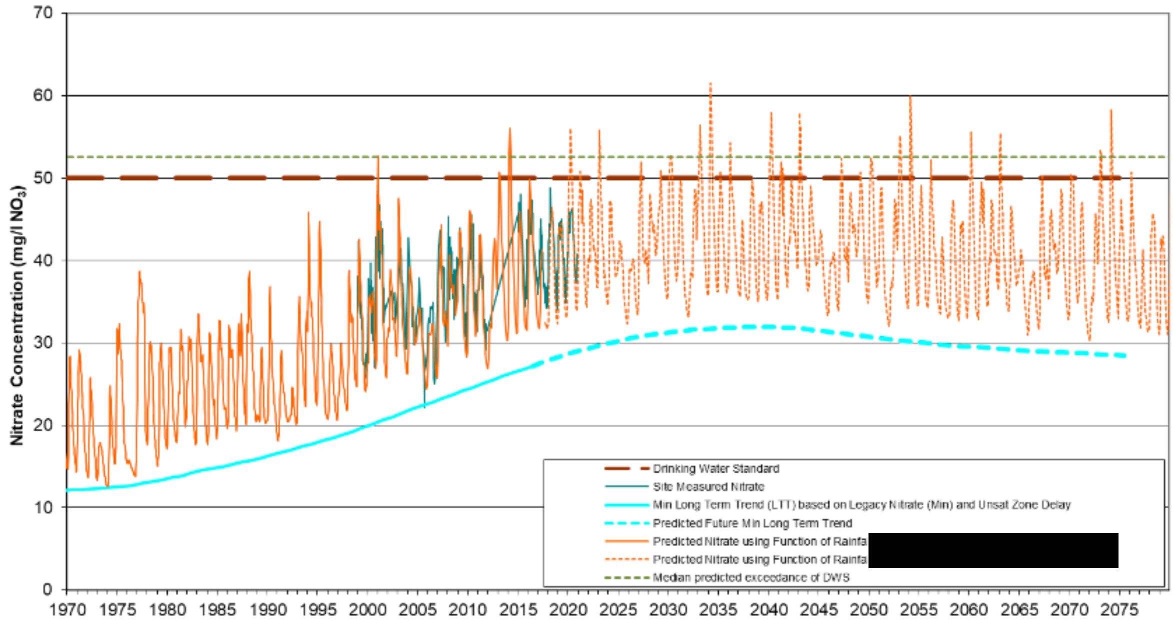
It is recognised therefore that new or enhanced control measures are required to continue to mitigate the high and rising nitrate risk in the [redacted] Supply System.

The higher the groundwater levels, the higher the observed nitrate concentration, that is during dryer years, nitrate concentration do not rise as high as in wet years. Hence, the proposed blending regime will vary year to year.

A raw water online nitrate monitor is installed at [redacted] WTW to provide real time nitrate monitoring (see figure 2 above). Monthly monitor validation samples are taken to confirm monitor accuracy. This frequency of validation samples increases to weekly once concentrations reach 45mg/l. In addition to the above, raw water grab samples for laboratory analysis are taken monthly, and treated water grab samples taken 8 times per year. Appendices PRT07.03.01 & 02 define this methodology.

Revised nitrate concentration predictive modelling using the most up to date data was undertaken by WSP (formerly known as Wood and AMEC Foster Wheeler) in 2022, which suggests that peak nitrate concentrations will occur in the mid-2030s. See figure 10 below.

Figure 10: [redacted] predictive modelling of nitrate concentrations



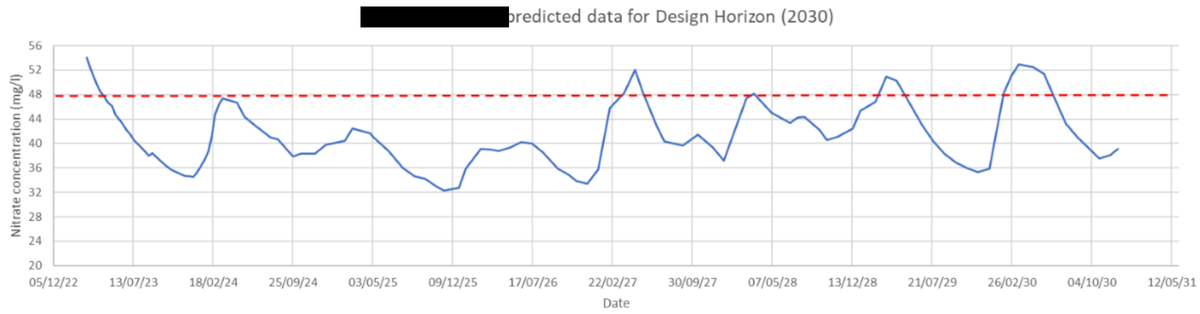
Source: 5220073-ATK-XX-XX-TR-PR-001 - Nitrate Resilience Strategy Optioneering Report.pdf

This time series nitrate predictive modelling is based upon a quantitative source/pathway conceptual model, utilising nitrate source apportionment data linked to land use, rainfall levels and hydrogeological factors, such as soil type, geology, depth to groundwater, and transmissivity.

Atkins (SNC-Lavalin) are currently engaged by Portsmouth Water to assist in defining options for mitigating Nitrate levels. Their report suggests potential blending options for [redacted] water summarised in figure 13 (below).

The models reflect real time experience and also show that threshold excursions above the 50mg/l statutory limit will occur as early as 2027, with a subsequently increasing trend (figures 11 and 12, below)

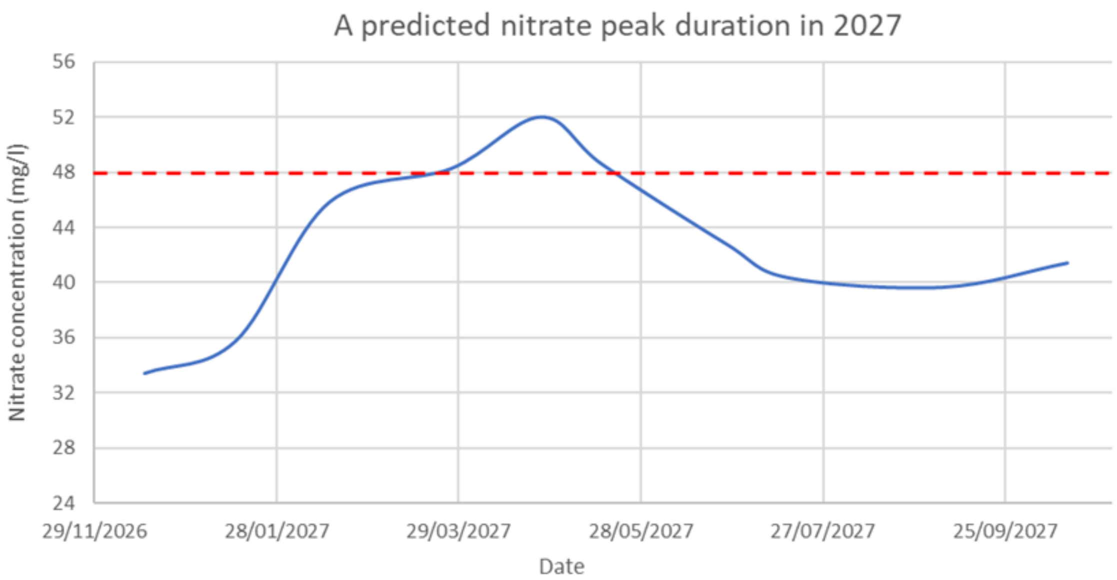
Figure 11: Predicted future nitrate trend at [redacted] WTW



The model predicts threshold breach in 2027, increasing trends to 2050, and reaching 52.5mg/l by 2036 (98%ile)

Source: 5220073-ATK-XX-XX-TR-PR-001 - Nitrate Resilience Strategy Optioneering Report.pdf

Figure 12: 2027: An example of a predicted nitrate excursion and its duration.



The assessment confirms that [redacted] is at risk of breaching PCV for nitrate under present day conditions. The model was therefore used to identify blending scenarios that would alleviate this risk. The initial target conditions used for the theoretical blend scenarios was to maintain a nitrate level below 48 mg/l until the design horizon of 2030.

The work by Atkins (SNC- Lavelin) (Atkins 5220073-ATK-XX-XX-TN-PR-001- Options Identification Technical Note, 17th March 2023 & 4th July 2023) which includes verification of the modelling data and consideration of mitigation options (figure 13 below) concludes that:

1. Feasible blending solutions to maintain nitrate levels below 48 mg/l up until 2030 are dependent on the extent and sustainability of water transfers from [redacted] SRV.
2. It is likely that transfers from one zone to another may need to be sustained for a duration in the order of 2-3 months, of each year, in line with nitrate level peaks observed in historical data.
3. If [redacted] can be sustainably deployed to the [redacted] network from [redacted] SRV, no immediate interventions are required (Option 1).
4. If [redacted] cannot be sustained from [redacted] SRV a blending point of [redacted] water may be considered. Commissioning of a blending tank at [redacted] would be a requirement to undertake this option. A minimum sustained supply of 8 Mld is still required from [redacted] SRV to the [redacted] zone to guarantee a compliant blend under worst case conditions. If [redacted] cannot be sustainably deployed from [redacted] SRV then further options require consideration (Option 2).
5. An option exists to transfer [redacted] from [redacted] WTW to blend at [redacted] WTW via the [redacted] service reservoir. This utilises the existing [redacted] pipeline via [redacted] valve. The model suggests that this is a feasible blending option until, under worse case conditions, nitrate concentrations may rise above 48mg/l around 2035. This option requires a blending chamber at the [redacted] site, a valve control system, and upgrades to booster pumps at [redacted] and [redacted] reservoirs (Option 3).
6. An option exists to commission a new Pumping Station and transfer pipeline to deploy water from [redacted] This could be as a combined blend with water from [redacted] SRV. The existing blending model indicates a sustained deployment of 5-7 Mld from the [redacted] system may be required if this option is selected. (Dependent on output from [redacted] SRV.) There is approximately 7 km between [redacted] WTW and [redacted] WTW by road, giving an indication of approximate pipeline distance needed (Option 4).
7. A nitrate treatment plant at [redacted] WTW may be considered as an option if deployment of water resources as suggested above is not possible (or if considered favourable against the above) (Option 5).
8. Catchment management controls should continue to, so far as possible, reduce nitrate inputs to the minimum achievable levels.

Options 1 & 2 (above) cannot be supported for the reasons described in 58 & 61 (above).

Option 4 (above) requires the overlanding running of a new pumping main at considerable cost and with planning and uncertainties and local disruption and inconvenience.

Option 3 (above) provides the most resilient response. However, would require the purchase of additional land at [redacted] for a new Nitrate treatment plant. The option represents a significant capital investment and substantially increases operating costs.

The preferred option for Portsmouth Water lies in option 3. Portsmouth Water recognise that, although the nitrate modelling is seen to be representing real-world experiences, there remains some inherent uncertainty in: the degree to which the statutory limits are exceeded, the duration of the exceedances, and, the point in time at which they end (as the historic nitrate diminishes in the catchment geology). The preferred option, and the option developed in this proposal, is to enable the blending identified in option 5 (above) whilst retaining the possibility of future treatment at [redacted] in the LTDS according to the monitoring plan.

Figure 13: [redacted] preferred blending option

[redacted]

B. Regulatory and Statutory Compliance

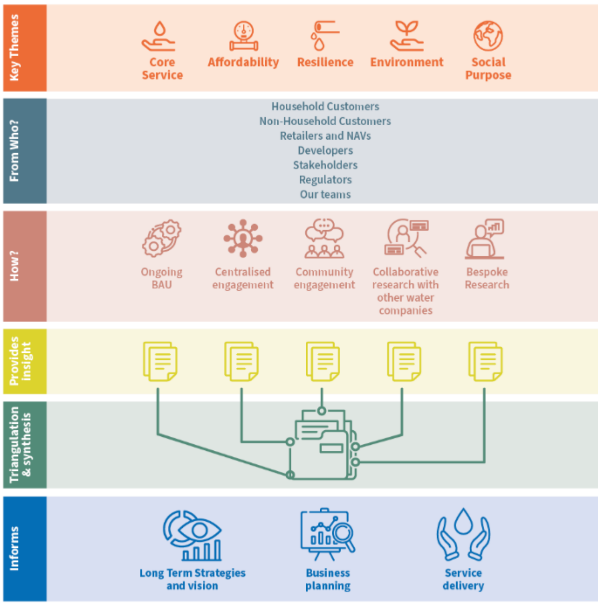
The prescribed limit for nitrate in drinking water is set in the drinking water standards as 50mgNO3/l at the consumers tap (DWI, 2023). This proposal provides a solution for Portsmouth Water to supply water below this statutory limit.

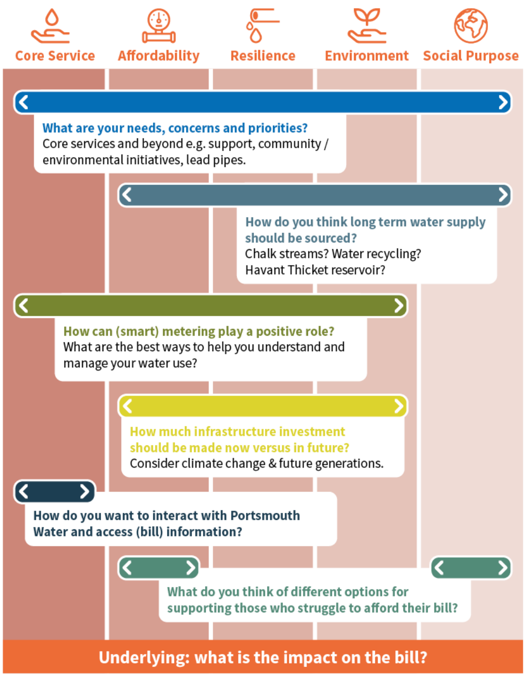
The prescribed limit for turbidity in drinking water is 1 NTU since above this limit micro-organisms can be shielded from chemical disinfectant. The tolerable operating limit for UV plant is 1 NTU. This proposal provides a solution for Portsmouth Water to maintain this condition under the elevated extraction and treatment conditions define for [redacted] under a drought order.

C. Customer Support

This business plan has been informed and shaped through insights gained through our Engagement Strategy and triangulation process which has been embedded from 2020 and continues to inform and adapt our service delivery plans through two key elements of:

Our Engagement Strategy (represented on the left below) and our Big Conversation Framework (represented on the right below).





In all phases of engagement our customers and

stakeholders feeding into our Vision, Long Term Delivery Strategy and this plan have supported the need for a secure and reliable water supply.
This is consistent across all engagement right through to achieving a great result in our Acceptability and Affordability testing with customers.

Our engagement approach for supporting the plan is set out in PRT03: Engaging with our Customers and Communities. Alongside this we have published all research on our website.

Customers really supported the need for us to maintain a secure and reliable water service across a number of phases of engagement. In phase 1 we focused on understanding priorities for our customers and our range of research alongside Ofwat's own ODI research ranked these areas of company activity in importance.

Insight we gained

The research established three key areas of:

Service Aspect Area	Importance
Water supply interruptions	High
Appearance, taste and smell of tap water	High
Do not drink notice	High
Boil water notice	Medium
Leakage	Medium
Pollution incidents	Medium
River water quality	Medium
Biodiversity	Medium
Carbon	Low
Customer satisfaction	Low
Hose pipe ban	Low
Severe drought	Low
Non-essential use ban	Low

Water quality and continuity of supply featured in the top elements of research findings.
This investment case is focused directly on ensuring the quality and availability of supplies and meets our customers ongoing priorities.

In selecting the preferred and proposed solutions, we have aligned its response to our customers priorities.

3. OPTIONS

1. Overview

Sub options were considered, and where appropriate these have been previously described in this paper. See 71to 75 (above). Further detail is available in the appended reports by Atkins (PRT07.03.04 & 05). These have been discounted on grounds of cost and/or operational resilience. A summary table of the considered options is given with each 'part' (below)

Option studies and supporting case for [redacted] nitrate mitigations.

- Appendix PRT07.03.04 – 5220073-ATK-XX-XX-TN-PR-101 – Option 5 Technical note (Atkins, 21/JLY/2023)
- Appendix PRT07.03.05 - 5220073-ATK-XX-XX-TR-PR-001 – Nitrates resilience strategy Options (Atkins, 2023)

Option studies and supporting case for [redacted] group nitrate mitigations.

- Appendix F – 5220073-ATK-XX-XX-TR-PR-001 – Nitrates resilience strategy Options (Atkins, 2023)

Option studies and supporting case for [redacted] DO enhancements.

- Appendix G – 52200984-ATK-00-GEN-RE-Z-0005 – [redacted] DO recovery Solutions report (Atkins, 2020)

Part 1 (below) describes the additional costs associated with a permanent UV installation at [redacted] and demonstrates how Portsmouth Water would add customer value by reducing costs through taking the more innovative approach described in the preferred option (3). Here the description for option 1 is limited to the additional cost and implications associated with procuring and installing a second UV plant dedicated for installation only at [redacted] (which is in addition to the plant provisioned for [redacted] under PRT07.02)

Part 2 (below) relates the costs associated with providing Nitrate treatment at [redacted] which though discounted in this paper may prove necessary somewhere between 2035-50 when nitrate levels are predicted to peak. The provision for any such future treatment at [redacted] should it prove necessary is included as a feature of the LTDS and subject to the associated monitoring plan.

Part 3 (below) relates the preferred option. This comprises:

- Nitrate Treatment at [redacted] and the associated blending control for the [redacted] group.

  Investigations and potential remediation of the turbidity challenges at [redacted]
- Drought provisions at [redacted]
- Nitrate blending at [redacted] and the associated blending control.

A. Part 1

Description

This option relates to the permanent installation of a UV plant at [redacted]

The preferred option proposes to use the UV plant, proposed for [redacted] (under PRT07.02), at [redacted] when [redacted] is required to operate under drought order conditions.

[redacted] and [redacted] are interoperable in severe dry weather. That is, [redacted] is only required to operate at elevated flows when a drought order is imposed, and a drought license granted. Under these circumstances [redacted] cannot be operated due to low groundwater conditions.

[redacted] only requires a UV plant for Ct support when operating at these elevated flow rates.

The UV plant at [redacted] may hence be relocated to [redacted] for the period of the drought order.

1. A dedicated UV plant at [redacted] would only be used in very rare circumstances and:
   - Cost an additional £1M in capital expenditure.
   - Incur additional operating costs associated with maintaining the 'off-line' asset. These estimated at c.£10k p.a.
   - Incur additional buildings and building services costs.

There are no significant additional costs associated with the preferred strategy.

Other options were considered. These are summarised in table 2 (below) and more detail is contained in appendix PRT07.03.06, available on request.

Table 2: [redacted] – summary of alternative process options

Option description	Capex £M	Opex £Mp.a.	Notes
Increased contact volume above ground + cartridge filters	2.04	0.132	Need for further land purchase. Substantial permanent infrastructure despite infrequent use. Planning risk to program. Adverse visual impact. Additional permanent assets to maintain. No change to chloring dosing or control.
Superdechlorination + cartridge filters	1.608	0.144	New chemical storage and dosing required at [redacted] reservoir. Dosing mixing and sample chamber required. New final monitoring required with associated control. Same chloring residual into supply maintained.
Membrane filtration	3.012	2.016	Major waste disposal challenge. Frequent tanker movements. Need for further land purchase. Planning risk to program. Additional chemical handling, storage, and delivery. Very high Opex costs Robust turbidity protection for extended high NTU periods.
Ultraviolet Disinfection + cartridge filters	1.548	0*	Possible short term increase in residual chlorine at [redacted] reservoir.

Preferred option.	Costs can be reduced by utilising UV from [redacted] No increase in permanently operating assets. Future proofing against further WQ (cryptosporidium risk) deterioration. * Opex increase nets off against [redacted]

The preferred option is to provide UV treatment and cartridge filters, with the UV plant translocatable with [redacted] as described.

The proposal was submitted to DWI and received their support. The DWI letter of support is appended (Appendix PRT07.03.08).

Long-term Delivery

There are no adverse implications for the LTDS. UV and cartridge filters provide the least cost option, and a no-regrets option that lies on all the adaptive pathways.

Costs

Not following the preferred strategy would add c.£1M to capital expenditure and c.10k. p.a. to operating expenditure.

Benefits

Given the rarity of use, there is no significant benefit in a dedicated UV plant at [redacted]

There is no cost benefit associated with any of the alternative (non-UV) options.

B. Part 2

Description

Part 2 relates to providing wholesome water by reducing Nitrate levels exiting at the [redacted] and [redacted] reservoirs.

Three options were considered, and the summary is presented here. Further detail is available in Appendix PRT07.03.04 & 05, available on request.

Option 1 (table 3. below) relates to the cost of providing nitrate treatment at [redacted] and to the cost of providing an overland route from [redacted] The two sub-options being mutually exclusive.

The provision of nitrate treatment at [redacted] is difficult to achieve since the spatial requirements exceed the available space on the existing site. Additional land would need to be purchased and the sites' location and surroundings limit the opportunity for this.

Nitrate treatment requires significant capital investment, incurs significant operating costs, and requires the disposal of significant quantities of waste (expended Brine).

The longer term does suggest nitrate treatment may be required sometime after 2035 however this is subject to the uncertainties of the predictive modelling described in 80 (above).

The cost alternative associated with this option are summarised in table 3 (below).

Option 2 (table 3. below) relates to the option of providing water for blending at [redacted] directly from the [redacted] WTW.

An overland route from [redacted] WTW is difficult to achieve, requires negotiation with multiple landowners, highways and planning authorities, with significant infrastructure investment in piping and pumping.

The costs of an overland route from [redacted] are summarised below.

Option 3 (table 3. below) relates to the option of providing water for blending at [redacted] from the [redacted] WTW via existing pipeline infrastructure, via the [redacted] reservoir.

Option 3 is the preferred option, since despite introducing some complexities in blending and leakage management (which can be mitigated through increased measurement), the option provides the most cost-effective solution.

Option 3 was submitted to the DWI with all the supporting data and modelling results. The proposal received their support. The DWI letter of support is appended (PRT07.03.07).

Long-term Delivery

The option for additional treatment at [redacted] is included in the LTDS for 2030-35, though does not appear on the core pathway nor as a preferred option.

The option is subject to the monitoring plan of the LTDS.

A decision to pursue the overland transfer or to treat for nitrate at [redacted] would be made according to the circumstances at the time and managed through the monitoring plan of the LTDS.

Costs

Not following the preferred blending option would add a minimum of £8.5M to capital costs and add up to 450,000p.a. to annual operating costs.

Given the uncertainties in the nitrate modelling, neither treatment at [redacted] nor the overland route from [redacted] can yet be justified.

Portsmouth Water

Table 3: [redacted] –Options: nitrate mitigation

Component	Capex £M	Opex £M p.a.	Cost source
Option1 Nitrate Treatment	10.500	0.600	Atkins
Option 2 Overland pipeline route from [redacted] WTW	10.5 to15	0.179	Atkins
Option 3 [redacted] Water via [redacted]	1.402	0.253	Atkins

Costs for option 1 are derived from Atkins (21st July 2023: report number 5220073-ATK-XX-XX-TR-PR-001 p.15) and are based on the Nitrate proposal for [redacted] with a £2.5M addition estimated for the additional land purchase and land stabilisation measures necessary at the [redacted] site.

Costs for option 2 are derived from Atkins (21st July 2023: report number 5220073-ATK-XX-XX-TR-PR-001 p.19)

Costs for option 3 are derived from Atkins (21st July 2023: report number 5220073-ATK-XX-XX-TR-PR-001 p.52)

Benefits

Treatment reduces reliance on other sources and hence option 1 provides the most reliant solution in terms of deployable output.

Treatment at [redacted] is likely to provide the optimal cost benefit approach if the blending option cannot be maintained in the longer term.

More certainty in real-world nitrate levels as they develop over the next ten years is required before a treatment solution can be recommended.

Option 3 provides the most cost-effective solution and meets the objective.

The proposal for nitrate treatment at [redacted] was submitted to DWI and received their support. The DWI letter of support is appended (PRT07.03.08).

C. Part 3

Part 3 defines Portsmouth Waters preferred strategy.

The preferred strategy is:

- To provide UV treatment and cartridge filters at [redacted] to meet the drought order obligations.
- To provide blending facilities enabling [redacted] Water to be blended with water from [redacted]
- To provide nitrate treatment at [redacted] and the essential controls.
- To investigate the cause and potentially mitigate the turbidity excursions at [redacted]

Note: within the [redacted] group there are no options other than to provide nitrate treatment. Such nitrate treatment could potentially be provided at either of the Water Treatment Plants at [redacted] or [redacted] at similar cost. However, the current unreliability of the [redacted] source under conditions of moderate to high rainfall makes [redacted] an unsuitable choice.

This technical detail, sampling data and risk profiles supporting the overall strategy were including in a proposal submitted to the DWI as 'appendix B' in March 2023, and their letter of support is appended (PRT07.03.08).

Description of the proposed strategy

The nitrate excursions within the whole [redacted] group are managed by side stream nitrate treatment of an appropriate portion of the [redacted] site water, with automation and optimisation of the blending arrangements across the whole group.

The enhanced Deployable Output of the [redacted] site, within the [redacted] group, during drought conditions, is enabled by the installation of cartridge filters to reduce turbidity, and UV treatment to support Chlorine contact times. Borehole pumps at [redacted] are provisioned to enable an expedition transition without unnecessarily incurring the efficiency loss associated with permanently installed, over-sized pumps.

Rising nitrate levels at [redacted] are managed by blending with water from [redacted] via [redacted] with a suitable blending tank and automated blending control at [redacted]

Investigate, using suitable experienced 3rd parties, the cause of the turbidity excursions at the [redacted] abstraction. To remedy if economically practicable.

That the other options for [redacted] are held within the LTDS and kept under review within the monitoring plan.

Long-term Delivery

The option for further nitrate control [redacted] is included in the LTDS for 2030-35, though does not appear on the core pathway nor as a preferred option. The option is subject to the monitoring plan of the LTDS and the pertaining levels of nitrate.

The components identified in 52-56 (above) above, are included on the least regrets, lowest cost, pathway of the LTDS and must be completed within AMP8. The plan may have to be adapted in the unlikely event that future nitrate rise beyond a level that can be mitigated by the blending strategy.

Costs

Not following the preferred option, in respect of the UV at [redacted] would add c.£1M to capital expenditure and c.20k. p.a. to operating expenditure.

Costs are summarised in table 4 (below).

Table 4: Preferred solution cost summary.

Component	Capex £M	Opex £M p.a.	Cost source
Install 'automated' blending control system including process control and additional monitors for the [redacted] Group	1.020	0.000	Trant
Necessary enhancements at [redacted] to facititate increased deployable output under drought order conditions (noting that the cost of the UV reactor is included in PRT07.02 and excluded here)	1.548	0.000	Atkins
Treatment at [redacted] for Nitrate - removing [redacted] as a single point of failure for the group.	9.420	0.670	Atkins
Turbidity investigation at [redacted]	0.500	0.000	Internal
Reduce Nitrate levels ex [redacted] WTW using water from [redacted] for blending	1.840	0.000	Atkins
Risk and Contingency	1.433	0.000	
PWL Management Overhead	2.149	0.000	
Subtotals	**17.910**	**0.670**	
Intrinsic allowance (deduction)	0.000	0.000	Internal
Delivery efficiency target (deduction)	3.915	0.080	Internal
Totals	**13.995**	**0.590**	

The costs are presented on a 22/23 price basis.

Costs identified as ‘Trant’ are derived from engineering estimates provided by Trant Engineering Ltd. Rushington House, Totton, Southampton SO40 9LT, and exclude Portsmouth Water risk and overheads.

Costs identified as ‘Atkins’ are derived from engineering estimates provided by Atkins (SNC Lavalin) that exclude Portsmouth Water risk and overheads. The cost estimate for the Nitrate treatment process at [redacted] was obtained from ACWA by Atkins, on behalf of Portsmouth Water.

If the solution is of lower order cost, then remediation of the [redacted] turbidity issue will be affected as part of this proposal.

The cost estimate for [redacted] must increase if PRT07.02 is not appropriately approved.

The confidence associated with estimates is believed to be within +10% to -5% .

The costs are considered enhancement costs since they relate to a deterioration in raw water quality through entirely exogenous factors, or to enhanced output requirements for drought resilience purposes.

There are no intrinsic costs associated with the proposal.

A full cost breakdown is available on request.

Benefits

The proposal reduces inter-reliance between sources. Whilst more resilient approaches are available (see Appendices PRT07.03.04 & 05) the preferred solution provides an adequate balance of resilience, risk, and cost, particularly given the inherent uncertainties in the mathematical modelling and future levels of nitrate in the raw water.

The proposal removes the current and unacceptably high dependency on [redacted] as the major source of low nitrate water for the [redacted] group. This increases the resilience of the whole [redacted] Water Supply Zone (WSZ) and the bulk supplies to Southern Water (see fig.1).

The proposal includes an innovative and cost-effective solution to enhance the output of [redacted] during drought conditions. Option 1 relates the higher costs of the traditional solution.

4. ANALYSIS OF OPTIONS

The paper has explained why the more resilient, though more expensive options, to treat at [redacted] or provide an overland pipe to [redacted] from [redacted] are not viable options until the uncertainties associated with the long-term trends of nitrate in the [redacted] catchment are more certain.

The paper has also explained the advantages of a translocatable UV plant at [redacted] to reduce both the capex and opex costs associated with the enhancement.

The paper has explained why nitrate treatment is necessary at [redacted] and why blending is necessary at [redacted]

1. Best Option

1. The paper has explained why the strategy in part 3 represents the best value for money for Portsmouth Water customers and why this strategy represents the favoured response until at least 2035, and possibly permanently, if nitrate levels do not rise as expected in the worst case modelled scenario.

2. Customer Impact

2. Customer can continue to be supplied with drinking water that meets the current drinking water standard of 50mg/l for nitrate.
3. Customers can continue to be supplied under the 1 in 200-year drought conditions of the dWRMP24.

Table 5: Annual costs and customer bill impacts

2022-23 prices	2025-26	2026-27	2027-28	2028-29	2029-30	AMP8 total
Capex £k	-	4,121	4,766	4,891	665	14,443
Opex £k	91	172	174	176	202	814
TOTEX	91	4,293	4,940	5,067	867	15,257
Bill impacts (average HH bill) (£)	0.21	0.75	1.5	2.26	2.68	

Source: Table CW3, Rows 99 and 102 (these rows in CW3also include costs from PRT07.02)

5. ASSURANCE AND BOARD APPROVAL

Production of this supporting document has been undertaken in accordance with internal governance and assurance procedures and processes. Third party assurance has also been provided by Jacobs Global Consultancy.

This comprised initial drafting by a Lead Author, under the direction of an Executive Owner who retains Executive responsibility for the document content including robustness and accuracy.

The document has undergone three stages of internal review and third-party assurance before being signed off by the Board. Internally this has included:

(a) Executive Owner, and subject matter experts for the Executive Owner,

(b) Nominated Executive,

(c) Internal Executive Review Team including the CEO and CFO.

Details of the third-party assurance, including findings/opinion, can be found in PRT15.04.

Supporting cost data has been provided by Trant Engineering Contractors and Atkins (AtkinsRealis Ltd)

The Board has been engaged in the development of the business plan and its content through subject specific discussions at monthly PR24 Steering Committee meetings that have taken place since late 2021. Minutes of relevant meetings are included in PRT15 Board Assurance, Appendix PRT15.01.

6. CONCLUSION

The preferred strategy 3 provides the most cost-effective solution to deteriorating water quality in the [redacted] and [redacted] WSZ's and meets the dWRMP24 requirement to provide additional capacity at [redacted] in times of drought.

The proposal provides maximum customer benefit, now and into the future, by cost-effectively and proactively planning to meet their aspirations for high quality water at an affordable price. By deferring potential future investment until statistical uncertainties become clearer then the customer is provided with a least regrets, low cost pathway to meet statutory obligations around water quality and water supply.

The proposal provides societal benefit in ensuring water supplies meet the required standards of wholesomeness and are resilient to environmental factors beyond the control of Portsmouth Water. The proposal achieves these objectives by minimising the environmental impact, by limiting civil works to the minimum necessary, and by employing an innovative strategy to 'share' process plant between different water treatment works according to their operating needs. The proposal limits energy inputs and minimises waste and waste transport costs. The proposal has limited impact on the environment and the chosen options avoid extending existing site boundaries and installing long lengths of new water mains in virgin grounds.

By treating the whole as a single program of work, the optimum supply chain arrangements can be made. These assumptions are built into the costs presented. The work will be carried out in AMP8 and integrated within a program of work that will ensure its timely delivery. The primary risk is associated with early design and procurement of process plant. Options have been selected that avoid planning risks. Delivery of the nitrate plant is quoted by the supplier as 7 months with 6-7 months for construction and completion. An early start in AMP8 is hence anticipated. An outcome related PCD is expected based on the delivery of the stated objectives around nitrate limitation.

The proposal is related to the disinfection proposal PRT07.02, and the relationship concerning the UV reactor for [redacted] and [redacted] has been explained. However, PRT07.02 also includes a proposal for a mobile UV plant and this, if approved, would be available to provide additional protection and resilience to the sites chosen as sources of blended water. The mobile UV plant can be quickly deployed to protect critical sites against the risk of cryptosporidium. In this way Portsmouth Water can reduce risk by employing innovative and integrated approaches to risk management, that minimises the cost impact to customers whilst also improving the resilience of their water supply.

The strategy relates to risk identified on our regulatory returns to the DWI. Portsmouth Water are grateful for the careful consideration given by the DWI to the analytical and microbiological data passed to them in the 'Appendix B' document submitted, by Portsmouth Water, in March 2023. The DWI agree that the strategy summarised in this paper reduces risk and we were grateful to receive their subsequent letter of support for the strategy.

PRT07.03 APPENDIX

PRT07.03 APPENDIX

PRT07.03.01: WQ 03 03 17 Determining Sample Frequencies – Portsmouth Water Operating procedure.

PRT07.03.02: WQ 03 04 23 Frequency_2023. – Portsmouth Water operating procedure..

PRT07.03.03: Document 302 Catchment Audit Procedure V4. Portsmouth Water operating procedure.

PRT07.03.04: Report 5220073-ATK-XX-XX-TN-PR-101 - Option 5 Technical Note. Atkins consultant technical report.

PRT07.03.05: Report 5220073-ATK-XX-XX-TR-PR-001 - Nitrate Resilience Strategy Optioneering Report, Atkins consultant technical report.

PRT07.03.06: 5200984-ATK-00-GEN-RE-Z-0005 [redacted] DO Recovery Solution Report Rev 2.0. Atkins consultant technical report.

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