4. SOLUTION DEVELOPMENT

4.1. Option 1: Tangmere WwTW Treatment Options

4.1.1. Current Works

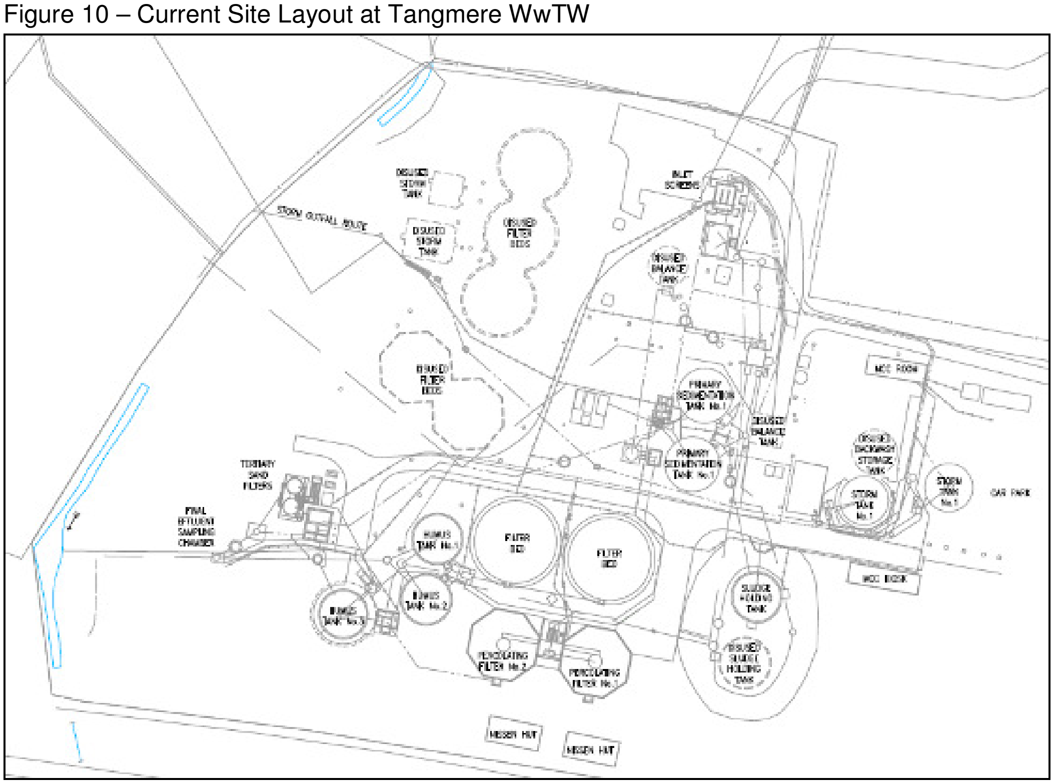
Tangmere is a plastic media percolating filter works with tertiary moving bed sand filters and currently serves a population equivalent of 4,312 residents. Flow arrives at Tangmere WwTW via three pumped mains to a raised inlet works and is screened via 1No. 6mm 2D screen. Screened flows pass out of the inlet works via a balancing tank. There is a storm overflow in the balancing tank whilst flow to the Primary Settlement Tanks (PSTs) is controlled using a floating arm.

2No. PSTs with moving half bridge scrapers and auto desludge then provide primary settlement before flows pass to an interstage pumping station. Flows are pumped up to 2No. Plastic media filters prior flowing out to 3No. HTs. Part of the flow is still being passed through 2No. Mineral media trickling filters directly after the plastic trickling filters. These have been kept online so they are operable if one of the plastic filters needs to be taken off-line for a snail kill. Flow from the mineral filters is only via Humus Tanks (HTs) 1&2 creating uneven flow distribution amongst the three HTs.

HT effluent passes to a sand filter feed Pumping Station (PS) which also acts as a recirculation PS (recirculating downstream of the PSTs) and washwater PS. 2No. Huber Sand Filters (SFs) then provide additional solids removal prior to the final effluent sampling point. Storm flow is returned upstream of flow measurement whilst storm discharges are monitored and pass to the receiving water (Aldingbourne Rife) just upstream of the final effluent discharge point.

The current works is shown on the site layout drawing below:

Figure 10 – Current Site Layout at Tangmere WwTW



4.1.2. Site Upgrade Considerations

There are three possibilities with regards to receiving additional flows at Tangmere WwTW:

1. Additional flow is received from new build housing to the East of Chichester and is transferred to Tangmere for Treatment.
2. New development occurs around and into the current Chichester catchment whilst existing flows from the East of the Chichester catchment are diverted and transferred to Tangmere for treatment.
3. New housing development occurs around Tangmere WwTW and flows directed into the existing Tangmere catchment.

Indeed a combination of all three scenarios is feasible. Although the nature of additional flows received will vary somewhat, depending on whether flows emanate from new build or existing housing. For a high level design and feasibility stand point, these small variations can be neglected and one main design upgrade to the on-site treatment works at Tangmere considered.

Significant variations to the requirements for the **overall** design may in the future, occur from three main areas:

1. Whether the future revised consent for Tangmere is reasonably aligned with that used for design, particularly if and how any future introduction of a Phosphorus consent to the works is handled.
2. The ratio of new builds at Tangmere to those at Chichester will impact the sizing and overall cost of the transfer pipeline and pumping stations. Additional costs will be incurred in the event of modifications to the catchment to allow flows to be sent to Tangmere instead of Chichester.
3. The total proportion of the possible 3,000 dwelling capacity shortfall that requires treatment at either Tangmere or Chichester and is not instead developed elsewhere in the district and treated at one of the other wastewater treatment sites.

These uncertainties will remain as major project risks and as such will be discussed in more detail in section 4.1.6.

To allow for the design of the upgrade to Tangmere, a future consent based on the increase in DWF flow, together with anticipated loadings at the 2026 design horizon have been assumed based on the flow and population figures tabulated below:

Table 12 – Future Design Criteria for Tangmere Site Upgrade

Key Design Parameters				
Total Adopted Population (hd)	12,966			
Dry Weather Flow (m^3/day)	3,000			
Flow to full treatment (m^3/day)	7,615			
Determinand WRA conditions				
	Summer Consents		**Winter Consents**	
	95%ile	Upper Tier	95%ile	Upper Tier
Suspended solids (mg/l)	10	-	15	-
BOD (mg/l)	5	20	10	28
Ammonia as N (mg/l)	1.5	10	2.5	10
Total Phosphorus Annual Average (mg/l)	1	-	1	-
Total Iron (mg/l)	-	3	-	3
Total N (mg/l)	-	-	-	-

The site would also be subject to UWWT regulatory treatment requirements.

The current works at Tangmere is identified as being under-sized to treat the anticipated flows, under-sized to treat the anticipated pollutant loads and under-specified in the current configuration to achieve the anticipated required future pollutant consents.

4.1.3. Scope

To achieve the low ammonia concentration and stringent 95 percentile summer BOD consent, it would be necessary to either convert the works to a two stage filtration arrangement with tertiary deep bed sand filtration or to replace the filter works with an oxidation ditch system with tertiary deep bed sand filtration. Two stage filtration would require a large number of additional filters to provide sufficient capacity in each stage and additional PST volume. The oxidation ditch design would negate the requirement for primary settlement and allow these tank volumes to be re-used as storm capacity and would be recommended as the more robust solution.

The scope of works at Tangmere treatment works is therefore comprised as follows:

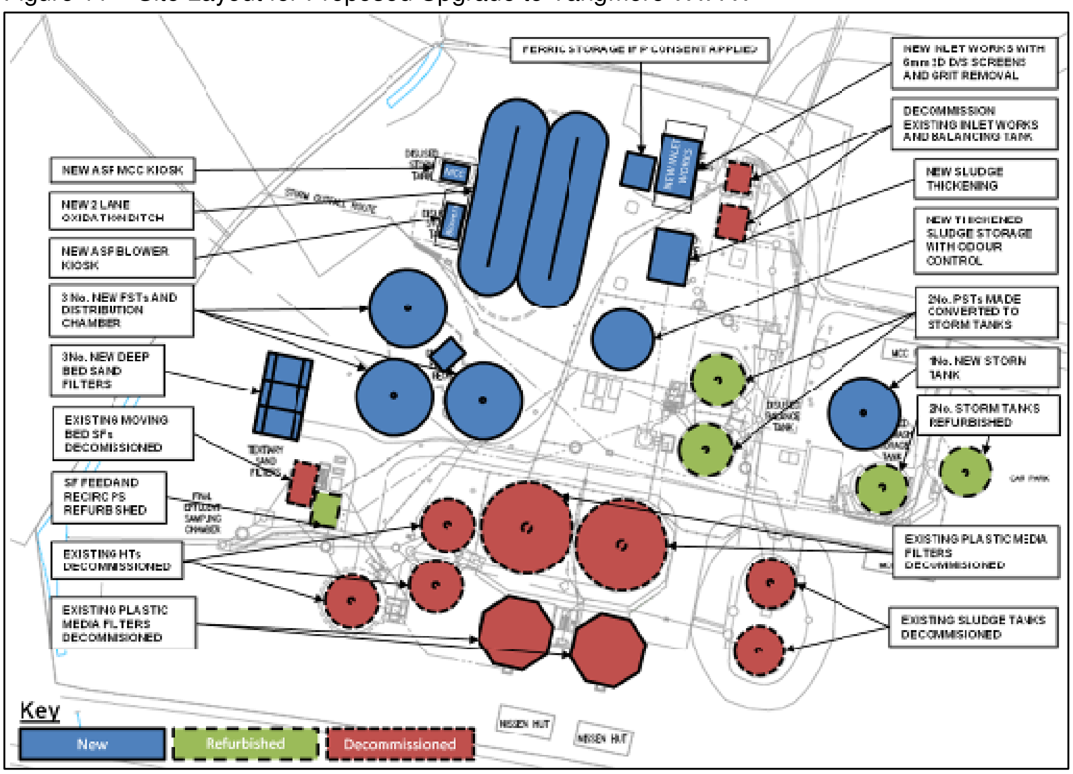
Table 13 – Scope of Works for Proposed Tangmere Site Upgrade

Item Summary	Notes
Replace Inlet Works, Screens and Screenings Handling	New Civil Inlet Works, install 2No. D/S 6mm 2D Screens, each capable of screening flows to 100 l/s with bypass, install 2No. D/S Washers/De-waterers, provide 1No. Covered Skip Bay
Provide New Grit Removal Stage	Provide 1No. Cross Flow Detritor with Bypass including 1No. Grit Classifier and 1No. Covered Skip Bay
Replace Inlet Flow Measurement	Provide 1No. Flow Measurement Channel and ultrasonic level measurement or 1No. Magflow
Install Ferric Dosing (Dependent on introduction of future P consent)	Ferric Storage Tank with 30.8 m3 working volume and Chemical Reception Point, D/S Ferric Dosing Pumps (Max 0.6 l/min) and an Air Curtain Mixing Point (400 W/m3).
Decommission Existing Inlet Works	Make existing inlet works and balancing tank safe
Refurbish Storm Tanks	Minor Tank Repairs, Refurbish Bridge drives, Set Storm Control Philosophy
Convert Existing PSTs to Storm Tanks	Minor Civil Tank Repairs, Convert Tanks to Storm Storage including adding Mixing System, Integrate with existing storm storage
Construct 1No. New Storm Tank	1No. New Tank, 12.6 m diameter, 2.4m deep (300 m3), Integrate with existing storm storage, Install mixing system
Demolish Already Redundant Filter Beds	Demolish Disused Filter Beds, Level ground for construction
Install 2 Lane Oxidation Ditch ASP	Construct 2No. Oxidation Ditch Lanes, base Slab, reinforced walls and inner baffle wall, 2No. Butterfly Mixers per lane, D/D/S Blowers 2,600 Nm3 air / hour each, 1725No. Fine Bubble Membrane Diffusers, ASP Kiosk and Blower PLC
Install 3No. Final Settlement Tanks	3No. Final Settlement Tanks (13.6 m Diameter) and Distribution Chamber, Half bridge scrapers with scum removal systems and provision for RAS recycle
Install RAS Pumping Station	RAS Return PS Civil Construct, RAS Return Pumps (175 m3/hr) and Facility to SAS from RAS Line

Install SAS Pumping Station	SAS PS Civil Construct, SAS Pumps (25 m3/hr), 8 hour operation per day
Install Sludge Thickening	2No. Drum Thickeners, 2No. Poly-Dosing Rigs supplied with make-up water supply
Install New Sludge Storage Facility	1No. New Tank (225 m3) with decant facility, Odour Control System, Tanker Reception Point
Install New Deep Bed Sand Filters	3No. Cells (2.5 m by 7m by 2m deep), Backwash Tank and Pumps
Convert Sand Filter Feed Pumping Station	Convert Current SF Feed PS to Feed New Deep Bed Sand Filters, D/S or D/A/S VSD pumps to new SFs, 100 l/s max combined flow
Make Existing Works Redundant	Make Plastic Media Filters Redundant, Make Mineral Media Filters Redundant, Make Humus Tanks Redundant, Make Existing Sludge Tanks Redundant, Make Moving Bed Sand Filters Redundant
Additional Site Requirements	To include upgrade of washwater system, footpaths, lighting and landscaping
Site Power Upgrade	Upgrade of Power Supply to Works

The proposed upgrade to the works is shown on the site layout drawing below, a full size version of which is available in Appendix A:

Figure 11 – Site Layout for Proposed Upgrade to Tangmere WwTW



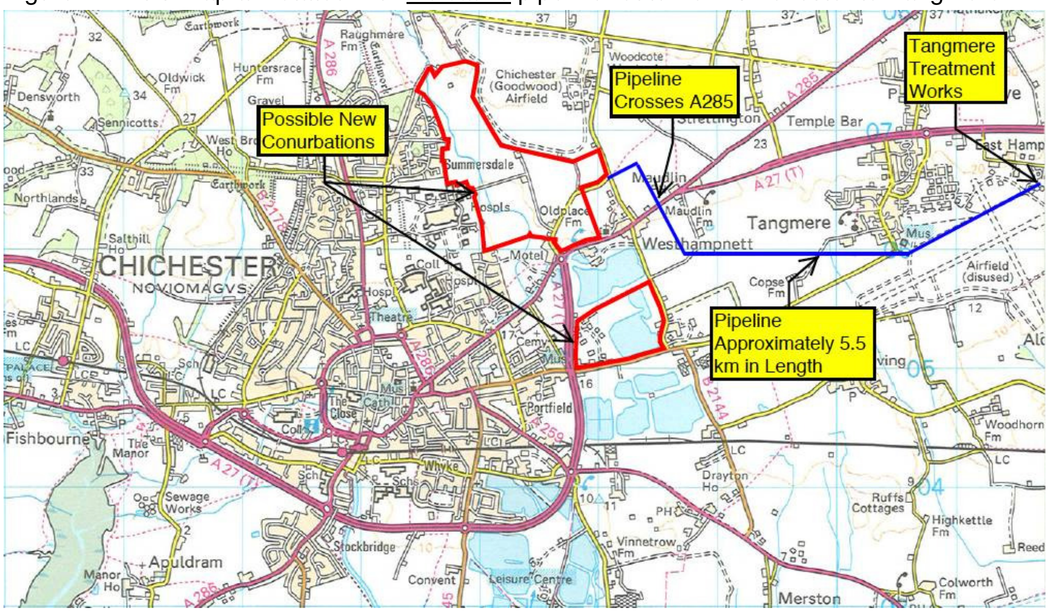
In addition, the scope for transferring flows to Tangmere is as follows:

Table 14 – Scope of Works for Proposed Transfer of Flows to Tangmere

Item Summary	Notes
Wet Well Pumping Station	4m ID 4m deep precast concrete wet well
Pipeline	5.5 km 400mm diameter PE mains. Laid entirely in fields, Allowance for Crossing A27 (directional drill), Allowance for crossing 6 no. B-roads / tracks and crossing one watercourse.

A theoretical transfer route is indicated on the OS map extract below:

Figure 12 – OS map annotated with indicative pipeline route from Chichester to Tangmere



4.1.4. Costs

The CAPEX cost of constructing the upgrade to Tangmere works, assuming flows are transferred from Chichester and the future requirement to meet a Phosphorus consent, is estimated via a high level top down appraisal at £10.75 Million. The total CAPEX spend associated with providing Ferric Dosing was assessed as £484,000 whilst the CAPEX costs associated with transferring flows across from Chichester was £2.26 Million. These can therefore been seen as possible reductions to the initial scheme cost, depending on the final scheme requirements and where development actually takes place. The CAPEX, OPEX and Whole Life Cost assessments (60 years, 6%) for the full scheme, Phosphorus Consent Requirements and Transfer part of the solution are presented in Table 15

Table 15 – Summary of Estimated Costs for upgrading Tangmere WwTW

	Solution Information		
	Full Scheme	**Phosphorus Related Scheme Elements**	**Flow Transfer Related Scheme Elements**
CAPEX	£10,754,000	£484,000	£2,259,000
Annual OPEX Increase	£80,000	£48,800	£6,300
WLC	£13,961,000	£1,383,000	£2,476,000

It should be noted that the current solution does not include for costs associated with altering the existing catchment to divert flows away from Chichester. Should it not prove feasible to simply transfer flow from new build developments, a significant network modelling exercise would be required to make a full appraisal of the extent to which flows from the current catchment would need to be diverted and the optimal interface points in the current network.

4.1.5. Environmental Impacts

Effluent flows to the Aldingbourne Rife would increase, however load standstill or tightening would be applied to minimise the impact on the watercourse. The only additional effluent load would result from the dosing of a ferric solution to perform Phosphorus removal. Modelling would be required to ensure the effluent iron upper tier consent applied was set to an appropriate value so as not to cause deterioration to the water course. The deep bed sand filters included in the scope would be particularly effective at removing any residual iron before the effluent was discharged so this is not anticipated to be an issue.

The site is positioned over one major aquifer and one minor one and this must be given consideration during design and construction. Reptile and Badger studies have been identified as requirements, prior to commencing construction.

The site power usage will increase as part of the scheme with the blowers used to aerate the oxidation ditch consuming a considerable proportion of the sites energy. In addition to these site based environmental impacts, the pipeline and transfer of flows would have the following construction / environmental implications:

- There is one watercourse to be crossed
- There are 7No. roads / tracks to be crossed, including 1No. A Road.
- Pipeline route crosses and old airfield (Unknown). The potential exists for contaminated land and archaeological/heritage issues, e.g. full watching briefs during construction.
- West end of the pipe is near to a registered park and garden which should not be affected by the works.

The length of the pipeline would also require an EIA being carried out. A heritage and landscape constraint map of the area the pipeline would transverse can be found in Appendix B.

The increase in carbon footprint for Tangmere WwTW by the implementation of this solution is assessed to be moderate to high. The significant civil changes to the works and construction of the pipeline would represent high embodied carbon costs. The conversion of the works to an activated sludge plant would lead to an increase in carbon emissions as a result of the more energy intensive nature of activated sludge treatment. The additional population treated by the works would also increase energy usage. The current works at Tangmere is relatively energy intensive for a filter works due to the significant interstage pumping requirements to pass flows through the works. Therefore, although the activated sludge works design would increase the energy usage at the site and therefore operational carbon emissions, the increase in operational carbon emissions would be less significant than if Tangmere was a more traditional gravity fed trickling filter works. Additional operational carbon cost will be incurred from the dosing of Ferric at the works should a new P consent be introduced.

4.1.6. Key Risks

There are a number of factors that have been identified that may have serious impacts on whether the proposed scheme at Tangmere remains a viable solution to the problem identified:

As of December 2009, there is no clear policy regarding the requirement under the Water Framework Directive for no deterioration with regards to Phosphorus effluent loads. There are a number of possible scenarios that might be anticipated:

1. Increased volume loading from new development resulting in no deterioration out of the current WFD class without P removal (if there is currently no P removal)
2. Increased volume loading from new development resulting in no deterioration out of the current WFD class with P removal to 1mg/l
3. Volumetric limit set with P removal to 1 mg/l and classification WFD "good status".

Scenario 1 would not impose a set limit on the DWF Phosphorus load discharged from the works. It therefore would allow the application of load standstill to the other pollutants such that DWF flow could be increased sufficiently to provide adequate additional treatment capacity.

Scenario 2 would prevent increase in the DWF Phosphorus load leaving the works above current levels. It would therefore allow for DWF flow to be increased sufficiently to provide adequate additional treatment capacity, assuming the current works is not already producing an effluent with a phosphorus concentration of less than approximately 2 mg/l. Such a low level in the dry weather flow effluent of a works is highly unlikely without a designated treatment process designed to remove Phosphorus, which Tangmere does not have.

Scenario 3, requiring the river quality class to be raised to "good" status would require a reduction in Phosphorus load being discharged from the works. Should the load reduction required be significant then this could well prevent flows being increased sufficiently to provide adequate additional treatment. This is because it would not be possible to guarantee reduction of the final effluent Phosphorus concentration below the BAT limit of 1 mg/l. Delivering the scheme would therefore not be capable of providing the required treatment capacity increase in its entirety if a concentration below this level is necessary to deliver the new target DWF effluent load at the new required DWF flow rate.

Thus if the final EA policy reflects scenario 3 it is likely that raising the river quality status to "good" since it is currently rated as "bad" may well limit any increase in capacity at Tangmere and prevent sufficient increase in capacity to alleviate the headroom deficit from upgrade to Tangmere works alone.

The Aldingbourne Rife into which Tangmere WwTW discharges is an additional source of risk to the project. The capacity of the river is limited and at times carries very little flow. Under low flow conditions, minimal dilution of works effluent may occur after flow passes into the river and thus the river water pollutant concentration would remain relatively high and thus realizing a very poor overall standard of quality.

Under high flow conditions, additional effluent flow from the works may lead to surcharging in the river and localised flooding downstream of the works. Although this is not commonly considered by the EA when proposing new consents, it has been identified as an issue at Tangmere and as such, could influence future consenting arrangements at the works. Mitigation measures such as flood compensation areas could be applied to alleviate this issue, however they would further increase the scope and cost of the upgrade.

4.2. Option 2: Lavant WwTW Treatment Options

4.2.1. Current Works

Lavant is a mineral media percolating filter works which currently serves a population equivalent of 2,465 residents.

Flow arrives at Lavant WwTW and passes via 1No. 6mm 2D screen and balancing tank to treatment. Flows greater than the consented FFT are separated and sent to storm storage and returned during periods of lower flow. Storm tank overflow currently over-spills to reed beds for treatment prior to discharging into the river Lavant.

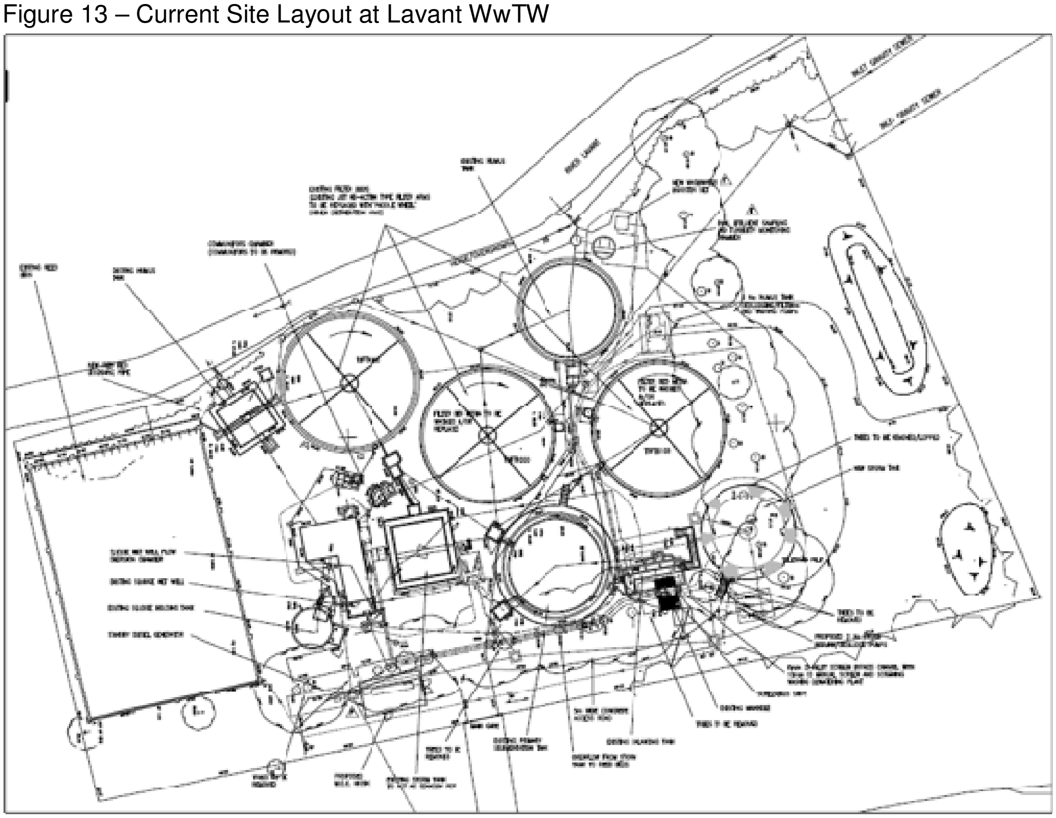
Primary settlement is undertaken in 1No. radial PST. Settled sewage then passes, via a copa sac chamber to a distribution chamber where it is fed to 3No. Mineral Media Tickling Filters for biological treatment.

Trickling Filter Effluent is then settled in 1No. radial Humus Tank prior and is discharged into the River Lavant via a final effluent sampling chamber.

Humus sludge is returned to the head of the PSTs and cosettled. Sludge is stored in 1No. un-mixed storage tank and tankered off-site periodically for further treatment.

The current works is shown on the site layout drawing below:

Figure 13 – Current Site Layout at Lavant WwTW



4.2.2. Site Upgrade Considerations

Since Lavant WwTW does not fall into the southern part of the district, construction around the current Lavant catchment would not count towards reducing the housing deficit in the south of the district. The position of the South Downs National Park also complicates any additional development at Lavant.

This constrains the use of Lavant WwTW to treating flows from a new conurbation in the south of the district that would then be transferred North to Lavant or diverting flows from the North part of Chichester catchment to Lavant for further treatment. Diverting flows would reduce the overall flows to Chichester works and allow for development elsewhere around the Chichester catchment.

Significant variations to the requirements for the **overall** design may occur from two main areas:

1. Whether the future revised consent for Lavant is reasonably aligned with that used for design, particularly if and how any future introduction of a Phosphorus consent to the works is handled.

2. The total proportion of the possible 3,000 dwelling capacity shortfall that requires treatment at either Lavant or Chichester and is not instead developed elsewhere in the district and treated at one of the other wastewater treatment sites.

These uncertainties will remain as major project risks and as such will be discussed in more detail in section 4.2.6.

To allow for the design of the upgrade to Lavant, a future consent based on the increase in DWF flow, together with anticipated loadings at the 2026 design horizon have been assumed based on the flow and population figures tabulated below:

Table 16 – Future Design Criteria for Lavant Site Upgrade

Key Design Parameters				
Total Adopted Population (hd)	9,651			
Dry Weather Flow (m^3/day)	2,882			
Flow to full treatment (m^3/day)	6,057			
Determinand WRA conditions				
	Summer Consents		**Winter Consents**	
	95%ile	Upper Tier	95%ile	Upper Tier
Suspended solids (mg/l)	16	-	16	-
BOD (mg/l)	8	20	8	20
Ammonia as N (mg/l)	2	6	2	6
Total Phosphorus Annual Average (mg/l)	1	-	1	-
Total Iron (mg/l)	-	3	-	3
Total N (mg/l)	-	-	-	-

The site would also be subject to UWWT regulatory treatment requirements.

The current works at Lavant is identified as being under-sized to treat the anticipated flows, under-sized to treat the anticipated pollutant loads and under-specified in the current configuration to achieve the anticipated required future pollutant consents.

4.2.3. Scope

To achieve the low ammonia concentration and stringent 95%ile summer BOD consent, it would be necessary to either convert the works to a two stage filtration arrangement with tertiary deep bed sand filtration or to replace the filter works with an oxidation ditch system with tertiary deep bed sand filtration. The current site at Lavant has limited additional space, favouring a more intensive treatment solution, constructing sufficient additional primary filter volume, interstage HTs and secondary trickling filters would require more land than is currently available for construction. The oxidation ditch design would negate the requirement for primary settlement and allow these civil structures to be re-used as storm capacity. Upgrading the works to an oxidation ditch design is therefore the recommended proposed design for upgrading Lavant works.

The scope of works at Lavant treatment works is therefore comprised as follows:

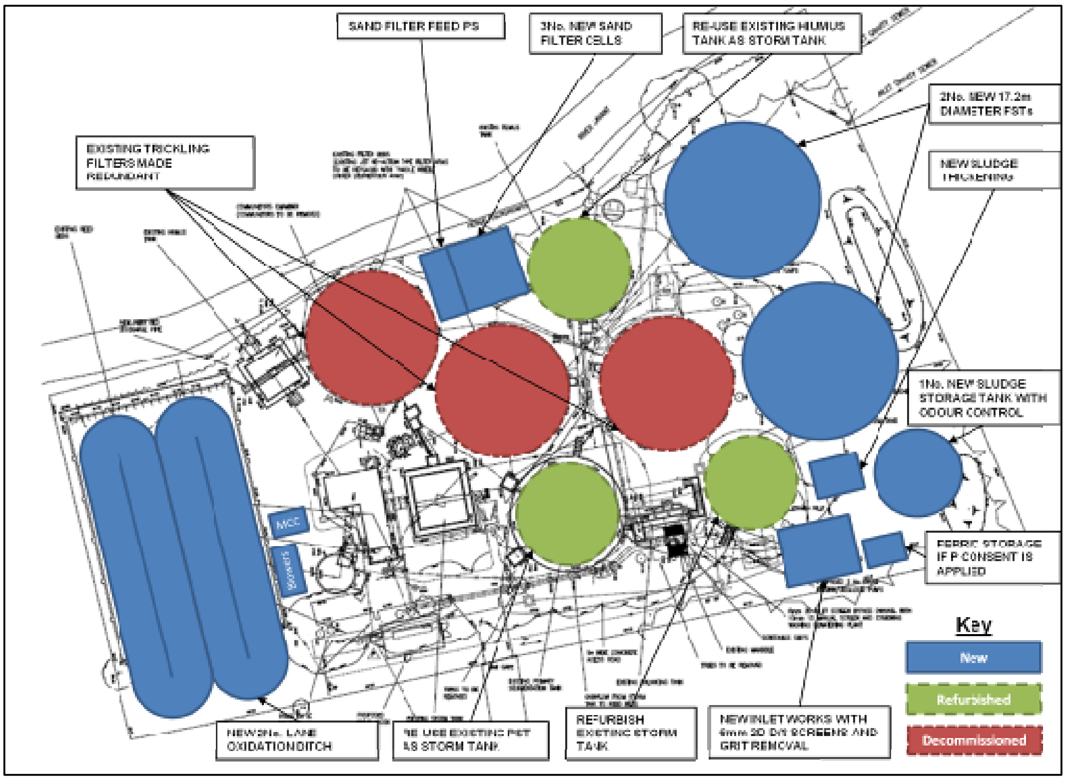
Table 17 – Scope of Works for Proposed Lavant Site Upgrade

Item Summary	Notes
Replace Inlet Works, Screens and Screenings Handling	New Civil Inlet Works, install 2No. D/S 6mm 2D Screens, each capable of screening flows to 80 l/s with bypass, install 2No. D/S Washers/De-waterers, provide 1No. Covered Skip Bay
Provide New Grit Removal Stage	Provide 1No. Cross Flow Detritor with Bypass including 1No. Grit Classifier and 1No. Covered Skip Bay
Replace Inlet Flow Measurement	Provide 1No. Flow Measurement Channel and ultrasonic level measurement or 1No. Magflow
Install Ferric Dosing (Dependent on introduction of future P consent)	Ferric Storage Tank with 28.3 m3 working volume and Chemical Reception Point, D/S Ferric Dosing Pumps (Max 0.5 l/min) and an Air Curtain Mixing Point (400 W/m3).
Decommission Existing Inlet Works	Make existing inlet works
Refurbish Storm Tanks	Minor Tank Repairs, Refurbish mixing systems, Set Storm Control Philosophy
Convert Existing PST to Storm Tank	Minor Civil Tank Repairs, Convert Tanks to Storm Storage including adding Mixing System, Integrate with existing storm storage
Convert Existing Radial HT to Storm Tank	Minor Civil Tank Repairs, Convert Tanks to Storm Storage including adding Mixing System, Integrate with existing storm storage
Construct 1No. New Storm Tank	1No. New Tank, 12.6 m diameter, 2.4m deep (300 m3), Integrate with existing storm storage, Install mixing system
Make Reed Bed System Redundant	Decommission Reed Beds and Remove Contaminated Material to allow for Construction of Base for New Oxidation Ditch System
Install 2 Lane Oxidation Ditch ASP	Construct 2No. Oxidation Ditch Lanes, base Slab, reinforced walls and inner baffle wall, 2No. Butterfly Mixers per lane, D/D/S Blowers 1,925 Nm3 air / hour each, 1,285 No. Fine Bubble Membrane Diffusers, ASP Kiosk and Blower PLC
Install 3No. Final Settlement Tanks	3No. Final Settlement Tanks (17.2 m Diameter) and Distribution Chamber, Half bridge scrapers with scum removal systems and provision for RAS recycle
Install RAS Pumping Station	RAS Return PS Civil Construct, RAS Return Pumps (140 m3/hr) and Facility to SAS from RAS Line
Install SAS Pumping Station	SAS PS Civil Construct, SAS Pumps (20 m3/hr), 8 hour operation per day
Install Sludge	2No. Drum Thickeners, 2No. Poly-Dosing Rigs supplied with

Thickening	make-up water supply
Install New Sludge Storage Facility	1No. New Tank (167 m3) with decant facility, Odour Control System, Tanker Reception Point
Install New Deep Bed Sand Filters	3No. Cells (2m by 6.95m by 2m deep), Backwash Tank and Pumps
Install New Sand Filter Feed Pumping Station	Construct new Feed PS Tank (92.5 m3 working volume), D/S or D/A/S VSD pumps to new SFs, 80 l/s max combined flow.
Make Mineral Media Filters Redundant	Make Mineral Media Filters Redundant, Isolate and Make Safe
Additional Site Requirements	To include upgrade of washwater system, footpaths, lighting and landscaping
Site Power Upgrade	Upgrade of Power Supply to Works

The proposed upgrade to the works is shown on the site layout drawing below, a full size version of which is available in Appendix C:

Figure 14 – Site Layout for Proposed Upgrade to Lavant WwTW



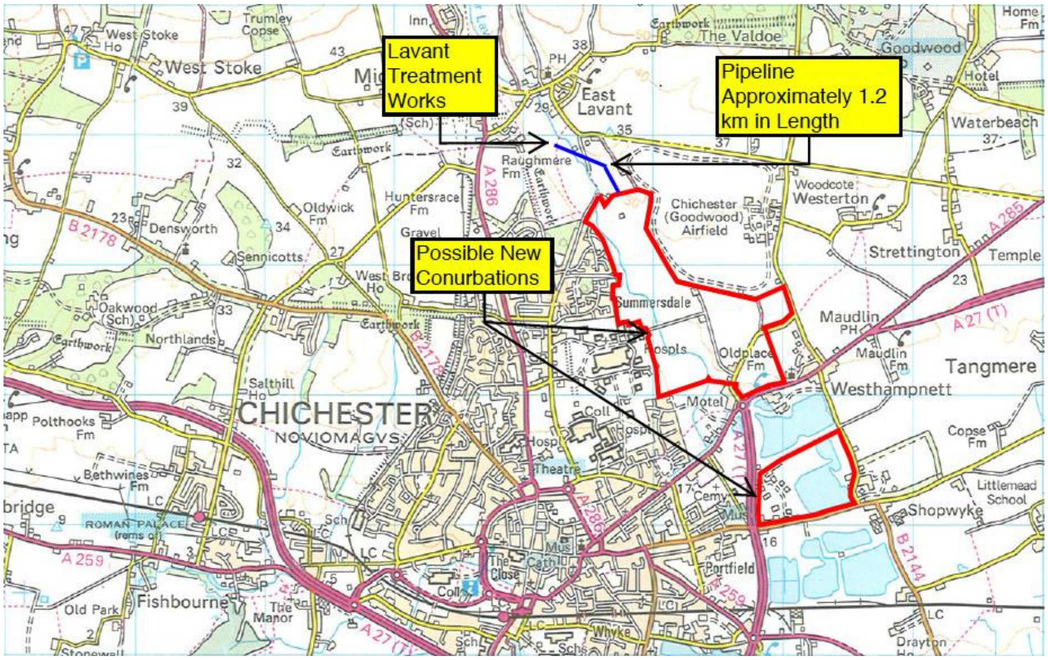
In addition, the scope for transferring flows to Lavant is as follows:

Table 18 – Scope of Works for Proposed Transfer of Flows to Lavant

Item Summary	**Notes**
Wet Well Pumping Station	3m ID 4m deep precast concrete wet well
Pipeline	1.7 km 350mm diameter PE mains. Laid entirely in fields, No road or track crossings required

The transfer route is indicated on the OS map extract below:

Figure 15 – OS map annotated with indicative pipeline route from North Chichester to Lavant



4.2.4. Costs

The CAPEX cost of constructing the upgrade to Lavant works, assuming that the future consent applied to the works contains the requirement to treat Phosphorus, is estimated at approximately £10.57 Million. The total CAPEX spend associated with installing Ferric Dosing is estimated at £604,000 and the cost of building the flow transfer pipeline and pumping station from the north of the Chichester catchment to Lavant WwTW as £598,000. Although the transfer cost is a certain requirement since flow must be transferred from the Chichester catchment for the scheme to work, the Phosphorus treatment element however can be seen as a possible reduction to the total scheme cost should the final consent issued to the works, not specify an effluent Phosphorus standard. The CAPEX, OPEX and Whole Life Cost assessments (60 years, 6%) for the full scheme, Phosphorus treatment part and transfer part of the solution are presented in Table 19.

Table 19 – Summary of Estimated Costs for upgrading Lavant WwTW

	Solution Information		
	Full Scheme	**Phosphorus Related Scheme Elements**	**Flow Transfer Related Scheme Elements**
CAPEX	£10,568,000	£604,000	£598,000
Annual OPEX Increase	£111,500	£36,300	£4,700
WLC	£14,767,000	£1,340,000	£715,000

It should be noted that the current solution does not include for costs associated with altering the existing catchment to divert flows away from Chichester. Note, the high predicted CAPEX cost is due to increased costs relating to lack of construction space on site and poor ground conditions which will both be expected to significantly delay and complicate construction at significant additional cost.

4.2.5. Environmental Impacts

Effluent flows to the River Lavant would increase, however load standstill or tightening would be applied to minimise the impact on the watercourse. The only additional effluent load would result from the dosing of a ferric solution to perform Phosphorus removal. Modelling would be required to ensure the effluent iron upper tier consent applied was set to an appropriate value so as not to cause deterioration to the water course. The deep bed sand filters included in the scope would be particularly effective at removing any residual iron before the effluent was discharged so this is not anticipated to be an issue.

The site is subject to extremely high infiltration and as such, can receive flows greater than the current works consented Full Flow to Treatment (FFT), for significant quantities of the year. The current works discharges storm flows from the works via a reed bed system, however to allow sufficient space on the current works it would be necessary to decommission this system to provide the area required for construction of the new Activated Sludge Plant (ASP). The benefit added by passing storm flows to discharge via the current reed bed system needs to be studied in order to determine if decommissioning is appropriate. Reptile and Badger studies have been identified as requirements, prior to commencing construction.

The site power usage will increase as part of the scheme with the blowers used to aerate the oxidation ditch consuming a considerable proportion of the sites energy. In addition to these site based environmental impacts, the pipeline route runs close to Goodwood motor racing circuit and the newly designated South Downs National Park and a Registered Park and Garden. None of these designations should be affected by the proposed pipeline however there are a number of residential properties along the route which potentially may be sensitive to any construction activities. A heritage and landscape constraint map of the area the pipeline would transverse can be found in Appendix B.

The increase in carbon footprint for Lavant WwTW by the implementation of this solution is assessed to be high. The significant civil changes to the works and construction of the pipeline would represent high new embodied carbon costs. The conversion of the works to an activated sludge plant would lead to an increase in carbon emissions as a result of the more energy intensive nature of activated sludge treatment. The additional population treated by the works would also increase energy usage. The current works at Lavant uses mineral media trickling filters which are hydraulically driven and so once flow has been raised to the distribution arms, do not require energy to operate. The increase in operational carbon emissions would therefore be significant, especially with the lack of space on site necessitating interstage pumping to move flows from one process across site to another, rather than being able to rely on gravity. Additional operational carbon cost will be incurred from the dosing of Ferric at the works should a new P consent be introduced.

4.2.6. Key Risks

There are a number of factors that have been identified that may have serious impacts on whether the proposed scheme at Lavant remains a viable solution to the problem identified:

As of December 2009, there is no clear policy regarding the requirement under the Water Framework Directive for no deterioration with regards to Phosphorus effluent loads. There are a number of possible scenarios that might be anticipated:

1. Increased volume loading from new development resulting in no deterioration out of the current WFD class without P removal (since there is currently no P removal)

2. Increased volume loading from new development resulting in no deterioration out of the current WFD class with P removal to 1mg/l

3. Volumetric limit set with P removal to 1 mg/l and classification WFD "good status".

The uncertainty around which scenario may be adopted leads to a degree of uncertainty around the level to which the policy may allow the application of load standstill to be applied.

Scenario 1 would not impose a set limit on the DWF Phosphorus load discharged from the works. It therefore would allow the application of load standstill to the other pollutants such that DWF flow could be increased sufficiently to provide adequate additional treatment capacity.

Scenario 2 would prevent increase in the DWF Phosphorus load leaving the works above current levels. It would therefore allow for DWF flow to be increased sufficiently to provide adequate additional treatment capacity, assuming the current works is not already producing an effluent with a phosphorus concentration of less than approximately 2 mg/l. Such a low level in the dry weather flow effluent of a works is highly unlikely without a designated treatment process designed to remove Phosphorus, which Lavant does not have.

Scenario 3, requiring the river quality class to be raised to “good” status would require a reduction in Phosphorus load being discharged from the works. Should the load reduction required be significant then this could well prevent flows being increased sufficiently to provide adequate additional treatment. This is because it would not be possible to guarantee reduction of the final effluent Phosphorus concentration below the BAT limit of 1 mg/l. Delivering the scheme would therefore not be capable of providing the required treatment capacity increase in its entirety if a concentration below this level is necessary to deliver the new target DWF effluent load at the new required DWF flow rate.

Thus if the final EA policy reflects scenario 3 it may well limit any increase in capacity at Lavant and prevent sufficient increase in capacity to alleviate the headroom deficit from upgrade to Lavant works alone.

The River Lavant, into which Lavant WwTW discharges, is the basis of a key risk to viability of the project. The river frequently contains little flow in addition to that of the works effluent. Under low flow conditions, minimal dilution of works effluent may occur after flow passes into the river. This could result in Phosphorus levels at a downstream monitoring point being recorded that indicate a deterioration in WFD water quality status, despite the works effluent already being treated to the 1 mg/l BAT limit. This would prevent flows from being increased to the degree necessary for this scheme to prove to be a viable solution.

The River Lavant discharges into the Chichester Channel and therefore, any load from this works could potentially increase the overall nutrient loading into the harbour. There will be a significant proportion of natural assimilation of any effluent pollutant loads along the length of the river Lavant, prior to flows passing out into the harbour, however the exact reduction that may be achieved and therefore the additional load entering the Chichester Channel via this route is difficult to predict. In addition, there is a possibility that since the River Lavant ultimately runs into Chichester channel; the works may receive a Total N consent in AMP6 or beyond. This may also prevent flows from the works from being increased to the level required for the solution to be viable.

The current upgrade to the works relies on freeing up area for construction by decommissioning the existing reed bed system and providing area to construct the new ASP. The current works storm consent mentions the reed bed system by name when describing the works storm consent and thus removing it requires consultation with the EA. Should it be not be deemed possible to discharge storm flows directly to the river, the scheme may require a compulsory land purchase order to free up space for construction which would significantly increase the time to completion of the project, as well as the associated cost implications.

The very limited space on site remains a construction risk, the reduced working area has the effect of increasing construction costs due to the difficulties of working in conditions with poor access and the additional temporary equipment required (such as over-pumping) at stages of complex construction overlapping with existing assets. In addition the water table at Lavant is particularly high and therefore poor ground conditions are to be expected. This further complicates and elongates the construction process at may lead to significant cost increases through delays in the program. Any contaminated land, especially from decommissioning the reed beds, is likely to require disposal off-site since there is little space and therefore opportunity to re-use any excavated material around the site itself.

From a constructability standpoint, the PST and radial HT tanks are intended to be re-used as part of storm storage volume. Should either or both of the tanks be unsuitable for further use, it would be necessary to construct a new storm tank to provide sufficient storage volume to meet consent. The volume of the existing storm tank is also unknown. Should it be significantly under-sized for current storm storage requirements, constructing a new storm storage tank may be necessary. If however it is over-sized, it may provide sufficient volume that only the PST needs converting to provide the additional required volume, negating the requirement to refurbish the Humus Tank and offering a potential saving.

4.3. Option 3: Chichester Long Sea Outfall Option

4.3.1. Current Works

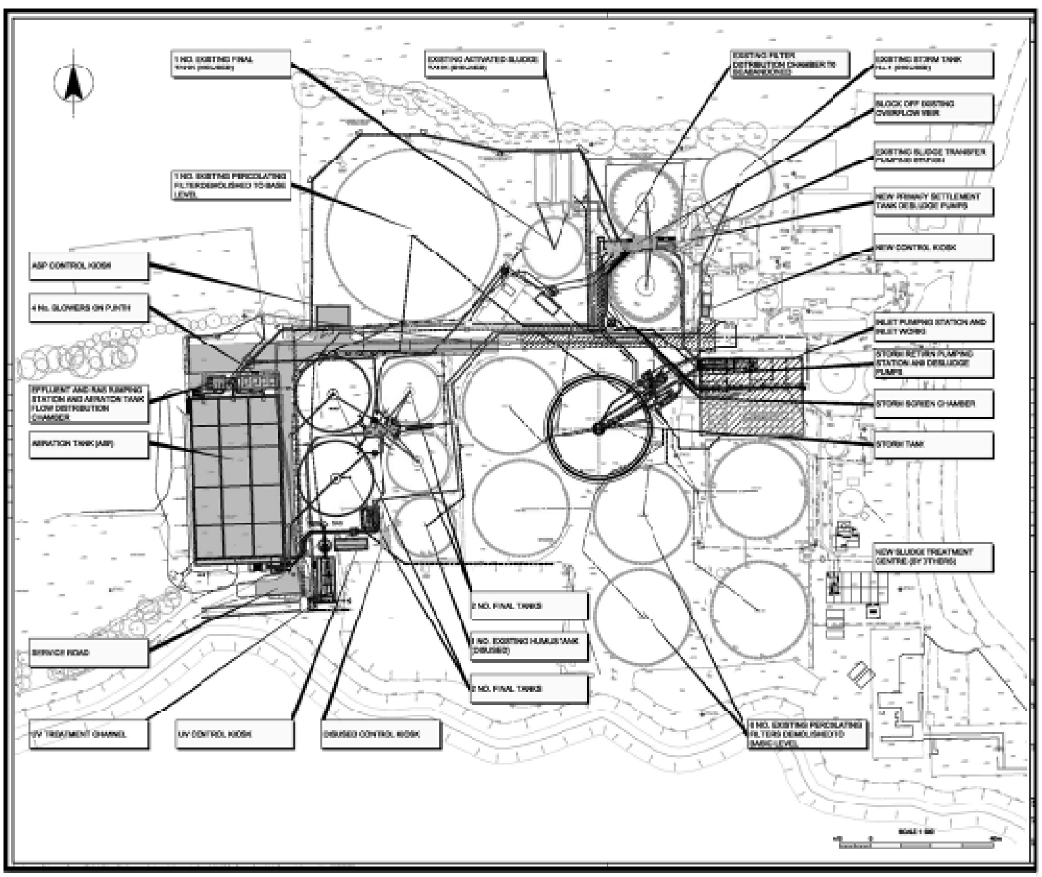
Chichester wastewater treatment works is currently a Modified Ludzack-Ettinger (MLE) works with tertiary UV treatment requirements. The site has a cess reception centre and it is an intermediate sludge treatment centre which only treats indigenous sludge. The works currently serves a population equivalent of approximately 35,609 residents.

Currently all crude sewage including cess and storm flows are screened via 6mm screens and de-gritted via a detritor. The treatment of full flow to treatment consists of two circular primary tanks, anoxic and aeration zones with four final settlement tanks. Final effluent then passes through ultra violet treatment channels for disinfection prior to discharge to outfall. Storm flow is settled via one storm tank, and screened prior to discharge to outfall.

Surplus activated sludge from the aeration lanes is mixed with polymer and thickened in drum thickeners prior to store in sludge holding tanks. Primary sludge is directly transferred to sludge holding tanks. The combined sludge is mixed with polymer and dewatered by centrifuge. The treated sludge is then removed from site as sludge cake for further disposal.

The current works is shown on the site layout drawing below:

Figure 16 – Current Site Layout at Chichester WwTW



4.3.2. Site Upgrade Considerations

Development around the current catchment at Chichester is desirable for future housing development as set out in the SE Plan and other government policy objectives, building in the most sustainable locations. Although the assessment here will centre on the capacity at the existing works at Chichester, network issues within the existing catchment may also impact on where best to place future developments. A network modelling study would be required to identify any hydraulic bottlenecks in the current system that should be avoided. For design purposes here it will be assumed that the current catchment would be sufficient to pass all flows to the existing works effectively, without modifications to the network itself.

Significant variations to the requirements for the **overall** design may occur from two main areas:

1. The exact change possible to the current consent structure and parameters by the installation of a Long Sea Outfall (LSO).
2. The total proportion of the possible 3,000 dwelling capacity shortfall that is constructed around Chichester and is not instead developed elsewhere in the district and treated at one of the other wastewater treatment sites.

These uncertainties will remain as major project risks and as such will be discussed in more detail in section 4.3.6.

To allow for the design of the upgrade to Chichester, a future consent based on the increase in DWF flow, together with anticipated changes in consent from the design of a suitable long sea outfall discharge pipeline and loadings from the 2026 design horizon have been assumed based on the flow and population figures tabulated below:

Table 20 – Future Design Criteria for Chichester LSO Site Upgrade

Key Design Parameters				
Total Adopted Population (hd)	47,563			
Dry Weather Flow (m^3/day)	15,262			
Flow to full treatment (m^3/day)	31,253			
Determinand WRA conditions				
	Summer Consents		**Winter Consents**	
	95%ile	Upper Tier	95%ile	Upper Tier
Suspended solids (mg/l)	41	-	41	-
BOD (mg/l)	32	63	32	63
Ammonia as N (mg/l)	-	-	-	-
Total Phosphorus Annual Average (mg/l)	-	-	-	-
Total Iron (mg/l)	-	-	-	-
Total N (mg/l)	-	-	-	-

The site would also be subject to UWWT regulatory treatment requirements and retain the current effluent UV treatment requirement driven by the bathing water directive.

The current works at Chichester is identified as being under-sized to treat the anticipated flows, particularly the current inlet works is at its limit hydraulically. The current configuration treating to a Total N of 9mg/l means that the current ASP structure would actually be significantly over-sized with regards to moving to treat to a BOD/SS consent only with no stipulated ammonia removal requirement.

4.3.3. Scope

To achieve the new consent without Total N requirements, it would be necessary to modify the existing ASP and reduce the aeration volume whilst down-sizing the blowers and associated aeration equipment. The inlet works is not suitable for any further increase in flows and therefore requires replacement. Additional PST volume would be beneficial to operation and will be provided. Further final settlement capacity is not identified as necessary. The additional sludge production would require increasing the on-site thickening and dewatering capacity.

The long sea outfall itself would consist of an on-site pumping station sized to pump the flows along the length of the onshore pipeline and out to sea without the requirement for an interstage pumping station. The pipeline itself would run to the coastline, south of Chichester. It would be desirable to run the outfall out down a steep incline in sea bed to minimise the length of the LSO due to the significant unit cost per length of marine outfalls.

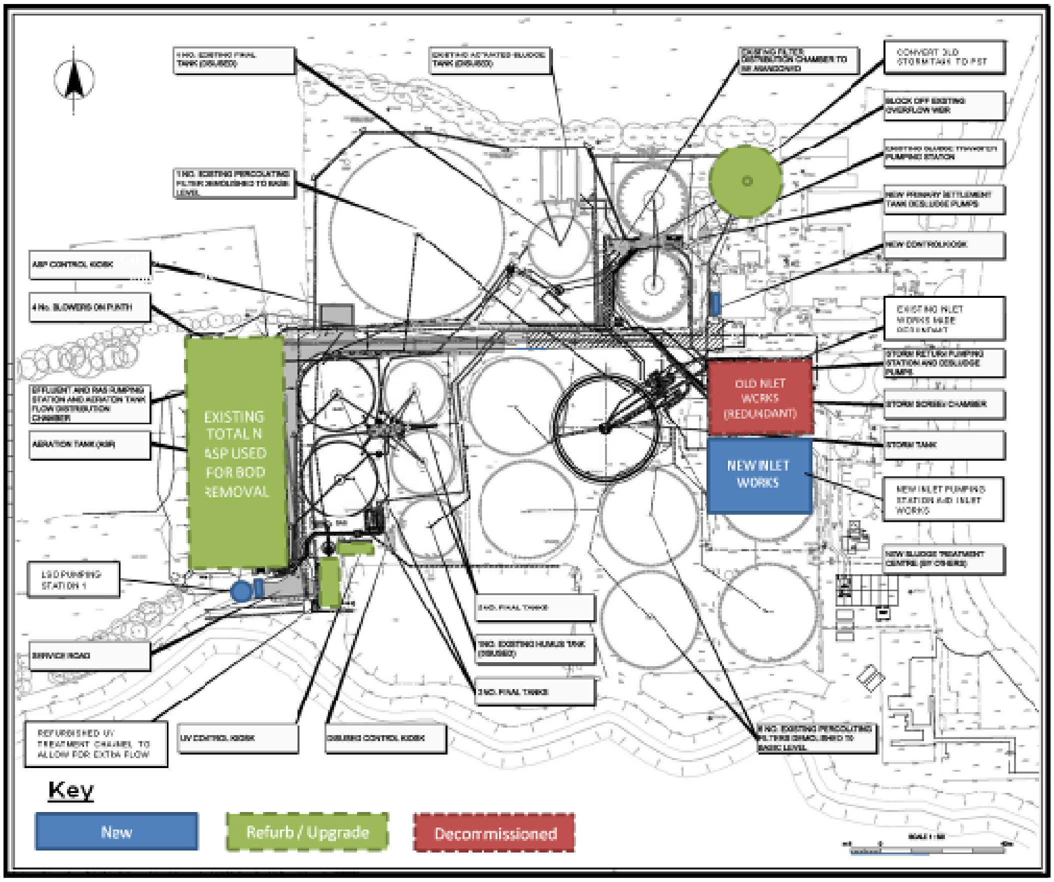
The scope of works at Chichester treatment works would be comprised as follows:

Table 21 – Scope of Works for Proposed Chichester LSO Site Upgrade

Item Summary	Notes
Replace Inlet Works, Screens and Screenings Handling	New Inlet Works Civil Structure to handle increased flow, Install 2No. D/A/S 6mm 2D Screens, each capable of screening flows up to 550 l/s with hydraulic bypass, 2No. D/S Macerators, 2No. D/S Compactors, 1No. Cross Flow Detritor with Bypass, 1No. Grit Classifier, 2No. Covered Skip Bays and odour control.
Flow Measurement	Magflow flow measurement system
PSTs	Convert 1No. Disused Storm Tank to form a Third PST, Scraper Refurbishment on existing PSTs
ASP - Conversion of Existing Volume	Convert existing ASP Volume to Carbonaceous ASP, Block off excess diffusers (Approx 1,850 diffusers required) alter pipework etc
ASP Blowers	Replace blowers with smaller models, D/D/D/S each capable of 1,850 Nm3/hr
RAS/SAS Pumps	Down-size RAS pumps to achieve 320 m3/hour
SAS Thickener	1No. Additional Drum thickener and Poly Dosing unit
Centrifuge	1No. Additional Centrifuge Unit
UV Works	Modify treatment channel facility to increase capacity and allow for extra flows, Modify/upgrade UV control panel
Additional Site Requirements	To include upgrade of washwater system, footpaths, lighting and landscaping

The intended upgrade to the works is shown on the site layout drawing below, a full size version of which is available in Appendix D:

Figure 17 – Site Layout for Proposed upgrade to Chichester WwTW, LSO option



In addition, the scope for transferring flows to the Bracklesham coast and building the LSO is as follows:

Table 22 – Scope of Works for Proposed Long Sea Outfall from Chichester WwTW

Item Summary	Notes
Wet Well Pumping Station	6m ID 6m deep precast concrete
Pipeline	11km long PE mains 700mm diameter. Full length in field. Allowance for washouts and air valves along route. Multiple road and water course crossings
LSO	2.5km long sea outfall 700mm diameter c/w ancillaries / diffusers etc

The design flows for the pipeline are summarised below:

Table 23 – Design parameters around the design of a 3DWF LSO Pipeline for Chichester

Solution	Maximum Flow through Pipe	Average Flow of Transfer	DWF Flow Transfer Rate	Minimum Night Flows
Chichester 3DWF LSO	400 l/s 34,560 m^3/day	221 l/s 19,077 m^3/day	177 l/s 15,262 m^3/day	40.4 l/s 3,490 m^3/day

An indicative route of the pipeline is shown in Figure 18 with the pipeline entering the sea to the east of Selsey Bill.

An alternative route to the west of Selsey Bill (between Bracklesham and Selsey) may be feasible. This route is slightly shorter than the route shown in Figure 18 and shipping maps indicate that there is a steep incline within the sea at that point – which may result in the outfall itself being shorter. However, it is known that there are environmental constraints along this route – including a managed realignment exercise of the flood barriers and a fossil bed SSSI. Discharging into this location is also more likely to impact on the Harbour water quality.

Therefore, at this initial stage, a route to the east of Selsey Bill has been selected – however, a more detailed route investigation may determine that an alternative route is preferred. Full marine modelling would be required to ascertain any effects on the harbour of the selected discharge point and evaluate the full extent of the consent limits still required.

Figure 18 – OS map with indicative pipeline route from Chichester WwTW to the LSO

Based on this pipeline route, the pipeline would be approximately 15 km in length. Initial hydraulic calculations show that the diameter of the pipeline would be in the order of 0.7m diameter, material would be Polyethylene. The gradient of the land is generally fairly flat, however localised washouts / air valves will be required. The pipeline construction is likely to be open trench for a majority of the route with occasional direct drilling to avoid obstructions (e.g. roads and canals).

Within the scope of this investigation, it has not been possible to undertake a dispersion modelling exercise to determine the length of the outfall. This activity would be required at a subsequent design stage. However, based on other similar outfalls in that area, it is considered appropriate to take the outfall out into the sea until a depth of at least 10m is achieved. The purpose of this depth is to achieve sufficient current to enable the effluent to be taken away from the land, and also to ensure there is sufficient depth between the outfall and light shipping in that area. Based on this depth requirement then it is estimated that an outfall length of approximately 2.5km will be required.

In terms of construction, the LSO itself would likely to be partly tunnelled and partly "float and sink" construction method into a sea bed trench. The outfall will generally be approximately 2m below sea bed level. Typically an outfall of this size will have approximately six diffusers which will protrude about 1.65m above sea bed level.

4.3.4. Costs

The CAPEX cost of modifying Chichester WwTW and building the pipeline and LSO is estimated at approximately £35.3 Million. This splits down into approximately £2.95 Million to make the modifications to the treatment works and £32.34 Million to build the LSO and associated infrastructure. Overall, a slight decrease in OPEX costs was initially estimated, based on the implementation of the solution. Although the pumping station to the pipeline itself and the increase in capacity of sludge treatment facilities would increase energy requirements, the reduction in aeration requirements would be significant. Due to the uncertainty inherent in calculations at this level, rather than take a credit for a possible decrease in OPEX, it was elected to set the net OPEX change to zero. The CAPEX, OPEX and Whole Life Cost assessments (60 years, 6%) for the full scheme and LSO infrastructure elements are detailed in Table 24.

Table 24 – Summary of Estimated Costs for Installing an LSO for Chichester WwTW

	Solution Information	
	Full Scheme	**Pipeline and LSO Related Elements**
CAPEX	£35,293,000	£32,341,000
Annual OPEX Increase	≈ £0	≈ £0
WLC	£37,002,000	£33,385,000

4.3.5. Environmental Impacts

Effluent flows into Chichester Harbour would decrease as a result of building the LSO. Discharge into Chichester Harbour would only occur during a severe storm event when the storm tank at the works filled and overflowed. All flows less than the consented flow to full treatment figure would be treated on-site and then discharged via the LSO, directly into the English Channel, bypassing the harbour entirely. The diversion of this loading away from Chichester Harbour would be anticipated to improve the water quality in this sensitive area. The increase of loading into the English Channel would have a very minimal effect on water quality since a well designed and positioned outfall would rapidly disperse and dilute any pollutant still present in the effluent to levels that would not be harmful to aquatic life.

The construction on-site would not have any significant environmental impact, outside of those commonly associated with a standard construction project. It is the laying of the pipeline to the coast and the construction of the LSO itself that are both likely to have the most environmental impact and some of the main considerations include:

- There are potentially 8 watercourse crossings (including a canal). This will involve input on flood risk assessment and numerous land Drainage Consents. Potentially involves lengthy consultation with EA and British Waterways.
- There are 4 road crossings.
- The North of the route is within Chichester Harbour Area of Outstanding Natural Beauty.
- The North of the route also passes very close by (300m) to several major International and European designations around the Chichester and Langstone Harbour areas. They include an SPA, SAC, Ramsar, SSSI and Important Bird Area.
- There are several Scheduled Ancient Monuments 0.5km to the North West which may indicate that the County Archaeologist may be interested in this area. The work however will not directly affect these designations.
- The South of the route passes through Bracklesham Bay SSSI and RSPB Reserve. It may be possible to avoid the RSPB reserve with the pipeline route but not the SSSI.

This would require a full screening opinion request from the LPA and most likely a full EIA. A heritage and landscape constraint map of the area the pipeline would transverse can be found in Appendix E.

The change in carbon footprint resulting from constructing and operating the LSO option would mainly result from an increase in embodied carbon costs from the modifications to the existing works and construction of the pipeline to the coast and LSO. Operational energy is not anticipated to increase or decrease significantly from the operational levels and there is not a requirement to dose any chemicals as part of the solution so carbon emissions from operating the process would not be expected to vary significantly. The overall increase in carbon footprint by the implementation of the solution is therefore assessed to be moderate to low.

4.3.6. Key Risks

Overall it is assessed that the development of the Long Sea Outfall, subject to approval of the pipeline route, would offer a viable solution suitable to allow increased flow to the works. There are a number of risks associated with the planning and cost of the final scheme, but none that would currently be expected to prevent its implementation altogether, only to serve to modify the transfer pipeline route and ultimate discharge location.

After sufficient modelling has been performed to identify the optimal position for the sea outfall pipe, the revised consent is anticipated to closely resemble that detailed in section 4.3.2. If this only allowed for a relaxation of the current Total N consent or if an ammonia consent was applied instead, it would significantly alter the upgrade requirements at the works. In this case, additional ASP volume would be necessary and additional final settlement capacity. This would likely increase the works CAPEX element of the scheme cost by £4-5 Million, whilst also increasing OPEX due to the increased aeration requirements of a nitrifying ASP.

4.4. Possible Future Opportunity: Chichester WwTW BAT Improvement

4.4.1. Current Works

Chichester wastewater treatment works is currently an MLE works with tertiary UV treatment requirements. The site is described in more detail in section 4.3.1, together with a site layout plan.

4.4.2. Site Upgrade Considerations

Chichester WwTW is currently headroom limited because the Total N treatment consent of the works will, during AMP5, reach the currently accepted BAT treatment limit for Total N of 9mg/l. It may however, become possible in the future with increased pilot trials and improvement in design to reach a point at which this level may be lowered. There therefore exists a possible opportunity that an upgrade to Chichester WwTW may be possible in the future. Although this cannot be recommended as an option at this stage because of the uncertainty around this, it would be prudent to include an appraisal of the likely design and cost of such an option, so that should the accepted BAT limit for Total N be lowered in the future, this opportunity has been registered and may be re-visited to determine its viability at that stage.

The site has currently been designed based on the assumption that the entire housing shortfall capacity identified in the region is constructed around the current Chichester catchment and will be treated at Chichester works. In actuality, it is likely that a reasonable proportion of this approximately 3,000 dwelling shortfall we be constructed around the catchments of other works in the region and will reduce the final flow and load increase on Chichester WwTW to below the values considered here for design purposes.

Table 25 – Future Design Criteria for Chichester BAT Improvement Site Upgrade

Key Design Parameters				
Total Adopted Population (hd)	47,563			
Dry Weather Flow (m^3/day)	15,262			
Flow to full treatment (m^3/day)	31,253			
Determinand WRA conditions				
	Summer Consents		**Winter Consents**	
	95%ile	Upper Tier	95%ile	Upper Tier
Suspended solids (mg/l)	41	-	41	-
BOD (mg/l)	32	63	32	63
Ammonia as N (mg/l)	-	-	-	-
Total Phosphorus Annual Average (mg/l)	-	-	-	-
Total Iron (mg/l)	-	-	-	-
Total N Annual Average (mg/l)	8.1	-	8.1	-

The site would also be subject to UWWT regulatory treatment requirements and retain the current effluent UV treatment requirement driven by the bathing water directive.

The current works at Chichester is identified as being under-sized to treat the anticipated flows, under-sized to treat the anticipated pollutant loads and under-specified in the current configuration to achieve the anticipated required future Total N consent.

4.4.3. Scope

Although the current works will be treating the effluent quality to a Total N of 9mg/l, any further decrease would force the adoption of a 4 Stage Bardenpho configuration to guarantee the works would be capable of the required process performance. This in turn would require the provision of an external carbon source, methanol, to ensure that efficient denitrification would be possible. This would require provision of a new methanol dosing plant. The existing ASP volume could be re-used as part of a 4 Stage Bardenpho design but additional ASP volume would still be required and need to be constructed separately and connected to the existing system.

The inlet works is not suitable for any further increase in flows and requires replacement. Additional PST volume would be beneficial to operation and will be provided. Further final settlement capacity would also be required with provision of 1No. New tank and the UV treatment facility would require upgrading to handle the additional flows. Additional sludge thickening and dewatering capacity would also be required on-site to allow for treatment of the extra sludge resulting from the increase in population and loading onto the works.

It is anticipated that the scope detailed below would be suitable to achieve a total N of 8 mg/l, however this is unproven for this works configuration within the UK and as such cannot currently be guaranteed. The scope should be viewed as a tentative assessment of the design of an appropriate BAT challenging process, however pilot trials would be necessary to confirm performance on a smaller scale with raw sewage characteristics in-line with those received at Chichester and ambient conditions reflecting the range that would be experienced year-round at the works.

The proposed scope of works would currently be as follows:

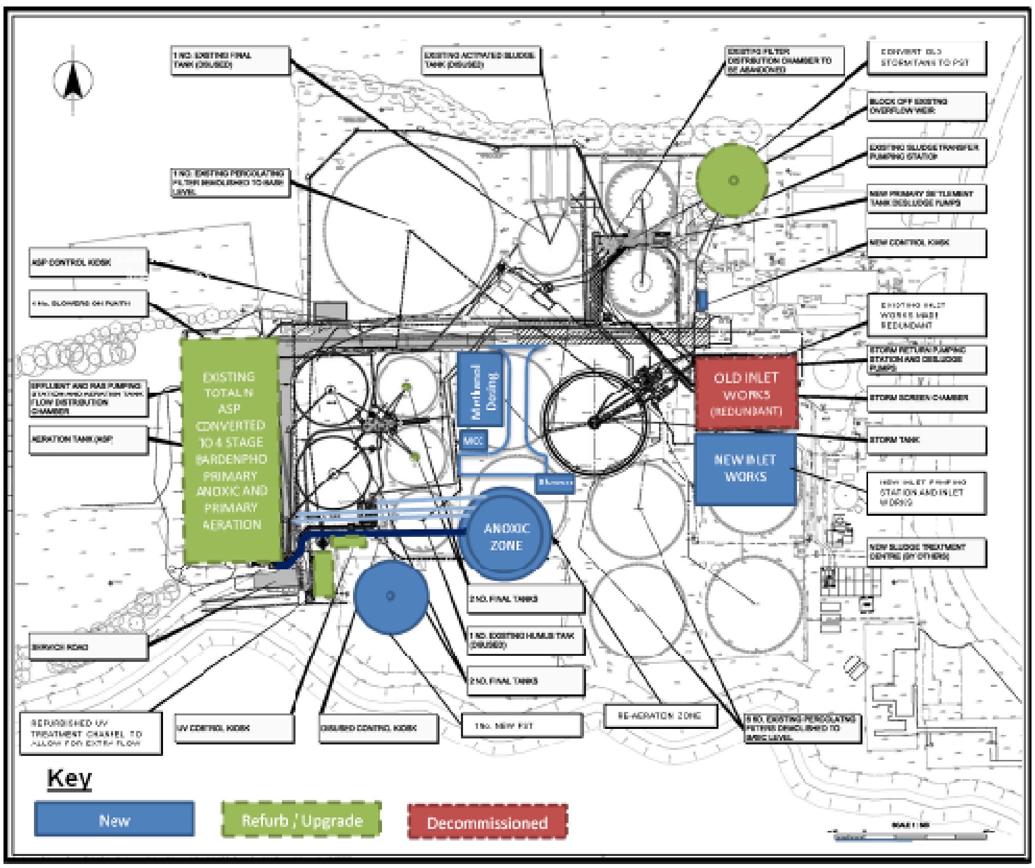
Table 26 – Predicted Scope for a 4 Stage Bardenpho Delivering a Total N of 8mg/l

Item Summary	Notes
Replace Inlet Works, Screens and Screenings Handling	New Inlet Works Civil Structure to handle increased flow, Install 2No. D/A/S 6mm 2D Screens, each capable of screening flows up to 550 l/s with hydraulic bypass, 2No. D/S Macerators, 2No. D/S Compactors, 1No. Cross Flow Detritor with Bypass, 1No. Grit Classifier, 2No. Covered Skip Bays and odour control.
Inlet Works - Flow Measurement	Flow Measurement Channel or Magflow
PSTs	Convert 1No. Disused Storm Tank to PST, Scraper Refurbishment on existing PSTs
ASP - Conversion of Existing Volume	Convert existing ASP Volume to Primary Anoxic (≈ 2,495 m3) and Primary Aerobic Zones (≈ 6,300 m3), Refurbish ancillary equipment and modify for new configuration
ASP - New Anoxic & Re-Aeration Zones	Construct 1No. Circular Secondary Anoxic tank (≈ 2,495 m3) with re-aeration annulus (≈ 1,200 m3), 2No. Mixers in Secondary Anoxic Zone, D/D/D/S Blowers, each capable of up to 3,500 Nm3 of air / hour, 3,500 Fine Bubble Membrane Diffusers in total, including existing diffusers in primary aeration zone
ASP - Methanol Dosing Facility	Provision of new Methanol storage and dosing plant, sized to deliver 220 kg/d to secondary anoxic zone, with associated compound, access road etc.
FST - 1No. New Tank	Install 1No. New FST of similar dimensions to the existing works (23m Diameter), Half bridge scrapers with scum removal, Actuated Bellmouth and connection to RAS Recycle PS
RAS / SAS Pumping	Increase capacity of RAS PS system to allow for RAS returns up

Stations	to 1,350 m3/hr, Increase capacity of SAS PS system to allow for SAS flows up to 80 m3/hr
UV Works	Modify treatment channel facility to increase capacity and allow for extra flows, Modify/upgrade UV control panel
SAS Thickener	1No. Additional Drum thickener and Poly Dosing unit
Centrifuge	1No. Additional Centrifuge Unit
Additional Site Requirements	To include upgrade of washwater system, footpaths, lighting and landscaping
Site Power Upgrade	Upgrade of Power Supply to Works

The intended upgrade to the works is shown on the site layout drawing below, a full size version of which is available in Appendix F:

Figure 19 – Site Layout for Proposed upgrade to Chichester WwTW, Total N 8mg/l



4.4.4. Costs

The CAPEX cost of upgrading Chichester WwTW to a new 4 Stage Bardenpho configuration and upgrading treatment capacity to allow for the additional flows is estimated at approximately £7.15 Million. The OPEX costs associated with operating the works would increase both from increased power demands and the additional yearly chemical costs of approximately £22,000 based on an assumed methanol price of 20p per litre and 300 litres used per day. The price of methanol has varied considerably in recent history and therefore this yearly cost will remain a significant uncertainty whilst estimating the likely WLC of the project. Should this opportunity be re-visited in the future, the WLC should be re-calculated with an updated methanol price and, should the price of methanol have significantly increased, the use of alternative carbon sources considered.

The CAPEX, OPEX and Whole Life Cost assessments (60 years, 6%) for the full scheme are detailed in Table 27.

Table 27 – Summary of Estimated Costs for upgrading Chichester WwTW

	Whole Works Upgrade
CAPEX	£7,154,000
Annual OPEX Increase	£69,400
WLC	£10,132,000

Although this appears to be a cost effective option, the technology cannot yet be relied on within the UK to achieve the treatment level that would be required to allow this solution to be implemented. It cannot therefore be relied upon at this stage.

4.4.5. Environmental Impacts

Effluent flows into Chichester Harbour would increase as a result of developing this scheme and receiving additional domestic flow for treatment at the works. The loads discharged into Chichester Harbour would however remain unchanged by reducing the pollutant consents in accordance with load stand still. Consideration needs to be made in detailed design and operation to minimise the likelihood of failures of the BOD or COD consents from over-dosing of methanol. The development would however, with careful design, be anticipated to have negligible impact on the receiving waters.

The power consumption at the works will increase as a result of the additional equipment installed, particularly the increase in aeration requirement from the current arrangement.

Since there are no pipeline requirements to either transfer extra influent to the works or remove effluent from the works, there will be minimal environmental disruption outside the boundary of the current site apart from construction traffic to or from the works.

The increase in carbon footprint by the conversion to of Chichester from an MLE ASP to a 4 Stage Bardenpho design is assessed to be moderate. A large proportion of the existing infrastructure could be re-used in the new design, unlike the options discussed for Tangmere and Lavant where the entire biological treatment process would need to be replaced. The increase in blower size required from treating to a more stringent Total N standard and treatment of additional flows and loads would increase energy usage and thus operational carbon costs. There would also be additional operational carbon costs associated with the dosing of methanol. The total increase in energy usage would only represent a small fraction over that of the current works since this is already a relatively energy intensive process.

4.4.6. Key Risks

The most significant risk here, and the reason this possible future opportunity cannot currently be recommended as an option, is the current uncertainty around the robustness of this, or any similar solution in meeting a low effluent Total N concentration. With coastal schemes increasingly becoming subject to tight Total N limits, it is critical that the limits of the various “improvement in BAT” technologies discussed in section 3.3 are better understood in order to allow development around these sites in the future.

Without trialling these technologies in the near future, the headroom deficit in the south of the district may eventually halt any further housing development around BAT limited works. It is therefore critical that investment is made now to prevent serious issues from arising in 20 years time.

The remaining risks associated with the works are all asset based risks where the current scope is to modify an existing asset and detailed investigation may indicate that it was instead necessary to construct a completely new unit. There is however, significant space available on-site from where the old trickling filters were decommissioned and substantial additional development at the works would not be space limited.

4.5. Comparison of Options

The three options and future opportunity are summarised below:

Table 28 – Summary Table for the Options / Opportunity detailed within this study

	Option 1 Upgrade Tangmere WwTW	**Option 2** Upgrade Lavant WwTW	**Option 3** Construct Chichester LSO	**Future Opportunity** Chichester BAT Improvement
CAPEX Cost	£10,754,000	£10,569,000	£35,146,000	£7,154,000
OPEX Increase	£80,000	£111,500	≈ £0	£69,400
Whole Life Cost	£13,961,000	£14,767,000	£36,827,000	£10,132,000
Key Project Risks	- EA future Policy with Regards to No Deterioration on Phosphorus caps DWF flow to the works. -Insufficient additional volumetric capacity identified in the Aldingbourne Rife during periods of high rainfall is indentified, leading to additional flooding abatement elements being added to the scheme and increasing the overall cost -Conversion / Re-use of existing assets is not deemed possible at detailed design. -Modification to the existing Chichester catchment is likely to be required which may carry considerable additional expense.	- EA future Policy with Regards to No Deterioration on Phosphorus caps DWF flow to the works. -A Total N consent is applied to the works in the near future, preventing expansion. -Insufficient flow is identified in the River Lavant to allow for sufficient dilution of effluent to retain the current WFD water quality status of the river. -If the current reed bed storm discharge system cannot be decommissioned to free up area for development on-site, land purchase would then be required to allow sufficient area to construct the new ASP. -The limited space on-site prevents the construction as initially anticipated and additional land purchase is identified as necessary. -Ground conditions are very poor and would significantly hinder construction. -Conversion / Re-use of existing assets is not deemed possible at detailed design. -Modification to the existing Chichester catchment is likely to be required which may carry considerable additional expense.	-Modelling of the receiving water indicates the current discharge site selected for within the scope is unsatisfactory and an alternative / longer pipeline is required. -Suitable LSO discharge locations are identified but the associated modified consent lists ammonia as a consented pollutant. This would require additional on-site treatment provision at considerable extra cost. -Conversion / Re-use of existing assets is not deemed possible at detailed design, necessitating construction of new assets at additional cost. - Route requires further investigation and assessment before the final route can be confirmed, this may result in additional cost	-Insufficient confidence exists in the ability of technology to meet more stringent effluent Total N concentrations than the currently accepted limit of 9mg/l. -The works, once constructed, fails to meet the required Total N treatment level. This would require a significant additional tertiary treatment development at the works at vast additional cost and adding years on to the construction program, leading to an extended duration where the works was non-compliant with consent and possibly resulting in litigation. - Conversion / Re-use of existing assets is not deemed possible at detailed design, necessitating construction of new assets at additional cost.
Advantages	Site has adequate space for required development. Site currently energy intensive for a filter works due to significant interstage pumping requirements – Net increase in energy usage from converting to an ASP works would be minimised.	Short Transfer Pipeline indentified as causing minimal environmental disruption at a moderate cost. Current consents are relaxed. If load stand still is assumed, future consents may be less stringent than those imposed elsewhere.	**Solution currently appears viable.** Highly Sustainable, no chemical requirements and not anticipated to increase energy costs. Treated effluent no longer discharges into the harbour – should improve water quality.	Lowest CAPEX and WLC. No complex flow transfer required, development can easily occur around the existing catchment. No additional pipeline construction required to cause disruption.
Disadvantages	Uncertainty around future P consent reduces confidence in the viability of the scheme. Uncertainty of river capacity to cope with additional flows without additional flood prevention measures. EIA likely required prior to finalising any pipeline route , extending project duration.	Uncertainty around future P & N consents reduces confidence in the viability of the scheme. Uncertainty of river capacity to cope with additional flows without additional flood prevention measures. Ground conditions at Lavant are particularly poor and space limited for additional construction. Upgrade would convert a low energy works to one consuming significant power to provide treatment. River Lavant still discharges into Chichester Harbour	Highest CAPEX and WLC reduces the desirability of the solution. Considerable third party and stakeholder consultations would be required to allow the construction of the pipeline. Significant Disruption to the Environment by construction of pipeline to coast and high expense of pipeline. Construction considered complex and high risk EIA likely required prior to finalising any pipeline route , extending project duration.	**Currently Not Viable** Additional chemical usage required in the form of methanol High aeration and pumping costs associated with operating a 4 Stage Bardenpho process

4.6. Funding

Each of the options listed here, assuming they were to be selected as the optimal solution, would be anticipated to be granted OFWAT funding, provided they were included in SW's PR14 Business Plan. The growth of population in the area necessitates an upgrade at Chichester to treat the additional population. The upgrade at Tangmere or Lavant or the conversion of Chichester to a 4 Stage Bardenpho are all similar in cost. Currently however, the only viable solution appears to be the LSO option which has been assessed with a significantly higher whole life cost.

Considering the costs per additional household, the LSO option comes out with a WLC of approximately £12,300 per household. Although this appears a significant cost per additional property, it is, for comparison, about 4% of the average cost of a property in the Chichester area (approximately £313,000, May 2009[10]) and is in-line with project costs, normalised in a similar manor, of schemes that have been granted funding during previous AMP cycles. OFWAT have a duty to ensure 'value for money' is provided from projects for which funding is granted and therefore, a high value scheme such as this would be anticipated to receive additional scrutiny before funding is granted.

Significant growth necessitates the provision of additional treatment capacity and therefore would require a suitable scheme to provide this extra capacity. As long as a wide range of solutions were considered and the scheme selected offered the lowest whole life cost of those solutions considered viable, there is no reason to anticipate that the scheme would not be funded. At this stage therefore it must be assumed that after applying in 2014, funding would be made available for development within AMP6.

4.7. Sequencing

It must also be demonstrated that a proposed solution would allow for sufficient development year on year to maintain housing allocation rates and provide the 7,100 properties required throughout the 20 year period.

With the current information and data available:

1. Analysis indicates that sufficient headroom capacity exists in all six catchments in the south of the district of Chichester for all of the housing development planned from 2006 until April in 2015.
2. Analysis also indicates that when considering allocating 355 dwellings per year, Chichester has approximately 2 years of additional headroom capacity for development from April 2015 before the current works DWF consent is anticipated to be exceeded.
3. The design and construction behind the three options taken forward for detailed analysis and indeed the future opportunity described previously are all assessed as being significant given the complex nature of each of the schemes. The complex nature of each scheme would imply a design and construction duration of approximately 4 years, whichever scheme was selected. Without completing a detailed design review of any of the identified options, it is not possible to give a more accurate assessment of this estimate or use it to subjectively rank one option against another.
4. Each option, if deemed viable based on a new consent structure being issued in-line with that assumed for design, would, upon completion, provide sufficient headroom to allow for the required housing

[10] BBC - http://news.bbc.co.uk/1/shared/spl/hi/in_depth/uk_house_prices/html/45ud.stm

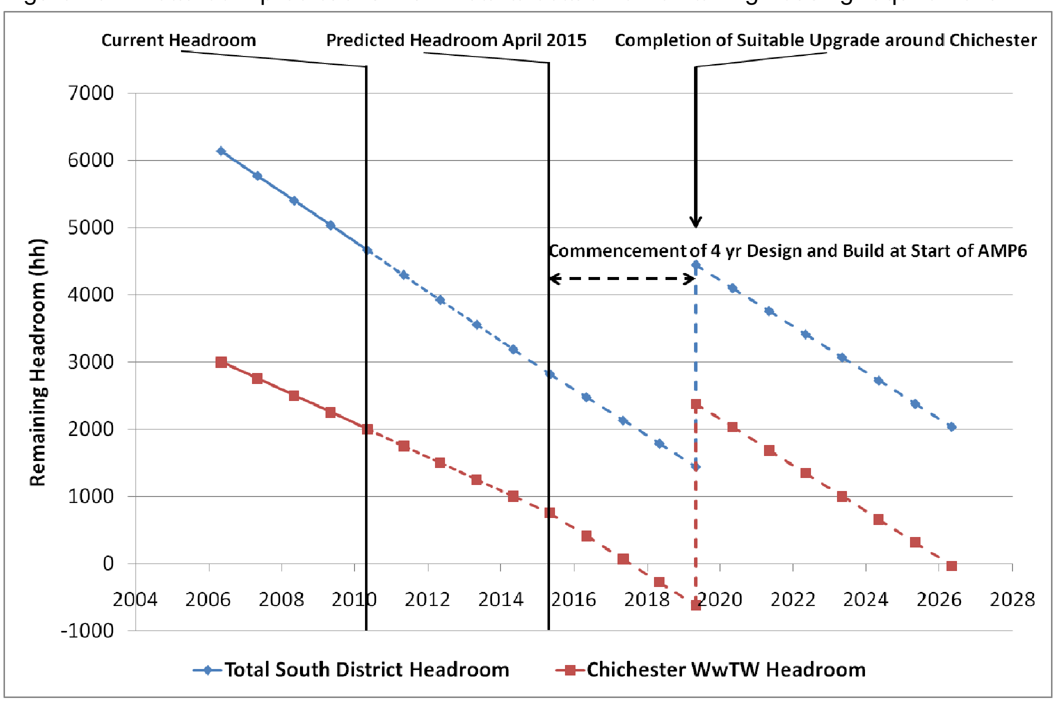
development around Chichester until 2026. This assumes that in the case of flow transfers, new developments and an appropriate proportion of existing catchment flow can be successfully routed to the transfer pipeline and on to treatment at the desired works.

Capacity issues arise early within AMP6 when, if construction at a rate of 355 dwellings per year is consistently achieved into the current Chichester catchment, the remaining headroom estimated at Chichester works will be utilised approximately 2-3 years into the AMP6 period, around the end of 2017. **After this, without successful completion of a scheme to increase headroom around Chichester, further development will not be possible.**

By the 31st March 2015, it is anticipated that 355 Dwellings per year should have been allocated since 2006. This equates to the provision of 9 × 355 = 3,195 dwellings. According to the data available to the end point of the five year supply figures 2009-2015[11] 3,315 dwellings will have been constructed, will be in construction or will have had planning granted and be awaiting construction. Therefore, at this point, the development will actually be slightly ahead of the required allocation rate. To meet the total requirement of 7,100 dwellings in the south of the district and maintain an average housing allocation of 355 households per year across the 20 year period, 3,785 more dwellings will need to be developed (≈ 344 hh/year from 2015-2026).

Figure 20 shows the predicted headroom availability calculations based on continuing to allocate the remaining 3,785 dwellings, on a linear basis, around the Chichester catchment, to the 2026 design horizon.

Figure 20 – Headroom predictions with linear allocation of remaining housing requirement



The design and construction of whichever option is finally selected has been assumed to take place directly at the start of AMP6, providing the additional headroom early in 2019. It can clearly be seen from the Chichester headroom that

[11] Table 2, Southern Water Position Statement: This information is now housing assumed from the Council's Five Year Housing Land Supply 2010-2015 document.

this scenario is unworkable since the estimated Chichester headroom drops below 0, at which point the works would be anticipated to be exceeding its DWF consent. There are two contributing issues here:

1. That all of allocation continues around the Chichester catchment when there is limited capacity remaining at this works but residual capacity identified amongst the other works in the south of the district.
2. That waiting until AMP6 to commence design and construction of a suitable solution does not allow for sufficient time to deliver the additional headroom before the current identified remaining headroom in the Chichester catchment is depleted.

There are therefore, two options to overcome the above scheduling problem:

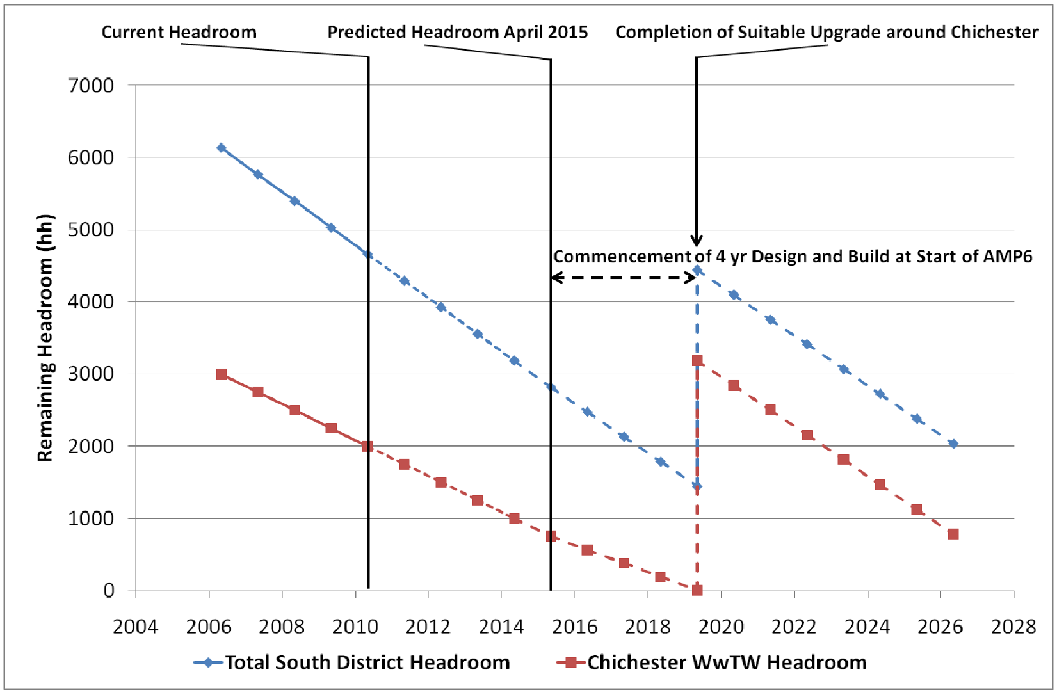
1. To reduce the rate of construction into the Chichester catchment and instead encourage development around the remaining works in the district as their remaining headroom allows.

   OR

2. To bring forward the design and construction of a suitable solution such that the scheme would be in place and operational prior to the time at which the current headroom at Chichester is anticipated to be depleted.

Reducing development around the Chichester catchment from April 2015 until the completion of the scheme around April 2019 to **188 hh/year** is currently projected to allow for sufficient time for a scheme to be delivered at the start of AMP6 (2015) for additional headroom to be provided, without ceasing development around the catchment entirely at any point. This scenario is presented in Figure 21:

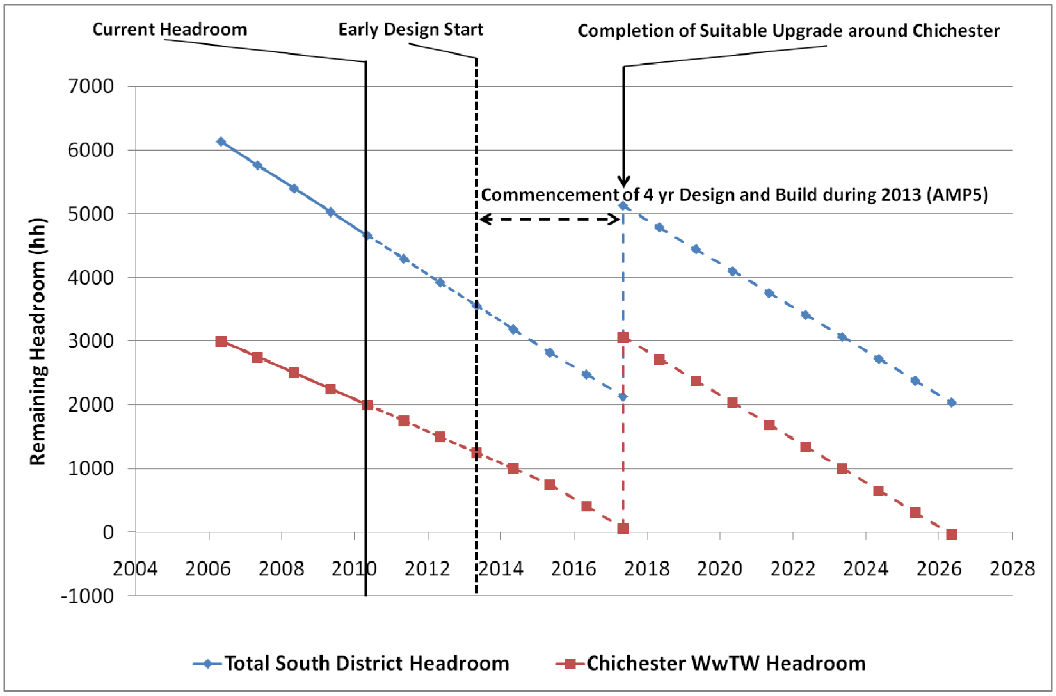
Figure 21 – Headroom predictions with development limitations imposed around Chichester



During this period, development around the other sites would be maintained so as to maintain the overall housing provision required in the south of the district to provide 7,100 additional houses by 2026. From the point where the scheme is completed, all future development is again assumed to take place into the Chichester catchment until the 2026 design horizon. This scenario would worsen the headroom issues at the other sites in the district but would leave Chichester with residual headroom from 2026.

Bringing forward design and construction of a scheme to allow for completion prior to headroom being depleted in the Chichester catchment would prevent from having to limit development into the current Chichester catchment for a period of time. This would be more desirable from a development stand point but complicated from the point of view of funding. The degree by which it would be necessary to bring forward design to is demonstrated in Figure 22:

Figure 22 – Headroom predictions with early start of suitable scheme design and construction



Water utilities are sometimes willing to self-fund early start work in some cases to aid delivery of schemes early on within an AMP period. For them to be willing to do this however, they need to have confidence that funding will be granted and generally would only take this risk to combat an event leading to pollution or a public nuisance where there is a significant risk of continued environmental damage and/or public perception of the company may be at stake. It is only at the draft determination stage that the water utility companies receive any validation that a scheme is likely to be funded and this occurs around 9 months prior to the start of the AMP period.

It therefore appears unlikely that a growth issue would attract sufficient attention to warrant this significant acceleration of the delivery process and even if it did, design would be necessary more than two years prior to the start of AMP6 which would be highly improbable and therefore prevents this approach from being recommendable.

5. RECOMMENDATIONS

Of the four main options taken forward, the LSO option currently offers the highest degree of certainty that implementation would be feasible to free up the required level of development capacity around Chichester. The solution carries the highest whole life cost of all of the four scenarios considered, but developing at Tangmere and Lavant are both constrained by the uncertainty with regards to the EA's future policy on no deterioration of Phosphorus. As stated previously, there is not sufficient confidence in the treatment technology within the UK to upgrade Chichester to a 4-Stage Bardenpho design and challenge the BAT treatment standard for Total N.

Until the EA clarify their position on future policy with regards to no deterioration and Phosphorus, neither the Tangmere nor Lavant options can be relied upon as a viable option. Therefore, until the EA finalise their no deterioration policy with regards to Phosphorus, the LSO option represents a backstop which ultimately demonstrates a viable solution to alleviate the identified development headroom deficit.

Development at Lavant is generally viewed as less favourable than at Tangmere due to the range of construction issues discussed which afflict this site, the possibility the works may receive a future N consent which may also limit any increase to the DWF consent and the fact the effluent ultimately still discharges into Chichester harbour which flows from Tangmere do not.

Development at Tangmere would appear a desirable option due to the significantly lower costs involved than those estimated for construction of the LSO. Should the final policy on no deterioration and Phosphorus allow for the required changes to be made to the Tangmere consent for sufficient increase of the consented DWF, the benefits of option 1 and option 3 should be re-assessed to determine which offers the best value for money and represents an effective solution moving forward. This assessment is therefore recommended once the EA have clarified this policy.

The future opportunity of enhancing process technology at Chichester WwTW to allow for treatment to more stringent standards than the currently accepted limit of 9mg/l will not be viable until greater confidence can be gained that one or more types of the treatment technology detailed in section 3.3 can be successfully employed to robustly achieve these targets in the UK.

Although it appears possible to alleviate the current treatment capacity deficit issue by implementing a solution that avoids challenging the current BAT treatment level for Total N, there are multiple sites within the South of Chichester District that are governed by this consent. It is highly likely that these sites will run into the same headroom issue identified at Chichester in the near future. Thus it is critical to improve confidence in the treatment technologies available to ensure development in the district does not become constrained in a similar way again in the future. The cost of a small pilot trial would be significantly less than the £20+ Million difference in cost between upgrading a treatment works with an innovative new design and being driven towards building an LSO as the only mechanism of circumventing a BAT limited Total N consent. To provide trial results by a sufficiently early date so they would be beneficial to option selection for this problem, it would be necessary to provide funding for the trial outside of the AMP funding structure.

Each of the options detailed in this report have been designed to provide treatment capacity to the 2026 design horizon but not significantly beyond that point. At this point, similar issues to those driving this study would again be anticipated if improvement on accepted BAT treatment levels have not been realised. Pilot trials of technology are therefore critical in the interim period to ensure that the current headroom deficit issue is not simply shifted forwards in time and therefore should be carried out within AMP6 if it is not possible to do so before.

Re-assessment of the remaining available headroom at the works at a time closer to the point at which the Chichester headroom is anticipated to be used up is important to identify if the headroom reduction has been as substantial as has been estimated in this study. Should DWF headroom not have been used up as anticipated (e.g. through the application of sustainable housing practices leading to lower flows into the catchment than have been allowed for in calculations), it is possible that this future re-assessment may indicate a less substantial solution is necessary than the designs and measures that have been detailed in this report. It is therefore recommended that a study to re-assess the headroom in the district and re-evaluate the best option to take forward is completed towards the end of AMP5 so that appropriate measures can be implemented early in AMP6.

Although an Infiltration Study of Chichester cannot guarantee to identify possible measures that would reduce dry weather flows to Chichester WTW, the level of improvement that might be possible will remain unknown until the results of such a study are publicized. Significant gains may be identified that may be more cost effective than the options described in this report. It is therefore recommended that a suitable study be undertaken in the near future.

To mitigate against flow increases in all for the catchments, it is highly recommended that sustainable housing practices and water reduction techniques are imbedded within future district policy. These include:

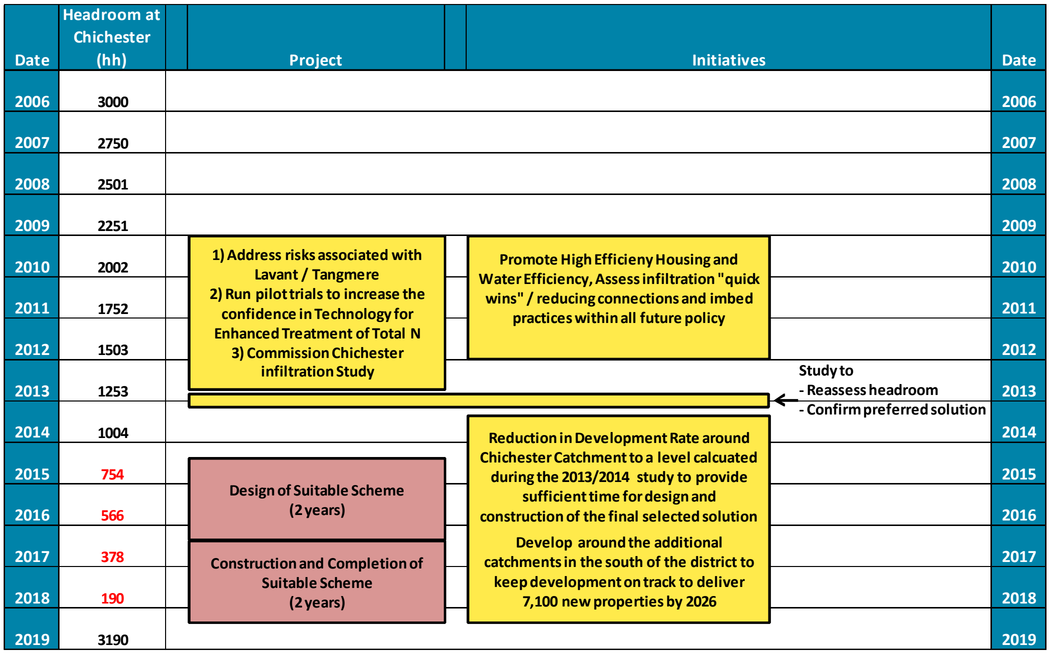
- Apply category 5/6 requirements, wherever possible, to all new housing developments and, as a minimum, category 3/4.
- Support and run campaigns to reduce per capita water consumption and educate the public towards consideration in water usage.
- Retrofitting existing housing schemes with facilities/technologies designed with lower water usage. The availability of grants or sponsorship of projects by CDC to deliver these changes would be beneficial.
- Increase the level of / introduce compulsory water metering to aid in per capita water usage.

Although, as stated previously, these practices cannot be relied upon to provide a solution to the headroom deficit problem, wide scale adoption and implementation can only serve to minimize any increase in DWF flows and reduce the scale of the problem identified here wide-scale adoption does have the potential to reverse the trend of headroom reduction entirely. In particular, they are of substantial importance in reducing water usage in the long-term and mitigating against water capacity issues arising in the future. These techniques should therefore be recommended or dictated to new build projects and as retrofits to existing properties, wherever possible.

The sequencing of events is paramount in consideration of whether an option is not only deliverable but deliverable in a suitable timeframe that will allow the requisite continued development in the south of Chichester District. The consideration of the sequencing issue dictates that if current predictions of headroom reduction in the district hold, it will be necessary to reduce development into the Chichester catchment until the point at which additional headroom can be made available. The exact level to which yearly development must be reduced to is currently estimated at 188 hh/year but this needs to be re-assessed during the next proposed study to identify if reduction to this level is necessary or if development at a higher rate can be sustained.

A timeframe for the consideration of recommendations and completion of tasks, based on the current headroom analysis is shown in Figure 23. Since this timeline has been produced and assessed against what is considered to be a 'worst case scenario', adhering to this timeline should prove effective, even with deviation away from the figures estimated within this report.

Figure 23 – Timeline plot of the main scheduling activities recommended from this study



It is thus concluded that by following the recommendations made within this report and adhering to the practices and timeline as detailed above, the development requirements of the South East Plan for the South of Chichester District can be met to 2026, whilst avoiding exceedance of the DWF consents at any of the works.