Dŵr Cymru
Welsh Water

Ref 5.8R

PR19: Wastewater Treatment Maintenance

September 2018

Wastewater Treatment Maintenance

Dŵr Cymru Welsh Water

Contents

Executive Summary

Driver for Investment

The £185m pre-efficiency investment proposed in this investment case includes expenditure for the maintenance of our wastewater treatment works (WwTWs) and outfalls to estuarine and coastal waters, together with expenditure to address sites non-compliant with dry weather flow (DWF) and pass forward flow (PFF) permits as agreed with regulators in a phased programme.

Maintenance funding is required to ensure the reliability and ongoing integrity of processes and assets associated with wastewater treatment activities. Any operational or asset failure can result in flooding, pollution or flows not being adequately treated, with potential detrimental impacts on the environment and public health, as well as non-compliance with statutory requirements. In order to achieve the levels of service expected by our customers, we must maintain our assets to ensure their reliable, safe and efficient operation at the lowest long-term cost. The DWF and PFF expenditure is required to address confirmed flow compliance issues at our WwTWs.

Investment will contribute to the sustainable management of wastewater to ensure the protection of public health and water quality (both of our rivers and coastal waters). It will therefore support our customer priorities, which showed a strong support for investment in this area. 'Cleaner rivers and beaches', 'better water quality for all' and 'working with nature for cleaner water' are all seen as very important – topping the list for all demographic groups. 'Cleaner rivers and beaches' was the statement given the highest importance overall and gained very high scores for all demographic groups.

The Investment

Our proposed investment is shown in Table 1. Figures are pre-efficiency and expenditure will reduce when efficiencies are included. Performance and investment options were reviewed with our Executive Team before the balance of risk and investment was agreed on.

The expenditure is proposed for the following.

WwTW and outfalls maintenance

We propose to invest £145.1m over AMP7 to maintain our 835 WwTWs and £8.8m to maintain our 459 outfalls discharging storm and treated flows to coastal and estuarine waters (together with associated navigational aids). Our approach to identifying and prioritising the expenditure required over AMP7 has been underpinned by our aims to:

- Meet regulatory obligations and performance targets set out in our Measures of Success (MoS);
- Maintain our WwTWs to protect river and coastal water quality and public health;
- Develop sustainable solutions to operational problems to achieve the best possible standards for river and coastal waters;
- Reduce pollution occurrences at our WwTWs;
- Maintain serviceability and asset health;
- Manage risks, costs and performance so as to reduce our average cost to serve and deliver the benefits to our customers and the environment at an affordable cost.

DWF and PFF Compliance

We propose to invest £11.8m and £19.5m to address sites non-compliant with dry weather flow (DWF) and pass forward flow (PFF) permits respectively, as agreed with regulators in a phased programme. The investment is driven by the requirement to comply with flow permits. DWF expenditure is based on twenty schemes at sites where DWF exceedances (Q90 > DWF permit) occurred between 2011 and 2016 inclusive. PFF expenditure is specifically for schemes where a risk to PFF compliance was identified by 2016.

Programme of work	AMP7 Capex Base	AMP7 Capex Enhancement	AMP7 Capex Total
WwTW maintenance	£143.1m	£2.0m*	£145.1m
Outfalls	£8.8m	£0.0	£8.8m
DWF	£9.4m	£2.4m*	£11.8m
PFF	£19.5m	£0.0	£19.5m
Total programme (pre-efficiency)	£180.8m	£4.4m	£185.2m
Total programme (post-efficiency)	£162.5 m	£4.0m	£166.5m

Table 1: Capital Expenditure

* The proportional allocation to enhancement is due to some additional capacity being incorporated to allow for growth.

The post-efficiency capital investment incorporates planned capital savings resulting from on-going improvements in operational efficiency, e.g. from our Maintenance and Reliability Support (MaRS) and LEAN projects, together with savings resulting from efficiencies in the delivery of schemes by our Alliance Framework.

The proposed pre-efficiency investment of £185.2m is higher than our forecast outturn for AMP6 of £166.2m. The increase is due primarily to the additional flow compliance schemes we have identified. However, after application of our efficiency challenge, the proposed expenditure reduces to £166.5m, very similar to our projection for AMP6.

Delivering for our customers

This proposed investment will contribute to meeting the following of our customer promises:

Safeguard our environment for future generations: We will maintain our wastewater assets to safeguard the environment and health of our customers and reduce the risk of pollution and flooding incidents

Put things right when they go wrong: We will reduce the need for reactive maintenance through new operational activities so as to meet our customers' expectations and reduce the risk of service failure.

A better future for all our communities: We will provide a more resilient wastewater treatment service to protect our environment and help communities create a better future for themselves.

Delivering for the future

In Welsh Water 2050, we identified future trends. Our proposed investment will ensure that our critical wastewater assets are maintained to help address the following trends:

Changes in customer expectations: Our maintenance will help ensure that all customers have a minimum universal service standard.

Protecting essential infrastructure: Our initiatives to improve efficiency and reduce reactive maintenance will contribute to the management of an ageing asset base, which presents increasing issues with respect to reliability and resilience.

Protecting public health: We will contribute to healthier and more sustainable lifestyles for our customers.

Delivering our Strategic Responses

In Welsh Water 2050, we set out to deliver 18 Strategic Responses. Whilst there are no Strategic Responses identified in the document that cover WwTW Maintenance specifically, this investment will contribute to the following:

Cleaner Rivers and Beaches

With increasing pressure on the natural environment from increased population, changing land use, climate change and new sources of pollution, we will maintain the integrity and performance of our wastewater assets to help achieve 'good' environmental status for our rivers, lakes and coastal waters.

Protecting our Critical Wastewater Assets

Our maintenance works will help us manage increased risks associated with our ageing assets and external pressures such as an increase in severe weather as result of climate change and reduced customer acceptability of pollution events.

Achieving our measures of success

This investment will contribute to achieving the Measures of Success (MoS) and associated performance targets identified in Table 2. These reflect our customers' willingness to pay and expectations.

Measure of Success	End of AMP6 Performance Target	End of AMP7 Performance Target
Water and wastewater treatment work compliance (En1)	100%	100%
Wastewater treatment works 'look-up table' compliance (En2)	99%	100%
Pollution incidents from Wastewater (En3)	107	90

Table 2 Measures of Success

1 Delivering our customer outcomes

Need for investment

The proposed £185.2m expenditure is for the maintenance of our wastewater treatment works (WwTWs) and outfalls to estuarine and coastal waters, and schemes to address sites non-compliant with dry weather flow (DWF) and pass forward flow (PFF) permits as agreed with regulators in a phased programme.

Maintenance funding is required to ensure the reliability and ongoing integrity of our wastewater treatment assets and outfalls. Any operational or asset failure can result in flooding, pollution or flows not being adequately treated, with potential detrimental impacts on the environment and public health, as well as non-compliance with statutory requirements.

From 2025, flow permit compliance will be monitored in the Environmental Performance Assessment (EPA). Continuing investment in DWF and PFF schemes in AMP7 will help us prepare for this change.

Background

We operate 835 WwTWs, of which 558 have numeric permits and the remainder descriptive permits. Numeric permits have certain regulatory parameters we have to meet for the flowrates to be treated and effluent concentration standards to be achieved, along with a number of descriptive requirements to meet the required obligations for the discharge. Descriptive consents have basic requirements for operations on site and condition of the receiving water. The permit conditions we have to meet are set and monitored by Natural Resources Wales (NRW) in Wales and the Environment Agency (EA) in England.

The WwTWs are 'banded' according to the Population Equivalent (PE) load treated by the works. The PE includes not only the resident population but also the population equivalent of the trade effluent, tankered sewage and sludge discharging to the works. The combined total PE currently treated by our WwTWs is just over four million (2017/18 APR Table 4S).

The numbers of WwTWs in each band are shown in Table 3.

We also maintain 459 sea outfalls that discharge storm flows and treated sewage effluent to estuarine and coastal waters, together with associated navigational aids, some of which form part of permits administered by Natural Resources Wales (NRW) under the Coast Protection Act 1949.

Ofwat Band	PE Range	Number of WwTWs
1	PE <250	464
2	PE>250 <500	114
3	PE >500 <2,000	130
4	PE >2,000 <10,000	78
5	PE >10,000 <25,000	26
6	PE >25,000	23

Table 3 Number of WwTWs in each Ofwat band

In order to achieve the levels of service expected by our customers, and the performance targets required by our regulators, we must maintain our assets to ensure their reliable, safe and efficient operation at the lowest long-term cost.

NRW and the EA have improved their focus on flow compliance in recent years and this pressure is set to increase further in AMP7. By the end of 2017, we were measuring and reporting DWF at 387 (46%) of our WwTWs, and we are installing further meters to ensure we can report on every WwTW treating over 50m^3/d.

As well as meeting our sanitary permit limits, we need to demonstrate through flow compliance that the loads we discharge to the environment do not prevent achievement of target water quality standards.

The need for investment is to achieve the following objectives:

- Maintain our wastewater treatment works to ensure compliance with discharge permits; to protect river and coastal water quality and public health;
- Maintain the integrity of outfalls so as to maintain compliance with the EU Urban Wastewater Treatment, Bathing Waters and Shellfish Waters Directives;
- Minimise pollution occurrences at our WwTWs;
- Maintain serviceability and asset health;
- Meet performance targets set out in our measures of success;
- Manage risks, costs and performance so as to deliver the benefits to our customers and the environment at an affordable cost;
- Ensure compliance with flow permit conditions (DWF and PFF) at our WwTWs;
- Maintain navigational aids to ensure regulatory compliance.

Views of our customers and stakeholders

We have engaged with our customers and stakeholders throughout AMP6 to understand their expectations and preferences, including consultations on the use of customer dividend money in AMP6 and the PR19 Business Plan. Our Welsh Water 2050 strategy consultation, held in the summer of 2017, engaged with 20,000 customers. We have also utilised wider industry-level research and assessed its implications for our region, our stakeholders and our future plans.

We identified our customers` priorities through our engagement, which showed strong support for investment which contributed to 'Cleaner rivers and beaches', 'Working with nature for cleaner water' and 'Better water quality for all' – topping the list for all demographic groups.

We will continue to act on feedback throughout AMP6 and AMP7 by working with the Customer Challenge Group and listening to focus groups.

Our environmental regulators, NRW and the EA, are, of course, very important stakeholders for us. The fact that they expect 100% compliance with all permit conditions is fundamental to our WwTW maintenance strategy.

Affordability of bills

As identified from our customer engagement initiatives, there is a particular drive from across our customer base for us to reduce pollution incidents, to protect our rivers and coastal waters and to reduce flooding risk in a cost-effective manner.

We have engaged with our customers to better understand their Willingness to Pay (WtP) for improvements to reduce pollution and flooding incidents, the predominant risks of a wastewater asset failure. Table 4 provides a summary of what our customers would be willing to pay per affected property, demonstrating that our customers consider the consequences of a wastewater asset failure to be an important area for investment.

Wastewater Treatment Maintenance

Customer feedback measure	Willingness to Pay per property
Significant pollution incident	£2,128
Minor pollution incident	£805
Major flooding inside property	£22,470
Minor flooding inside property	£13,024
Sewer flooding outside property	£3,090
Sewer flooding in a public area	£1,979

Table 4 Summary of stakeholder feedback on Willingness to Pay

Benefits for our customers

WwTWs maintenance

Our proposed investment for Wastewater Treatment Works and Outfalls Maintenance together with investment to address flow (DWF and PFF) issues will contribute to the sustainable management of wastewater to ensure the protection of the public health, water quality (both our rivers and coastal waters) and the environment.

It will therefore support our customer priorities which showed a strong support for investment in this area, with 'Cleaner rivers and beaches' being the statement given the highest importance overall with very high scores across all demographic groups.

2 Investing now and for the long-term

In our Welsh Water 2050 strategy document we have set out our long-term vision and our approach to achieving this, so that we can demonstrate how we will continue to meet our customer needs into the future. It considers both the direction for our own business and outlines the impact we want to have on the people, economy and natural environment of our operating area in Wales and England in the long-term.

Our Welsh Water 2050 strategy identifies significant trends (external factors) over the next 30 years and how these will impact on us and our customers. The trends related to wastewater management are set out in Figure 1.

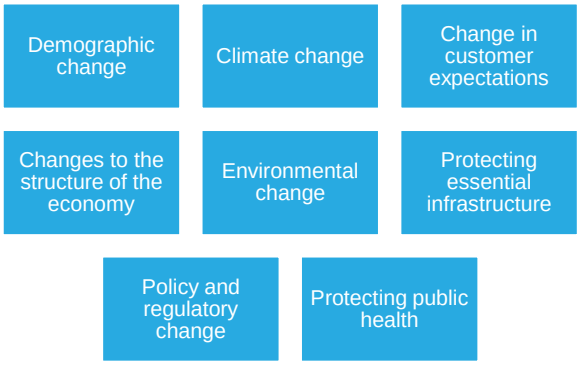

Figure 1: Trends impacting on wastewater management

Details of the challenges related to this Investment Case are set out below.

Future challenges

Maintaining the integrity of our assets

At the end of 2020 circa 370 of our 835 WwTWs will have had no major refurbishment work for 50 years and by the end of AMP7 this figure could reach circa 460. With an increasing proportion of our assets reaching or surpassing their design life, there is a greater risk of asset failure. This, in conjunction with a reliance on ageing infrastructure of other utilities (for example, energy and transport), may affect the reliability of our services. Our plans will prioritise investment on those assets that are most at risk of failure, having regard to environmental impacts and cost-benefit.

Achieving regulatory requirements

Our aim is to comply with all regulatory requirements 100% of the time. The challenges we will need to overcome are:

- Meeting our regulatory permits with an ageing asset base and ever tightening environmental standards;
- Addressing climate change impacts including protecting our WwTWs from increased risks of flooding and making them robust to manage flows adequately in extreme weather conditions (including high temperatures), and ensuring the integrity of outfalls in more extreme storm conditions in coastal areas;
- Managing increased flows due to growth. Projected population growth between now and 2035 is a 19% increase in England and a 13% increase in Wales.
- Managing our sewerage assets to ensure we limit infiltration to acceptable levels to minimise the impact on WwTWs.

Reducing ‘average cost to serve’

We have a high number of WwTWs for the population served relative to the majority of other water companies. In particular, 574 of our 835 WwTWs (nearly 70%) serve a population equivalent of less than 500. This contributes to our average cost to serve for wastewater treatment being relatively high compared to most other water companies.

To date, our investigations have identified that opportunities to rationalise the number of WwTWs are limited as the topography of Wales is such that connecting rural communities to larger consolidated WwTWs is generally not cost beneficial nor in many cases sustainable in terms of energy use. However such opportunities continue

to be investigated having regard to efficiencies and innovation in the delivery of schemes.

Managing customer expectations

Changing customer expectations will require us to ensure that all customers have a minimum universal service standard. For example, reduced customer acceptability of pollution events, along with increasing improvements in water quality increasing the impact of pollution on the waterbodies, means that the service we provide will need to be more resilient to minimise this risk.

Managing economic changes

It is expected that there will be considerable volatility in the market for energy in the future, with electricity potentially becoming more expensive and less secure. This will need to be taken into account by developing sustainable solutions that minimise energy use. Our proposals for the further provision of alternative / back up supplies (through our resilience investment proposed in the Wastewater Enhancement Investment Case) will support the protection of our wastewater services.

Building on progress

The following paragraphs describe our historical and current performance with respect to compliance and Measures of Success.

WwTW performance

WwTW performance has primarily been measured to ensure compliance with regulatory requirements and over AMP6 the following MoS and associated targets and outcomes.

Wastewater Treatment Works Look-up Table Compliance: MoS B2

Target 2020 – 99% compliance with permits. Outcome "Protecting our environment". Historic performance, measured as percentage of WwTWs in breach of their numeric permit (Look up Table), is shown in

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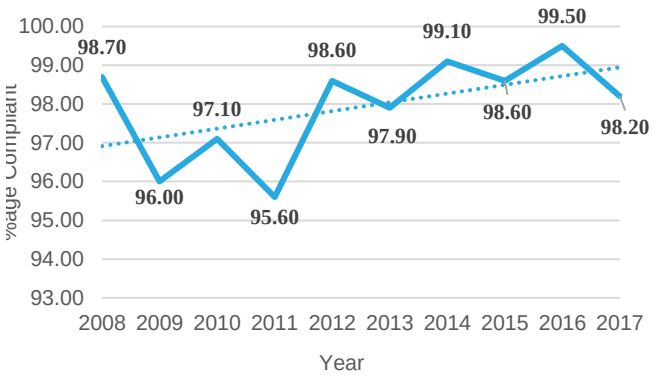


Figure 2: Historic WwTW compliance with numeric permits

Over the period 2009 to 2011 permit compliance was not where we wanted it to be, but the position improved during 2012 and has since continued with a generally improving trend. Improvement in performance was due to:

- Improved data use relating to performance, together with increased reporting, which enabled proactive works to be undertaken to address identified compliance risks before they became a reality;
- The setting up and role of the Compliance Steering Group. This group was able to utilise improved performance data from monitoring activities to identify WwTWs at risk of compliance failure. This information was then used to review priorities with respect to our operational activities and investment required to address compliance risks;
- A significant increase in capital maintenance expenditure;
- Training and focus on fully understanding root causes of failures;
- The adoption of LEAN processes to realise efficiencies at WwTWs.

Compliance performance can however, still vary year-on-year. This can be due to a number of contributing factors e.g. extreme weather conditions, telemetry failures and asset failures.

Over the remaining years of AMP6 we will aim for 100% compliance and build on the last few years' trend of improved performance. This will be facilitated through increased emphasis on forward looking capital maintenance through the increased implementation of predictive analytics, improved monitoring of assets / processes and the further development of operational processes and workforce skills.

Preventing Pollution: MoS B3

Target 2020 - no more than 131 category 3 pollution incidents.
Outcome - "Protecting our environment".

Our MoS B3 Pollution target relates to all our wastewater assets, including our sewerage networks and sewage pumping stations, which are addressed in other investment cases. Figure 3 shows the historical Category 3 pollution performance from our WwTWs (dark blue line) in the context of our overall Category 3 pollution performance (light blue line).

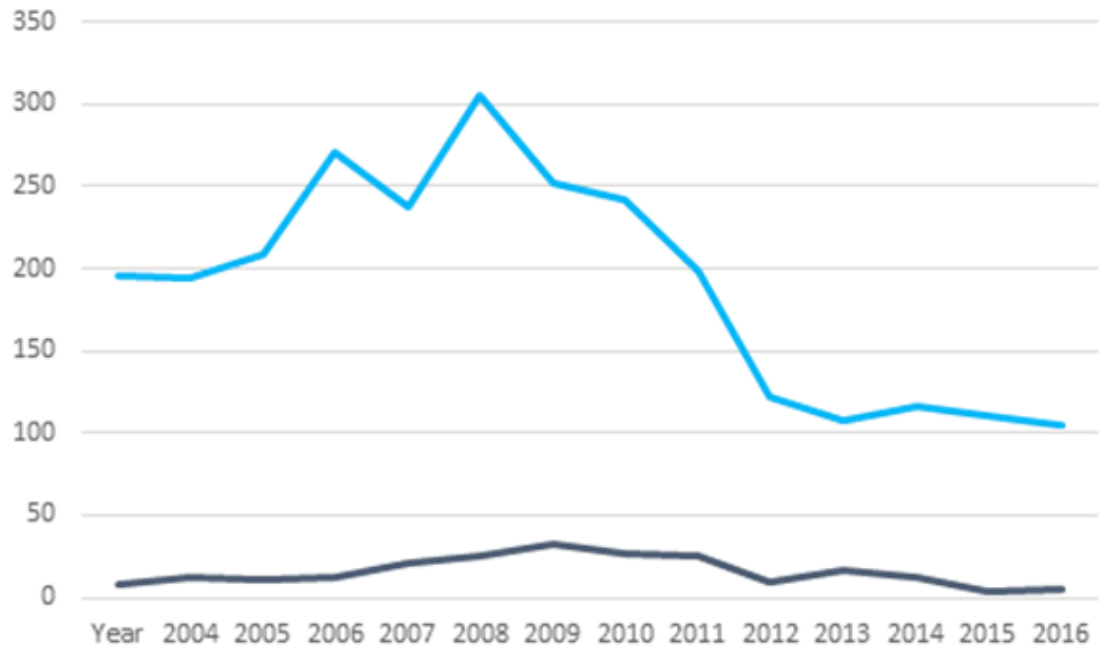


Figure 3: Historic Category 3 pollution incidents

The reasons for improved performance in recent years include:

- Improved data availability and reporting relating to performance, which enabled proactive works to be undertaken to prevent pollution incidents;
- The setting up of the Compliance Steering Group to utilise improved performance data from monitoring activities to identify potential pollution risks;
- An increase in capital maintenance expenditure.

We also implemented a number of initiatives to help reduce the risk of pollution from our WwTW assets including:

- Raising public awareness around the risks associated with sewer blockages, including television and radio campaigns, open days at WwTWs and other local initiatives;
- Utilisation of the 'SmartHub' telemetry and control team to support alarm management and ensure that we respond swiftly to potential issues.

The rise in incidents over 2017 was the result of varying causes including operational issues, asset damage and compliance failures, demonstrating the need to further develop our operational processes to support capital investment made.

Asset Serviceability: MoS F1

Target 2020 – stable performance. Outcome "Asset Stewardship".

This MoS relates to several factors but the relevant sub service assessment is wastewater non-infrastructure. The serviceability indicators for the performance assessment include unplanned maintenance, equipment failures, pollution incidents, %PE in breach of permit and % WwTWs in breach of numeric permit.

Our assessment of Serviceability is "Stable" in relation to the Wastewater Non-Infrastructure indicators, including our WwTWs and outfalls, as it has been for a number of years.

Outfall performance

In conjunction with other elements of our wastewater systems, our sea outfalls help to ensure that compliance with the EU Urban Wastewater Treatment, Bathing Waters and Shellfish Waters Directives is maintained. Compliance performance at these waters is monitored by the water quality regulators, NRW and EA.

Marine water quality results are a good indicator of our historical performance when it comes to our outfall assets. Bathing water quality in Wales is generally good, with a high compliance against the revised Bathing Waters Directive (rBWD). The rBWD came into force in 2015 and tightened the bacteriological standards significantly. Sampling for the revised Bathing Water Directive began in 2012), however 2015 was the first year that the new classifications were used for calculating and reporting. Table 5 shows the outturn position up until the end of the 2017 bathing season (in September).

Regular inspections are carried out on our Sea Outfalls through our investigative programme, and our navigational aids (marker buoys and beacons) are inspected on an ongoing basis by our designated subcontractors, currently Trinity House.

Standard Achieved	2015 Number of Bathing Waters	2016 Number of Bathing Waters	2017 Number of Bathing Waters
Excellent	82	84	80
Good	16	13	18
Sufficient	4	5	5
Poor	0	1	1
TOTAL	102	103	104

Table 5: Wales rBWD results

Although there has been a slight decrease in the number of excellent bathing waters this has not been associated with performance / integrity of our outfalls.

DWF compliance

Compliance monitoring against DWF permits at MCERTS-monitored WwTWs has been enforced by Natural Resources Wales (NRW) and the Environment Agency (EA) since 2011. The DWF 'trigger' is where the Q90 flow exceeds the DWF permit (Q90 is the daily flow (m3/d) that is exceeded on 90% of days). Figure 5 shows the number of sites where Q90 exceeds permit between 2011 and 2017. Forty eight WwTWs had DWF permit exceedances in 2017, of which twelve were new.

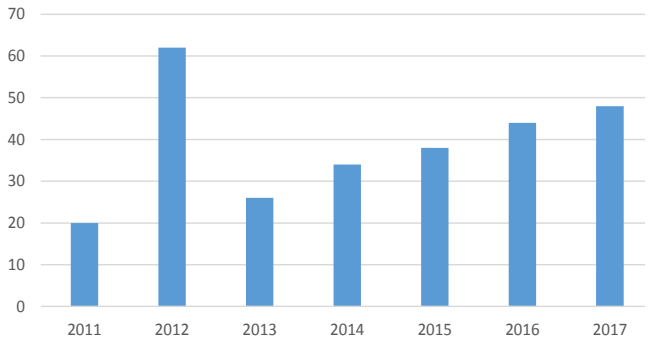


Figure 4: Number of WwTWs where Q90 exceeds DWF permit (2011 to 2017)

Based on our initial reporting to NRW/ EA, the number of first time failures in each year since 2011 are shown in Table 6.

Year	No. of DWF permit exceedances	Notes
2011	20	Most now addressed and compliant, following sewerage rehab or permit reviews.
2012	n/a	n/a – excessively wet year
2013	17	Most progressing through delivery process; 3 deferred to AMP7 in agreement with NRW/EA
2014	10	Majority data errors or recirculation issues; some catered for by 'other driver' AMP6 schemes, e.g. Johnston
2015	12	Under investigation; 5 sites have 'other driver' AMP6 schemes.
2016	9	Under investigation; some likely to be data errors

Table 6: Number of DWF permit exceedances since 2011

Through close liaison with the NRW/EA, we have worked to agree priorities and deliver improvements to restore compliance. In most cases, compliance has been achieved through reduction of infiltration into the sewerage network. In others, the flow compliance issue is due to population growth since the permit was written. In these cases it has been necessary to apply for a new, higher DWF permit and upgrade the WwTW to cope with the associated tightening of sanitary permits, where necessary. In total, twenty sites will have been addressed by the end of AMP6.

PFF compliance

This is a relatively new area of investment so historical data is limited. We have found that many of the 'apparent' failures were due to poor data, and that the sites are in fact compliant. We have also found that solution costs vary significantly, from effectively zero (minor operational adjustments) to very high (complete new WwTWs). As our investigations through AMP6 reveal the root causes, the number of sites needing to be addressed in AMP7 has changed. As it stands, our investment plan is based on six sites confirmed as needing capital schemes to address compliance.

It is important to add that, with a single exception, none of our assets are currently set up to monitor the Pass Forward Flow conditions that are specified on our permits. The installation of monitoring specifically for this purpose will be undertaken n AMP6 and AMP7 under enhancement investment at sites listed on our WI(NEP). However, we are proactively monitoring the available data through an agreed process with our regulators, NRW and the EA. Each year we assess this data and notify the regulator of potential non-compliances. Through our Flow Strategy and Steering Group we agree an investigation programme and, if necessary, a programme to address issues.

WwTW expenditure

Expenditure has been focused on maintaining compliance with regulatory permits and MoS targets, and providing a stable, cost-effective service for our customers. Our capital expenditure since 2011 /12 is indicated in Figure 5. A significant increase in expenditure was made over 2012/13 to

address deteriorating compliance performance and the consequent improvement in compliance performance can be seen in

(refer to 'Wastewater Treatment Works Look-up Table Compliance: MoS C2').

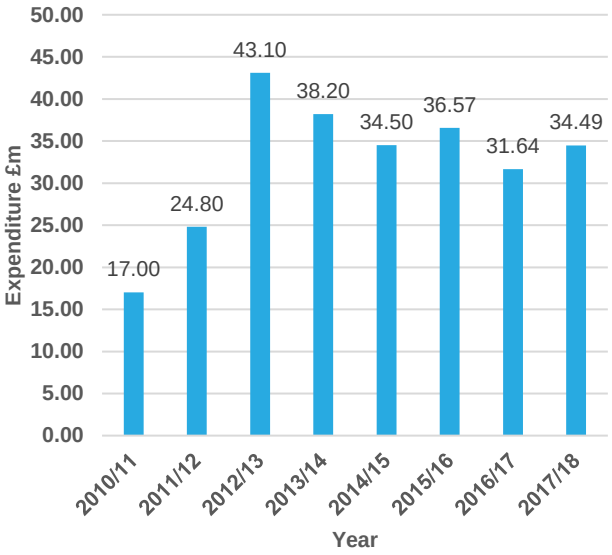
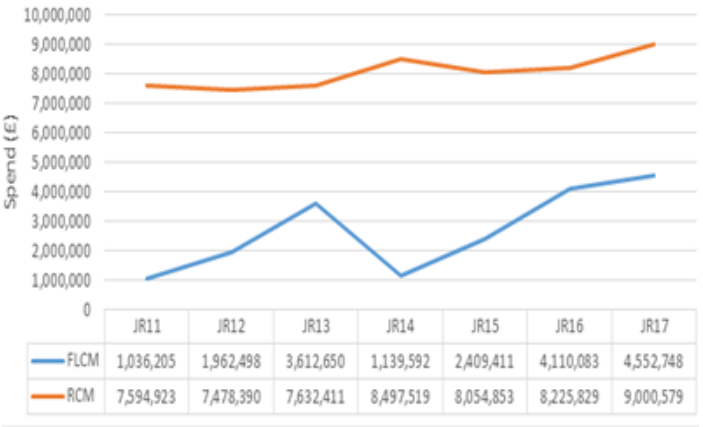


Figure 5: WwTW capital maintenance expenditure

The historic trend shows an increase in Reactive Capital Maintenance (RCM) and Forward Looking* Capital Maintenance (FLCM) expenditure. This is illustrated in Figure 6. The RCM increase is due to both increasing numbers of assets on sites from permit tightening in previous AMP periods - the large number of new phosphorous limits imposed is a good example - and our ageing asset base. The increasing FLCM is following our strategy of preventing service failure by concentrating on critical assets.



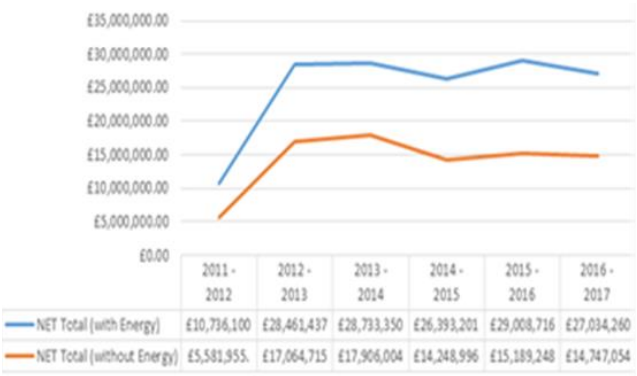
	JR11	JR12	JR13	JR14	JR15	JR16	JR17
FLCM	1,036,205	1,962,498	3,612,650	1,139,592	2,409,411	4,110,083	4,552,748
RCM	7,594,923	7,478,390	7,632,411	8,497,519	8,054,853	8,225,829	9,000,579

Figure 6: Historic RCM and FLCM expenditure at WwTWs

As can be seen there has been a bigger rise in FLCM as we have taken more proactive role in preventing failures before they occur and cause service failures.

Operational expenditure

After a significant increase in operational costs early in AMP5 (corresponding directly to the improved performance of our WwTWs), operational expenditure has remained generally consistent since. Our operational expenditures including energy, are shown in Figure 7.



	2011 - 2012	2012 - 2013	2013 - 2014	2014 - 2015	2015 - 2016	2016 - 2017
NET Total (with Energy)	£10,736,100	£28,461,437	£28,733,350	£26,393,201	£29,008,716	£27,034,260
NET Total (without Energy)	£5,581,955.	£17,064,715	£17,906,004	£14,248,996	£15,189,248	£14,747,054

Figure 7: Historic opex at WwTWs

Outfall expenditure

The forecast out-turn expenditure on outfalls over AMP6 is £9.71m, which has been primarily focused on the rehabilitation of outfall structures. Expenditure over AMP5 was £12.66m,

demonstrating a downward trend in investment. Investment levels are, however, dependent on the specific outfalls requiring remediation – although there is a base level of spend on navigational aids.

DWF and PFF expenditure

Our historical costs for DWF schemes are nearly all for Below Ground Asset (BGA) solutions, where infiltration flows into the sewers are reduced through sewer rehabilitation or replacement. This is our preferred approach. Figure 8 shows 'latest best estimate' costs for sixteen AMP6 BGA schemes.

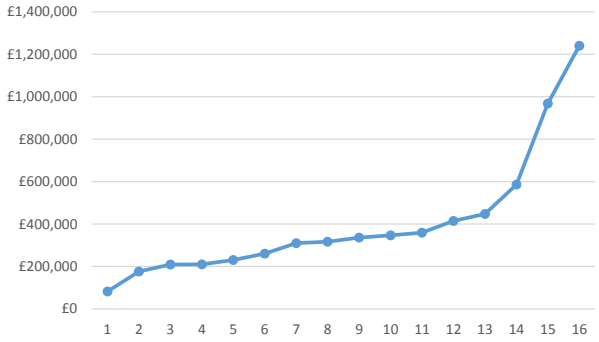


Figure 8: DWF scheme costs in AMP6, where solved through infiltration reduction

Where a new, higher DWF permit is required, there may be an associated tightening of sanitary limits, depending on water quality requirements of the receiving water. To date in AMP6, we have only completed one scheme where this applied. This was at Llanpumsaint WwTW and the scheme cost was £2.4m for a complete works replacement (735 population equivalent).

Planning for the future

Our approach to identifying and prioritising expenditure required over AMP7 and beyond has been underpinned by our aims to comply with regulatory requirements, achieve our Measures of Success, meet the aspirations of our customers at an affordable cost and ensure compliance with permitted flow criteria, where evidence demonstrates there is a risk to non-compliance.

We also aim to increase efficiency and lower our average cost to serve so as to achieve upper quartile performance compared with other water companies, and maintain affordable bills for our customers. To help achieve this aim we will:

- Reduce costs through innovative capital solutions and more efficient delivery of schemes;
- Support targeted capital investment through operational initiatives such as MaRS (see Appendix 1) and SORT;
- Improve instrumentation, monitoring and control. Better on line instrumentation will reduce the need to visit WwTWs to check performance of assets and lead to more speedy intervention when things go wrong.

Forward looking analysis - performance

WwTWs

Depending on permit requirements, we measure the concentrations of determinants such as Biological Oxygen Demand (BOD), Suspended Solids (SS), Ammonia (NH4) and Phosphorous (P) in the effluent from our WwTWs. The quality achieved is reviewed against the quality criteria included in permits from NRW and EA.

Generally the performance of our WwTWs is predicted to improve. This however assumes continued investment in our assets, particularly at those WwTWs with identified high risks with respect to treatment processes and growth pressures, together with on-going operational improvements.

Additional compliance criteria may also be included in the future with regards to effluent standards to be met and requirements for further chemical sampling.

Outfalls

Outfalls are highly variable in terms of construction material, length, location and the impacts from the local marine environment. For this reason deterioration studies by the industry remain limited. Our aims over AMP7 are primarily focused on maintaining the integrity and performance of

our outfalls, ensuring these do not contribute to any compliance failures / pollution incidents, and maintaining serviceability.

An Investigative Programme is proposed to be undertaken early in AMP7, to include surveys of assets to improve our knowledge of the existing performance and asset condition. This will support us with the prioritisation of outfall maintenance programme and define future investment proposals (AMP8 and beyond).

Flow issues

On-going monitoring of flow will be undertaken to verify the extent and impact of any flow permit compliance issues at our WwTWs. This information will consequently be used to determine our AMP8 programme of works having regard to other initiatives developed through our NEP programme, in particular investment to address issues identified through EDM monitoring.

DWF

Without investment, we would expect an increase in DWF permit exceedances due to:

- Sewer deterioration causing increased infiltration;
- Population growth causing increased domestic foul flows;
- Economic development causing increased commercial flows or trade effluent;
- Network modifications to reduce spills to the environment, where it is deemed there is an impact and it is cost effective to do so

PFF

We anticipate that PFF issues will increase as we increase the number of monitors to record PFF under the NEP FLOW4 and 4W drivers.

As we move into AMP7, we will have 21 sites where we have accurate measurement of our Pass Forward Flow, as agreed with the NRW and EA. As more will be installed in AMP7 we anticipate a small rise in the number of sites which are identified as non- compliant with permit conditions.

Further PFF issues may emerge from increased external scrutiny (EA documents suggest they will be doing this), ongoing internal data analysis and repair / refurbishment of monitors to improve accuracy of measurements.

Integrated and long-term planning

The proposals included in this investment case will link with initiatives and investment in other wastewater investment cases to ensure a holistic approach to wastewater investment. One such initiative is the Drainage and Wastewater Management Plan (DWMP) process which emerged through the 21st Century Drainage programme.

3 Options

Background

Our approach to identifying and prioritising expenditure required over AMP7 has been underpinned by our aims to:

- Maintain our WwTWs to protect river and coastal water quality and public health;
- Ensure compliance with permit conditions, including flow;
- Maintain the integrity of our outfalls;
- Develop sustainable solutions to operational problems to achieve the best possible standards for river and coastal waters;
- Reduce pollution occurrences at our WwTWs;
- Maintain serviceability;
- Comply with regulatory requirements 100% of the time;
- Achieve performance targets set out in our Measures of Success;
- Manage risks, costs and performance so as to deliver the benefits to our customers and the environment at an affordable cost.

In identifying our proposed expenditure for this investment case, we had regard to a number of factors:

- Current and historical compliance against regulatory permits and performance against Measures of Success targets;
- Estimated out-turn investment in AMP6 with respect to WwTW and Outfall maintenance as performance has generally been maintained over the period;
- Flow measurements and analysis at WwTWs;
- Investigations undertaken to confirm flow issues and cost assessments undertaken to maintain compliance;
- Analysis undertaken to identify the degree of risks, associated mitigation costs and outline cost-benefit analysis;
- Operational initiatives such as LEAN and MaRS (refer to Appendix 1) which have demonstrated success in supporting improved performance and mitigating risks not addressed through capital investment. Such initiatives would continue to be developed and implemented across additional WwTWs over AMP7 leading to further efficiencies.

Supporting analysis

IM optimisation and cost curves

We used Investment Manager (IM) to identify the risks and needs associated with the maintenance of our WwTWs and outfalls. Optimisation of these risks was undertaken, which identified the annual risk exposure required of circa £95m for our WwTWs and circa £2m for our outfalls.

A further, more detailed assessment has also been undertaken to help understand the predominant risk areas related to our WwTW sites and outfalls, in order to help prioritise discrete programmes of work identified in our funding proposals.

Further information on the IM analysis, IM curves produced and risks associated with work programmes is included in Appendix 2.

High-level options appraisal

The following high-level options were considered in the development of this investment case for AMP7.

Option 1: Reactive only

An option to review the costs and consequences of reacting to failure (fix on failure) rather than proactively reducing the risk of service failure.

The impacts of this investment decision would be an increase in the number of WwTW compliance failures, together with increased pollution and flooding incidents. Such incidents would also occur as a result of any outfall failure.

Failure to address flow issues at our WwTWs would also result in permit conditions not being met with consequent increased risks of pollution to inland

and coastal waters, and enforcement/prosecution by our environmental regulators.

Through our customer engagement programme, described in supporting document 1.2 PR19 Stakeholder Engagement Report, "Cleaner rivers and beaches' was identified as having the highest importance overall for our customers and there was a particular drive from across our customer base for us to reduce pollution incidents to protect our rivers and coastal waters and improve flooding performance in a cost-effective manner.

As this option does not meet the aspirations of our customers and would result in increased non-compliance with permits and lead to prosecution, it is not considered to be tenable.

Option 2: Maintain current expenditure - £185m

A breakdown of the proposed expenditure for this option, at 2017/18 prices, is shown in Table 7.

Programme of work	AMP7 capital investment	AMP6 forecast out-turn expenditure
WwTW maintenance	£145.1m	£156.5m
Outfalls	£8.8m	£9.7m
DWF	£11.8m	*
PFF	£19.5m	*
Total programme (pre-efficiency)	£185.2m	-
Forecast AMP6 out-turn	-	£166.2m

Table 7: Option 2 Capex Breakdown

* Expenditure on DWF and PFF in AMP6 is included under WwTW maintenance.

The proposed WwTW maintenance expenditure was identified following a review of AMP6 performance and expenditure, and a review and analysis of risks on IM. The expenditure is similar to current predicted out-turn AMP6 expenditure once allowance is made for increased AMP7 efficiencies.

The expenditure on outfalls is based on an analysis of risks on IM and the identified annual risk exposure. The expenditure equates to current predicted out-turn AMP6 expenditure allowing for AMP7 efficiencies.

The DWF expenditure assumes that twenty schemes will be required to address the remaining confirmed DWF compliance failures from 2011 to 2016 inclusive, based on unit costs derived from AMP6 schemes.

The PFF expenditure is based on outline costs for six schemes where the PFF compliance risk was known by 2016 and the need for capital expenditure has been confirmed by site investigations and root cause analysis.

Overall expenditure for this option equates to current level of AMP6 expenditure once allowance is made for increased efficiencies to be delivered over AMP7. Our proposed post efficiency expenditure is £166.47m; compared to £166.2m predicted out turn over AMP6.

As such having regard to performance improvements made over AMPs 5 and 6, it is considered that on-going investment levels will meet identified performance measures relating to compliance, flooding and pollution. However, to achieve these targets and in particular the 100% target with respect to compliance, then this investment would need to be supported by the effective implementation of the MaRS and LEAN projects. These will help improve our operational performance by ensuring a more proactive approach to maintenance through a multi-skilled workforce, who can identify and address performance issues prior to any Service failure.

Option 3: Increase total expenditure to £300m

A breakdown of the proposed expenditure for this option, at 2017/18 prices, is shown in Table 8.

An additional investment (as compared to Option 2) of circa £90m on WwTW Maintenance and £10m on outfall maintenance was considered in addition to an additional £20m on flow related expenditure. This provided an additional circa £120m as compared to Option 2, which would focus on:

- The delivery of a small WwTWs (less than 1000 population equivalent) replacement / refurbishment programme and additional programmes of work at WwTWs. The overall investment could address 50% of risk values on IM;
- Additional outfall rehabilitation works to address up to 90% of recorded risks on IM;
- Additional DWF and PFF schemes to address issues emerging after 2016.

Programme of work	AMP7 Capital Investment
WwTW maintenance	£230m
Outfalls	£18m
DWF	£22m
PFF	£30m
Total programme (pre-efficiency)	£300m
Total programme (post-efficiency)	£280m

Table 8: Option 3 Capex Breakdown

This additional funding would lower the risk position against our serviceability and MoS targets.

However, given our WwTW performance levels have generally improved over AMP5 and AMP6 and investment on descriptive works, access and structures may have limited impact on our Measures of Success, no justification can be made for additional expenditure in this area. It was also considered that the further implementation of operational initiatives and the development of innovative solutions for small works and treatment processes in AMP7 would need to be evaluated, pending evaluation of additional investment needs during AMP8.

Regarding additional expenditure on outfalls, it was concluded that given the assessed annual risk exposure of £1.9m identified through IM analysis, an additional £10m expenditure could not be justified.

For DWF and PFF it was considered that additional expenditure could not be justified as this would allocate funding for permit failures which had not been fully confirmed. In some cases, DWF exceedances are found to be data or operational anomalies (requiring only minor maintenance to resolve), and the sites return to compliance in the following years. Similarly, confirmation of genuine need for capital intervention on PFF requires careful data checks, site investigations and root cause analysis.

4 Preferred option

Summary

Option 2 was identified as the preferred option following scrutiny of potential expenditure scenarios by the Executive team.

In reviewing options for expenditure, regard was given to proposed AMP7 performance measures to be achieved, proposed capital and operational expenditure in other wastewater related investment cases, customer expectations and willingness to pay and affordability. Consideration was also given to outcomes of negotiations with the EA and NRW on investment to address flow issues.

We consider that the proposed pre-efficiency expenditure of £185m provides a balanced programme, developed following an analysis of the challenges, opportunities and risks, and presents the best value for money to help achieve performance targets identified in our Measures of Success at an affordable cost to customers.

Programme of work	AMP7 Capex Base	AMP7 Capex Enhancement	AMP7 Capex Total
WwTW maintenance	£143.1m	£2.0m*	£145.1m
Outfalls	£8.8m	£0.00	£8.8m
DWF	£9.4m	£2.4m*	£11.8m
PFF	£19.5m	£0.00	£19.5m
Total programme (pre-efficiency)	£180.8m	£4.4m	£185.2m

Table 9: Preferred option capex breakdown

Investment proposals were developed around four key areas as identified in Table 9. The small allocation to enhancement is a result of allowing for additional capacity in maintenance-led schemes to allow for growth.

The following sections give further information on the four key programmes of work.

WwTW maintenance

A breakdown of our proposed investment is included in Table 10 and further detail is provided below (all costs are pre-efficiency):

- **Reactive Capital Maintenance (RCM) and Forward Looking Capital Maintenance (FLCM): £55.4m**. RCM expenditure is included to address asset and equipment failures and breakdowns. FLCM is to address deterioration of equipment / assets and performance risks which should they fail would have an impact on service to our customers. With the implementation of more efficient and effective wastewater operations, in particular through the LEAN and MaRS projects, we are developing our systems and workforce competencies to focus more on FLCM so as to proactively address risks before failure occurs. This reduces our overall expenditure requirement and reduces WwTW failures and pollution incidents. The forecast AMP6 RCM + FLCM out-turn expenditure is circa £12.7m/year and hence the proposed investment incorporates challenges to reduce this over the AMP7 period. The level of challenge is £1.67m per annum.
- **Planned Capital Maintenance – Base Maintenance: £15.7m**: This incorporates funding to address service risks identified over AMP7;
- **Planned Capital Maintenance – Operation Delivery: £4.9m**: This relates to money allocated to Operations to reduce smaller risks with high impact, which will be prioritised

through IM. Current expenditure is £0.95m/year and so this is on par with AMP6;

- **De-minimus Pot: £5.4m**: This money allows the Operations team to deal swiftly with minor issues on site before they grow to a level where major investment would be required and to invest in small scale building repairs, maintaining compliance through small local improvements.
- **Planned Capital Maintenance – Maintenance Schemes and Programmes of Work: £63.5m**: This expenditure is included to address prioritised maintenance schemes in AMP7. In particular, we will undertake discrete programmes of work on identified pieces of common equipment / assets across a number of WwTWs identified through our Investment Manager system to be of particular concern and risk to achieving our Measures of Success, have a high service impact and are cost-beneficial. These include:
    - Inlet works (and screens in particular);
    - Automatic storm tank emptying and sludge return;
    - Diffusers / Blowers;
    - UV improvements;
    - Structural improvements.

We have identified a priorities list of assets where risk is sufficient that investment will be required but the programme for AMP7 will retain a lot of flexibility as the risk profile changes.

Element	AMP7 Capex Base	AMP7 Capex Enhancement	AMP7 Capex Total (pre-efficiency)	AMP7 Capex Total (post-efficiency)
FLCM	£21.4m	£0	£21.4m	£21.2m
PCM Base	£15.7m	£0	£15.7m	£14.3m
PCM Base (Ops delivery)	£4.9m	£0	£4.9m	£4.6m
RCM	£34m	£0	£34m	£33.7m
M De minimus Pot	£5.4m	£0	£5.4m	£5.3m
Programme of planned capital schemes	£8.2m	£2.0m	£10.2m	£9.3m
Programmes of Works (incl. inlet works, UV, storm tank emptying, diffusers, blowers)	£53.5m	£0	£53.5m	£48.6m
IBR saving includes MARS, LEAN	-	-	-	-£7.1m
WwTW Maintenance Total	£143.1m	£2m	£145.1m	£129.9m

Table 10: WwTW Maintenance Expenditure

Comparison with AMP6

The forecast AMP6 out-turn expenditure at 2017/18 prices is £156.5m. This is higher than our proposed AMP7 investment as it does not incorporate the efficiencies through innovation and delivery of scheme outputs and reductions in expenditure due to operational initiatives. Expenditure over AMP6 also includes limited expenditure on flow investigations and mitigation, which is included in separate programme of work in AMP7.

Outfall maintenance

A total expenditure of £8.8m is proposed which would address about 80% of the annual risk exposure identified through IM analysis. A breakdown of our proposed investment is included in Table 11. However, we need to undertake a full suite of surveys to fully understand our outfall risks which will mean that overall we may end up with more risks to address.

Element	AMP7 Capex Base	AMP7 Capex Total (pre-efficiency)	AMP7 Capex Total (post-efficiency)
PCM Base	£6.9m	£6.9m	£6.3m
Investigative studies	£0.4m	£0.4m	£0.4m
Navigational aids (Inspection, repair / replacement)	£0.5m	£0.5m	£0.5m
RCM / FLCM	£1m	£1m	£1m
Outfalls Total	£8.8m	£8.8m	£8.2m

Table 11: Outfall Maintenance Expenditure

- **Reactive Capital Maintenance / Forward Looking Capital Maintenance (£1.0m)**. This programme will cover the cost of reacting to incidents and restoring sea outfalls and navigational aids to a serviceable state after failure has occurred. The programme cost of £1m has been estimated from analysis of historical programme costs in AMP6.
- **Navigational Aids Programme (£0.5m).** This incorporates expenditure for the ongoing annual monitoring and reporting of the condition of our sea outfall navigational aids by our designated subcontractors, currently Trinity House (through the Statutory Maintenance department). Trinity House also annually monitors and reports our compliance under the Coast Protection Act 1949, as amended. The condition of all our navigational aids are reported with operational defects identified for intervention under reactive maintenance budgets. The programme cost of £0.5m has been derived from analysis of expenditure in AMP6.
- **Investigative Programme (£0.4m).** Data in our sea outfalls database will be used to develop a prioritised strategy for surveys, based on a prediction of the consequence of failure (criticality) and the probability of failure (condition).
- **Planned Capital Maintenance (PCM) (£6.9m)**. PCM will be used to address a prioritised range of risks identified on IM and also through the findings of the investigative programme. A programme will be drawn up to specify which assets will have remediation work undertaken over AMP7, primarily based on the results of investigations and risks on IM.

Ongoing operational initiatives will help us manage risks not addressed through capital expenditure.

Comparison with AMP6

The predicted AMP6 out turn based on 2017/18 price base is £9.7m. Expenditure is reduced based on assessed annual risk exposure of risks on IM having regard to efficiencies to be delivered over AMP7.

DWF and PFF

Proposed expenditure to address DWF and PFF compliance is shown in Table 12.

Row Labels	AMP7 Capex Base	AMP7 Capex Enhancement	AMP7 Capex Total (pre-efficiency)	AMP7 Capex Total (post-efficiency)
DWF schemes - past failures (2011 to 2016 inclusive)	£9.4m	£2.4m	£11.8m	£10.7m
PFF schemes - confirmed (to 2016)	£19.5m	£0	£19.5m	£17.7m

Table 12: DWF and PFF capex breakdown

The proposed expenditure on DWF schemes is £11.8m. This is based on twenty schemes at sites where DWF failures (Q90 > DWF permit) occurred between 2011 and 2016.

It has been assumed that eighteen of the twenty schemes will be on below ground assets (BGA) to reduce infiltration flows into the sewerage network. We assumed a unit cost of £0.4m for these, based on an average derived from sixteen AMP6 schemes. We assumed two of the twenty will be AGA schemes, solved by applying for a new, higher DWF permit because infiltration is already low. We have used a cost of £2.4m for these, based on the out-turn cost of an AMP6 AGA scheme of similar size.

The PFF funding is specifically for schemes: (a) which we knew we would not be able to deliver in AMP6; (b) where the PFF non-compliance risk was known by the end of 2016, and; (c) where the need for capital expenditure had been confirmed through site investigation and root cause analysis.

5 Cost efficiency and innovation

Cost efficiency

Our intention over AMP7 is to build on initiatives developed in AMP6 and to maximise efficiencies through the continuation of internal business review (IBR) initiatives, such as MaRS and Lean, and the further development of efficiencies through our Alliance Partners in the planning and delivery of our AMP7 interventions.

The IBR savings relevant to this Investment Case are circa £7.1m and this will be achieved primarily in the WwTW maintenance programme and through our MaRS and Lean projects. However, we propose to deliver a further saving of £25.8m through improved efficiencies in the delivery of schemes by our Alliance Partners, including maximising opportunities to innovate.

The overall efficiency savings to be delivered are included in Table 13.

Programme of work	AMP7 Capital Investment pre-efficiency	AMP7 Capital Investment post-efficiency
WwTW Maintenance	£145.1m	£129.9m
Outfalls	£8.8m	£8.2m
DWF	£11.8m	£10.7m
PFF	£19.5m	£17.7m
Total (pre-efficiency)	£185.2m	-
Total (post-efficiency)	-	£166.5m

Table 13: Cost Efficiencies

Summary of innovation

We are working on a number of innovations, including:

- Maintenance and Reliability Support (MaRS) project.
- LEAN strategy
- Efficiency initiatives in WwTW compliance, increased automation and small community treatment works.

An outline of these proposed operational initiatives and innovation opportunities is included in Appendix 1.

These initiatives will also be supported by the development of our Drainage and Wastewater Management Plans (DWMPs) that we will produce in AMP7. The development of DWMPs will enable us to maximise our understanding of the risks we face across all of our wastewater assets and ensure that our interventions are proportionate and sustainable.

We will also continue to share best practice across the industry through conference attendance and the Innovation Forum.

Partnering and co-creation

Working closely with our partners is an essential part of our plan. Our 2050 strategy highlights this through identifying partners for each of our programmes of future work.

In particular, we will be using stakeholder partnership approaches to allow us to move away from end-of-pipe solutions for some of our National Environment Programme schemes. This approach should provide a lasting benefit by reducing maintenance costs in the long term.

We aim to undertake this work in partnership with customers and communities and our Customer Challenge Group.

6 Value for money and affordability

Impact on customer bills

We understand the importance of balancing the need for investment with the affordability of our bills. We believe the investment will help to deliver the level of service our customers and regulators expect, and represents an optimal approach for sustained long-term improvement.

Value for money

We recognise the need to demonstrate value for money in everything that we do. In arriving at the proposed investment, we have closely considered the costs and benefits of different approaches to make sure that the investment represents long-term value to our customers.

As outlined in Chapter 5, we will also seek to ensure value for money by promoting innovation throughout the delivery chain, by learning lessons from the work we have delivered to date, and by working closely with our partners to encourage best practice and incentivise efficiency.

7 Delivery

Procurement

The various projects will be managed by our Wastewater Assets (WWA) team with scope and programme adjustments being made as necessary to address operational and other issues.

Programme

The WWA team will develop a prioritised programme of capital expenditure, incorporating reactive and forward looking capital maintenance, investigations, projects and schemes, linked to the wider wastewater investment cases and programmes of work. These will be prioritised based on the associated benefits of the interventions. The programme will be developed and optimised early in year five of AMP6.

The WWA team will monitor performance, expenditure and customer data to respond to new challenges and identify circumstances that lead to opportunistic interventions. The WWA team will also manage projects month by month to respond to emerging signs of increasing costs and/or benefits not being delivered.

Our plan will be to continue with the investment programmes beyond March 2025 with the latest risk, deterioration modelling, cost, performance and benefits data being used to identify and optimise investment needs for PR24 and beyond.

We have currently only set out only the five year AMP7 programme; programmes for further AMPs will be based on our continuous review during AMP7.

Risk mitigation and customer protection

We will deliver our programme in a phased approach so that we can learn from and build upon our experiences of delivering interventions.

8 Assurance

Governance

Our performance is regularly reviewed and shared internally (daily with respect to WwTW compliance performance), to ensure that emerging trends and problem areas are targeted quickly. Our annual performance is reported externally to NRW and the EA.

All capital projects must pass through our gateway approval process to ensure there is sufficient scrutiny and challenge from senior management. Our Capital Programme Board (CPB) has the delegated authority to approve projects through the gateways. The approach provides strong governance for approving investment decisions and is transparent and fully auditable.

We will continue to apply these effective governance systems for our proposed AMP7 investment programme.

The programmes of work proposed in the Investment Case have been developed with our WWA and Environmental Quality teams and approved by the Wastewater Totex Steering Group. This group is chaired by the Director of Wastewater Services and has met monthly during the development of the Investment Case.

Our Board has reviewed this investment alongside all elements of the PR19 Business Plan.

Cost assurance

We have undertaken high-level feasibility studies to enable the outline scope of work and cost of the options to be assessed. We have produced cost estimates using our Unit Cost Database (UCD) models. These models are updated annually and externally benchmarked every five years to make sure that the costs remain current.

Customer consultation assurance

Our proposed investment for Wastewater Treatment Works and Outfalls Maintenance together with investment to address DWF and PFF compliance will contribute to the sustainable management of wastewater to ensure the protection of public health and water quality (both our rivers and coastal waters).

Our plan will therefore support our customer priorities, which showed a strong support across all demographic groups for investment which contributed to 'Cleaner rivers and beaches', 'working with nature for cleaner water' and 'better water quality for all'. 'Cleaner rivers and beaches' was the statement given the highest importance overall and gained very high scores for all demographic groups.

We will continue to act on feedback throughout AMP6 and AMP7 by working with the Customer Challenge Group and listening to focus groups.

Affordability of bills

We have engaged with our customers to better understand their Willingness to Pay (WtP) for improvements to reduce pollution and flooding incidents, the predominant risks associated with a wastewater asset failure.

There is a particular drive from across our customer base for us to reduce pollution incidents to protect our rivers and coastal waters, and to improve flooding performance in a cost-effective manner.

Our customers have consequently indicated that investment to reduce flooding and pollution are priority investments.

Measures of Success

Our MoSs related to pollution, flooding and compliance performance are reviewed daily by our operations teams and at least monthly by our Directors. MoS performance is also externally audited and aligned to track our progress.

Future assurance

We have strong governance procedures for the planning and delivery of our capital investment. Our Board will continue to provide the high level

overview and governance to ensure that we deliver these much-needed improvements in the interests of our customers.

Dŵr Cymru Welsh Water

Appendix 1

Operational initiatives and increased efficiencies

Operational initiatives

There are several ongoing operational initiatives which will support capital investment proposed across our management activities and improve efficiency and effectiveness of our operations.

The following strategies are particularly relevant to this Investment Case:

Maintenance and Reliability Support (MaRS) Project

The MaRS project aims to identify and reduce gaps in five major categories of our operations that have significant impact on plant performance and the cost of providing maintenance services. These categories form the recognised standard of performance in Maintenance and Reliability as defined by the Society for Maintenance and Reliability Professionals. These categories are:

- Business and Management;
- Process Reliability;
- Equipment Reliability;
- People Skills;
- Work Management.

The work being undertaken provides an evaluation and improved understanding of the gaps that exist between our practices and recognised industry best practices that drive physical asset reliability. As an example the strategy has reviewed the current processes from definition through to reconciliation for current expenditure types including Reactive Capital Maintenance (RCM), Forward Looking Capital Maintenance (FLCM) and Planned Capital Maintenance (PCM).

It identified that historical organisational changes and regulatory requirements have resulted in iterative changes to processes that have never been clearly re-defined and recommended changes to align processes utilised and utilise our corporate finance system (SAP) to provide a more effective resource and management tool.

Similarly initiatives to improve the categorisation and management of maintenance work, including resources and materials and time recording, have been identified to increase operational efficiency. Maintenance and materials management improvement plans will be developed to ensure an integrated and co-ordinated approach to improvements across the organisation.

LEAN Strategy

LEAN is a methodology that has been devised to help us to deliver on what our customers' value most by improving our processes and removing inefficiency. Its aims are to:

- Help specify and understand value;
- Help us to get better at what we do;
- Remove the things that get in the way of us doing our job;
- Increase empowerment and ownership;

- Be an enabler to help us deliver our business goals.

It incorporates the following principles:

- Engage colleagues – Our staff are experts in the use and application of our systems and processes and need to be involved in designing future solutions;
- Understand customer value – we need to know what our internal and external customers value about what we do;
- Remove waste and create flow – Removing the blockers to how we do our job and deliver customer value;
- Excellence in everything we do – Constantly trying to be the best.

The implementation of LEAN will result in:

- A proactive approach to maintenance and reduced reactive activities;
- The reduction of equipment failures through increased monitoring of equipment to identify reductions in equipment performance and potential failures more quickly;
- Improved operator engagement to include increased multi-skilling and hence reduced costs e.g. enable operators to make basic mechanical and electrical adjustments, calibrations and parts replacement;
- The increased implementation of planned preventative maintenance activities, developed through the application of reliability centred maintenance and the analysis of predictive maintenance / condition monitoring.

Efficiency Initiatives in AMP7

There are a number of innovation opportunities aimed at increasing efficiency at our WwTWs. These are broadly classified against three areas, namely:

- WwTW compliance;
- Increased automation;
- The concept of introducing small community treatment work sites.

Further information is included in Table 14.

Wastewater treatment works compliance	• Low cost on line monitors for effluent quality (Innovation) • Improved processes for removing phosphate (Innovation – National P trials) • Smart toilets - oxidation etc. of pharmaceuticals at source where concentrations are favourable (Research) • Energy recovery from process and products (Energy strategy/business cases) • Dynamic treatment to meet actual environmental needs - hot weather events impact on treatment when discharging into low flows, saline intrusion etc. (Innovation / technology development) • Environmental standards – move away from fixed asset design / performance to dynamic permits and/or management regimes (e.g. shellfish waters management plans). Increased dynamic control of processes (Innovation / technology development • Weather extremes – more flexible regulatory regime – rainfall and temperature issues (Research, trials and influencing) • Dynamic/seasonal/receiving water/catchment permits. Our current Seasonal UV is a good example of targeted resource use and flexible permitting approaches (Trials needed / learn from other trials e.g... Wessex catchment P permitting trials)
Reduce manual tasks on treatment works costs	• Lower energy activated sludge plants (Research need) • More cost effective and reliable screening (Research need) • Automation/monitoring of small works (Technology advances) • Maintenance strategies – smarter approach to monitoring asset condition and better understanding of resilience priorities - PE served, cause and consequence of failure etc. (Research / our processes)
Small community treatment works	• Consideration of different Rural and urban business/operating models e.g. “Your Community treatment works” – local customer engagement, different asset decision frameworks etc. (Engagement, our structures and processes) • Low cost “bolt on” processes to allow growth (Innovation / technology development) • Low tech/low chemical/low power processes (Innovation / technology development) High tech monitoring and rapid response/triaging of resources (Technology development and our processes)

Table 14: Efficiency initiatives

Appendix 2

Investment Manager Optimisation

We used Investment Manager to identify the risks and associated mitigation costs related to the maintenance of our WwTWs and outfalls.

WwTW maintenance

Our IM analysis identified that an assessed £1.45b capital expenditure would be required to address these risks. The expenditure required is however likely to be lower, as the root cause of several risks are likely to be linked, meaning one solution could eliminate multiple risks and therefore reduce the average.

Accepting the limitations of the IM analysis, it is still considered to be a reasonable approach to understanding the current risk position that we are exposed to and supporting the identification of operational and investment priorities.

The analysis of data in our Investment Manager system enabled the production of cost curve for WwTW Maintenance. Figure 13 shows how the WwTW Maintenance curve would look when the most cost-beneficial risks are programmed to be delivered first. The initial steep trajectory of the curve indicates the delivery of the highly cost-beneficial solutions before the graph tails off as the solutions become less cost-beneficial (N.B. the triangle on graphs indicates the point at which cost-benefit becomes less than 1).

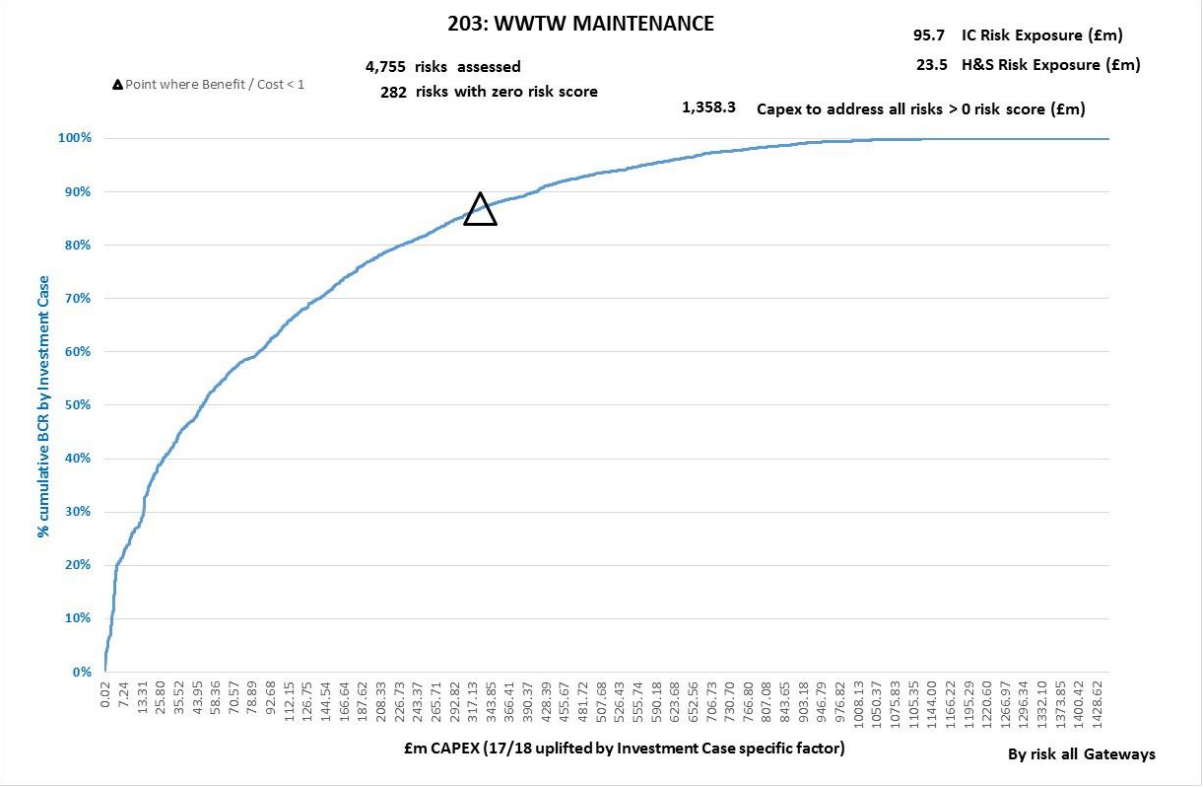


Figure 13: WwTW maintenance IM cost curve – individual risks

This graph helps put the high capex requirement into perspective in that only around £330m of solution costs can be apportioned to risks that are cost-beneficial. If the numbers are scrutinised further, it shows that by targeting the most cost beneficial risks individually first, there is the potential to reduce half of the risk score for approximately £50m.

It was, however, recognised that for most WwTWs there is more than one risk at each site and that addressing each risk individually would not happen in reality. Hence it was decided to produce a risk curve as above but based on the clustering of all of the risks to site level (Figure 14).

This approach shows a different pattern with fewer data points due to a lower number of WwTW sites compared to the total number of risks / needs in Figure 13. The graph identifies an increased expenditure required to address risks at site level, as more of the non-cost-beneficial risks are rolled up at site level. Whilst this is invariably true, the extra spend would be offset in reality, by savings attributed to reduced site setup costs. There would be significant additional costs incurred if risks were addressed individually by moving from site to site, rather than addressing multiple risks at the same time at one site.

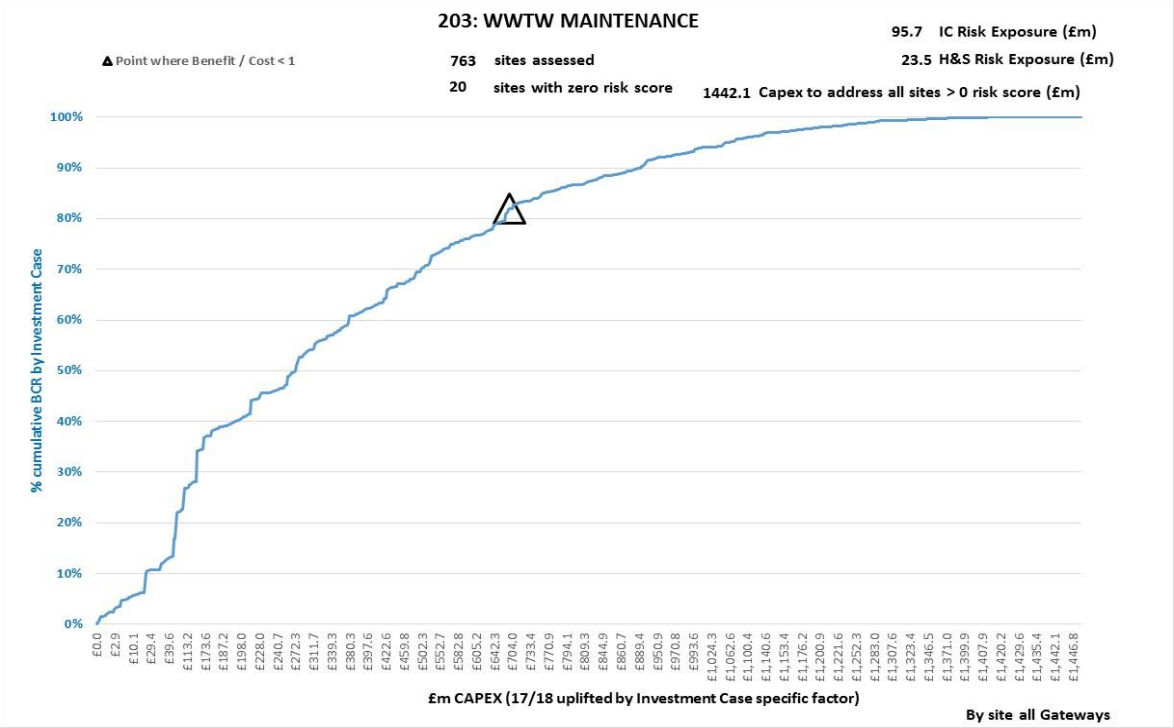


Figure14: WwTW maintenance IM cost curves - site-wide risks

A further, more detailed assessment has been undertaken to help understand where the predominant risk areas are at WwTW sites, in order to help prioritise discrete programmes of work. The breakdown of risks / needs to various programmes is included in Table 16. This shows a breakdown of the 4,755 risks / needs on Investment Manager assigned to WwTW Maintenance, and how they align to various programmes.

Wastewater Treatment Maintenance

Dŵr Cymru Welsh Water

Programme of Works	Number of Risk / Needs	Risk Score (without Willingness to Pay) £/year	Capex Cost (2017/2018 cost base) £	Uplifted Capex Cost £
Blank	1	£ -	£ 65,484	£ 292,715
Access	963	£ 7,761,287	£ 36,685,622	£ 163,984,731
Aeration	32	£ 519,493	£ 2,068,211	£ 9,244,903
Automation, Telemetry & Control (AT&C)	128	£ 3,475,886	£ 6,756,834	£ 30,203,049
Blowers	43	£ 1,331,986	£ 10,705,218	£ 47,852,325
Building	77	£ 4,084,638	£ 3,082,005	£ 13,776,562
Compliance	196	£ 6,323,539	£ 17,650,393	£ 78,897,256
Diffuser	27	£ 402,989	£ 2,529,329	£ 11,306,102
Digester	27	£ 1,560,644	£ 790,387	£ 3,533,030
Electrical	48	£ 2,194,304	£ 2,999,721	£ 13,408,754
Energy	9	£ 950,491	£ 269,198	£ 1,203,316
Flooding	51	£ 582,856	£ 2,618,192	£ 11,703,318
Flow	202	£ 3,376,282	£ 16,845,176	£ 75,297,939
Final Settlement Tanks (FST)	102	£ 1,928,675	£ 9,501,836	£ 42,473,205
Fuel tank	7	£ 27,629	£ 356,843	£ 1,595,088
Generator	59	£ 1,040,998	£ 2,268,684	£ 10,141,018
Health & Safety (H&S)	54	£ 1,170,586	£ 1,956,140	£ 8,743,947
Humus Tank	121	£ 1,503,685	£ 8,505,918	£ 38,021,455
Inlet Works	419	£ 12,369,824	£ 35,709,630	£ 159,622,045
Landscaping	38	£ 974,431	£ 1,481,062	£ 6,620,346
Media	58	£ 1,002,696	£ 5,522,545	£ 24,685,775
Noise	5	£ 79,912	£ 237,081	£ 1,059,751
Outfall	46	£ 293,836	£ 2,077,959	£ 9,288,479
Primary Settlement Tanks (PST)	280	£ 3,735,303	£ 24,880,478	£ 111,215,735
Pumps	95	£ 2,820,311	£ 5,032,206	£ 22,493,961
Rotating Biological Contactor (RBC)	20	£ 687,441	£ 1,208,677	£ 5,402,786
Saline Intrusion	7	£ 212,513	£ 343,722	£ 1,536,439
Sample Chamber	30	£ 225,778	£ 718,856	£ 3,213,288
Seasonal Issues	24	£ 577,531	£ 4,843,140	£ 21,648,834
Septic Tank	30	£ 909,867	£ 1,893,905	£ 8,465,758

Siphon	11	£ 181,758	£ 338,902	£ 1,514,892
Site Wide Risk	166	£ 9,129,507	£ 10,504,703	£ 46,956,022
Sludge	254	£ 4,622,364	£ 17,775,612	£ 79,456,985
Spills	52	£ 1,970,931	£ 5,903,116	£ 26,386,928
Statutory Maintenance	13	£ 516,495	£ 309,328	£ 1,382,697
Storm Tank	112	£ 1,425,561	£ 6,266,213	£ 28,009,971
Structure	452	£ 9,185,463	£ 37,408,659	£ 167,216,707
Trade Effluent	12	£ 239,816	£ 1,365,247	£ 6,102,654
Unconsented Combined Sewer Overflow (UCSO)	2	£ 16,111	£ 935,260	£ 4,180,613
Ultra Violet (UV)	33	£ 1,000,844	£ 2,466,459	£ 11,025,074
Filter	62	£ 678,909	£ 4,861,074	£ 21,728,999
Asbestos	1	£ 19,052	£ 5,809	£ 25,967
Washwater	21	£ 149,372	£ 687,253	£ 3,072,019
Recirculation	40	£ 415,760	£ 1,487,347	£ 6,648,440
Capacity	15	£ 185,097	£ 3,335,349	£ 14,909,011
Mixers	9	£ 103,367	£ 529,664	£ 2,367,597
Infiltration	49	£ 323,908	£ 2,947,733	£ 13,176,368
Non Essential Maintenance	11	£ -	£ 748,111	£ 3,344,058
Valves	20	£ 284,394	£ 1,144,457	£ 5,115,721
Rainscape	1	£ -	£ 70,649	£ 315,802
Power	38	£ 242,354	£ 2,107,599	£ 9,420,969
Combined Sewer Overflow (CSO)	2	£ -	£ 127,774	£ 571,150
Tank	30	£ 308,949	£ 2,252,379	£ 10,068,132
Resilience	3	£ 174	£ 841,714	£ 3,762,462
Security	7	£ 21,319	£ 229,072	£ 1,023,950
Drainage Survey	15	£ 7,851	£ 84,714	£ 378,671
De-sludge	1	£ 2,613	£ 1,643,353	£ 7,345,786
Overflow	2	£ 343	£ 137,996	£ 616,840
Cost	1	£ 200	£ 84,714	£ 378,671
Fat, Oil & Grease (FOG)	4	£ 25,120	£ 217,756	£ 973,371
Welfare	17	£ 53,582	£ 378,451	£ 1,691,678
Storm Return	33	£ 914,893	£ 2,689,583	£ 12,022,436
Blockages	9	£ 133,787	£ 703,316	£ 3,143,824
Grit	7	£ 57,654	£ 324,262	£ 1,449,452
De-sludge	36	£ 745,286	£ 2,418,030	£ 10,808,595
Pipework	2	£ 4,440	£ 132,571	£ 592,594

Rising Main	5	£ 329,674	£ 567,620	£ 2,537,260
Water Regulation	2	£ 3,992	£ 74,332	£ 332,264
Water Supply	6	£ 248,792	£ 298,392	£ 1,333,812
Grand Total	**4755**	**£ 95,675,143**	**£ 324,009,028**	**£ 1,448,320,355**

Table 15: WwTW maintenance programmes of work

Outfall Maintenance

We used Investment Manager (IM) to ascertain how many sea outfalls linked risks / needs exist across our catchments. Table 16 shows how the total number of risks have changed over the last six years since Investment Manager was first utilised to capture risk information. The total risk scores are also included, which indicate the annual risk exposure associated with the outfalls.

Year	No. of Outfall Related Risks/ Needs on Investment Manager	Risk Score (without Willingness to Pay) £/year
2011	0	
2012	11	231,303
2013	19	372,033
2014	25	522,849
2015	37	1,499,326
2016	47	1,758,457
2017*	54	1,868,234

*2017 figure is the cumulative figure up to August 2017

Table 16: Sea outfall risks in IM (2011-2017)

The analysis of data recorded in Investment Manager, led to the production of the cost curve as shown in Figure 15. This graph identifies that a capital expenditure of £38m would be required to address / mitigate the 54 risks on Investment Manager. It also identifies (black triangle) that only around £6m of solution costs can be apportioned to risks that are cost-beneficial

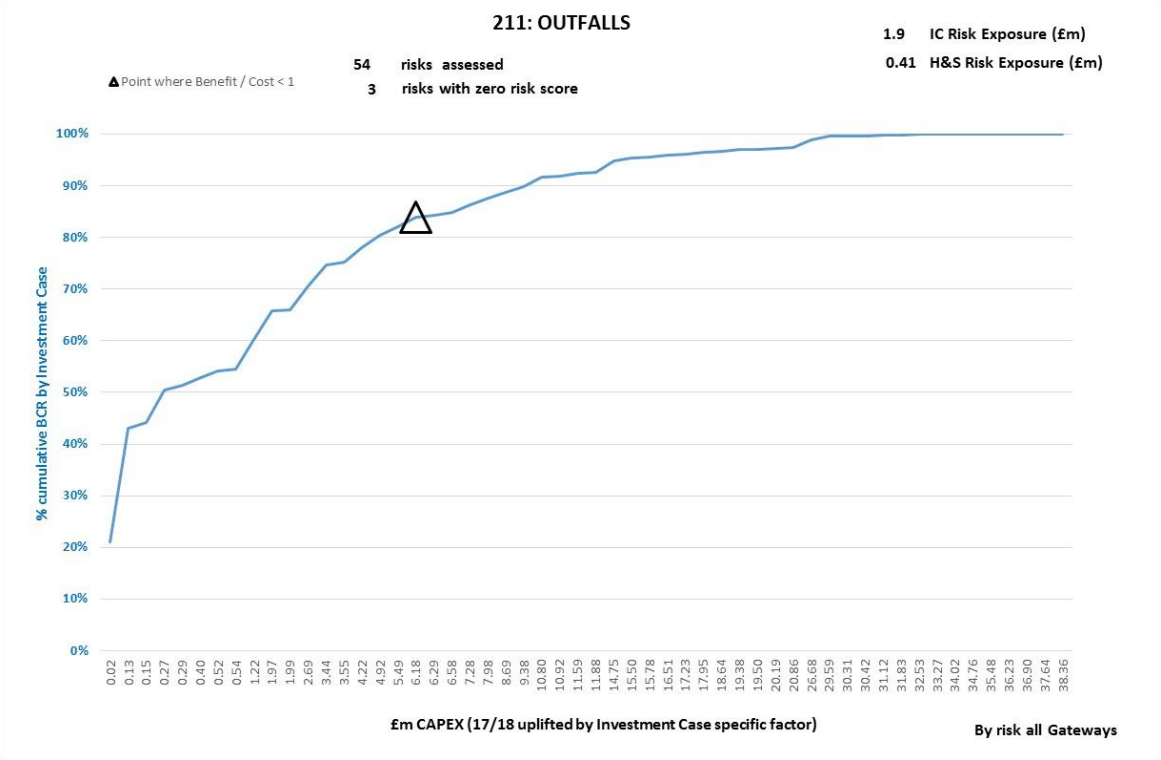


Figure 15: Sea outfalls IM cost curve - individual risks

The capital expenditure required to address these risks is more uncertain for outfalls than other assets, as the location and nature of sea outfalls makes it more difficult to fully assess risks and understand the extent of any remedial works required. The challenges faced by construction teams working on Sea Outfalls schemes are considerable and varying, resulting in the potential for costs to escalate. However, the above analysis of IM is considered a reasonable approach to understanding the current risk position related to Outfall assets.

A further, more detailed assessment has been undertaken to help understand where the predominant risk areas are related to outfalls. The breakdown of risks / needs to various programmes is shown in Table 17.

Programme of Works	Number of Risk / Needs	Risk Score (without Willingness to Pay) £/year	Capex Cost (2017/2018 cost base) £	Uplifted Capex Cost £
Blank	1	£ 2,402	£ 5,253	£ 18,386
Abandoned	1	£ 21,729	£ 5,253	£ 18,386
Blockage	6	£ 88,435	£ 1,254,608	£ 4,391,128
Blockage / Crude Discharge	1	£ 87,209	£ 202,374	£ 708,308
Capacity	3	£ 64,823	£ 1,894,335	£ 6,630,173
Civils	4	£ 85,646	£ 581,188	£ 2,034,160
Diffuser	1	£ 44,995	£ 200,190	£ 700,666
Discharge	4	£ 523,668	£ 533,727	£ 1,868,044
Outfall - CSO	2	£ 11,190	£ 412,788	£ 1,444,758
Structural	28	£ 907,151	£ 5,641,357	£ 19,744,749

Surface Water	1	£ -	£ 191,978	£ 671,925
Valves	2	£ 30,986	£ 37,954	£ 132,840
Grand Total	54	£ 1,868,234	£ 10,961,006	£ 38,363,522

Table 17: Outfalls programmes