Building Resilience: infrastructure health in the water sector

Briefing Slides for 21 May

Context to the project

Problem statement

The overall problem that the project is directed at is a set of four inter-related concerns with the current regulatory framework which relate to capital maintenance and risks to future outcomes. The initial phase of the project comprised two pieces of research.

- A workstream led by Reckon concerned potential problems with Ofwat's current regulatory framework, regarding the treatment of capital maintenance expenditure, asset health and risks to customer service and environmental outcomes in the future. It explored potential reforms to the regulatory approach to tackle these problems, including changes to the approach to cost assessment and incentives.

- A workstream led by Jacobs identified and assessed a range of metrics that could help to reveal current and future asset health risks and historical trends in asset health, including metrics that could support the potential changes to the regulatory approach identified in the Reckon workstream.

Aim of Jacobs' workstream: to support the development of an approach to secure long-term resilience of assets and service from sustainable levels of capital maintenance through the development of suitable asset health / resilience metrics.

In this context, we had two primary objectives:

1. To assess how well existing metrics help to reveal future asset health risks and to identify the characteristics of metrics that would help to close any gaps.

2. To understand what types of metric could be used to improve regulation of capital maintenance (linking to Reckon's work).

Informational concern - that there is not enough useful information available about the risks of service disruption and adverse environmental outcomes in the future that may arise from asset deterioration or poor asset health, and how these risk are being managed by water companies.

Behavioural concern - that the behaviour and decision-making of water companies in relation to capital maintenance, which is heavily influenced by the regulatory approach, is not well-aligned with the achievement of good outcomes for customers and the environment over the long term, especially in terms of the adequacy of investment in asset health to manage future risks to outcomes in an efficient way over time.
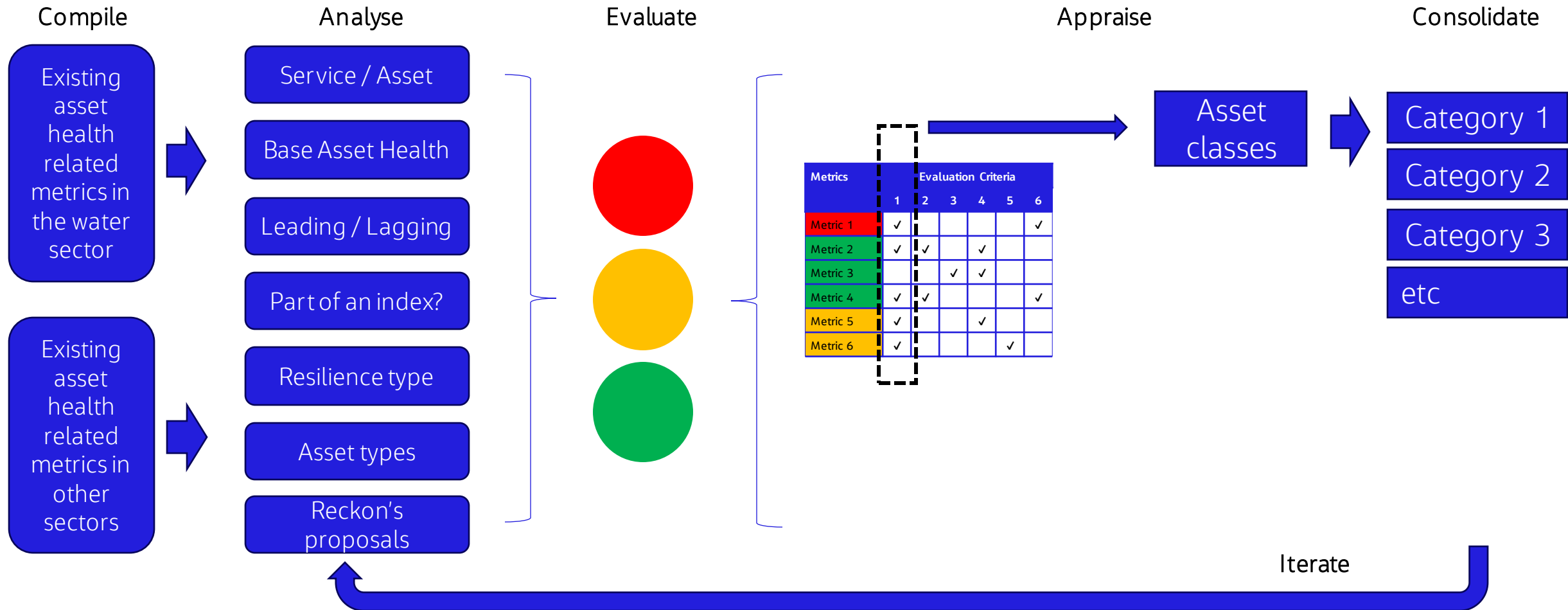
Funding concern - that the funding available to water companies from customer bills, as governed by the regulatory arrangements, would not be sufficient to properly remunerate efficient companies who adopt good behaviour in relation to asset health and the management of future risks.

Responsibilities concern - that, given how companies act (or are likely to act) under the current regulatory framework, the regulator may not take enough responsibility for understanding and mitigating - through its own actions and decision-making (e.g. in relation to the adequacy of cost allowances) - long-term risks to customers and the environment that may arise from asset deterioration or poor asset health.

Project methodology

Jacob's work applied the following methodology and incorporated regular engagement with Steering and Working Groups, and collaboration throughout with Reckon.

Compile

Existing asset health related metrics in the water sector

Existing asset health related metrics in other sectors

Analyse

Service / Asset

Base Asset Health

Leading / Lagging

Part of an index?

Resilience type

Asset types

Reckon's proposals

Evaluate

Appraise

Metrics	Evaluation Criteria					
	1	2	3	4	5	6
Metric 1	✓					✓
Metric 2	✓	✓		✓		
Metric 3			✓	✓		
Metric 4	✓	✓				✓
Metric 5	✓			✓		
Metric 6	✓			✓		

Asset classes

Consolidate

Category 1

Category 2

Category 3

etc

Iterate

Compiling and analysing asset health metrics

Initial findings: compiling asset health metrics

We reviewed a range of water industry and other industry documentation to compile a long list of metrics and asset health approaches.

	Number
Raw list of metrics/indexes and approaches	456
Unique metrics / indexes	**315**
Of which, from the water sector	267
Of which, from other sectors	48

Our reviewed sources included (but were not limited to):

- Ofwat publications concerning current and past price reviews, annual performance reporting, asset management and resilience.

- Performance reporting by the DWI and the Environment Agency.

- Asset management publications by water companies in England and Wales and research bodies (UKWIR).

- Publications related to asset health and asset management from other sectors (highways, rail, electricity and gas) and other geographies (Scotland, Australia, Global – International Water Association).

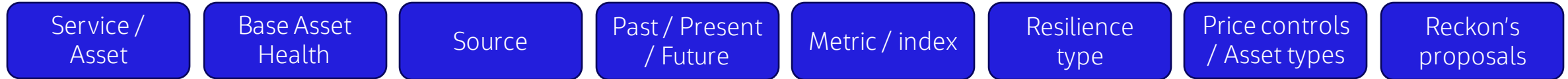# Initial findings: analysing asset health metrics

We grouped the asset health metrics in our long list by applying the following lenses:

Service / Asset	Service	Asset / system	Maintenance	Organisational capability
Base Asset Health	Wellness	Fitness	Life expectancy	
Source	England and Wales water sector	Other sectors		
Past / Present / Future	Retrospective	Present-focus	Forward-looking	Combination
Metric / Index	Metric	Index (comprising multiple metrics)		
Resilience type	Resistance	Reliability	Redundancy	Response and recovery
Price controls / Asset types	Multiple asset classes aligned to Water Resources	Multiple asset classes aligned to Water Network+	Multiple asset classes aligned to Wastewater Network+	Multiple asset classes aligned to Bioresources

We also applied a further breakdown to asset classes

Reckon's proposals: Inventory | Activities | Observed asset failures / under-performance | Modelled probability of failure or under-performance | Asset age | Remaining asset life | Condition data | Redundancy | Response & Recovery | Risk metrics | Remaining life vs target life | Organisational capability | Modelled probability of outcomes | Outcomes attributed to asset failure | Outcomes attributed to other causes | Overall outcomes

Initial findings: analysing asset health metrics

| Service / Asset | Base Asset Health | Source | Past / Present / Future | Metric / index | Resilience type | Price controls / Asset types | Reckon's proposals |

- Some lenses were easier to apply than others.

- The process is subjective and different people will categorise in different ways. We have tried to manage this through review and challenge.

- We found the use of Lagging and Leading restrictive. We have therefore adopted Retrospective/Present-focus/Forward-looking/Combination.

- We found many more metrics focussed on asset health/performance than system health/performance. This might make it hard to distinguish between companies where resilience is delivered through more resistance/reliability versus those with more redundancy / response & recovery.

- It was hard to find metrics that helped us distinguish between Wellness and Fitness (in the Base Asset Health lens). Many metrics could apply to either, under different circumstances. This observation also applies to some of the other lenses (e.g. Retrospective/ Forward-looking)

- There are a large proportion of asset failure and condition metrics. Very few of these metrics define cause of failures or provide a link to outcomes to customers and/or the environment.

Initial findings: analysing asset health metrics

| Service / Asset | Base Asset Health | Source | Past / Present / Future | Metric / index | Resilience type | Price controls / Asset types | Reckon's proposals |

	Retrospective	Present-focus	Forward-looking	Combination	Example
Inventory	12	15	0	0	Number of flow monitors
Activity	61	8	0	0	Length of mains replaced
Observed asset failures / underperformance (Asset Reliability / Resistance)	61	7	1	0	Sewer collapses
Modelled probability of failure / underperformance (Asset Reliability / Resistance)	8	2	5	0	Water mains modelled failure rate
Asset age (Asset Reliability / Resistance)	0	3	0	0	Sewer age profile
Remaining asset life (Asset Reliability / Resistance)	0	2	8	0	Life expectancy
Condition data (Asset Reliability / Resistance)	20	12	0	0	Asset condition: water treatment works
Redundancy	0	1	2	0	Single source of supply
Response & Recovery	7	0	0	0	Alarm time response
Risk metrics	11	6	3	1	Asset risk / network risk (NARM)
Remaining life vs target life	0	1	1	1	Base asset health
Organisational capability	2	2	0	0	AMMA
Modelled probability of outcomes	4	1	2	0	Risk of flooding in a storm
Outcomes attributed to asset failure	0	0	1	0	Water service resilience
Outcomes attributed to other causes	1	0	0	0	Drinking water quality compliance measures – enforcement actions
Overall outcomes	41	2	0	0	Internal sewer flooding

- We found that metrics / indices could be assigned to a single category within this lens.
- There are a large proportion of asset failure and condition metrics.
- Activity metrics are mostly associated with maintenance.
- Very few metrics define cause of failures / outcomes.

Evaluating asset health metrics

Evaluation criteria

Scoring framework:
A Red/ Amber/Green score was assigned to each of the seven criteria for each metric. This scoring was then considered when identifying suitable metrics or metric types for further development in Phase 2 of the project. Scoring has informed findings and recommendations but we deliberately applied no scoring thresholds.

🟢 Yes, metric achieves criterion

🟡 Metric might achieve criterion

🔴 No, metric doesn't achieve criterion

Merit

1. Metric is diagnostic of changes in asset health
- Metric is able to provide diagnostic and/or prognostic information to support a compelling investment case
- Metric's relationship to asset health can be disaggregated from operational activities

2. Metric can be used to provide insight into future risks associated with health of assets
- Metric can be used to expose future risks associated with asset health
- Metric increases confidence and trust in the ability of the sector to deliver reliable services (improved identification of long-term risks to operational resilience)

3. Metric is sensitive to and responds quickly to performance changes
- Metric responds in an appropriate time frame to expose undesirable performance or impacts of corrective actions

Deliverability

4. Metric is clear and can be easily understood by range of stakeholders
- Metric can be explained to and understood by customers and regulators
- Metric can be consistently defined

5. Metric can be applied and measured consistently across the industry
- Metric can be implemented easily across the industry to allow for comparison when making investment decisions
- Metric can be quantified, has strong evidence base and is likely to endure over time
- Challenges and risks associated with implementing the metric are minimised
- Metric supports increased transparency of operational resilience

6. Metric can be implemented quickly
- Metric is collected widely in the sector or could be quickly collected
- Adoption of the metric could be implemented in the short term

7. Measurement of metric is cost-effective and doesn't create undue burden (or could achieve this through innovation and/or collaboration)
- Metric does not require significant investment in monitoring, or monitoring may be cost effective in an appropriate timeframe through technology developments
- Metric supports promotion of innovation and collaboration
- Metric minimises ongoing regulatory and administrative burden

Summary of findings: metrics to reveal future asset health risks

Types of metrics which could be used to reveal future asset health risks

- Reckon has identified five Packages which describe different ways in which the regulation of capital maintenance could be improved.

- Each of these packages require different types of metrics.

- We have evaluated the strengths and weaknesses of existing examples of these metrics and identified eight categories of metrics and indices that we think could help to reveal future risks associated with asset health.

Package	P1	P2	P3	P4	P5
High-level approach to cost assessment?	Adjustments to base cost model results from Ofwat reviewing company proposals for additional investment in asset health	Ofwat assessment to consider industry-wide forward-looking adjustments to base cost model results, using range of evidence	Ofwat detailed assessment of capital maintenance using a range of its own models and tools (move away from base cost models)	Use of approach from package 2 and/or 3, in a way that draws on NARM data	Ofwat cost assessment starts from review of each company's business plan for capital maintenance (move away from base cost models)
Role for industry-wide adjustment mechanism for outturn expenditure?	No	Yes	No	No	No
Is capital maintenance funding tied to within-period deliverables?	Yes - PCDs in specific areas for which additional funding provided	No	No	Yes - NARM-style composite asset risk metric used to assess delivery against ex ante allowances	Yes - PCDs for all/bulk of capital maintenance based on detailed investment plan or granular asset health metrics
Other remedies to address behavioural and informational concerns?	Narrow set of informational remedies	Enhanced set of incentive and informational remedies	Enhanced set of incentive and informational remedies	Narrow set of informational remedies	Narrow set of informational remedies

Categories of metrics and indices

1. **Individual resistance and reliability metrics**, which focus on the components of resilience which have the closest link to asset health.

   Existing examples include: sewer collapses (090), mains bursts (100).

2. **Asset life metrics and indices**, which calculate or indicate remaining asset life in some way

   Existing examples include: cost per year of life (WICS) (045), Base Asset Health (004), Asset health deficit (455).

3. **Risk indices**, which calculate an asset risk level, score or value, often then summarised into risk categories

   Existing examples include: asset risk / network risk (NARM) (251), Compliance risk index (141).

4. **Outcome-based metrics**, which measure outcomes to customers and/or the environment

   Existing examples include: interruptions to supply (081), internal sewer flooding (171).

5. **Qualitative, multi-dimensional indices**, which assign qualitative scores to a set of discrete categories

   Existing examples include: Overall Equipment Effectiveness (269) and Current Health Index (041).

Lower priority

6. **Activity metrics**, which relate to a range of activity types

   Existing examples include metrics related to maintenance work (e.g. 377), surveys (e.g. 343), alarms (e.g. 376) and operational activities (e.g. 429).

7. **Redundancy metrics**, which capture or relate to back-up or parallel capacity.

   Existing examples include: customers with a single source of supply (380).

8. **Response and recovery metrics**, which relate to responses to incidents.

   Existing examples include: resilience in the round wastewater (446).

Linking Packages to Categories of metrics and indices

Type of metric	Packages as identified by Reckon					Categories of metrics and indices
	P1 Base cost models with improved process for Ofwat review of company proposals for additional investment in asset health	**P2** Base cost models with forward-looking and dynamic industry-wide adjustments and enhanced incentives on long-term performance	**P3** Ofwat-owned assessment of capital maintenance with enhanced incentives on long-term performance	**P4** NARM-based funding and delivery accountability arrangements	**P5** Regulatory review of business plans for capital maintenance with granular PCDs	
Activities	3	1	1	1	5	[Category 6](#)
Asset reliability, performance and resistance	3	5	5	3	3	[Category 1](#)
Redundancy	1	2	2	1	1	[Category 7](#)
Response and recovery	1	2	2	1	1	[Category 8](#)
Risk metrics	2	4	4	5	2	[Category 3, Category 5](#)
Remaining asset life vs target life	2	3	3	2	2	[Category 2](#)
Adverse outcome events attributed to asset failure	2	4	4	2	2	
Adverse outcome events attributed to other causes	2	4	4	2	2	[Category 4](#)
Modelled probability / frequency of adverse outcome events	2	4	4	2	2	
Outcomes experienced by customers and the environment	5	5	5	5	5	
Summary of metric types required under each package and links to Objective 1 categories	Focus of P1 is on refinement to existing approach. No fundamentally new metrics needed. Cat1 and Cat4 will therefore be of most relevance. Review of activity metrics also required.	P2 Interested in a range of evidence, so conclusions related to Cat1, 2, 3, 4 and 5 are relevant.	P3 Interested in a range of evidence, so conclusions related to Cat1, 2, 3, 4 and 5 are relevant.	P4 is primarily focused on risk metrics so our conclusions against Cat 3 are of most relevance.	Fundamentally a different approach – potentially all metric types could be important. Conclusions related to Cat1, 2, 3, 4 and 5 are relevant	**Note:** 1-5 shading indicates relevance of metric to package with 1 being very low and 5 being very high.

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A note on asset types

- The water sector is characterised by a range of asset types and this range is more diverse than other sectors, for example electricity. It is also more capital intensive than other UK sectors.

- Ofwat's RAG 4 series presents a taxonomy of 100+ asset types across the water resources, water network +, wastewater network + and bioresources price controls.

- We have simplified this to 17 asset types for the purposes of assessing coverage of asset health related metrics.

- The number of individual assets within each asset type for each water company varies significantly.

- The financial value of each asset type also varies significantly. We can use this information to infer the importance of asset types for capital maintenance decision making.

Asset type	Water Resources			Water Treatment		Water Networks					Wastewater Networks				Wastewater Treatment		Bioresources
	Dams and impounding reservoirs	Transmission and aqueducts	Booster pumping stations	Water treatment works Civils	Water treatment works MEICA	Booster pumping stations	Service Res + Water Towers	Water mains	Communication pipes	Customer meters	Sewers	Sewage pumping mains	Overflows	Sewage pumping stations	Sewage treatment works Civils	Sewage treatment works MEICA	Sludge treatment plant
Broad asset life	Longer	Longer	Shorter	Longer	Shorter	Shorter	Longer	Longer	Longer	Shorter	Longer	Longer	Longer	Shorter	Longer	Shorter	Shorter
Indicative financial value	High	High	Low	High	Medium	Low	Medium	High	High	Medium	High	Medium	Medium	Medium	High	Medium	Medium
Relative importance	Higher	Higher	Lower	Higher	Lower	Lower	Higher	Higher	Higher	Lower	Higher	Higher	Higher	Lower	Higher	Lower	Lower

For the purposes of this table:
- Longer life assets are those that typically have a lifetime of greater than 30 years. Shorter life assets have a lifetime of up to 30 years.
- Indicative financial value scores are based on Jacob's experience of asset valuation work for several water companies in England and Wales. It is indicative only, intended to give a qualitative indication of higher value asset type categories.
- Relative importance is based on comparative financial value and broad asset life. Longer life assets are those for which there is greater scope for decisions about when to schedule capital maintenance.

C1. Individual resistance and reliability metrics

Description of category

Metrics associated with the resistance and reliability components of resilience include those related to observed and modelled asset failure, age and remaining life, and condition. These metrics includes the 3x asset health performance commitments. Resistance and reliability metrics are directly or indirectly related to asset health and resilience whereas those associated with redundancy and response and recovery are more reflective of system resilience. These metrics usually describe a specific asset group or type and are not aggregated across asset groups with different failure modes.

Examples of existing metrics and indices in the England and Wales water sector, and other sectors

Observed asset failure or under performance: 70 metrics identified including, sewer collapses, mains burst, leakage, unplanned maintenance.

Modelled probability of asset failure or under performance: 15 metrics identified including, mains deterioration modelling, WWTW at risk, mean time to failure.

Condition data: 32 metrics identified including, visible inspections, CCTV surveys and health indices. Energy consumption metrics have also been grouped into this category.

Other sectors: Tend to have similar metrics to the E&W water sector – defects, condition, mean time between failure. Health indices exist in the electricity sector which combine scores for age, expected life, location factors, duty factors, condition and reliability.

Coverage and quality of existing metrics and indices across asset types

Asset type	Water Resources			Water Treatment		Water Networks					Wastewater Networks				Wastewater Treatment		Bioresources	Metrics applicable to all assets
	Dams and impounding reservoirs	Transmission between raw water sites	Booster pumping stations	Water treatment works Civils	Water treatment works MEICA	Booster pumping stations	Service Res + Water Towers	Water mains	Communication pipes	Customer meters	Sewers	Sewage pumping mains	Overflows	Sewage pumping stations	Sewage treatment works Civils	Sewage treatment works MEICA	Sludge treatment plant	
Importance	Higher	Higher	Lower	Higher	Lower	Lower	Higher	Higher	Higher	Lower	Higher	Higher	Higher	Lower	Higher	Lower	Lower	N/A
Coverage	Many	Many	Many	Many	Many	Many	Many	Many	Sparse	Sparse	Many	Many	Many	Many	Many	Many	Many	Many
Quality	Red	Amber	Amber	Amber	Amber	Amber	Green	Red	Red	Amber	Amber	Amber	Red	Amber	Amber	Amber	Red	Green

Observed and modelled asset failure: the metrics we found tended to focus on water and wastewater treatment plants and networks where the observed failure history supports statistical analysis, however simple retrospective failure metrics exist for most major asset categories. They typically reveal asset health related failures but do not indicate future asset health risks. As such, most of the Quality scores are Amber or Red.

Condition: metrics and approaches to assess condition exist for all major asset types. Again, they typically reveal asset health related risks but do not indicate future asset health risks.

Recommended activities to reveal future risks associated with asset health

- Define a package of reliability and resistance metrics for each asset category.
- Assign criticality to each asset category (the relative importance we have defined could be used as a starting point)
- For higher criticality asset categories first, develop methodologies to produce forecasts of existing or new metrics under defined future scenarios.

C2. Asset life metrics and indices

Description of category

Asset life assessments define some form of remaining life position across the asset base or a portion of it. In some instances, this remaining life position is then monetised or compared to an idealised position.

Examples of existing metrics and indices in the England and Wales water sector, and other sectors

Asset age and remaining asset life metrics: 13 identified including, averaged age / remaining life metrics.

Asset age and remaining asset life indices: three identified: **Base asset health:** Considers effective age (adjusted by condition and performance) as a proportion of economic life and applied to the gross modern equivalent asset value (GMEAV). This index was derived by UUW where it is applied across different groups of assets. **Asset health deficit:** metric developed by TWL which comprises solution costs to address asset risks above a threshold, unreliable assets and assets in poor condition. **Cost per year of life:** developed by the Water Industry Commission for Scotland this metric combines replacement cost and average remaining life across asset types.

Coverage and quality of existing metrics and indices across asset types

Asset type	Water Resources			Water Treatment		Water Networks					Wastewater Networks				Wastewater Treatment		Bioresources	Metrics applicable to all assets
	Dams and impounding reservoirs	Transmission between raw water sites	Booster pumping stations	Water treatment works Civils	Water treatment works MEICA	Booster pumping stations	Service Res + Water Towers	Water mains	Communication pipes	Customer meters	Sewers	Sewage pumping mains	Overflows	Sewage pumping stations	Sewage treatment works Civils	Sewage treatment works MEICA	Sludge treatment plant	
Importance	Higher	Higher	Lower	Higher	Lower	Lower	Higher	Higher	Higher	Lower	Higher	Higher	Higher	Lower	Higher	Lower	Lower	N/A
Coverage	None	None	None	None	None	None	None	Sparse	None	Sparse	Sparse	None	None	None	None	None	None	Many
Quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A			N/A	N/A	N/A	N/A	N/A	N/A	

Simple age and remaining life metrics exist and can be defined for all major asset categories. Specific asset category life metrics are less common. The age and remaining life metrics do not include consideration of future pressures (hence given quality scores of Red or Amber).

We found three indices, two of which were developed by companies in England, which link remaining life to cost to replace. These are, in theory, applicable to all asset types. They do not currently include consideration of future pressures.

Recommended activities to reveal future risks associated with asset health

- Consider different approaches to monetise end of life assessments (building on the three indices reviewed).
- Evaluate how risk could be included in the metric / index. This could include, for example, exploring and refining the concept of tolerable service life.
- Test the application of asset life assessments under different future scenarios.

C3. Risk indices

Description of category

Aggregation of information about single or multiple asset groups considering factors relating to likelihood (for example through condition) and consequence of a hazard occurring. Indices group together individual pieces of information and therefore help with understanding at a broader level, thereby helping to inform strategic decisions.

Examples of existing metrics and indices in the England and Wales water sector, and other sectors

We found a total of six risk indices, three from the England and Wales water sector and three from other sectors.

The water sector examples include Compliance Risk Index, which considers failure significance, cause and location. It is retrospective and influenced by multiple asset types. Its component data sources are influenced by asset performance and operational response.

Examples outside the water sector include: Ofgem's asset risk / network risk (sum of the expected values of each consequence associated with that asset and a function of the probability of each failure mode occurring), and Network Rail's Composite Reliability Index and Composite Sustainability Index (remaining life or asset condition score weighted by replacement value).

Coverage and quality of existing metrics and indices across asset types

Asset type	Water Resources			Water Treatment		Water Networks					Wastewater Networks				Wastewater Treatment		Bioresources	Metrics applicable to all assets
	Dams and impounding reservoirs	Transmission between raw water sites	Booster pumping stations	Water treatment works Civils	Water treatment works MEICA	Booster pumping stations	Service Res + Water Towers	Water mains	Communication pipes	Customer meters	Sewers	Sewage pumping mains	Overflows	Sewage pumping stations	Sewage treatment works Civils	Sewage treatment works MEICA	Sludge treatment plant	
Importance	Higher	Higher	Lower	Higher	Lower	Lower	Higher	Higher	Higher	Lower	Higher	Higher	Higher	Lower	Higher	Lower	Lower	N/A
Coverage	None	None	None	Sparse	Sparse	None	Sparse	Sparse	None	None	None	None	None	None	None	None	None	None
Quality	N/A	N/A	N/A			N/A			N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Existing water sector risk indices limited to Compliance Risk Index (CRI), Event Risk Index and Risk Assessment Risk Index, all associated with water treatment and distribution.

These indices incorporate multiple data points related to event severity, cause, control measures and operational response. They do not conform to a likelihood x consequence = risk structure.

As 'cause' is used in CRI, it could indicate asset health issues, or other causal factors. None of the three indices is forward-looking.

Recommended activities to reveal future risks associated with asset health

- Engage companies and regulators in other sectors to understand their perspectives on the strengths and weaknesses of existing metrics.
- Building on the analysis of indices from other sectors, design and test a risk metric for a selected asset category / categories.

C4. Outcome-based metrics

Description of category

Individual metrics which describe a direct outcome experienced by customers or the environment. The outcome can be influenced by asset health and/or other factors.

Examples of existing metrics and indices in the England and Wales water sector, and other sectors

We found 42 metrics in this category, 40 of which were from the water sector of England and Wales.
Examples include customer experience metrics and complaints, unplanned outage, sewer flooding, storm overflows, pollution incidents.
The existing metrics are a mix of performance commitments and other widely reported metrics.

Coverage and quality of existing metrics and indices across asset types

Asset type	Water Resources			Water Treatment		Water Networks					Wastewater Networks				Wastewater Treatment		Bioresources	Metrics applicable to all assets
	Dams and impounding reservoirs	Transmission between raw water sites	Booster pumping stations	Water treatment works Civils	Water treatment works MEICA	Booster pumping stations	Service Res + Water Towers	Water mains	Communication pipes	Customer meters	Sewers	Sewage pumping mains	Overflows	Sewage pumping stations	Sewage treatment works Civils	Sewage treatment works MEICA	Sludge treatment plant	
Importance	Higher	Higher	Lower	Higher	Lower	Lower	Higher	Higher	Higher	Lower	Higher	Higher	Higher	Lower	Higher	Lower	Lower	N/A
Coverage	Sparse	Sparse	Sparse	Many	Many	Some	Some	Some	None	None	Some	Some	Sparse	Some	Some	Some	None	Many
Quality									N/A	N/A							N/A	

The existing metrics cover most of the asset base but are typically not related to specific assets. As they are outcomes-focused, they are influenced by the performance of several asset types.
All of the existing metrics are retrospective in focus. Very few of the metrics link an outcome to a cause (water service resilience, a bespoke PC for AMP8 is an exception).

Recommended activities to reveal future risks associated with asset health
- Select group of outcome-based metrics and undertake mapping process to link these to resistance and reliability metrics.
- Review how outcome-based metrics were projected into the future in the business plan / long-term delivery strategy process.

C5. Qualitative, multi-dimensional indices

Description of category

Indices which collate qualitative data describing several individual metrics into an overall score or performance grading. Each component of the index is typically assigned 1-5 score which is then aggregated into a single score. This score can then be used to prioritise action.

Examples of existing metrics and indices in the England and Wales water sector, and other sectors

The two examples we found were from other sectors.
BAE Systems Overall Design Authority Rating - reliability, maintainability, fit for purpose, regulatory compliance, condition, life expectancy
Overall Equipment Effectiveness - Availability x Performance x Quality

Coverage and quality of existing metrics and indices across asset types

Asset type	Water Resources			Water Treatment		Water Networks					Wastewater Networks				Wastewater Treatment		Bioresources	Metrics applicable to all assets
	Dams and impounding reservoirs	Transmission between raw water sites	Booster pumping stations	Water treatment works Civils	Water treatment works MEICA	Booster pumping stations	Service Res + Water Towers	Water mains	Communication pipes	Customer meters	Sewers	Sewage pumping mains	Overflows	Sewage pumping stations	Sewage treatment works Civils	Sewage treatment works MEICA	Sludge treatment plant	
Importance	Higher	Higher	Lower	Higher	Lower	Lower	Higher	Higher	Higher	Lower	Higher	Higher	Higher	Lower	Higher	Lower	Lower	N/A
Coverage	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
Quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

- We found no indices in this category in the England and Wales water sector.

Recommended activities to reveal future risks associated with asset health
- Consider role for this category of metric to act as a dashboard representing broad performance. This could then be linked to other categories of metric/index which provide specific information about asset health.

C6. Activity metrics

Description of category

Metrics related to a range of activity types including maintenance work, surveys, alarms and operational activities.

Links to Workstream 2

Concern	Relevance
Informational	Medium
Behavioral	Low
Funding	Low
Responsibility	Low

Examples of existing metrics and indices in the England and Wales water sector, and other sectors

We found 69 metrics of which 63 related to the water sector. Of these 62, 18 related to maintenance activity, 12 related to enhancement activity, 9 related to sampling or inspection and the majority of the remainder related to operational activities.

Coverage and quality of existing metrics and indices across asset types

Asset type	Water Resources			Water Treatment		Water Networks					Wastewater Networks				Wastewater Treatment		Bioresources	Metrics applicable to all assets
	Dams and impounding reservoirs	Transmission between raw water sites	Booster pumping stations	Water treatment works Civils	Water treatment works MEICA	Booster pumping stations	Service Res + Water Towers	Water mains	Communication pipes	Customer meters	Sewers	Sewage pumping mains	Overflows	Sewage pumping stations	Sewage treatment works Civils	Sewage treatment works MEICA	Sludge treatment plant	
Importance	Higher	Higher	Lower	Higher	Lower	Lower	Higher	Higher	Higher	Lower	Higher	Higher	Higher	Lower	Higher	Lower	Lower	N/A
Coverage	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Many
Quality																		

- Several of the Activity metrics (recording of alarms, sampling and maintenance activity) are applicable to most or all asset types. There are fewer asset-specific metrics and these mostly record specific maintenance or operational activities.
- Records of maintenance could be used to infer a level of asset health but this would be indirect and not particularly helpful without supplementary data. An Amber quality score is therefore applied.

Recommended activities to reveal future risks associated with asset health

- Lower priority category (as identified by Reckon mapping)
- Understand which specific Activity types are useful under each regulatory aspect
- Deliver refinements alongside other categories (not as a category in own right)

C7. Redundancy metrics

Description of category

Metrics which capture or relate to the provision of back-up or parallel capacity such that the impact of events can be mitigated.

Examples of existing metrics and indices in the England and Wales water sector, and other sectors

We found three metrics related to redundancy, all from the England and Wales water sector.
Customers with single source of supply is a direct measure of redundancy, or rather a lack of it.
Metrics associated with the calculation of the supply-demand balance (target headroom and outage allowance) relate to redundancy but are not direct measures of it.

Coverage and quality of existing metrics and indices across asset types

Asset type	Water Resources			Water Treatment		Water Networks						Wastewater Networks				Wastewater Treatment		Bioresources	Metrics applicable to all assets
	Dams and impounding reservoirs	Transmission between raw water sites	Booster pumping stations	Water treatment works Civils	Water treatment works MEICA	Booster pumping stations	Service Res + Water Towers	Water mains	Communication pipes	Customer meters	Sewers	Sewage pumping mains	Overflows	Sewage pumping stations	Sewage treatment works Civils	Sewage treatment works MEICA	Sludge treatment plant	
Importance	Higher	Higher	Lower	Higher	Lower	Lower	Higher	Higher	Higher	Lower	Higher	Higher	Higher	Lower	Higher	Lower	Lower	N/A
Coverage	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	None	None	None	None	None	None	None	None	None	None
Quality									N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

- The metrics we found relate to water resources and water network +. We found no metrics related to wastewater or bioresources.
- Water mains is given an Amber quality score as the single source of supply metric is a good measure of redundancy but does not capture future forecasts. Other Amber scores relate to the role of redundancy in supply-demand balance calculations which is indirect, but does incorporate aspects of forecasting.

Recommended activities to reveal future risks associated with asset health
- Lower priority category (as identified by Reckon mapping)
- Select group of outcome-based metrics and undertake mapping process to link these to redundancy metrics. Completing this process alongside mapping of resistance and reliability metrics will help to reveal role of asset health.

C8. Response and recovery metrics

Description of category

Metrics which capture or relate to responses to incidents such that the impact of events, and the time over which they are felt, can be reduced.

Examples of existing metrics and indices in the England and Wales water sector, and other sectors

We found seven metrics related to response and recovery, all from the England and Wales water sector. Three are associated with alarm response times and delays in responding to incidents (indicating a lack of or a poor response). Two are associated with time taken to respond to customer contacts.
One is a bespoke PC in AMP7 which measures the percentage of customers whose drinking water supply service to the tap can be restored within 24 hours of a failure event.
One is a bespoke PC designed to ensure resilience action plans are put in place at wastewater treatment works.

Coverage and quality of existing metrics and indices across asset types

Asset type	Water Resources			Water Treatment		Water Networks					Wastewater Networks				Wastewater Treatment		Bioresources	Metrics applicable to all assets
	Dams and impounding reservoirs	Transmission between raw water sites	Booster pumping stations	Water treatment works Civils	Water treatment works MEICA	Booster pumping stations	Service Res + Water Towers	Water mains	Communication pipes	Customer meters	Sewers	Sewage pumping mains	Overflows	Sewage pumping stations	Sewage treatment works Civils	Sewage treatment works MEICA	Sludge treatment plant	
Importance	Higher	Higher	Lower	Higher	Lower	Lower	Higher	Higher	Higher	Lower	Higher	Higher	Higher	Lower	Higher	Lower	Lower	N/A
Coverage	None	None	None	Sparse	Sparse	Sparse	Sparse	Sparse	None	None	None	None	None	None	Sparse	Sparse	None	Sparse
Quality	N/A	N/A	N/A	Amber	Amber	Amber	Amber	Amber	N/A	N/A	N/A	N/A	N/A	N/A	Amber	Amber	N/A	Red

- We found no metrics related to water resources, wastewater networks nor bioresources
- The two bespoke PCs are given Amber scores as they do indicate ability to respond and recover, however they do not make forecasts into the future.
- Simple alarm response times are crude measures and therefore assigned a Red quality score.

Recommended activities to reveal future risks associated with asset health

- Lower priority category (as identified by Reckon mapping)
- Select group of outcome-based metrics and undertake mapping process to link these to redundancy metrics. Completing this process alongside mapping of resistance and reliability metrics will help to reveal role of asset health.

Summary of findings for each category

Our review of existing metrics and indices from the water sector and other sectors has identified eight broad categories of metrics and indices that could help to reveal future risks associated with asset health. For each of these categories of metric and index, we assessed how well the existing metrics / indices reveal future asset health risks and what could be done to improve this.

Category	Coverage of existing metrics across asset base	Quality of existing metrics across asset base	Recommended activities to reveal future risks associated with asset health
1. Individual resistance and reliability metrics	**Many** More than 100 existing metrics identified. Many are widely applied across the water sector.	**Amber** The metrics often reveal asset health related failures but do not indicate future risks and do not link failure to cause.	• Define a package of reliability and resistance metrics for each asset category. • For higher criticality asset categories first, develop methodologies to produce forecasts of existing or new metrics under defined future scenarios.
2. Asset life metrics and indices	**Sparse** We found 16 existing metrics / indices, three outside the England and Wales water sector. Several are applicable to all or many asset types. There were very few asset-specific metrics in this category.	**Amber** The metrics we found do not consider of future scenarios. We found three indices, which link remaining life to cost to replace. These indices therefore reveal investment needs.	• Consider different approaches to monetise end of life assessments. • Evaluate how risk could be included in the metric / index. This could include, for example, exploring and refining the concept of tolerable service life. • Test the application of asset life assessments under different future scenarios.
3. Risk indices	**Sparse** We found a total of six indices, three from the England and Wales water sector. Metrics from the water sector are related to water treatment and distribution.	**Amber** The influence of asset health may be masked by other causal factors, and by other elements of the index. All the indices are retrospective.	• Engage companies and regulators in other sectors to understand their perspectives on the strengths and weaknesses of existing indices. • Building on the analysis of indices from other sectors, design and test a risk metric for a selected asset category / categories.
4. Outcome-based metrics	**Many** We found 42 metrics in this category, 40 from the water sector of England and Wales. The metrics cover most of the asset base but typically not specific assets.	**Amber** As they are outcomes-focused, these metrics are influenced by the performance of several assets. Very few link an outcome to a cause. All of the existing metrics are retrospective in focus.	• Select group of outcome-based metrics and undertake mapping process to link these to resistance and reliability metrics. • Review how outcome-based metrics were projected into the future in the business plan / long-term delivery strategy process.
5. Qualitative, multi-dimensional indices	**None** The two examples we found were from other sectors.	**N/A** Asset health influences likely to be masked by other factors. The examples we found are retrospective.	• Engage companies and regulators in other sectors to understand their perspectives on the strengths and weaknesses of existing metrics. • Consider role for this category of metric to act as a dashboard of broad performance.
6. Activity metrics	**Many** We found 69 metrics related to a range of activity types including maintenance, alarms and operations.	**Amber** Records of maintenance could be used to infer a level of asset health but this would be indirect.	• Lower priority category (as identified by Reckon mapping) • Understand which specific Activity types are useful under each regulatory aspect • Deliver refinements alongside other categories (not as a category in own right)
7. Redundancy metrics	**Sparse** We found three metrics related to redundancy, all from the England and Wales water sector and relating to water resources and water network +.	**Amber** Water mains is given an Amber quality score as the single source of supply metric is a good measure of redundancy but does not capture future forecasts.	• Lower priority category (as identified by Reckon mapping) • Select group of outcome-based metrics and undertake mapping process to link these to redundancy metrics. Completing this process alongside mapping of resistance and reliability metrics will help to reveal role of asset health.
8. Response and recovery metrics	**Sparse** We found seven metrics related to response and recovery, all from the England and Wales water sector (water network + only).	**Amber** Two bespoke PCs are given Amber scores as they do indicate ability to respond and recover, however they do not make forecasts into the future.	• Lower priority category (as identified by Reckon mapping) • Select group of outcome-based metrics and undertake mapping process to link these to redundancy metrics. Completing this process alongside mapping of resistance and reliability metrics will help to reveal role of asset health.

Summary of findings for common challenges

Delivering the recommended activities to reveal future asset health risks associated with any of the categories requires the consideration of several common challenges.

We have identified recommended activities to address each common challenge:

Common challenge	Detail	Things to consider
Which asset types to focus on	The use of a common set of 'asset classes' as the basis of making asset health forecasts would aide comparison across the sector and would therefore support application in a future regulatory framework	Longer-life assets. Pipe networks and civil assets?
How to represent the future and deal with uncertainty	It is likely we will need to define a set of future scenarios to ensure consistent consideration of future asset health risks across the industry	Could we develop scenarios consistent with the Common Reference Scenarios in the Long Term Delivery Strategy guidance but covering capital maintenance?
How to represent different levels of asset health intervention to reveal the future	If a comparison of the impact of different asset health interventions across the industry is required, it will be necessary to define the performance under several intervention levels.	What if question. What performance and service would be achieved if interventions levels were. 1: Do nothing, 2: Maintained at historic levels (last 5 years), 3: Maintain sustainable level?
Defining and achieving an appropriate degree of standardisation across the sector	Greater standardisation may be desirable because it would support inter-sector comparison for stakeholders and build confidence with consistent evidence.	We could choose to have very rigid definitions of minimum health/performance thresholds/standards, or we could allow companies to define what reflected local their local conditions and explain their choices.
Balancing the need for detail and standardisation with the need to minimise reporting and regulatory burden	Developing and reporting metrics which reveal future asset health risks will inevitably increase reporting requirements and very likely increase regulatory burden.	Focus on the most important asset classes first. Which are most important.

Next steps for the project

Next Steps

- Phase 1: creation of workplans identifying actions to improve metrics associated with each of the packages being developed by Reckon. Key recommendations include:
  - Define one or more reliability and resistance metrics for each asset category, and link these to outcome metrics where possible.
  - Design and test a risk metric for a selected asset category / categories
  - Consider different approaches to monetise end of life assessments and consider how risk could be included in the assessment.
  - Develop methodologies to produce forecasts of the metrics under defined future scenarios
- Phase 2: deliver the workplans