"Risk management of wastewater systems – past, present and future"

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In this paper, we will attempt to:-

- review the changes that have occurred in the management of wastewater systems. We will look at the implications of a risk based approach to management, particularly in the use of data models and systems. The paper will draw on the authors' experience and specific projects;

- trace the path from return period estimations of probability, to current use of stated preference techniques in establishing monetarised service consequence;

- along the way note the shifts in available techniques and the drivers which fostered their use, such as health / environmental legislation and privatisation;

- look at what has caused the expansion of risk based techniques, and how these may be used in the future: experience from other industries will be briefly included;

- take stock of current best practice and identify relevant trends in policy;

- seek to highlight the potential drivers of future developments in risk-based asset management, and the possible implications for the use of current tools and techniques.

But first…

What's risk?

"The product of the probability, duration and consequence of a specified undesirable event occurring". Undesirable in this sense means that it is counter to achieving the objectives of the organisation/business.

Duration x consequence is sometimes referred to as "impact" although there is considerable interchange of these terms. Another common error is to use "risk" to mean "probability" – one of the authors spent six months talking to an economist who used "risk" this way (because that's their terminology) before the communication gap was closed!

An agreed terminology is something which the industry knows that it needs as a matter of some urgency. We were in one meeting with two asset managers from the same company who acknowledged that they both used the word "asset" with different meanings…

Risk used to be thought of mostly in terms of Health & Safety and financial risk, and largely on projects. This thinking has changed significantly in utilities over the last seven or eight years, to be more about business risks, which are those ongoing before / after the project was initiated / completed.

Why assess / manage it?

There are numerous reasons for risk assessment and management. These largely divide into

- external risk drivers e.g.
    - environmental non-compliance,
    - regulatory penalties,
    - reputational damage

and

- business drivers e.g.
    - controlling whole-life costs,
    - delivering service,
    - achieving efficiency targets for shareholder value.

The divide between the two can become indistinct, for instance when reputational damage affects share price and consequently credit status (and most of the multi-billion pound capital programmes have funded by borrowing).

How did we get to here?

Early steps in recognising risks included:

- Formula A (recognising consequence of higher loads from intermittent discharges – and what happened to B and C…?);
- Sewer Rehabilitation Manual criticality (mostly consequence as cost to the business but some elements of disruption and sensitive customers; also defined structural condition grades, effectively as precursors of likelihood of failure);
- final effluent consenting on a Monte Carlo basis (recognising that the probability of a given FE flow/concentration combining with a given river flow/concentration was best expressed as a distribution)

More recent developments:

- Urban Pollution Management (UPM) standards – the return period/duration/magnitude criteria in UPM standards basically map onto p x d x c, being derived from toxicological studies on impacts (with safety factors);
- sludge quality control moved to a HACCP basis along the same lines as risk controls in the food industry;
- Bathing Water Directive (BWD) standards seem to be moving to a risk basis to include beach management practices and antecedent rainfall (but still limited links to quantified health impacts).

Current “best practice”:
The start point for any of the better risk management approaches is in having a set of asset registers which are sufficiently well-populated with attributes such as location, material, age, depth, dimensions, condition etc, all of which help in risk analyses. Superimposed on these data is information which can help to relate where the asset “lives” to the likelihood and consequences of its failure (e.g. does it receive aggressive trade effluent, is it adjacent to a sensitive location (river, customer), is it in a former area of mining?).

A variety of assumptions are generally made:-
i) about how to translate relative likelihood (as opposed to probability) of failure into a timescale for an intervention;

ii) what form of intervention is appropriate, be it an operational fix, capital refurbishment or capital replacement
iii) how effective the intervention is in mitigating the risk
iv) what residual level of risk there is following the intervention.

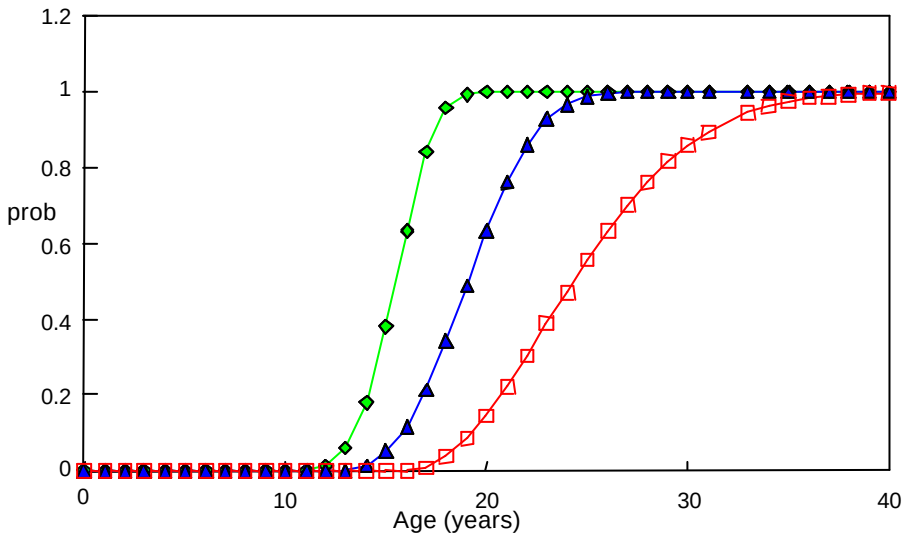
Running investment scenarios is often limited by the need to move information from one element of the asset management systems to the next. Generally this is because existing legacy systems do not capture the information in the desired format so workaround systems have been developed by asset management functions. The problem this poses is that there can be “multiple versions of the truth” within a company regarding asset information which is compounded by separate off-line analysis.

Most risk assessments being undertaken are looking at ***relative*** risks (p,c) posed by assets to service to customers and to the environment. Note the shift to risk of loss of service, away from just cost to the business, means that wastewater assets approach parity with the service from clean water assets. Although interruptions to supply are still the number one issues for customers when consulted, internal flooding of property by foul sewage (Ofwat’s DG5 measure) is close behind, and then most of the rest are wastewater ones.

As things currently stand in risk assessment for investment planning, *consequence* estimation by asset managers is still qualitative, but curiously is the easier part when looking at the level of individual pipe lengths and plant using models. As we hope to highlight further on, this big gap in the risk toolkit will become even more pronounced due to recent regulatory statements.

State of the art:
The quantified estimation of *probability* of service loss due to asset failure using deterioration models still uncertain. However, statistical estimation of p is quite well developed by some companies through use of techniques such as mortality (Weibull) curves and Markov chains. Some companies can reflect the way in which an asset that is working hard / subject to greater loads / not the right piece of kit will “die” quicker than one which lives the easy life (Figure 1).

Figure 1: Weibull Cumulative Probability of Failure



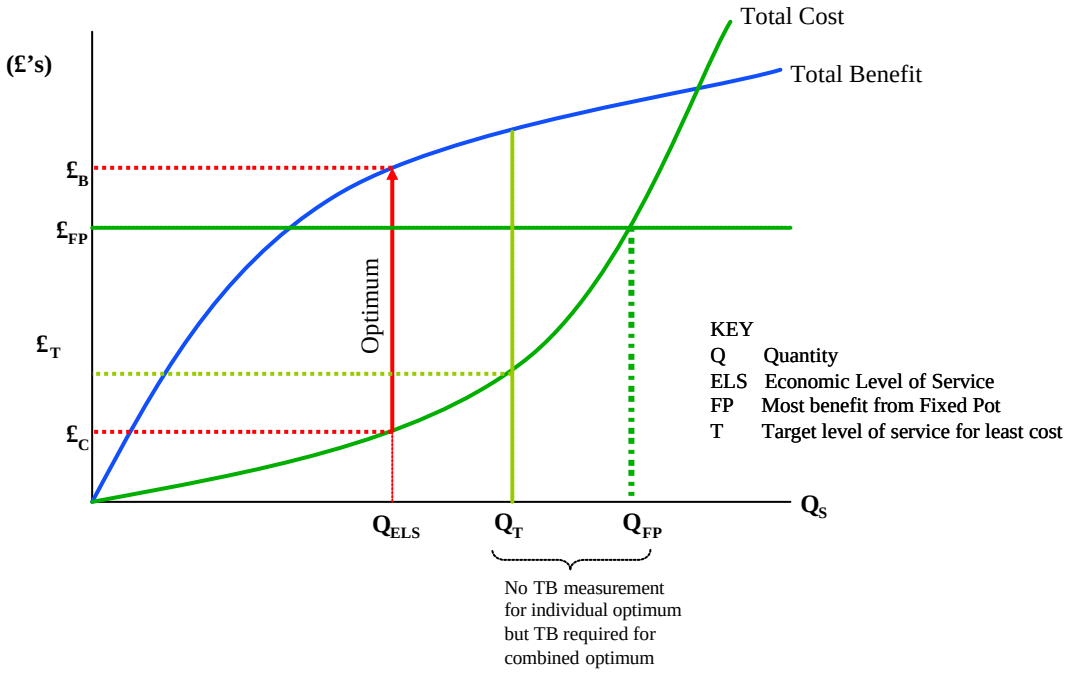
Much of this thinking originally came from the aeronautics, oil/gas and electricity sectors, into the mechanical and electrical domain of the water utilities where due to the fast-wearing nature of the assets the relevance was most clear. The methods can also be applied to above ground M&E kit at a low level in the asset hierarchy such as plant item. They have been applied to the slow-degrading below ground civils assets such as sewers and mains, but at best at the level of "families" of assets (e.g. post-war 450mm cast iron mains in corrosive soil).

One challenge which faces the industry is to adapt such techniques so that they can use the attributes of each asset at the level of pipe length to quantify the probability of asset failure and hence service loss. Again, this is a gap in capability which will become more significant moving to the next periodic review.

The state of the art for estimation of *consequence* has moved to valuing the service provided by the assets. In essence this is what a non-monopoly service provider does in the market, by conducting customer research. This type of research reveals **why** some people are prepared to pay three times the price of a Virgin Cola to get value from their Coca Cola.

At present in the water industry, this has been done through looking at Willingness-to-Pay. Without going into detail, the technique used has been stated preference through choice experiments, where customers are presented with different levels of service with different "price tags". The preferences which emerge from this process establish monetarised service consequence and show what the economic level of service should be (figure 2). How else to weigh up literally thousands of potential schemes, deciding between 27 DG2s (low water pressure properties) against 2 1:10yr DG5s against a final effluent failure at a 3,000 pop. equivalent works against 17 Category 1 pollution incidents?

Figure 2: Economic Level of Service for single service measure



What's driven these changes?

Let's explore the, probably contentious, premise that generational changes in risk management techniques and their implementation have been driven by external events such as legislation (H&S, environmental), and by comparative regulation, which seeks to benchmark companies against each other in their performance (financial, regulatory, service, efficiency).

Timeline:

1970's:
Formula A and Monte Carlo consenting of final effluents were really first widely applied, outside the academic environment, in the lead up to the creation of Water Authorities. Possibly this was a more receptive period for these methods than had been the case in the past, driven by the increased accountability resulting from consolidation.

1980's:
The mid-1980's saw a burgeoning of activity in risk approaches. In the asset maintenance field, the Sewer Rehabilitation Manual's 1st Edition appeared in the lead up to privatisation. While the spectacular sewer asset failures which ostensibly catalysed the creation of the SRM were the most obvious driver, another factor would have been the recognition of the need for more objective means of prioritising asset investigations and investment.

On a similar basis, with the imminence of privatisation pushing companies to update (or create) their asset registers, approaches such as stratified sampling and Bayesian statistics were appearing around 1988 to infill data gaps and look at likelihoods of e.g. condition and performance grades.

1990's:
On a parallel timeline with this, much research into urban river quality impacts was taking place in a co-ordinated manner through river basin management programmes of research. Ultimately these resulted in the UPM approaches (inc. BWD impact modelling) which were then driven by both AMP2 programme cost-effectiveness / affordability business needs and by Environment Agency consenting policy.

In the mid-90s, there were huge ramifications from the handling of the drought, most notably in Yorkshire (more of which later). Changes in sludge risk management were also very clearly the results of poor risk communication by the industry in the face of public perception, driven by the Press and by the British Retail Consortium.

The 1999 periodic review (PR99) saw the first green shoots of risk-based asset management as a discipline in its own right within the water industry. The affordability issues within the AMP2 CSO Quality programmes, about getting the most "bangs per buck" from investment, were being applied across all asset types to get the most from capital maintenance expenditure.

Post-2000:
Currently, risk practice in wastewater asset management is under the banner of the UKWIR Capital Maintenance Planning Common Framework ("Common Framework" or CMPCF). This was a new phenomenon in that it was a truly collaborative effort between the industry and the regulators, Ofwat, DWI and Defra being particularly

participative. However, it still stemmed from the perceived crisis triggered by Ofwat's 1999 Final Determination, which trimmed companies' CM estimates, substantially in many cases.

It was further driven by Ofwat laying out, very categorically, what it felt the steps were "***to demonstrate how the flow of services to customers can be maintained at least cost in terms of both capital maintenance and operating expenditure, recognising the trade off between cost and risk, whilst ensuring compliance with statutory duties"*** in time for this periodic review [MD161, Maintaining serviceability to customers, 12/4/00]

Current benchmark asset management:
A CapGemini survey two years ago put the water sector in the lead of utility asset management. The widely-regarded benchmark within the water industry is currently Yorkshire Water's LEADA (Leading Edge Asset Decisions Assessment) systems.

We propose that this outcome is due to several factors, starting with YW responding to an overwhelming failure of risk management and communication ("the drought"), which led to a Board-led answer to the question "why manage assets?" - namely "to deliver service/compliance/value", three of YW's four strategic themes. Several similar, but piecemeal, existing risk tools were converged, improved and built into corporate systems to allow "business-as-usual" rather than resource-consuming and separate scenarios run solely for Ofwat reporting purposes.

However, the step change for YW in developing LEADA was to move away from simply prioritising on cost-effectiveness, to optimising on cost-benefit, using service valuation as the measure of benefit. This approach effectively sets the weightings on the various service measures such as water pressure, foul flooding and pollution incidents by actually finding what the market demand was for those benefits.
One of the outcomes from this way of determining investment needs is that the SRM critical / non-critical sewer distinctions become irrelevant, and the emphasis moves to "service critical / non-critical". For instance, Section 24 sewers are particularly service critical on failure but are SRM non-critical. The SRM is an area for the industry to consider moving into AMP4, regarding criticality / non-criticality and in disaggregating condition/performance grade information into the asset attributes which inform risk.

So far LEADA appears to be nearest to delivering the requirements of MD161 and most aligned with the Common Framework (e.g. NAO "Public Sewer Network" report, para 2.27). Consequently, it is being closely observed by other companies in its success at justifying capital maintenance investment requirements to Ofwat at PR04.

The future looks….risky?

Defra in its Principal Guidance, the National Audit Office in its recent "Public Sewer Network" report and the Drinking Water Inspectorate (through its Distribution & Operational Maintenance Strategy requirement) are all advocating developments to risk-based asset management which will require the industry to move on from where it is today. It seems that, just as the companies and the economic regulator have "got risk" in the context of capital maintenance, the environmental regulators for England and Wales have moved away from previous successful approaches such as UPM, and are returning to frequency-based standards in setting consents to discharge. We believe that there are several areas where their expertise could be engaged.

In the next few years, we can expect to see requirements such as:-

1. benefit assessment (inc. health aspects)

2. wider use of sustainability criteria (an area in which the environmental regulators could bring their expertise to bear)

3. net present costs (i.e. capex *and* opex) being the only acceptable form of costing

4. quantifying the investment implications of new development and growth (i.e. change in flows in networks, including climate change – again, an area in which the Agency could play a role)

5. a further move to more "bottom up" to meet point 4 above and to directly inform delivery programmes (i.e. no more planning at whole DAZ level but at individual pipe lengths)

6. explicit statements by companies about what the assumed "acceptable" (tolerable) level of risk is in their risk management policies

Why are we so certain?

Firstly, because all of the criteria within Ofwat's MD161 became features of the Common Framework and are among the criteria by which Ofwat judge the quality of each company's capital maintenance plans.

Mostly, though, because this is what these regulatory bodies have said:-

NAO: "Only one company has [developed robust cost-benefit analysis] to date…Ofwat should encourage the industry to carry out co-ordinated studies on customers' willingness-to-pay…to give a rigorous understanding of which more expensive schemes are worth pursuing in each company's particular circumstances." (Recommendation C, NAO Report HC161 "Ofwat and the public sewer network in England and Wales", 16/1/04)

NAO: "**Full** implementation of the common framework by each company **at** the 2009 review should enable them to make robust and convincing assessments of…needs which can be largely relied upon by Ofwat when it sets price limits for 2010 and beyond." (Recommendation G, *ibid*, authors' highlighting)

NAO: "Developments such as climate change, the Water Framework Directive and new housing development will place new demands on the performance of the sewerage network and the way investment in the network is prioritised…Consequently there may be a need for more robust assessments of future demands on the networks, as currently happens for clean water through water resource plans….The industry…should work together to establish a framework" (Recommendation H, *ibid*)

Ofwat: "Our expectations for AMP4 and towards AMP5 & 6

- maintaining the right balance and managing risks (= probability x impact) appropriately and openly
- explicit decision making using whole life costs

- expose judgements made about the “tolerable” level of risk to service/environment
- appropriate use of sound cost-benefit analysis to inform all change in service decisions (up and down)
- acquire data to inform future planning

CMPCF must be seen to be the business as usual…

intellectual neglect claims won’t stick this time!“

(Bill Emery, presentation to Utilities Asset Management, 25/2/04, his emphases)

Defra: “The Government, after discussions with Ofwat and the Environment Agency, has concluded that there may be a case for sewerage undertakers to draw up integrated drainage plans. These would have a similar basis to water resource plans drawn up by water undertakers.” (Section 7.3.2, Principal Guidance to the DGWS, March 2004)

In addition, the PAS 55 (Publicly Available Specification for Asset Management) being launched <**today**> by the British Standards Institute as an asset management “standard” will add further sophistication to the mix. There were three regulators and two government departments on the steering group for this document, as well as seven utility companies (including three water companies). PAS 55 will push the use of risk-based asset management firmly into the “business as usual” mode of working rather than being what might have been an investment planning add-on. This is clearly a key Ofwat criterion for what provides confidence in companies’ plans. There are explicit requirements within PAS 55 for:-

- Asset management policy and strategy
- Asset management information, risk assessment and planning
- Implementation and operation
- Checking and corrective action
- Management review and continual improvement (inc. audit)

All of these developments mean that risk management, in an asset management context, will be something for us all to understand better into the future.