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water
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INTERNATIONAL

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A new resource for asset managers

Welcome to the first edition of Water Asset Management International. The International Water Association held in July 2005 its first Leading Edge Conference on Strategic Asset Management. A key outcome of this conference identified a gap of a regular reference document that could identify some of the leading and emerging practices in asset management internationally. This newsletter seeks to close this gap.

The newsletter's aim will be to provide a forum for water industry asset managers. Contributions will focus on the leading edge practices, and regular contributions from chief executives of water utilities will also enable sharing of the view from the top of many organisations.

Asset management is not a short-term issue: it is paramount to being a leading edge water utility. As Kevin Young, Managing Director of Hunter Water in Australia notes in his CEO's view, 'Asset management when done well provides a great foundation to drive better confidence and a better framework for regulator, utilities and customers.' Asset management is the platform of being a good water service provider.

We trust you will find this newsletter informative and an excellent platform for sharing asset management knowledge. We would like to invite readers to also consider what they are doing in their business and provide articles for future editions.

Andrew Foley, Co-editor

Ofwat targets greater efficiency from English and Welsh water utilities

The water companies of England and Wales have been granted price increases by economic regulator Ofwat for their next five year programme (2005-2010) that were far lower than they had been hoping to achieve, on the basis of hoped-for further efficiencies and an emphasis on asset management.

This approach is predicated by the Common Framework for Capital Maintenance Planning, which had its genesis in criticism of both Ofwat and the industry after AMP 3, the privatised industry's previous programme, for the backward-looking approach to asset management.

There was a recognition that the industry had good core tools - serviceability indicators (SIs) such as data on the number of mains bursts, coliform failures and so on. General indications suggest that since privatisation the industry's assets have performed well, but using such data to predict future asset management needs meant extrapolating the future purely from the past - clearly an unsatisfactory solution.

'People were concerned that providing funding on that basis was not a good indicator of what would happen in future,' notes George Butler, capital maintenance team leader at Ofwat. Because of this, Ofwat and the industry joined in an UKWIR project, tasking consultant Tynemarch with developing a Common Framework for capital maintenance needs. This incorporated a risk-based approach to future asset needs.

'This approach has been developed in other industries - offshore gas and oil, for instance - but for the water industry it was new,' Mr Butler adds. 'It meant developing sub-threshold indicators to show what was likely to be a problem in the future and fund appropriately for future maintenance.'

Collaboration was the watchword for the Common Framework, which was developed with input from the Environment Agency, Drinking Water Inspectorate, Ofwat and the water companies and the Water Industry Commissioner for Scotland. A steering group was formed from representatives of all these bodies.

As a framework, each company was able to take the principles and incorporate them ➤ *cont:*

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Water Asset Management International is an international newsletter on asset management in water and wastewater utilities. The focus of the newsletter is on the strategic aspects of this developing field, providing utilities with international perspectives on infrastructure planning and maintenance as they seek to deliver cost-effective services to their customers.

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New asset management initiative for US water industry

A group of leading US water utilities and related organisations are planning a two-day meeting of water industry representatives, with the aim of developing a strategy for moving forward water asset management in the US.

Billed as 'A National Working Session Exploring Opportunities to Enhance Collaboration by Water and Wastewater Utilities in Advancing Asset Management', the organisers state their objectives as:

- **To further the knowledge about tools, techniques, processes, and emerging practices;**
- **To bring about a utility lead consensus on needs and priorities and provide a strategy and roadmap for the next three to five years regarding the development, coordination and improved sharing of knowledge about advanced asset management.**

Delegates from over 180 US and international bodies are expected to attend the conference on 5-6 May this year, with the organisers extending an invitation to any water or wastewater utilities with a desire to contribute and a belief in the value of collaborative leadership.

It is hoped that the new meeting will build on the success of an earlier EPA sponsored, WERF-led session. A number of promising projects and working relationships emerged from this session, and the upcoming conference will provide attendees with an opportunity to report on these projects and share the lessons of their experiences.

Speaking of his hopes for the project, Steve Allbee of the US EPA told WAMI: 'I think this is going to be a really good session. It's the first time we are bringing together a broad-cross section of the water sector to have this discussion under an integrated format.'

➤ into its own way of working, just as Ofwat incorporated the methodology into its assessment techniques for PR 04. 'It is a very significant step,' notes Mr Butler. 'Generally everyone has bought into it as the way forward.'

Ofwat used a four-stage approach to assess companies business plans - in stage A, if the SIs suggested problems these were investigated and, if they represented genuine challenges, extra funding was made available. This stage, which is still backwards-looking as it is based on the SIs, represents about 75% of the funding. Stage B is the new risk-based element, in which companies use risk assessment to predict changes in their requirements for the future.

In stage B 'lumpy' items - those that have to be paid for in one go, such as Northumbrian's new sewage sludge transport ship - are taken out and challenged, checked with company reporters and a decision made as to whether there is a need for the item and the timing is right. If the case is proved, the item can be funded in full.

With the risk-based approach there is obviously an element of doubt about costs - how fast, for instance, will mains deteriorate? An assessment is made, says Mr Butler, against the process used to arrive at the figure, based on 18 criteria, drawn from the Common Framework. Some items, such as a need to repair a dam, depend very much on expert judgements, while others rely on trends and solid data.

At this stage, some companies' processes are more robust than others. 'We look for companies to take a risk-based approach rather than just age and condition,' notes Mr Butler. 'That risk is to service to customers. The asset may not look nice but may perform adequately for many years.'

There followed a somewhat contentious element. If the risk-based approach suggested that a company had a very sound plan (graded A) funding was provided in its entirety. Less rigorous plans (grade B) received 75% of the funding, and so on. Robert Weedon, trade body Water UK's chief economic advisor, says: 'The amount of money was altered depending on the quality of the business plans. It was a fairly arbitrary adjustment that annoyed some companies.'

Stage C of the assessment process relates to efficiency and Stage D examines overlaps between the capital maintenance programme and the still-major quality improvement programme, and provides a balancing element that takes these into account.

The effect of the change can be seen in the effect on capital maintenance funding between AMP 3 and the determinations of PR 04 (the latest price review) - in AMP 3, capital maintenance funding stood at £6.9 billion. At PR 04, this figure rose to £8.4 billion. 'This is a very significant increase, primarily because of the need to continue to maintain the improvements in water quality and discharges to the environment gained since privatisation,' says Mr Butler. There is also a recognition that maintenance costs will continue to increase for the foreseeable future - at least the next two AMPs.

The last periodic review was undertaken in the knowledge that companies were at widely varying stages in their ability to provide the data needed to move to a risk-based approach. 'There was a recognition at the time that there were some leaders and some laggards,' Mr Butler says. 'PR 04 was a transition. Most companies had not fully developed the data and processes - during the AMP 4 period they should incorporate the Common Framework into their daily working practices.'

The important thing, he notes, was the general acceptance of the approach. Moving forward, UKWIR is beginning new research looking at how the companies feel the Common Framework has been applied and how to take it forward. This review could provide feedback on the 18 Ofwat-generated criteria, for instance whether they are the right ones and if the weightings are correct.

The review is due out around August this year. It should mean that by the start of the next periodic review all of the companies have the correct processes in place to make the most of the framework. It's not a prescriptive approach, Mr Butler notes, because Ofwat does not want to stifle innovation, but a case of enabling everyone to be clear about what they have to do.

The water industry itself views the framework in a very positive light. Mr Weedon says: 'It has got the support of everyone. The important thing is that everyone is on board.' ● **Lis Stedman**

Dispel the myths

Asset management - a CEO's point of view

Kevin Young, Hunter Water Corporation

World wide there is a great diversity in the different suppliers of water and wastewater services – from the small outback town in Australia to major metropolises like Los Angeles, Sydney and London. While objectively an observer would note that we all use common identifiable materials for our pipes and pumps, there are dramatic and challenging changes in the different regulatory structures, use of technology, approaches to the replacement, operation and maintenance of assets and to the use and integration of competition and private industry in the business. With tongue firmly in cheek, I can say that the only thing all of the utilities generally agree on is that the approach that they have adopted is the right one!

Despite all of these differences, my view is that there are unifying principles that are making a difference to how utilities are managed, regulated and operated and these principles are covered, of course, by asset management. If applied appropriately and systematically, good asset management should lead to effective regulation, focussed management, confident decision making and, importantly, the best results for customers and the environment. Good asset management should also proactively drive appropriate regulation.

2004 saw the first IWA leading edge workshop in asset management. What I drew from the presentations and discussions was the following:

- Best practices in the principles of asset management is not the domain of any country or any sector, water or wastewater or any organisation, public or private and it was clear that good asset management is being practiced in pockets globally. This means that we need to share a lot more and we need to have good principles of asset management being part of university training for engineers, economists and scientists. Future leading edge workshops in Asset Management will also be of assistance.

- Good Asset Management unifies the different disciplines (engineering, accounting, economists, managers) into a team with a business focus.

- Leading edge workshops are a great opportunity to meet key people, get some ideas and be inspired – in short, if you didn't get to the last one, don't miss the next workshop!

- A strong point coming from the conference is that you can't 'sell' asset management into an organisation. If it looks like just the newest fad that has come and gone, it will not last. Good asset management becomes part of an organisation if it simply becomes enshrined in the culture of an organisation and the way that you do business. This gives it a longevity and the best chance for survival and good results.

For all the tremendous strides that have been made over the last decade, I'm still amazed that in different pockets globally organisations use asset management as a cover for practices that would not be considered good asset management. I've listed three of these practices (there are many more!) and I hope this may stimulate discussion from others to this newsletter on these points:

❍ Some organisations have a proactive euthanasia of assets / pipes that don't need replacement but are replaced because the funding has been committed, their age is up, there is a general need to increase the percentage of pipes that need to be replaced; or a regulator has approved an amount of money for replacement and we need to spend it. I was told by one organisation that I visited, that water mains in a particular suburb needed to be replaced because they had reached a long age and there was a potential that they could fail some time in the next few years.

Explain this to customers! The utility rips up the street, causes disruption to traffic along the road and difficulties with customers getting their cars in and out of their driveways. Safety and environmental issues are raised and this is being traded off against the potential impact that sometime in the next three years the water main will fail and about thirty customers will be without water (if they are at home) for a period of up to four hours!! Is this good customer service and asset management?

❍ There is still a great lack of risk assessment in undertaking operations, maintenance and replacement programs. What I often see when visiting a number of utilities is a great aversion to risk rather than a great management of risk. The truth is there will never be enough money on the planet to complete eliminate risk and what is required is a more objective assessment of the risks faced, the costs involved and the overall benefits to the community and environment. This acceptance of risk must be understood not only from a regulatory basis and from senior management of the utility but right ➤ *cont:*

biography

KEVIN YOUNG IS CURRENTLY the Managing Director at Hunter Water Corporation, which is a water and wastewater utility serving 500,000 people in the Lower Hunter region on the east coast of Australia.

Kevin has over 24 years of experience working in private consulting both in Australia and overseas and working for government utilities. He has held a diverse range of positions across the range of utility functions including operations, planning, construction, asset management, strategic policy and liaison. He was Hunter Water's first Manager Assets in the early 90's and since then Hunter Water has developed a strong reputation both within Australia and internationally in asset / utility management.

Kevin worked with Seattle Public Utilities (SPU) for eight months until late April 2003 to lead their asset management programme and to look at issues of change management and organisational structure. In the first year of implementing asset management, SPU saved over $25M in operating and capital costs.

He has a degree with honours in engineering and a Master of Business Administration. Kevin is a Fellow of the Institution of Engineers Australia and a Member of the Australian Institute of Company Directors. He was chosen by the International Water Association to co-chair a one-day Strategic Asset Management workshop as part of the Conference in Melbourne Australia in 2002, and was the conference chairman for IWA's first leading edge workshop on asset management held in San Francisco in late July 2004. ●

Poor rating for US infrastructure

The American Society of Civil Engineers' (ASCE) annual infrastructure report card warns that the country requires a $390 billion investment over 20 years in its ageing wastewater systems and faces an $11 billion annual shortfall in funding to replace potable water facilities to meet regulations.

The wastewater element of the report gives the public system a D minus, with D representing classification as 'poor'. It says that 'the physical condition of many of the nation's 16,000 wastewater treatment systems is poor, due to a lack of investment in plant, equipment and other capital improvements over the years.'

Many systems are at the end of their useful design lives. Older systems suffer chronic overflows during major storms and heavy snowmelt and, the report adds, 'intentionally or not, are bringing about the discharge of raw sewage into US surface waters'.

The US Environmental Protection Agency estimated last year that the volume of combined sewer overflows discharged across the country equates to 850 billion gallons (3200Mm^3) annually. Sanitary sewer overflows (SSOs), caused by blocked or broken pipes, release as much as 10 billion gallons (38Mm^3) of raw sewage each year.

Federal funding has remained flat for a decade and further cuts are proposed for next year. It warns: 'If the nation fails to meet the investment needs of the next 20 years, it risks reversing the public health, environmental, and economic gains of the past three decades.'

The report says: 'The case for increased federal investment is compelling. Needs are large and unprecedented; in many locations, local sources cannot be expected to meet this challenge alone and, because waters are shared across local and state boundaries, the benefits of federal help will accrue to the entire nation.'

ASCE supports a federal water infrastructure trust fund act, which would provide a reliable source of federal assistance for the construction and repair of publicly-owned treatment works to reduce the enormous funding gap. It also urges a similar scheme for potable water.

In the interim it suggests a $1500M annual appropriation from the State Revolving Loan Fund programme - and a further $1000M for potable water. ASCE also supports the establishment of a federal capital budget 'to create a mechanism to help reduce the constant conflict between short-term and long-term needs'.

On potable water, ASCE also gives the system a D minus and notes: 'The nation's 54,000 drinking water systems face staggering public investment needs over the next 20 years.'

It notes: 'New solutions are needed for what amounts to nearly $1 trillion dollars in critical drinking water and wastewater investments over the next two decades. Not meeting the investment needs of the next 20 years risks reversing the public health, environmental and economic gains of the past three decades.'

A significantly enhanced federal role is urged. Possible solutions include grants, trust funds, loans and incentives for private investment. 'The question is not whether the federal government should take more responsibility for drinking water improvements, but how,' ASCE adds.

The society warns: 'Clean and safe water is no less a national priority than are national defense, an adequate system of interstate highways, and a safe and efficient aviation system. These latter infrastructure programs enjoy sustainable, long-term federal grant programs; under current policy, water and wastewater infrastructure do not.'

It calls for federal investment including grants, loans, and other forms of assistance and research into water reuse and purification technology.

Jack Hoffbuhr, Executive Director of the American Water Works Association (AWWA), issued a statement saying: 'Good stewardship implies the need to increase investment in infrastructure over the next several decades. The time to start this important work is now.'

Lis Stedman

➤ through an organisation to the people that operate and maintain. The past was a period of risk aversion where from an operator's viewpoint there could never be enough redundancy or enough new equipment. Any failure of any equipment on their shift was seen as a reflection on the individual operator. Good asset management of course needs everyone to understand that failure can occur.

❍ The use of common benchmarks between different utilities to drive spending. It is clear by visiting a number of utilities that all of the different utilities have been dealt different 'sets of cards'. Some utilities have new assets that were virtually all built after the second world war, stable soils, good geography and this means, that they achieve low break rates in pipes and they have lower operation and maintenance costs. Other utilities have reactive soils, mine subsidence, older assets, poorer geography and larger levels of breaks. I'm in constant amazement that comparisons are drawn between the two utilities above and the utility with older assets and poorer soils is criticised for having a higher level of breaks. The reality is the utility with the older pipes may be twice as efficient and be implementing excellent asset management. A drive by the utility with older pipes to achieve comparable results will drive significant increases in customer bills which isn't traded off by benefits to the community or the environment. It is clearly a case of 'one size (or measure) does not fit all'.

Asset management when done well provides a great foundation to drive better confidence and a better framework for regulator, utilities and customers. When it's done well it provides a correct link for a social contract between the utility and its customers and for a healthy robust relationship between utilities and regulators which is driving good results. Asset management is moving ahead in leaps and bounds at the present time. There are still many water utility urban myths that are in place and these will dispelled with time. It's important that we all get together and support sharing of information and improvement in practices.

Kevin Young
Managing Director, Hunter Water Corporation, Australia

South Staffordshire Water adopts IT solution

FastNET ASP - a new trading division within the SoftSols Group of companies - has announced that the UK's South Staffordshire Water is the first company to utilise its recently launched rapid application development framework. The utility, which serves 1.2 million people in the Black Country region in the UK, has purchased a licence for FastNET ASP, the customisable asset management technology, in order to dynamically develop internal management applications that are flexible enough to keep pace with the company's developing asset management programme.

Adrian Leadbeater, IT Manager of South Staffordshire Water, explains: 'Like most companies that have physical assets, we capture ongoing data about our assets such as running costs and general maintenance data. This allows us to get the best value for money from those assets. Our information needs for the planning of asset maintenance are quite complex, as a large proportion of the data we capture has to comply with the requirements of external governing bodies such as OFWAT, as well as our own internal business needs. Instead of adding complexity to our core applications to help meet higher demands, we identified the need for a more flexible development environment that could evolve with our changing business needs.'

Risky business: two case studies in asset risk management

V. Kenneth Harlow
Vice-president
Brown and Caldwell
USA

Risk and the perception of risk permeate asset decision-making. Most decisions on preventive maintenance, refurbishment, and replacement are typically made to avoid the risk of unexpected asset failure. Even decisions regarding expansions, improvements, and new facilities are usually made to reduce risk - risk of not meeting growth in demand, risk of failing to comply with regulatory guidelines, or risk of experiencing incidents with consequences for public health or employee safety. In other words, risk drives the asset decisions and the results of asset decisions that generate the bulk of all operating and capital expenditures of most water and wastewater utilities.

And yet risk is seldom overtly considered in asset decisions, at least in a quantifiable way. There are probably two reasons for this:

1) The industry lacks a practical framework for dealing with risk; and

2) Without such a framework, the industry doesn't know what kinds of asset data are required to support it.

This article describes an effective approach to a risk-based asset decision framework, and by doing this it also suggests the kinds of asset data that the industry must develop to use the framework in a practical way.

The concept of 'risk' by itself is not very meaningful. For example, there is a risk that the world will end tomorrow. Yes, it could happen, though we might consider it unlikely. There is also a risk that interest rates will rise sometime in the next five years. This might be thought more likely, although the impacts would hopefully be less dramatic. But how do we compare these two risks?

The paragraph above already suggests the answer: for a risk to be evaluated, it needs to be clearly understood as including two separate and distinct characters - a probability of occurrence and a consequence of occurrence. Figure 1, below, illustrates the two risks above in these terms.

We typically think about our infrastructure and its risks similarly:

- We have a few assets whose consequences of failure are very high. In asset management terms, these are 'critical' assets. We do not want these assets to fail. We are willing to invest a lot of money to monitor their condition, to maintain contingency plans, and even to replace them proactively. In other words, we reduce their probabilities of failure.
- We have a lot of assets that are less critical. We might monitor some, just do our normal maintenance on others, or even ignore many until they fail.
- We have no assets whose probabilities and consequences of failure are both high. This is because we have spent a lot of our customers' money to make sure that we have none. We have added redundancy to reduce the consequence of failure, over-engineered the asset to reduce the probability of failure, or taken other steps to avoid the upper-right 'doomsday quadrant'.

This two-dimensional dispersion of assets, and our responses in managing the assets, are very intuitive. We have been designing and operating our systems in these terms for a long time. But the historical approach leaves a lot to be desired. A more rigorous approach to dealing with risk can and does yield considerable gains over the traditional intuitive approach.

Figure 2
Calculation of risk cost of asset ownership

RISK COST =

Frequency of Failure (Projected events per year)	X	Consequence of Failure (Dollar cost of each event)

COST MEASURE: $/YEAR

Quantification of Risk in Dollar Terms

Risk cost is a cost of asset ownership. It is the product of the probability of the risk, expressed in occurrences per year, and the consequence of the risk, expressed in dollars. The result, risk cost of ownership, is expressed in dollars per year.

An everyday example will illustrate this. Your auto insurance carrier estimates the probability of an accident based on your age, driving record, etc, and multiplies it by the most likely consequence (dollars paid out) derived from industry averages. In effect, it calculates your risk cost of auto ownership, expressed in dollars per year. It

Figure 1
Dimensions of risk, two possible occurrences

	Probability	Consequence
World ending tomorrow	Very low	Very high
Interest rates rising	Medium to high	Varies - but certainly lower than the world ending

then offers to assume this risk in return for those dollars per year plus a profit premium.

An example from closer to home: a review of our CMMS (computerised maintenance management software) records tells us that a motor-pump combination of a certain type fails unexpectedly on average about every five years. We have one of these combinations in a plant process where the failure will have a cost of $8,000 including technician time, shop time, and likely process disruption. So the risk cost of owning this particular pump is $1,600 per year.

If we could buy a pump with similar function but better reliability, we could save money. For example, a pump that failed only every ten years would reduce the risk cost of ownership by $800 annually. If that pump cost $2,000 more than the current pump, there would be an excellent business case for upgrading the pump upon next failure – or perhaps even before (see the second case study below).

This latter example illustrates an important point. Once risk cost is fully factored into asset decisions, those decisions can be made in a fully rational and quantified way. This has a further implication: an asset decision – a new facility, for example – can be analysed and judged in terms of whether it is or isn't good value for customers. In other words, the concept of 'prioritisation' of capital projects is discarded and projects can instead be fully justified in terms of customer value – a major change for many utilities.

Introduction to the Case Studies

In asset management, all asset decisions are made on a whole-of-life basis, considering the effects of these decisions over many years. The time frame considered may vary from ten years to a hundred years or more, depending on the life of the asset(s) involved and other factors.

Costs, including risk costs, and benefits are projected over the time frame and the resulting annual net benefits are 'brought back' to present time as a single number using discounted cash flow analysis, also known as present value or PV analysis.

The following case studies presume some knowledge of PV analysis. They show how different approaches to risk can be used depending on the situation at hand and the skill of the asset management analyst.

Case Study 1: Water supply pipeline

This is a very simple risk case study – it's hard to imagine one simpler. Nevertheless, a major asset decision was made and carried out as described. The source of this case study is Kevin Young, Managing Director of Hunter Water Corporation, Australia.

A water utility in Australia had a key water supply pipeline that was worrisome. It was made of lead-jointed steel and ran aboveground for much of its route.

Because of temperature changes and joint stresses from ground movement, constant attention was required. Annual maintenance and repair costs were about $0.4M.

Staff considered replacing the line with buried pipe, which would avoid the $0.4M annual expenditure. The replacement would cost $10.4M. However, based on a savings of only $0.4M a year, a 20-year return on the $10.4M investment would be a negative two percent, not even a break-even proposition for the utility's customers.

Staff were aware that the location of the pipe was subject to rare flooding. In fact, in their research, they came across an event that had been totally forgotten due to turnover. The pipe had washed out in a flash flood in the early 1950s during a 100-year storm. As a result, 50,000 customers were without water for 14 days and numerous businesses had to close their doors.

If the same flood were to occur today, 90,000 customers and numerous business and industries would be affected. Staff calculated the impacts, including:

- Cost of mobilizing every water tanker available and tankering water to the area
- Expected claims for loss of production, etc
- Estimated values of residential customer water interruption – very high for such a long-duration outage
- Costs of emergency response to pipe failure over and above routine response.

The total cost was estimated at $60M.

Now staff had the information they needed to calculate the risk cost of ownership quite simply – a consequence of $60M with a probability of one percent per year based on the 100-year storm. So the risk cost of owning the pipeline was $0.6M a year, which, like the maintenance cost, could be avoided by burial.

So the burial cost of $10.4M would result in the avoidance of $1M annually – $0.4M in O&M cost plus $0.6M in risk cost. The new 20-year return on investment was seven percent, which management felt represented a good investment of customer dollars.

The decision: replace the line.

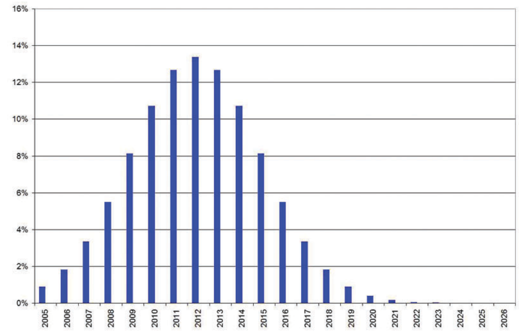


Figure 3
Distribution of failure probabilities, existing pump

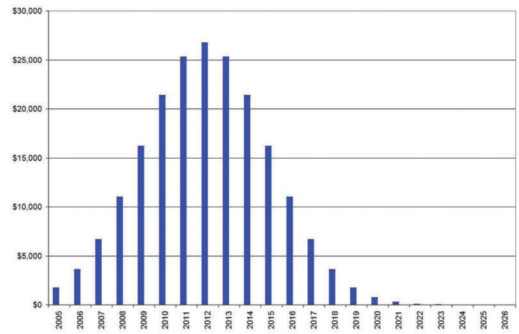


Figure 4
Distribution of risk costs of ownership, existing pump

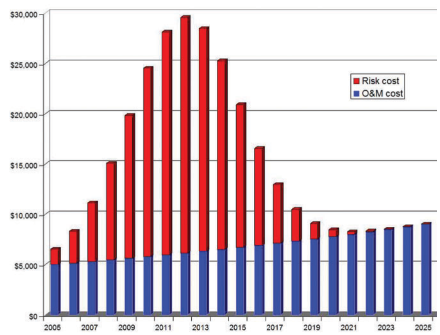


Figure 5
Expected annual total costs of ownership, existing pump, from a 2005 perspective

Case Study 2: Major pump replacement

This case study seems complex, but conceptually is quite simple. For many assets, the risk of failure changes over time. If asset failure cost is distributed according to the same pattern, then classic present value analysis will yield the right result.

Background

The Maintenance Supervisor says: 'I worry a bit about the main feed pump to the final chambers. This is an expensive item and it's getting old. Maintenance is going up – about $5,000 a year now and increasing about five percent a year in real terms, or so the accountants tell me.'

'We can keep fixing the problems, but I'm more concerned with an unexpected catastrophic failure requiring replacement. This would damage some other equipment and really upset the processes, and there would be a lot of overtime crew costs and contractor charges. Overall, the cost of a catastrophic failure would be about $175,000; these are costs we would not incur in a planned replacement.'

'If I were pressed on what year the failure will occur in, my best guess would be about seven years from now, in 2012. But that's pretty rough. I'd feel more comfortable saying that I'm 95% sure that the failure will occur between next year, 2006, and 2018.'

'A replacement will be expensive – about $220,000. I'd expect its life to be about 25 years. It would cut annual maintenance costs in half and they'd go up more slowly, probably about two percent a year.'

This is an interesting case. The 'best guess' failure year is quite a bit in the future, but the cost of failure is quite high. And the failure can occur, in fact, at any time – even today!

Failure probabilities

Let's look first at the failure probabilities. Conceptually, we can consider the probabilities of failure to be distributed in a normal 'bell' curve with a central mean of 2012 and a distribution around this mean.[1] The width of the distribution is defined by the standard deviation. In this case, the Supervisor's '95% sure' means that portion of the bell curve within two standard deviations from the mean.[2]

From the Supervisor's comments, then, we know that the distribution of failure probabilities is based on:

- A bell curve centered on 2012, and
- A standard deviation of three years – since 2006 is six years before 2012 and 2018 is six years past 2012, each interval being equal to two standard deviations.

So the standard normal curve formula gives this distribution of failure probabilities for our existing pump, as shown in Figure 3. The area under the curve is 1.0, since the pump is 100% certain to fail sometime in the future, even where the bars are too short to see. There is a 95% probability of failure, though, between 2006 and 2018 – as the Maintenance Supervisor says.

Cost Category	50-year Present Value	Basis
Initial cost PV	$0	No initial capital cost
O&M cost PV	$242,718	$5000 annual cost increasing at five percent
Risk cost PV	$142,608	$175,000 failure cost, seven years to mean year of failure, three-year standard deviation
Total 50-year PV	$385,326	Sum of above

Figure 6
Present value of future ownership costs, existing pump, from a 2005 perspective

Risk costs

The next step is simply to spread the failure cost, $175,000, by these probabilities, as shown in figure 4.

This gives us the risk costs by year of owning this pump. The total area under the curve is now $175,000. Again, 95% of this cost is incurred between 2006 and 2018.

If we combine the risk costs and expected future O&M costs, we can see the pattern from today's viewpoint of future ownership costs of the existing pump (Figure 5).

Do we replace today?

Now for the beginning of the real analysis. We follow this rule:

'We replace an asset when the present value of its future costs of ownership exceeds the present value of the costs of ownership of a replacement asset, including the replacement cost.'

This may sound familiar, but remember that costs of ownership include risk costs!

Let's look first at the 50-year present value (PV) of costs of the existing pump, from the perspective of 2005. Figure 6 shows those costs, without inflation, using an inflation-free discount rate of three percent.

We can similarly calculate the 50-year PV of costs of the replacement pump, as shown in Figure 7.

So we conclude that it is not yet time to replace the asset, since today's PV of ownership costs of the existing pump is lower than the PV of ownership costs of the asset pump.

When DO we replace?

So far clear enough – we hope! But we need to stop a moment and consider what happens to the distribution of failure costs as we move forward in time. This is important because, in the analysis that follows, we need to think about not just what things look like today, but what they will look like as time passes.

Every year we move forward, and if the asset survives, we are truncating the left edge of the failure probability curve and spreading the entire cost of failure over the remaining set of probabilities, which still sums to 1.0. For example, if the asset survives until 2014, two years past the mean failure year of 2012, the annual risk costs of ownership at that time can be described by the graph shown in Figure 8.

The area under the curve is still $175,000, but now immediate failure is far more likely and things are getting risky indeed. The increased immediacy of risk is reflected in the present value calculations, of course.

So we repeat the same calculations we did above from the standpoint of 2005, except that we move forward to 2006, 2007, 2008, and so forth, each time looking ahead fifty years and recalculating our PVs on that basis. We find that the PV of the replacement asset is unchanged, so we really don't need to recalculate that at all – but that the PV of the existing asset rises as we

Figure 7
Present value of future ownership costs, replacement pump

Cost Category	50-year Present Value	Basis
Initial cost PV	$220,000	Cost of replacement asset
O&M cost PV	$96,507	$2500 annual cost increasing at two percent
Risk cost PV	$86,619	$175,000 failure cost, 25 years to mean year of failure, three-year standard deviation
Total 50-year PV	$403,126	Sum of above

move through time because O&M costs increase and the risk situation grows more serious.

Figure 9, for example, shows the future costs of ownership of the existing pump, assuming it survives, as they would look in 2014.

Obviously quite different from the view of future costs we see in 2005, as shown in figure 6 above!

We are looking for the first year that the 50-year PV of the existing asset, as seen from that year, exceeds the 50-year PV of the replacement asset. We do that by calculating the prospective PV of ownership costs of the existing asset, year by year, and comparing those PVs with the PV of ownership costs of the replacement asset.

The results of that analysis are shown in Figure 10. This is shown graphically in Figure 11.

So for planning purposes, we schedule the pump replacement in 2007, the first year that the PV of ownership costs of the existing pump is expected to exceed the PV of costs of the replacement. This is a full five years before the 'mean failure year', our best estimate of when the pump will catastrophically fail.[3]

We might suspect that the high failure cost of the pump is driving the early replacement year – and we'd be right. If the same pump in another application had a failure cost of $50,000, less than a third of this pump's $175,000, a similar analysis would indicate its replacement in 2018 – six years after the mean failure year.

This case study is an excellent illustration of the concept of 'economic useful life'. We know intuitively that critical assets should be replaced early and non-critical assets replaced later or perhaps not at all prior to failure, but the methodology described here quantifies the factors involved and makes replacement timing much more precise – fully to the economic benefit of our customers.

Summary and Conclusions

The alert reader will have noticed in these case studies concepts familiar from reliability-centred maintenance (RCM): how do assets fail? What are the frequencies of failures? What are the impacts of failures?

As this paper demonstrates, the application of these concepts is not limited to maintenance optimisation but serves capital decisions just as well.

As more water and wastewater utilities develop their asset management programs, they quickly identify risk management as an area with immediate and major benefits. It soon becomes apparent that the expansion of RCM concepts from the maintenance to the capital arena offers immediate savings and improved service delivery, without a corresponding effort – and expense – to develop and maintain new asset data. And, of course, the quality of capital decisions is improved dramatically.

Indeed, there is really no difference between a capital and a maintenance decision. Once risk is seriously considered, both are approached in exactly the same way. ●

Footnotes

[1] *Many asset analysts prefer other types of failure distributions curves, notably Weibull curves. The normal curve is used here for convenience and because it is familiar.*

[2] *In a normal distribution, about two-thirds of the probabilities will lie within one standard deviation from the mean, and 95% will lie within two standard deviations from the mean. Here, we are working backwards from the Supervisor's 95% estimate to find the standard distribution of failure probabilities.*

[3] *Schedule only! We will certainly revisit the situation with the Maintenance Supervisor before actually undertaking the replacement.*

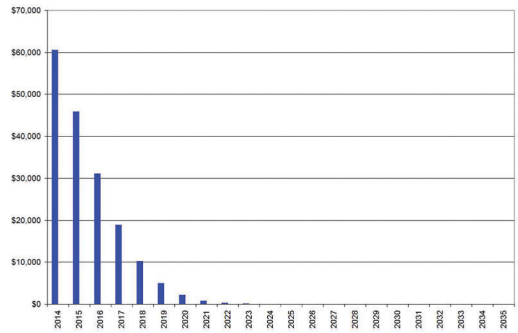


Figure 8
Expected annual risk costs of ownership, existing pump, as it survives and from a 2014 perspective

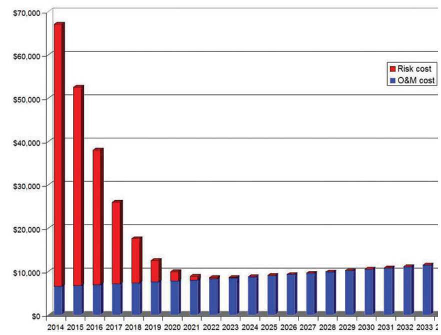
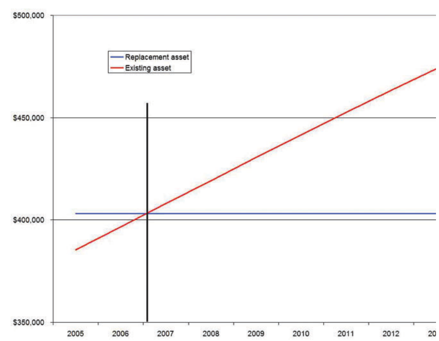


Figure 9
Expected annual total costs of ownership, existing pump, as it survives and from a 2014 perspective

Figure 10
Expected PVs of ownership costs, existing pump versus replacement pump

	Existing Pump	Replacement Pump
2005	385,326	403,126
2006	396,590	403,126
2007	407,943	403,126
2008	419,284	403,126
2009	430.521	403,126
2010	441,600	403,126
2011	452,507	403,126
2012	463,266	403,126
2013	473,926	403,126
2014	484,547	403,126
2015	495,190	403,126

Figure 11
Expected PVs of ownership costs, existing pump versus replacement pump, graphical



America's pathway to sustainable water and wastewater systems

This article is designed to stimulate discussion on strategies concerning America's water assets. The article explores pathways that could serve as catalysts toward sustainable water infrastructure. The presentation reviews the post second world war history of the extension and upgrade of centralised water and wastewater services. It examines a framework for advancing best practices across a broader cross-section of communities and identifies where strategic adjustments are critical to bringing about a new paradigm for services that are sustainable.

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USA

America's water assets are critical to the country's public health and economic, environmental and cultural vitality. The delivery of water and wastewater services is accomplished though infrastructure composed of collection and delivery systems, treatment and distribution facilities, public and private sector resources, and the use of sophisticated science, engineering and technological applications. The infrastructure also includes a complex web of local, state and federal regulatory requirements, and the involvement of human resources on a wide and varied scale.

The management of this infrastructure, in all its complexity, cannot be a hit-or-miss activity. It requires that the latest techniques, the best science, the most appropriate engineering and the most effective human and financial resource management be universally available to systems of all sizes in all communities.

Good ideas and steps toward more efficient and effective management abound, but the changes are piecemeal, unsystematic, and not as widespread as needed. A great many service providers have little or no wherewithal to proceed along a pathway to improved practices and modernisation if left entirely to their own devices.

Author's note: The United States Environmental Protection Agency (USEPA) employs Steve Allbee. The views in this discussion document are solely those of Mr Allbee and he alone is responsible for its content.

A Strategic-level Glance at the Past

In the post second world war era, water and wastewater were part of a family of modern infrastructure investments that governments undertook in order to bring about general improvements in the quality of life. To meet public health concerns in urbanising areas, governments replaced the shallow wells, outhouses and privies with central systems. As the population shift accelerated toward suburbia, water and sewer services followed. The centralised services were extended into far less densely developed areas. Over time, citizens came to view these services as essential and available regardless of where they lived.

A whole series of urban infrastructure investments were interdependent, but not approached strategically in an interlocking manner. The investments in the related infrastructure systems (roads, water, sewers, schools, etc) did not necessarily occur at the same time, but investments in one area virtually preordained that investments in other types of urban infrastructure would come next.

In combination, these urban infrastructure systems had huge economic and growth-enabling consequences. However, the long-term economic impacts on the community and the encumbered revenues required for maintenance, repair, renewal and replacement were not well understood. Typically, no grand scheme drove minimising the long-term public costs of achieving shared public health, environmental and economic outcomes.

In America, since 1970, centralised services were extended to about fifty million more households and plant removal efficiencies were raised, dramatically. The impact has been momentous. The effluent discharges are half of what they were despite waste loads that grew by more than a third, keeping pace with growth in the population and the economy.[1] The increased investment resulted from a combination of requirements and incentives. The incentives were lodged in an extensive set of water and sewer infrastructure subsidies. The notion of the subsidies was to bring more resources to bear from what were perceived as 'deeper pockets' to address the readily apparent problems associated with serious degradation in the condition of our nation's surface waters.

As a result of the milestone 1972 amendments to the Federal Water Pollution Control Act, the United States Environmental Protection Agency (USEPA) came to play an important role as a fiscal partner in wastewater funding. Within a decade, it became apparent that the investment required was far greater than the willingness to commit Federal funds. The Federal government began to consider an exit strategy (a strategic way of ending federal subsidies) in the early 1980s. The idea was that a way out needed to be firmly incorporated before the second wave of investment requirements (renewals) arrived. The State Revolving Fund Program (SRF) was conceived as a strategic shift in the subsidy scheme, but also as an integral part of a phased Federal exit strategy.

The tacit understanding of the Construction Grants Program, the State Revolving Fund Program and a series of programs for economically disadvantaged communities was that they would serve as a catalyst to bring systems into initial compliance. Government officials viewed the framework as transitional. After the initial capital infusion, the reasoning went that these systems would gain a solid financial footing, at which point fees and associated local financial instruments would be sufficient to cover the full cost. However, as is the case with most subsidy schemes, constituencies became vested and, predictably, became advocates for continuing financial assistance arrangements.

Today, America has very high-level service expectations. Water and wastewater is considered so basic to the wellbeing of America's citizens that it has come to be taken for granted. Most, but not all of our population has access to safe drinking water and adequate sanitation facilities. Our nation acted with a sense of commitment to make high quality water and wastewater services available to everyone equally, regardless of geography, income levels or social circumstances. Despite the progress, the needs that demand attention continue to grow unabated.

To protect the gains of the last thirty years, the most significant upcoming challenge is to efficiently and effectively manage an ageing system. Many water and wastewater service providers are tested with renewing the ageing parts of systems, upgrading the system performance to align with higher environmental objectives, expanding the service to accommodate growth, all while sustaining low fees for services. Confronting this puzzle demands proficiency in assessing tradeoffs as disputes arise among environmental, economic and community priorities. From almost any viewpoint, for these systems the period ahead will be more demanding than what America has experienced to date.

Trends in the Sources of Funds

In 1999, the United States Congressional Budget Office (CBO) examined public spending patterns on eight categories of infrastructure. Overall, these trends, underway for decades, documented a paradigm shift in the fiscal structure of paying for infrastructure. The Federal budgetary shifts lowered the amount of Federal funds directed toward these investments. The shift is longstanding, but the consequences of the transition are only now being felt and the fiscal impact has not fully registered.

Water and wastewater systems have their own unique financial history. Between 1956 and 1994, about $1 trillion (valued in 1997 constant dollars) in public funds (capital expenditures and operation and maintenance) was spent on the nation's drinking water and wastewater systems. Even though this was a period of substantial Federal presence, overall more than 90% of the water and wastewater expenditures was derived from local government funds. Since 1970, America's public spending on wastewater systems has tripled and spending on water systems has doubled (valued in constant dollars).[2] Public spending on water and wastewater systems continues to increase and it represents a growing share in the total spending relative to other municipal infrastructure. The growing claim on resources is a manifestation of the extension and significant upgrade of service levels, and was quite predictable, but not fully transparent.

...the most significant challenge is to efficiently and effectively manage an ageing system...

The capital to make these investments is acquired from diverse sources, ranging from the bond market to a multitude of Federal and State assistance programs. By far the largest source for water and wastewater capital is debt financing. Most of the debt financing comes from the municipal bond market, which is underpinned by access to tax-advantaged capital as an incentive to encourage public purpose projects. Capital for wastewater, in particular, has benefited from Federal funds. While there have been changes in the relative amounts derived from the various sources, capital spending (in constant dollars) for water and wastewater systems has remained in the $18-20 billion range since the 1970s.[3] The growing accounts are in operation and maintenance.

The publicly issued State and local debt for drinking water and wastewater projects has remained at approximately the same level since the mid-1980s (on an annual basis in constant dollars).[4] Federal funds for capital investments for water and wastewater systems continue to this day. Although they are not as prominent as before, the amount of Federal funds is more than is frequently cited.[5]

Quantifying the Challenge

To gain a better understanding of the quantitative aspects of the water infrastructure challenge, the U.S. Environmental Protection Agency (EPA) has conducted a study, the Clean Water and Drinking Water Infrastructure Gap Analysis. The definition of the gap is the difference between what we are currently spending and what we expect to need to spend over the next 20 years.

On a national basis, the Gap Analysis estimates a capital gap for clean water of $122 billion ($6 billion per year). For drinking water, we estimate a capital gap of $102 billion ($5 billion per year). The operation and maintenance (O&M) gaps for clean water and drinking water are estimated at $148 billion ($7 billion per year) and $161 billion ($8 billion per year), respectively. In broad terms, the conclusion is that if revenues were increased at a rate of 3% real per year, this gap would not result. A 3% real growth in revenues is 3% over and above the rate of inflation. Revenue growth at this level will result in charges for these services that will, in real terms, approximately double over the next 20 years. This report can be viewed online: **http://www.epa.gov/owm/gapreport.pdf**

The costs for providing higher service levels and achieving environmental objectives will increase. The impact will be primarily felt through rising water and wastewater rates, but the impact on fees can be significantly mitigated by aggressively adopting proven best practices to manage these critical assets. The pathway forward demands innovation and gains in productivity to reduce costs and assure better use of the resources. Some communities will virtually bankrupt themselves by failing to grasp their situation until the problems of ageing become visually self-evident. Unfortunately, it is some of the communities that can least afford inefficiencies, which are most likely to defer making critical choices, thereby potentially missing out on the lowest life-cycle management strategies to solve their problems in the least costly manner.

The strategic long-term issue that has national implications is that all of the recent assessments[6] suggest that few, if any, of the core monetary principles of sustainable environmental infrastructure are being achieved. The current framework appears not to produce the most efficient and effective utilisation of capital and non-capital spending. It also fails to bring forward adequate capital to repair, renew and replace the existing systems and extend and upgrade services. Furthermore, the trends suggest that there is a growing subset of households where the affordability of the service levels may impede achieving broadly endorsed public health, environmental and service objectives.

Moving into Uncharted Territory in Water and Wastewater Infrastructure

Undoubtedly new commitments to upgrade and expand services that are based on earlier approaches can provide short-term, site-specific wins, but will also lead to a never-ending cycle of policies, programs and undertakings to resolve a recurring set of problems that will continue for generations. At the crux of the policy shortcomings are questions of inter-generational equity, effectively managing risk from the standpoint of the cost and benefit of alternative investments and bringing about adequate transparency in the costs and benefits of service level choices. It is America's grandchildren, and perhaps even its great-grandchildren who will bear the bulk of the costs burden of bringing forward the inefficiencies in today's practices. It is also the upcoming generations that carry the risk/consequence onus of increasing incidents of failure in the physical assets or failure in service levels. Those currently in charge have a responsibility to act with precautionary ethics when it comes to questions of adversely impacting the quality of life of future generations, by actions that diminish the capacity of these future generations to meet their water resources needs, or sustain the nation's ecological heritage.

...the environmental impact was not acceptable in the 1970s and it will not be aceptable in 2016...

At a time when our nation is faced with a plethora of current priorities, Americans have not given adequate thought as to how contemporary decisions about water and sewer services and infrastructure will impact the nation's environment, economy, and national competitiveness over the long-term. Some of the future costs of sustaining water and waste-water infrastructure are easy to predict. Economic and population growth will erode prior gains in effluent loading reduction. New investment will be required. If the performance of waste-water plants were to hold at current levels, by 2016 the total BOD (biochemical oxygen demand) loading amounts might reach rates similar to those of the mid-1970s.[7] The environmental impact was not acceptable in the 1970s and it will not be acceptable in 2016. There is little doubt that these investments must be made.

Other economic requirements are more difficult to quantify. For the first time, America will need to face the economic, institutional and managerial issues of finding optimal solutions to repair, renew and replace an ageing system. Approximately 75% of the investments in drinking water and wastewater infrastructure are buried. Much of the current inventory of pipe was laid in the period following the second world war, when suburban areas were rapidly developing. A significant portion of these networks are beginning to reach the end of their useful design life. Quite a few systems have critical parts of their networks in operation that date back to the late 1800s and early 1900s. Although the oldest parts of the system do not account for many miles of pipe, these are sometimes very critical assets within a particular network.

For the most part, these networks must be sustained into the indefinite future, for the services that are delivered by these assets will continue to be needed. As such, the management and organisation challenge is the need for a more rational, efficient and sustainable way to meet service objectives. At the foundation level, the pathway to sustainable systems must be grounded in sound institutional structures, observance of economic principles, and judicious adherence to business-like practices.

Five strategic elements in pursuing sustainable systems

First: asset management - a cornerstone

Asset management is the business linchpin to a culture of sustainability. Best practices in asset management are systematic applications of business-like decision rules and processes under a well thought out and deliberate strategy for achieving outcomes. The most salient and compelling feature of asset management is its easy-to-understand framework to improve service and control costs. Adopting asset management requires learning about and applying the best and most appropriate practices. Achieving excellence in asset management practices will only come about through the hard work and mastery of specific tools and techniques. Awareness of best and appropriate practices is growing fast. However, the transition is still in its early stages considering the wide range of communities involved in delivering services.

Some water and wastewater organisations manage their assets well. These utilities know the condition of their assets and are aware of the long-term fiscal requirements of sustaining their systems. However, it's common for systems to not have an adequate understanding of their assets. Far too many organisations fail to commit the resources that they need to gather the information essential to making critical choices. The data that is available is often incomplete. The quality of the decisions reflects professional judgment and experience, but guesswork and chance too often influence key choices.

The efforts of service providers to improve service and control costs need to become an integral part of every utility's organisational culture. New approaches must become second nature to the thousands upon thousands of people who labour in the trenches of the water and wastewater profession and who make hundreds of decisions within their respective utilities every day. These new approaches must overcome the limitations of organisational silos and the challenges of making high quality information available to the right people within the organisation.

True excellence in asset management will come about through learning how to apply asset management tools. Given the 'bottom-up' nature of the work, the most effective approach to educate practitioners about asset management is to ask innovative practitioners to share their knowledge with others until the leading-edge practices become the norm at all utilities. Bringing about excellence in the execution of particular processes, procedures, techniques and tasks is above all a function of hard work, training, coaching, peer-to-peer exchange, mentoring and benchmarking.

Realistically, asset management will not fully offset the need for additional resource investments. The cost of these services will grow dramatically for the reasons outlined earlier. In some cases, implementing best practice might even increase spending requirements over the short-term, but these new approaches will produce significant cost savings over the long-term and make meeting the infrastructure challenge more manageable. Consider the example of Seattle Public Utilities (SPU) who decided to move forward after researching the success of asset management with many Australian water utilities. SPU managers grew to realise that asset management could increase productivity, control costs, and improve services. To date, the asset management programme has saved SPU about $10M per year in operations and maintenance costs and about $40M in capital costs. The utility now considers its asset management programme a 5-10 year journey.[8]

Second - co-ordinate, collaborate and facilitate the transfer of knowledge

A pressing challenge for America lies in defining the effective avenues for steering, managing and accelerating this transfer of critical information from those on the cutting edge to the broader provider community. On its own, no single government agency, profession organisation, or individual has a complete grasp of the tools, information, skills, and resources necessary to advance a credible and rational plan of action for establishing an asset-centric focus in the water sector. The nature of the challenge demands a commitment toward collaborative strategies and new investments in knowledge transfer. The key features in such an undertaking include:

- A water sector-based asset management steering committee as a forum for negotiating and defining best and appropriate practice. A steering committee framework could be established quickly and offers a first step in effective coordination and collaboration. Assuming the utilities themselves are the principal owners of the process, a successful undertaking fosters consultation and participation by other stakeholder interests, such as consultants, that are involved in the provision of asset management services and Federal and State interest. Models of collaborative steering committees are already operational in for example Australia and New Zealand.
- A focus on getting institutes or training entities to upgrade instruction on asset management practices, processes, tools and techniques. The opportunities to develop and improve asset management skills are enhanced if recognised institutional structures (accredited institutions) provide this knowledge transfer in a quality-controlled learning environment. Degree concentrations and knowledge and skill certification processes could accredit the learning experience.
- The nation would benefit by having a focal point for national leadership. A Centre of Excellence should evolve as an expert entity. The Centre(s) would need unique capabilities to interface with America's highly decentralised water sector. The water and wastewater service providers need to undertake a collaborative dialogue to reach consensus on the vision, mission and goals, capabilities, governance arrangements, financial design and essential characteristics of such a Centre.

Third - utilise systems approaches

There are three major systems approaches that are applicable to the specific roles and responsibilities of service providers and that are being used by many developed countries: Ecologically Sustainable Development, Environmental Management Systems and Asset Management.

- Ecologically Sustainable Development relates to the establishment of measurable environmental, social and economically sustainable business practices. Its underlying ideals are the precautionary principle, concern for intergenerational equity, and conservation of biological diversity, ecological integrity, and improved valuation and pricing of environmental resources.
- Environmental Management System (EMS) is a structured set of policies, procedures and practices that emphasise the importance of continuous improvement process and data integrity. The underlying principles of Environmental Management Systems are the 'plan-do-check-act' approach. ISO 14001 is the most widely used EMS model and is widely respected for its process and for the integrity of its data, which is subjected to third-party audit.
- Asset management is an over-arching business management paradigm and is a core business process that is the focused on least live cycle costs of meeting service level and customer requirements. Decisions are based on risk/consequence tradeoffs and the water and wastewater managers are accountable for asset condition and performance. Management outcomes are audited for results.

Using these well-developed systems approaches integrates the critical aspects of strategically managing services. These frameworks are inherently flexible and locally driven providing an opportunity to tailor the particulars to individual circumstances. It is the way that these systems are used in tandem and how they relate to each other that provides a holistic pathway toward sustainable systems.

Fourth - emulate excellence

The vision of sustainability can be greatly informed by a strategic examination of service providers who are currently focused on this goal. There is an emerging profile of their key institutional skills and growing recognition of the importance of understanding the key characteristics of sustainable providers. When organisations have highly developed skills in these areas, they will attain excellent environment, social and economic outcomes. These are the features:

- Setting objectives for economic, social and environmental measures. The framework used by Sydney Water is one of the more advanced examples of this type of goal setting and reporting. Sydney uses a Toward Sustainability Report to track the changes in the ecological footprint of the organisation across a wide range of public policy measures and objectives. Sustainability reports can drive an organisation to think broadly about its role in the community. The report includes a verification statement from an independent auditor that attests to the use of the data and information represented in the report.
- Right-sizing the organisation to professionally manage its task. When governments seriously consider critical skills capacity it produces changes in the size, organisation and structure of service providers.
- Incorporating stewardship considerations for the total water cycle into management practices. The organisations manage from the point of water source acquisition, through treatment and distribution and collection and cleanup. The integrated providers have a more comprehensive approach to management and a broader vision of the options to meet service objectives. Effective co-ordination across the total water cycle is highly valued in decision processes.
- Focusing on excellence in the mechanics of efficiency, customer service and quality decision-making. These organisations have a business focus, they employ commercial tactics in their work and they are very skilled at customer service. They know what it costs to do business and are expert at valuing and pricing their service. They frequently solve problems through demand management techniques. They are experts at the full range of asset management skills. They do the right work at the right time in the right way. In addition, they have a highly developed sense of using risk assessment tools and techniques to understand options, make key decisions and to set priorities.
- Operating in a robust regulatory framework where regulatory authorities value and reward service providers that have adopted best and appropriate practices. The regulatory structure ensures that environmental objectives are met and that public health and environmental externalities are taken into account in policy decisions, but it brings

greater flexibility and broader sense of purpose in balancing the social, economic and environmental drivers.

- Maximizing the use of voluntary policies, procedures and practices that are externally audited. Sustainable service providers utilise the parts of the standard EMS approaches that work for them and build new components as they see the need. They view external auditors as a critical part of the transparency/accountability equation in building public confidence in their practices and use of data and information.

Fifth - Focus on Priority Areas for Innovation and Reform

First, America should work toward restructuring its institutional arrangements. In many countries, reforms in provider arrangements have been underway for decades. Where reforms have taken hold, the adjustments are framed around competition policies and competitive neutrality between public and private owners, outsourcing models, organisational mergers, new approaches to overseeing and managing price regulation, and the establishment of commercial objectives for service providers.

According to commonly cited data, America has 54,000 community water systems and about 16,000 wastewater systems. Anecdotal information suggests that the number of service providers continues to increase. Our nation's management and delivery of services is one of the more decentralised service arrangements to be found in industrialized countries.

The promise of ushering in a new era of public health and environmental leadership in water services and sustainable infrastructure is highly dependent on the development of more robust and broadly capable service providers. An organisation that is unable to set services levels that successfully protect and promote the public health and ecological sustainability of the natural environment, or is incapable of obtaining the financial resources necessary to sustain the service levels, cannot be successful on a long-term sustainable basis. In this context, to be efficient and effective about doing this highly skilled work, provider organisations must have the wherewithal to become expert at deploying the tools and techniques of risk assessment and asset management, in order to decide upon priorities and select least-lifecycle-cost ways to accomplish tasks. Success is restricted by the inherent limitations in the capacity and capabilities of many service providers to acquire adequate human and organisational resources. Creating the conditions for success, demands major changes in how we have organized to do the work.

Second, affordability is central to a successful policy. Governments have the responsibility to protect public health and the environment and to ensure that their citizens can meet their basic water needs. Most developed countries establish arrangements that assure access to basic services for the lower income segments of its population. Overall, America has some of the lowest fees for water and wastewater services relative to income of any country in the developed world.

User charges have long been considered a best management practice, but, typically our user charges do not reflect the full costs of the long-term provision of the services. The forecast is that user charges will need to double in order to achieve prescribed service levels and maintain an ageing system. Full pricing will not be easy. Even for households where the amount of the fee is a relatively small part of its household income, the acceptance of price increases depends on the rate in which the increases take place and on the ability of the public to appreciate the benefit or value associate with the increase. About 75% of households will be well within the range of traditional affordability measures paying the full costs for water and wastewater services. However, the cost and benefit of services need to be more transparent and processes need to be in place to provide assurance that expenses are i) reasonable, and ii), necessary for the quality of the services. Sustainable practices require that the portion of the population that can afford the full price of services ought to pay the full price for these services.

Our nation has deployed a fairly extensive set of subsidies that provide support to communities as a whole to mitigate the pressures of increasing fees. Traditionally these subsidy arrangements have not been means tested to ensure that the benefits are accrued by the lower-income households. Policies should relate to households, not whole communities. Targeting assistance in the approach to subsidy arrangements is much more in line with how other developed countries assure basic services to lower income groups.

In addition, adjustments are needed in determining the impact of affordability on service levels and schedules for investments. Using the shorthand of medium household income across a community that relies on medium and averaging techniques fails to accurately indicate where policies have serious consequence for particular households. Much better identification of the number and location of affected households is needed, and that could be accomplished by focusing on income quintiles within a particular community. A transparent, clear and accurate disclosure of the specific affordability impacts within a community will result in policies more in line with a comprehensive consideration of the social, economic and environmental consequences of alternative investment strategies.

Doing the right thing involves more than expert asset management. America needs to review and potentially modify how decisions about service levels are made. The nation can progress along the lines of good innovations regarding asset management, but if the methods and approaches for setting service levels are in question, then few positive outcomes will come about. The regulatory community, in general, needs to put more effort into defining which failures have water quality consequences and then focusing their priorities accordingly. There are gaps between designated uses, reporting and permit writing, setting of enforcement priorities and negotiating consent degrees, which leads to prioritizing the wrong work.

Service providers are on a continuum, from those organisations that typically fail to meet expectations and are nonchalant about goals and objectives, to those 'first adopters' that are always on the cutting edge, who value being first in class and are willing and capable of striving for more beneficial outcomes and collaborative relationships. There are opportunities to differentiate between provider organisations and make distinctions in the way regulatory bodies interact with the best, most capable providers. There is little common sense in dealing with the quality provider under the same structure as a recalcitrant, when there are huge differences in the nature, capacity and commitment of these organisations. It is critical to future progress to have more collaborative arrangement with leading edge providers, and there should be real benefits associated with choosing to be a leading edge provider. The system ought to reward 'best in class' with greater flexibility, more deference, and recognition of excellence in the context of a partnership-type relationship.

Conclusions

Investing in a shift toward this new paradigm will provide a real rate of return in the form of long-term economic dividends by broadly bringing about the opportunity for productivity gains throughout a wider cross-section of this highly decentralised sector. The stakes involved in increasing efficiency alone are impressive. Achieving 20% savings by improving capital and operating decisions and assuring lowest life cycle cost choices could realistically reduce future costs by billions of dollars. ●

Footnotes

[1] / *EPA 832-r-00-008, Progress in Water Quality – An evaluation of the National Investment in Municipal Wastewater Treatment, June 2000.*

[2] *Ibid. Author's note: The availability of reported spending data trails current year data by about five years.*

[3] *Author's Note: There are potentially several reasons why the $18-20 billion estimates reflects less than the actual amount of investment.*

[4] *Thompson Security Data, Municipal Water and Sewer Issuance's 1970 – 2000*

[5] *Congressional Budget Office, Congressional Research Service (Order Code RL30478) the $4.3 billion break-down (USDOI – Bureau of Recreation $33 million, USDA- Rural Utilities $631 million, EPA Federally Supported Water Supply and Wastewater Treatment Programs CWSRF l$1,350 million, EPA DWSRF $820 million, HUD CDBG Program, $1,240, EDA $206 million). These figures do not include Congressional Add-on projects, which have been in the range of $300-500 million per year over each of the last ten years.*

[6] *EPA-816-R-02-020, the Clean Water and Drinking Water Infrastructure Gap Analysis, September 2002. Available online at:* **http://www.epa.gov/owm/gapreport.pdf**
The Congressional Budget Office, the Future Investment in Drinking Water and Wastewater Infrastructure, November 2002. Available online: **http://www.cbo.gov/showdoc.cfm?index=3983&sequence=0&from=1**
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[7] / *EPA 832-r-00-008, Progress in Water Quality – An evaluation of the National Investment in Municipal Wastewater Treatment, June 2000.*

[8] *Seattle hops into the future – Seattle uses Australian Expertise to implement its asset management program. Young, Clarke, Allbee, Water Environment and Technology, August 2004.*

Capital maintenance: a good practice guide

Leading Edge Asset Decisions Assessment (LEADA)

This paper discusses the principles of a Leading Edge Asset Decisions Assessment (LEADA) initiative driven by Yorkshire Water. The process was developed in accordance with guidelines set down by industry regulators, with the aim of implementing a consistent methodology for making investment and maintenance decisions that would yield the highest benefits to the Water Service Provider and, therefore, its customers. Put simply, the process involved two main stages necessary to any efficient management practice: 1) identifying and collating the relevant data, and 2) using this data to make consistent, informed and effective decisions. A key part of the process was developing a system of risk assessment that allowed the WSP to describe the risks to an asset, and the cost associated with these risks, as a numerical figure. This process is outlined here and, like the rest of the initiative, is offered as an example of leading edge practice in water industry asset management.

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UK

This document sets out the principles of a Leading Edge Asset Decisions Assessment (LEADA) initiative driven by Yorkshire Water. LEADA was conceptualised during the post-PR99 review[1] of capital maintenance planning triggered by Ofwat's[2] letter MD161, and forms the basis of Part B of the Water Service Provider's approach to the UKWIR Common Framework.[3] Development and ongoing data collection commenced in mid 2001.

It is important to recognise that LEADA has built on the work undertaken by the WSP at the PR99 review in the areas of capital maintenance/serviceability and service enhancement. The concepts underpinning LEADA are well embedded, with the early versions of these systems being initiated in 1996, and used at and after PR99.

For PR99, in the area of capital maintenance a number of risk-based serviceability concepts and tools were developed by the WSP to determine which elements of the treatment and network assets presented greatest risk in terms of potential service loss. The document looks at how the WSP has identified risk on a consistent basis, using a unified risk process that allows the comparison of risk across the entire asset base.

Also for PR99, in the area of sewer flooding the WSP utilised benefit-cost analysis, based upon being able to meet customer aspirations for service improvement within a related Willingness-to-Pay (WTP) for that same service improvement. This was used to justify the 1999 Draft Business Plan (DBP) submission to Ofwat. LEADA has widened and enhanced this benefit-cost approach to cover the majority of services provided by the WSP.

These building blocks form the basis for LEADA and the WSP's decision to follow the benefit-cost route within the UKWIR Common Framework to provide an economic approach to investment planning.

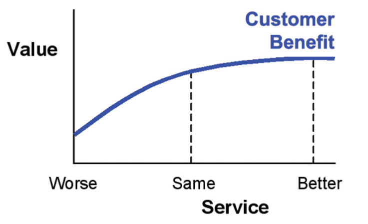


Figure 1
Customer demand for service

Objective

At a technical level the objective has been to develop the benefit-cost methodology outlined in the UKWIR Common Framework across the widest possible range of services and to use this to identify where greatest service value is delivered to customers. The desired outcome from this was to assist the WSP in identifying where and when to invest in the assets in order to maximise the service gain to customers.

A further and significant objective for LEADA has been to create a planning methodology, supported by IT systems, to ensure that the data and processes used for selecting which asset interventions are included within the DBP are those used in determining which receive investment, as part of the live capital programme.

Data Requirements

What Drives the Data

In order to run a benefit-cost approach to capital maintenance and investment planning the WSP considered the problem from an economic perspective, and particularly the economics of supply and demand.

The demand element relates to the customers of the WSP and their priorities and WTP for service quality.

The supply element relates to the ability of the WSP to reliably utilise and improve its assets to meet customer demand for service quality at least cost.

Demand Element Data

To estimate the demand from customers for the services, the WSP needed to identify the services deemed important by customers, and estimates of the annual monetary benefit associated with changes in service quality for each service. Figure 1 demonstrates total annual benefit delivered to customers from alternative levels of service.

The service areas had to be sufficiently broad to cover maintaining current service via capital maintenance, and service enhancement via enhancement programmes.

The resulting service areas used by

the WSP for data collection are indicated in the table on the right.

Water Service	Wastewater Service
Inadequate Mains Pressure	Sewer Flooding of Property
Interruption to Supply	Area Flooding
Security of Supply	Ecological Quality of Rivers
Drinking Water Quality (Biological/Chemical)	Pollution
Drinking Water Quality (Discolouration)	Bathing Water Quality
Leakage	Nuisance (odour and flies)
Pollution	Personal Injury
Personal Injury	

Supply Element Data

To estimate the supply element data, it was necessary to understand the capability of the WSP's assets and operation to deliver the service at acceptable cost. To do this the WSP has identified the risk of not delivering service across the asset base. Risk was expressed as a function of probability (p), severity (s) and quantity (q), defined as follows:

p = probability of at least one service failure occurring

s = severity of the impact on the customer or environment

q = scale of the impact

To determine which risks to address, it was necessary to identify:

- Solutions to risks,
- Estimates of the benefits from undertaking a solution, and
- Assessments of the costs involved in undertaking a solution.

Consequently the information required for a solution is:

p = probability of at least one service failure occurring (post solution)

s = severity of the impact on the customer or environment (post solution)

q = scale of the impact (post solution)

Capex = any necessary capital expenditure

Opex = any operating cost effects

The Opex and Capex have been used in the calculation of an annualised net present cost, for direct comparison with the annual monetary benefit. Consequently there was essential physical asset data required: asset reference, asset type and asset class.

To ensure that the most appropriate balance of Opex, Capex and risk are included in the WSP Cost build up it is necessary to consider, where appropriate, more than one solution to a risk, each one having different cost make-up and different risk improvement.

Determining probability, severity and quantity

The methodology of the WSP recognises that service is placed at risk via assets failing in different ways (failure modes). These can essentially be split in to three categories: operational, asset capability and asset death related.

Where asset death was involved in the consideration of a specific failure mode, for the purposes of asset planning over five, ten and fifteen years additional data was required to facilitate the estimation of probability. In this instance a series of probability distributions based around Weibull were created to cover many of the asset groups operated by the WSP.

The data collected to drive the Weibull distribution was:

- Commissioning data or age
- Condition grade
- Asset loading (working effort)
- Duty arrangement
- Standby backup

This data then allowed the WSP to use generic asset group distributions and make them asset specific by reflecting the physical attributes of a given individual asset and its working environment.

In terms of determining the collection of severity data, the WSP has created a series of standard definitions used in the assessment of risk impact. This also defines the measurement of quantity placed on each risk (See Figure 4).

The important element to these scales is that the definitions of impact severity are aligned with the service areas included in the demand side data, so that identified risks can be mapped and compared directly with customer benefit.

These scales are used in the assessment of risk at defined studies or during dedicated data collection exercises, and are coded in to the WSP's software associated with the prediction of asset death.

Figure 2 Comparing customer demand with WSP cost

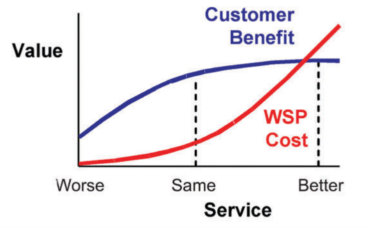
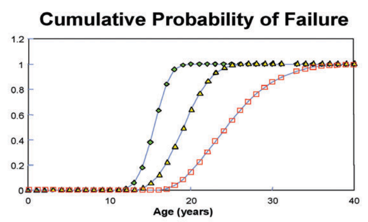


Figure 3 Weibull distribution for probability



Data for network assets

Where network assets were involved then the prediction of risk was less obvious due to the 'hidden' nature of the asset and the transferable nature of the consequence in relation to the cause asset.

In this case the data collected involved the analysis of Geographical Information System (GIS) and other spatially related data to inform the probability and consequence of failure. Before this could occur, the WSP reviewed its 'failure mode trees' created in the run up to PR99 to account for

Figure 4 Example of risk impact table for wastewater (severity and quantity)

A QUALITATIVE IMPACT SCALE FOR WWBU — 30-Apr-02

	VL	VL	M	H	VH	QUANTITY
Internal Flooding	Damp patch - unused cellar	Damp patch - used cellar	Foul water in cellar	Dampness in living accomodation	Foul water in living accomodation	No. of properties
Area Flooding	Damp patch - seepage	Sewage escape	Localised flooding sensitive customers	Significant area &/or volume - Access/Traffic disruption	Severe & significant depth. Major road disruption/closure	X 1
Pollution (including bathing beach litter)		Cat 4 A reported polluting discharge but not severe enough to damage the environment	Cat 3 Noticeable but minor impact on habitats & amenity value (no fish kills)	Cat 2 Significant but localised effect on habitats (eg, a few fish kill &/or minor health risk)	Cat 1 or other EA enforcement Major impact with habitat devastation (many fish kills &/or serious health risks)	No. of incidents
Flow Compliance					Consent Failure	Population Equivalent
Final Effluent Compliance				Sample Failure(s) but not failing	Consent Failure	Population Equivalent
Bathing Water Compliance				Individual failure(s) but not beach failure	Mandatory or guideline failure	TBD
Nuisance Odour/Fumes/ Flies/Noise		Customers Aware	Local action or pressure group	Env. Health active involvement	Statutory Nuisance Order	No. of properties affected
Sludge Quality/Compliance			Loss of normal disposal route - alternative or similar process	Loss of normal disposal route - alternative incinerator	Loss of normal disposal route - alternative landfill	Quantity in P.E.
Personal Injury	Incident but no injury	Injury with no time off work	Non-reportable accident (<3 days off work)	Reportable accident (>3 days off work)	Fatality or permanent disability resulting in permanent inability to work	X 1

new and better data sources for the assessment of risk.

For each catchment the tree detailed below (Figure 5) is populated as fully as possible at the bottom level, to inform the assessment of risk at the upper level. As in all other cases the risk is presented in the form of probability, severity and quantity.

Methodology

The LEADA Approach to Capital Maintenance and Investment Planning

Figure 6 illustrates the LEADA planning process and its key components. It is broken down into the key stages the WSP considers necessary for efficient asset management and investment planning.

Stage 1 – Identify Risks to Service

The WSP assessed the risks of non-delivery of service via the collection and analysis of asset related data on its above and below ground assets. This has been referenced back to asset inventories to allow for detailed programming as part of its capital programme following the Final Determination. The data collected allows the WSP to identify the probability of asset failure at given points in time using the mathematical distributions referred to earlier, hence allowing it to identify current and future risks to service delivery. The use of these distributions to determine deterioration of asset performance is a key assumption in the WSP's methodology, and it is critically important that the output is validated and/or calibrated with historical observations where possible.

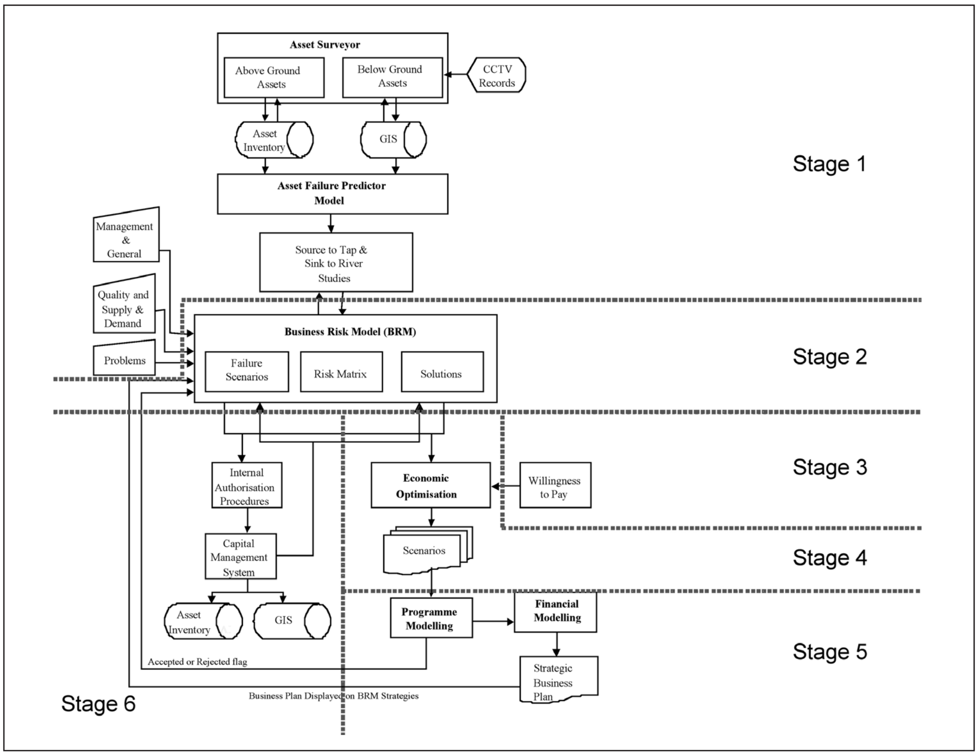


Figure 6
LEADA systems for asset management and investment planning

Also critical at this stage is data quality and quantity. In terms of data quality, the WSP ensures consistency by the use of 'technical approach' manuals. These set out the detailed requirements of the data, formats for collection, and definitions. The process has been managed and audited by centrally based teams to ensure consistency and completeness. In terms of quantity of data, the appropriate degree of resolution is of significance and much consideration has been placed on what asset level gives sufficient resolution for consistency with project delivery at the

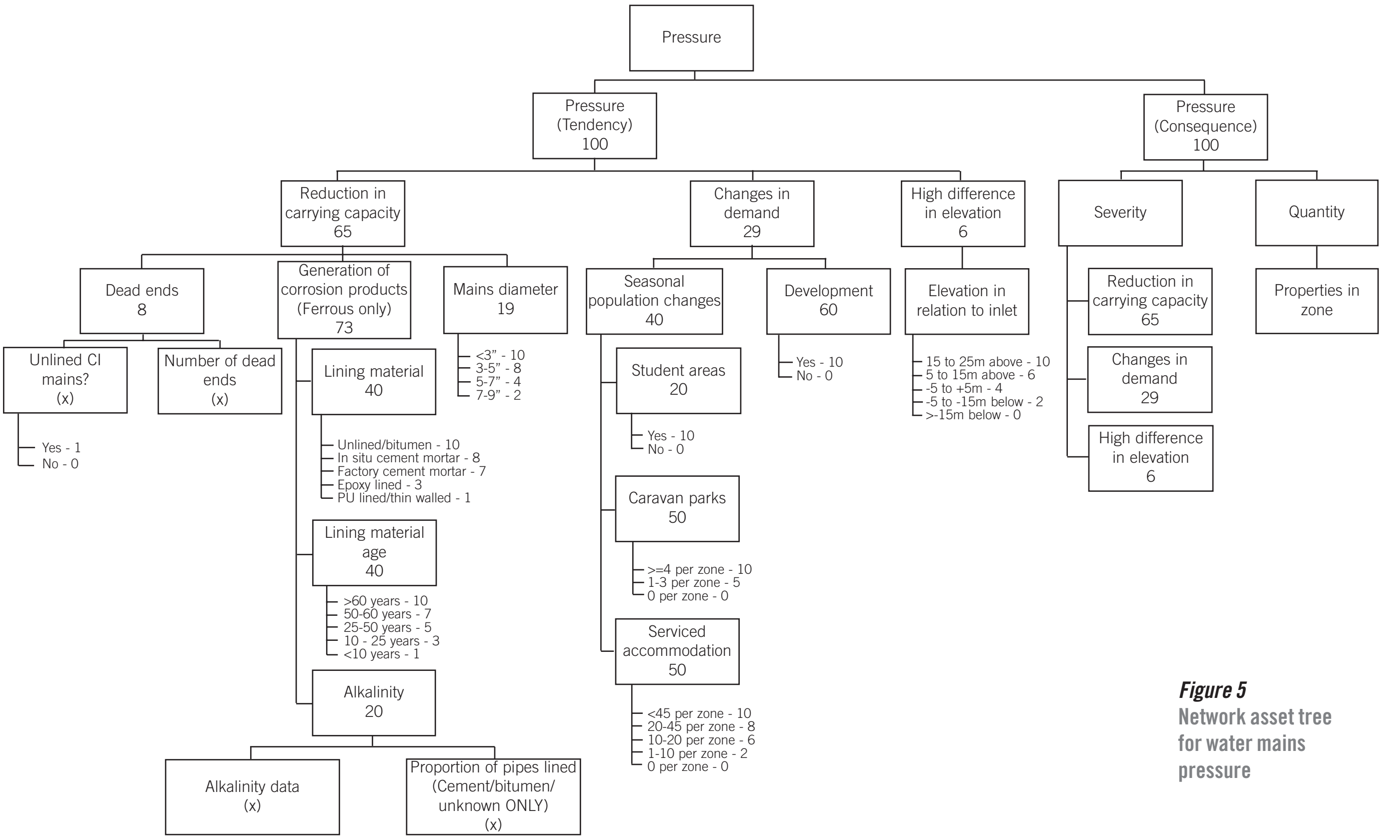


Figure 5
Network asset tree for water mains pressure

same time as not overloading the asset management processes.

In this case the WSP has selected element component level as the general level, but in some cases goes lower in to the asset hierarchy to assembly level where there are assets of a significantly different type or age performing one joint task. This is of particular significance to wastewater treatment works where similar assets of a similar type (e.g. filters) have been built at different periods in time, as demand on the works has grown.

An example of a process element is shown in Figure 7.

For the purposes of asset death related risk the WSP has completed site surveys to collect data, and has developed software to ensure consistency of collection. This is vital for the data to be used in failure mode and consequence modelling. Figure 8 is an example of the collected data as stored within the WSP's IT application, referred to as its Asset Surveyor.

The assets have been classified in terms of their failure modes and how they would contribute to an impact on service provision. This work was undertaken utilising the expert opinion of the asset management and operation teams, who deal with these assets on a day-to-day basis.

The data from the survey was then passed into a risk model, identified as Asset Failure Predictor in Figure 6, where probability is calculated utilising the Weibull distribution and this is then combined with failure mode definitions to identify risks of service failure at the current data and for 20 years into the future. The risks are expressed in terms of the probability, severity and quantity parameters identified earlier.

Operational Risks

For risks that occur for reasons other than asset death, but lead to service failures against current objectives, due to issues such as reliability, or catchment deterioration, then the WSP captured these risks via Source to Tap and Sink to River studies. These were facilitated events where catchments were studied in detail by operational and asset management teams, covering above and below ground assets. The teams reviewed historical data and knowledge to identify and challenge risks and to propose outline solutions to risks.

In dealing with these types of risks, it was necessary to distinguish between those that are occurring already and those that are forecast to occur for the first time at some point in the future, as the correct treatment of this information is critical for the correct estimation of probability. To deal with this the WSP devised a methodology for assisting the study teams in capturing the relevant information to allow the derivation of probability.

Site	Installation	Process Group	Process	Element	Element Component	Assembly
Esholt	WWTW	Primary Treatment	Radial Sediment-ation	Building	Component 1	Tank 1
				Civil Structure	Component 2	
					Component 3	
				M & E	Component 4	
					Component 5	
				Media	Component 6	
						Tank 2

Figure 7 **Illustration of data resolution used for identifying risk**

Further quality assurance and consistency work has been undertaken by the WSP by holding a series of Regional Challenges, where company experts have reviewed the assessment of risks and solutions to ensure that processes and procedures have been followed in line with technical approach guidance issued to the asset management teams. Stage 2 outlines how the WSP has used IT to assist with consistency.

This same methodology was equally applicable to asset capability risks where a new obligation would render an asset or group of assets incapable of meeting the future need. It was important to capture this information if the objective of undertaking the benefit-cost analysis was to be fulfilled and the assessment of where to enhance service levels made.

Stage 2
Consistent Risks and Solutions

All risks, regardless of their origin, have been stored within a system referred to as the Business Risk Model (BRM). The BRM formalises the Company risk methodology and ensures that all risks are scored and stored in a consistent manner. It is also used to capture relevant 'output' and 'activity' information needed for effective asset management and completing the relevant DBP tables (See Figure 10).

The BRM system allows the WSP to cost solutions using unit cost models contained within its unit cost database. Again this is about achieving consistency. The process allows for alternative solutions to the same risk, each requiring different levels of Capex, and/or Opex, with each having potentially different levels of risk improvement to be captured and hence made available for the economic modelling (benefit-cost) assessment, in stage 4. The costs used in the economic optimisation are the Capex and Opex expressed as an annualised NPC to make them directly comparable with data from Willingness -to-Pay described in stage 3.

Stage 3: Market Research - Willingness-to-Pay

As a result of the WSP adopting the cost-benefit assessment approach of the Common Framework across a wide range of services, it was essential to generate estimates of customer benefit for as many services as possible. These were listed earlier. This was achieved by following a three-step process:

- A qualitative phase to determine general priorities
- A quantitative phase to capture Willingness-to-Pay (WTP) information
- Benefit estimation associated with service change

The qualitative phase consisted of eight focus groups and a number of business depth interviews to discuss service issues generally before focusing on the water and waste water services experienced. The areas covered during this phase were:

- The definition of what good service was and the perception of an ideal service provider
- The WSP's Service performance
- Clean Water and Waste Water areas for improvement and investment (spontaneous views, no prompting),
- Clean water and Wastewater areas for improvement and investment in the light of prompting re:
  - actual and alternative targets for service
  - alternative measures and attributes
- Ranking or prioritisation of service areas in terms of importance to the customer.

The quantitative phase was a much larger exercise, where stated preference Choice Experiments were undertaken

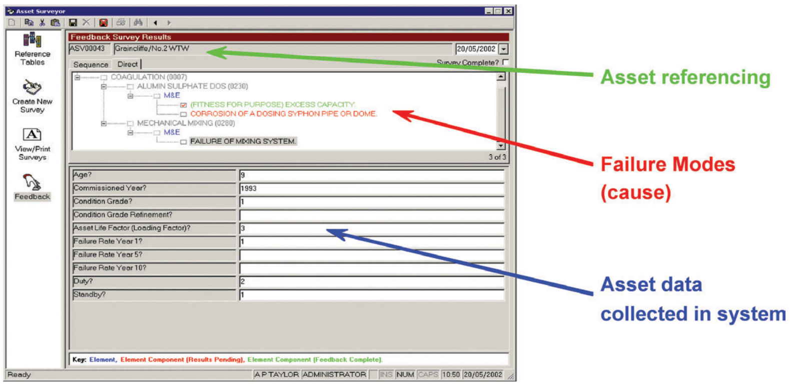


Figure 8
Tool for the collection of data for calculating probability

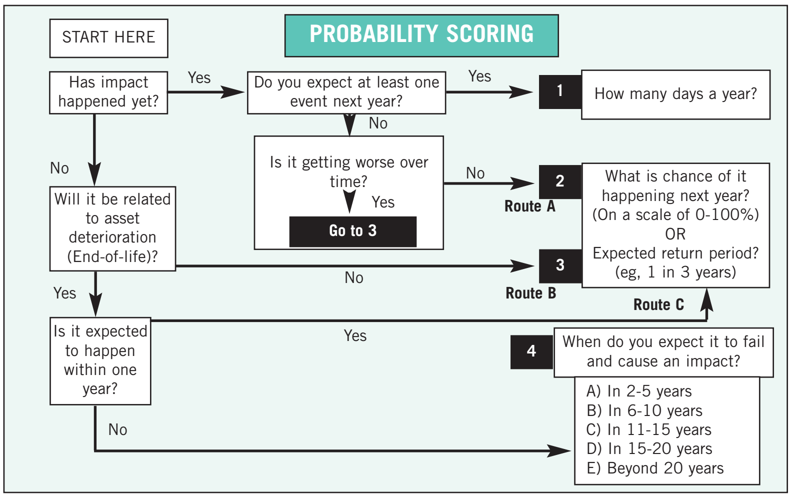


Figure 9
Decision tree guidance for the calculation of probability

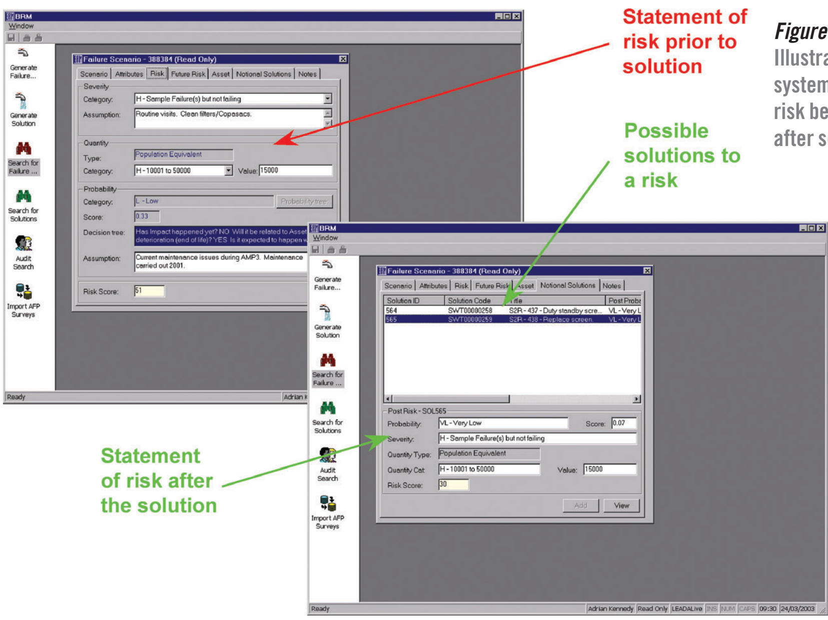


Figure 10
Illustration of system for scoring risk before and after solution

	Now	B	C
Supply Security	1 year in 500	1 year in 250	1 year in 750
Flooding	150	150	500
Discolouration	5,000	3000	2,000
Water Bill	£x	£y	£z

Figure 11
Pictorial representation of choice experiment

to generate Willingness-to-Pay for the priority services identified during the qualitative exercise. To undertake this in a robust manner, 1,500 face to face interviews were completed, covering representative samples of domestic and business customers. Each customer was offered a series of service packages, each with combinations of decreasing, improving or stable service levels. These service packages were traded-off against potential impact upon the individual customer's bill. In the example shown here the customer would be trading-off changes from the current situation (now) with two alternative service packages (B and C), both including a mixture of improving, and deteriorating service together with changes in bill levels. In this way it has been possible to elicit service valuation and how this value changed with service level change.

The key output from this stage was the ability to place a monetary benefit on the service provided by the WSP, and indeed every solution the WSP could consider.

The WSP followed the draft version of the DEFRA (the Department for Environment, Food and Rural Affairs) stated preference non-market valuation guidelines [Bateman et al (2002) Economic Valuation with Stated Preference Techniques, A Manual, published by Edward Elgar, in association with DTLR (the Department for Trade, Local Government and the Regions) and DEFRA].

The WTP functions provide monetary values of the changes in the quantity of service provided. Changes in the severity and probability of service impacts are incorporated into WTP by weighting the WTP for quantity service changes.

The benefits of a programme of investment to the average residential customer are described by the equation overleaf, taking the example of a quadratic benefit function. Clearly a similar function is required for business customers and the two aggregated to estimate the total benefit across the WSPs region from a programme of investment.

The ß and y coefficients were derived from estimated utility through the WTP study. The first a term is the current bill and the second is a service area specific constant. The change in the weight term (Δw) relates to the change in severity and probability.

The weights were required, as all solutions that could potentially enter the programme are quantified during the risk process by their pre solution risk (ie, probability, severity and quantity) and their post solution risk. Severity is classified into one of five

$$WTP_{RES} = \alpha_{RES} + \sum_{j=1}^{N}\left(\alpha_j^{RES} + \beta_j^{RES}\left[\sum_{i=1}^{M}\Delta w_{ij}Q_{ij}\right] - \gamma_j^{RES}\left[\sum_{i=1}^{M}Q_{ij}\right]\left[\sum_{i=1}^{M}\Delta w_{ij}Q_{ij}\right]\right)$$

Where: j = service areas, i = solutions, w = weight composed of change in severity and probability arising from solution, Q = quantity of service

Figure 12
Form of benefit equation for residential customers derived from Willingness-to-Pay

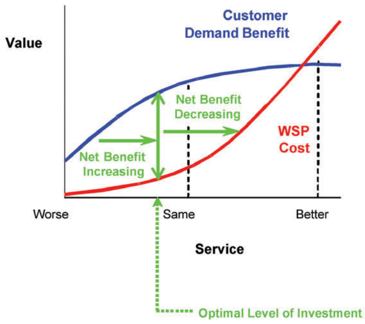


Figure 13
Illustration of how the benefit-cost assessment is carried out in ELSA

classes from Very Low to Very High. The weight is calculated as the pre solution severity weight multiplied by the pre solution probability minus the post solution severity weight multiplied by the post solution probability.

Stage 4 – Economic Optimisation
At this point in the process the WSP has identified individual asset and company level risk and expressed these in terms of service risk. The WSP has also generated one or more possible solutions to the risk (each of which has a specific improvement in risk following implementation) together with an associated cost. The WSP has also estimated the monetary valuation of service benefit from the market research WTP.

At this point the two sets of data are brought together and put through an economic optimisation engine, developed by the WSP. This is identified as the Economic Level of Service Assessment (ELSA) optimisation tool. Within the optimisation engine is the WTP benefit equation, which is used to assess risks in terms of their contribution to improvement in risk and allocate a monetary benefit to each solution. Given the non-linear nature of the benefit function the optimisation routine looks at benefit at a programme level. This is achieved by accounting for when individual solutions enter the programme, where on the benefit curve they are, hence what scale of benefit the solution should attract, and ultimately determine whether solutions are cost-beneficial, ie, are they making a positive contribution to the net benefit to customers? This is illustrated in Figure 13.

Clearly the process illustrated in Figure 13 would identify an economic level of service based on the information gathered on risk, cost and benefit. However, to meet the needs of MD161 and testing the balance of service, risk, cost and economics then the WSP has built the ELSA optimisation system with the facility to constrain the model in different ways to build programme scenarios. The model can be used to apply:

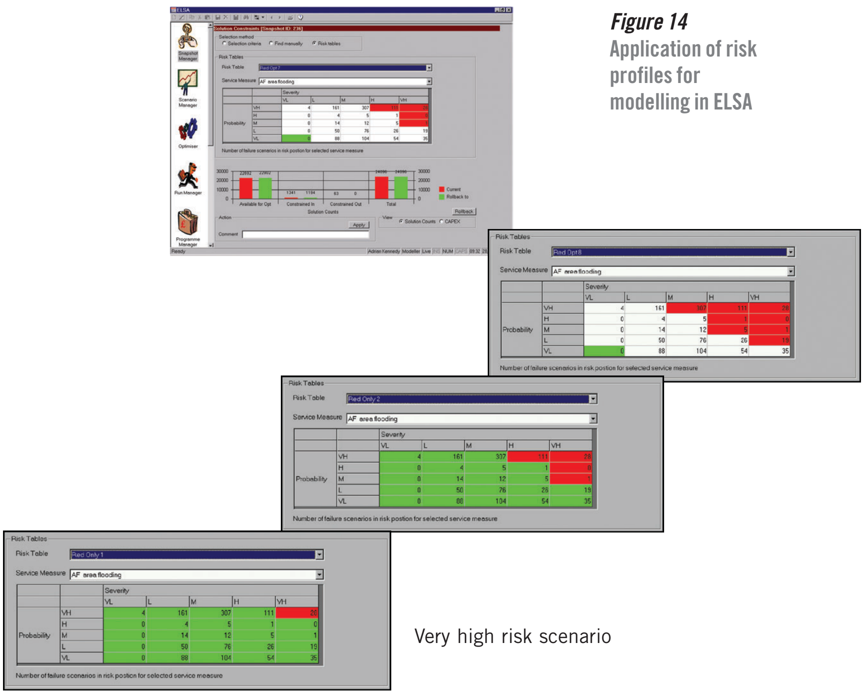
- Risk profile constraints to the risk data,
- Efficiency assumptions to Capex and Opex,
- Maximum and minimum service objectives,
- Maximum and minimum Capex and Opex objectives,
  - At a programme level
  - At a functional unit level
  - At an investment category level

Some examples of how this is achieved are illustrated in Figure 14. In the examples illustrated here, the risks contained in the red areas of the risk matrix would be constrained into a programme. Those in the green area would not be considered for inclusion in the programme. Any in the white would be subjected to the economic optimisation (benefit-cost assessment). Testing these risk levels allows the WSP to understand the service and cost implications of operating at different levels of risk.

The objective of being able to undertake these constraining actions within the context of the economic optimisation is that ELSA enables the WSP to answer different questions and develop different scenarios, balancing for example, capital maintenance with quality enhancement programmes. Examples of the scenarios the system is designed to model are to:

- Identify the economic level of service, given no cash or service constraints,
- Identify the required level of risk the WSP would have to accept, to achieve given service levels within a given budget,
- Identify the economic service levels possible for different levels of efficiency,
- Identify the impact of increased quality obligations on capital maintenance for an assumed affordability.

The output from the process is a view of service levels, expenditure requirements and risk profiles. For presenting risk the WSP has adopted a matrix approach, as illustrated on the ELSA system screens, to help understand the risk benefits being delivered. Examples of how risk might change



Very high risk scenario

Figure 14
Application of risk profiles for modelling in ELSA

following a programme of investment are illustrated in Figure 16.

The figures in the matrix cells relate to the number of risks identified across the asset base of the company, which have been considered as part of a specific scenario. In the case of the post investment matrix the small numbers in the top right hand corner of the cell represent the net change following investment.

Stage 5 – Financial Implications

The final stage of the process is to assess the impact of the investment programme on customer bills and company financing implications. To do this the WSP takes a programme output and passes it through a scheduling tool to apply spend profiles to each solution with the objective of fitting all the programmed solutions within a target spend profile (See Figure 17).

Following this the profiled Capex and Opex is modelled through the WSP's financial modelling package to determine the price and financing implications of running with a given programme.

Stage 6 – Investment Authorisation

The final stage of the LEADA process is an ongoing review of existing business processes associated with the WSP's Investment Authorisation Procedures (IAPs). These IAPs are part of the WSP's internal project investment authorisation processes. The WSP recognises the importance of integrating the LEADA processes and systems with its existing ways of working to ensure that the implementation of the common framework continues to deliver benefit to the business throughout the delivery of the resulting capital programme. ●

Figure 15
Application of service and budget objectives in optimisation

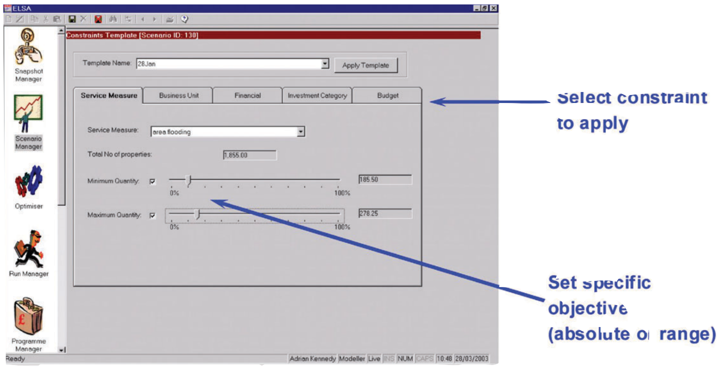


Figure 16
Risk movement from programme over five years, including deterioration

ELSA Programme ID 150 - All Investment Areas

Risk position 2010 pre investment

PROBABILITY		SEVERITY VL	L	M	H	VH
	VH	199	549	1072	645	772
	H	358	1293	1446	556	290
	M	242	1497	882	670	396
	L	212	1241	1073	614	592
	VL	1595	1803	1818	1373	3067

(red)	Total red risk	2103
(amber)	Total amber risk	9448
(green)	Total green risk	12704
		24255

ELSA Programme ID 150 - All Investment Areas

Risk position 2010 post investment

PROBABILITY		SEVERITY VL	L	M	H	VH
	VH	1128 1327	4059 4608	2264 3336	-210 435	-234 538
	H	-86 272	-687 606	-1160 286	-45 511	42 332
	M	155 397	-1172 325	-707 175	5 675	16 412
	L	-109 103	-980 261	-711 362	-292 322	-413 179
	VL	-980 615	-1067 736	341 2159	443 1816	400 3467

(red)	Total red risk	1717
(amber)	Total amber risk	13559
(green)	Total green risk	8979
		24255

Footnotes

[1] The PR99 review is the 1999 Periodic Review, a 5-yearly UK pricing/investment review.

[2] Ofwat is the Office of Water Services, the economic regulator for the water and sewerage industry in England and Wales.

[3] UKWIR is UK Water Industry Research Ltd. The UKWIR Common Framework sets out guidelines aimed at standardising asset management practice in the UK water industry, specifically in companies' analysis of the probability and consequences of asset failure.

Acknowledgements

The WSP would like to acknowledge the input made by the following consultants:

Accent: Market Research
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DStar: Statistics and Risk
Hartley McMaster Limited: Operations Research and Systems
ICS Consulting: Business User Requirements Specification
NERA: Economic Support and Audit
Tynemarch Systems Engineering Limited: Risk Analysis and Systems Specification

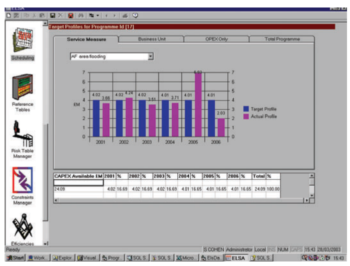


Figure 17
Output from scheduling to illustrate year on year breakdown for five year programme

Benchmarking asset management

The capital-intensive nature of the water industry demands that utilities should be good asset managers. An ability to demonstrate this has often been required by economic regulators. These regulators have sometimes imported expertise from overseas where drivers for capital expenditure often differ to those domestically. However, results are often non-transparent and provide little or no direction to the utility or the regulator as to how improvement can be achieved.

In response to this, the major urban water industry developed a framework that would facilitate transparent assessment of asset management practices and support communication of results to stakeholders. This paper describes the principles and objectives of the framework, and its implementation in a multi-national urban water industry project involving 23 participant utilities.

Andrew Foley
Water Services
Association of Australia
Australia

The Water Services Association of Australia (WSAA) is the peak body for the Australian major urban water industry. WSAA's members provide water and wastewater services to approximately 15 million people in Australia and New Zealand. The combined annual turnover is greater than A$4.7 billion[1] with assets of over A$47 billion[1] (written down replacement cost).

The capital-intensive nature of the industry demands that utilities should be good asset managers. An ability to demonstrate this has often been required by economic regulators. These regulators have sometimes imported expertise from overseas where drivers for capital expenditure often differ to those domestically. Additionally, results are often non-transparent and provide little or no direction to the utility or the regulator as to how improvement can be achieved.

Responding to this, the major urban water industry developed a framework that would facilitate transparent assessment of asset management practices and support communication of results to stakeholders.

Why benchmark asset management?

Recent process benchmarking exercises undertaken by WSAA members identified that best practice water utilities had implemented sound asset management practices. It should be noted that the converse was not necessarily true. Thus, a WSAA members' taskforce identified the need for a framework that facilitated assessment and comparison of asset management practices.

A working group was established to develop a framework that would support benchmarking and could be added to the list of tools to engage continuing regulatory and business improvement processes.

The framework now provides the user with a roadmap as to how performance can be improved, by providing direct inter-business comparison with appropriate industry peers. It must be emphasised, however, that the framework does not indicate whether improvement in any particular area is warranted.

The WSAA Asset Management Framework

Asset management was defined within the framework as optimising the whole of life cycle cost of the assets for a given set of service standards. Using this definition, the essential functions that make up the job of asset management were identified.

These functions were then systematically disaggregated into a hierarchy of parts which could then be assessed, scored and aggregated to give an overall score for the function. An asset management profile can then be established for the utility.

Structure

Seven key functional areas were identified as delivering the 'job' of asset management. Six of these functions are those a business would undertake in

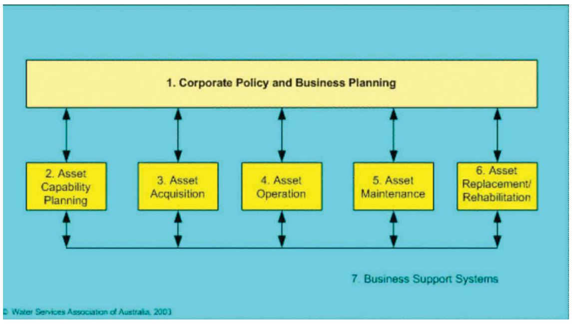


Figure 1
Framework structure and relationship between functions

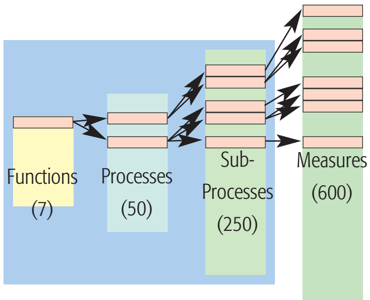


Figure 2
Hierarchy of processes and measures

achieving asset management outcomes. These functions are implicitly linked and rely on establishing strong communication across their boundaries to deliver effective outcomes.

The seventh function covers information systems which provide key data and information to support the other six asset management functions.

The framework structure and the relationships between the functions are demonstrated in Figure 1.

The disaggregation of the seven functions creates a hierarchy of

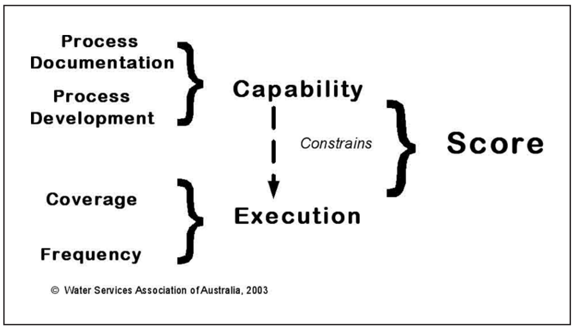


Figure 3
Diagram of the scoring framework

processes, sub-processes and measures. Ultimately, all assessment is done at the measures level; however, due to their discrete nature no comparison across organisations is meaningful below the process level.

Each of the hierarchical levels is defined below. A diagrammatical representation of this hierarchy is provided in Figure 2.

Assessment

Assessment is undertaken at measure level in the framework. The assessor is required to consider four elements in establishing the score. These are:

- Process Development
- Process Documentation
- Coverage
- Frequency.

The elements combine to give a multiplier from zero to one, which is then applied to a weighting on each measure. The measures are then aggregated to provide total scores at function and process level. Figure 3 provides a diagrammatical representation of the scoring framework.

Peer Review

WSAA appointed an independent consultant to undertake a peer review of the asset management framework. The role of the peer review was to assess the fitness for purpose of the framework defined as:

- Enabling agencies to benchmark Asset Management functions with other agencies with confidence and on a consistent basis.
- Enabling an agency to demonstrate to stakeholders its relative position in establishing and implementing good asset management functions and practices and in reporting improvements over time.
- Enabling agencies to identify the need for and promote improvements to asset management processes.

The approach of the peer review was to review and test the framework against its purpose under five key areas: the structure, scoring system, implementation, results and development. The consultant attended a two-day review of the framework with the WSAA working group, reviewed a sample of results from utility self-assessments and observed a sample of the audits.

The peer review concluded that the 'framework is robust, comprehensive and fit for purpose', subject to a few minor recommendations. It also noted that the 'findings and recommend-ations…reflect the need for completeness, consistency, linkage and balance rather than any fundamental change to the framework.'

WSAA has established a new working group to address and, where appropriate implement, the peer review recommendations. The working group will be ensuring that any changes that arise recognise the importance of maintaining an effective time series of data.

Implementation

The asset management framework was implemented as part of a major urban water industry subscription project. A total of 23 utilities participated in the project: 19 Australian, 2 New Zealand and 2 USA. An additional three Australian water companies have sought and obtained access to the framework. The implementation was undertaken in five key stages outlined below.

Initial Workshop

A full day workshop was held at the start the project. The aims of the workshop were to:

- Communicate the detail and use of the online framework
- Outline the audit verification process
- Agree on key dates, milestones and deliverables.

Self-assessment

Each participating utility undertook a self-assessment of its asset management practices using the framework. The self-assessment took from four to twelve weeks to complete depending on the size of the organisation and the availability of key resources.

Generally, the self-assessment was undertaken as part of a series of workshops in which key utility and external service provider staff related to the process or function being assessed was involved. This process ensured that a vertical slice, or cross-section, of the organisation's personnel was represented during the assessment and promoted organisational ownership of the results at all levels. The auditors noted that this approach generally provided the most representative result for the organisation and few assessments required changing.

An alternate approach adopted was for a handful of staff (or just one) to complete the full assessment on behalf of the organisation. Whilst this was more easily managed, the auditors noted that this approach did not have stakeholder ownership and often required material changes to the self-assessment.

Audit

The auditing of the self-assessment was undertaken by WSAA accredited auditors. The accreditation was completed over two days and provided the auditor with a detailed working knowledge of the framework's measures and scoring.

The role of the audit was to validate independently the self-assessment. The auditor sought to ensure consistency of understanding of the measures and scoring to ensure the assessment accurately reflected the utility's score in asset management. The audit was premised on a sample of approximately 25% of the measures, contributing to around 45% of the score.

Report

The results of the utility's assessment were examined by the auditor and opportunities to improve across processes and sub-processes were identified. The auditor was able to use any learning from the audit process plus additional information sought via questionnaire to contextualise any recommendations.

The large participation rate of utilities also enabled the participants to benchmark not only across the full data set, but also across a range of equivalent peers based on either scope (eg, wholesale only) or scale (eg, regional authority).

Whilst participants received individual reports targeted at improvements in their respective businesses, they also received an industry report. This report drew together the key observations from the project in the area of asset management for the major urban water industry.

Best Practice Workshop

The best practice workshop sought to provide the opportunity for those organisations identified as being best observed practice in key asset management areas to present on how this has been achieved by them. The workshop is considered one of the most valuable outcomes of the project as it allows participants seeking to improve asset management practices to hear first hand from the leaders in each of the key asset management areas. Where gaps were identified in the industry, the auditors provided direction on other possible organisations or industries that could be invited to the workshop to

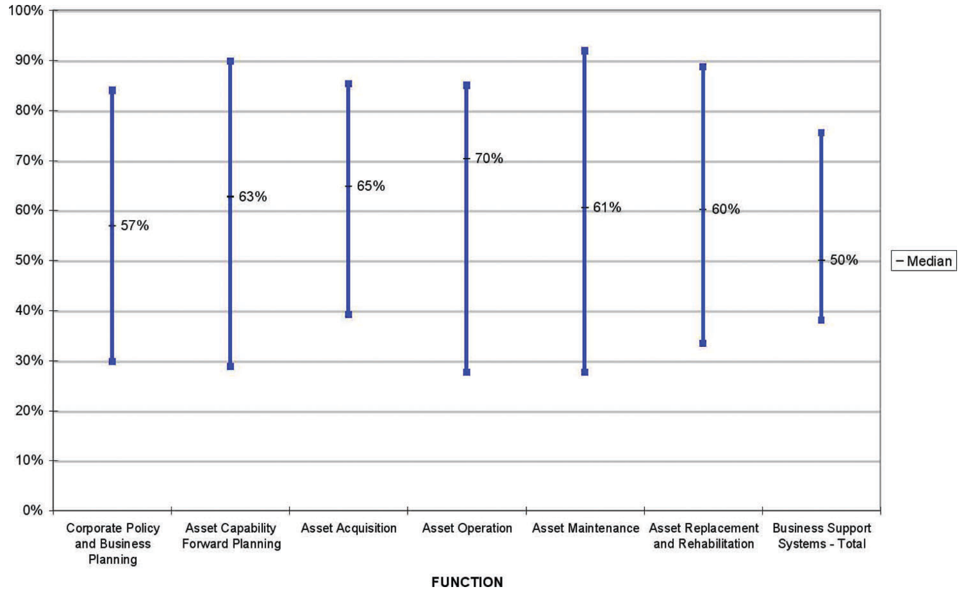


Figure 4
Overall industry metric results for the framework

provide a non-water industry perspective on achieving best practice.

Key Industry Outcomes from the Project

The overall industry metric results at function level for the asset management framework are shown in Figure 4. It is of interest to note the range of results in the asset operations and asset maintenance functions. These functions are traditional core engineering activities of a water utility. It was anticipated the output for both would reflect a concentration of results around a relatively high value median with limited spread. Asset operations have some bunching near the median, however there remain a few outliers at the lower end. Asset maintenance, however, has a much wider spread and highlights the opportunity the major water industry still has to improve in this function.

Key Observations

The metric results from the project identified that those participants that performed well in one function were consistently at the upper end for all other functions. These utilities tended to be large metropolitan businesses operating in a strong regulated environment and a large, concentrated customer base. These utilities also tended to have a stronger commercial focus and were often driven by an ageing asset base. The best performing businesses were also able to more easily demonstrate effective use of business support systems.

Utilities that performed toward the lower end tended to have younger infrastructure compared to the best performers. They were also often local government-owned, which constrained performance due to the council being required to focus on multiple objectives across a number of services.

Industry Good Practice

The project auditor identified that the major urban water industry was moving toward a more commercial and customer service focus. This move was driving progress in the asset management. Particular good practice within the industry was the degree of stakeholder buy-in across all levels of an organisation. The auditor noted that the industry has achieved a level of success in this area yet to be experienced by other industries.

This level of buy-in has then supported other notable developments. Organisations are effectively using skills matrices to support the asset management and people needs of the business. The business planning process is engaging staff across all levels, which is promoting the alignment of operations and maintenance strategies with the key business objectives.

Identified Opportunities

Whilst the industry is one of the leaders in asset management practices, a number of opportunities exist to further improve. The major urban industry still has insufficient understanding of asset performance, particularly the assessment of end of economic life. The auditors identified that improvement in undertaking post-completion reviews would be an appropriate first step in addressing this. Further, the implementation of these reviews would support the utility in being able to demonstrate that its asset procurement practices were delivering best value outcomes for

Figure 5a
Sample result for hypothetical participant

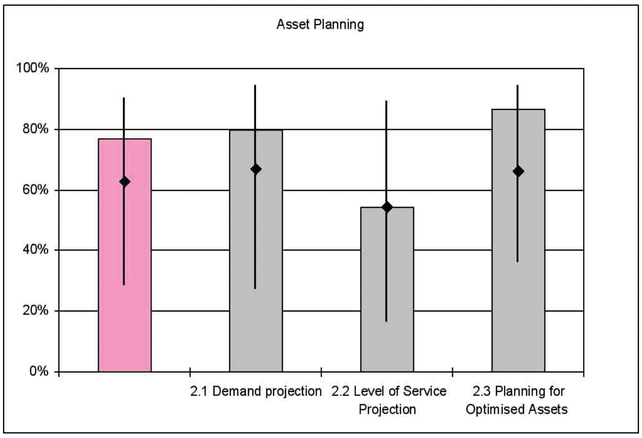
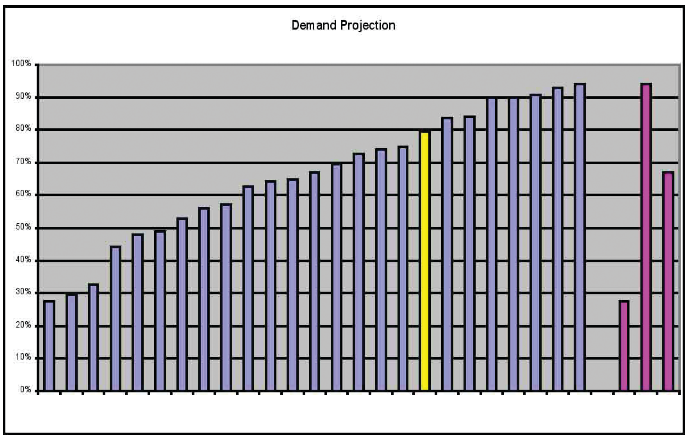


Figure 5b
Full distribution of data in ascending order for an asset planning process



the utility.

The industry also had gaps in projecting and addressing future levels of service. This has impacts on the level of current and future investment required to meet customer expectations.

Utility Specific Results

Results of individual utilities are not available for publication; however, Figures 5a and 5b have been included to provide an indication of the simple graphics available.

Figure 5a demonstrates a sample result for a hypothetical participant. It demonstrates the results for the asset planning function against the upper and lower bounds and median of the full data set. An equivalent plot is available against a selected peer subset.

Figure 5b provides the full distribution of data in ascending order for an asset planning process. The hypothetical utility is highlighted and the minimum, maximum and median values identified at the end of the chart.

Participants were also provided with a full printout of all the measures results into an Excel spreadsheet, enabling them to use the assessment information to prioritise the improvements.

Conclusion

The asset management benchmarking project was the largest syndicated process benchmarking project undertaken by the major urban water industry. The project used an industry-developed framework designed to provide transparent outcomes that could be easily communicated to stakeholders.

Comparability of benchmarked results was improved by engaging an independent third party auditor accredited by WSAA. Accreditation of the auditor ensured the individual had significant experience in asset management and had been provided with a detailed understanding of all measures being assessed.

A peer review of the framework was undertaken to ensure it was robust and fit for purpose. The peer review identified some minor opportunities to improve the framework noting that the framework was fundamentally robust and fit for purpose.

Participating businesses were provided with individual reports that enabled comparison of its results against the full dataset and a selected peer subset. Each participant has identified opportunities to improve and a roadmap as to how these improvements can be achieved.

The support of this project by the major urban water industry demonstrates its commitment to asset management and to continuous improvement of its business processes. ●

References

WSAAfacts 2001: The Australian Urban Water Industry, Water Services Association of Australia, 2001

Acknowledgements

The Water Services Association of Australia expresses its appreciation to WSAA members and staff for their support in the development and implementation of the asset management framework.

Using advanced asset management techniques to develop a 'Strategic Capital Improvement' business plan

A systematic reconciliation of technical requests with financial capacity, with example from Fulton County Georgia, USA

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T. Taylor Ph.D. P.E., Patrick O'Connor CPA,
L. Hensey P.E.
USA

Capital investment is one of the most important - and high consequence - decisions a utility faces. Because of the scale of investment typically involved, poor or wrong decisions can be very costly. To avoid the risk of poor decision-making, Fulton County Water Services Division developed and implemented a Strategic CIP Business Plan. A core tool in the advanced asset management tool bag, the Plan incorporates a whole-of-business perspective and provides for the systematic accumulation, preparation and - most importantly - presentation of key strategic material in the form of a business plan that identifies:

- The current state of the utility s infrastructure systems
- Its current financial condition
- The context for and the demand drivers of the need for capital investment
- The financial capacity of the utility s rate base to support a proposed CIP.

Most importantly, the plan is intended to give confidence to regulators and the public that the CIP makes prudent business sense, and that the management team/policy board are indeed acting as good stewards of the community's assets.

To illustrate the process, this paper outlines the application of the strategic CIP business planning process to a major CIP effort undertaken by the Fulton County Water Services Division

Capital investment is one of the most important - and high consequence - decisions a utility faces. Because of the scale of investment typically involved, poor or wrong decisions can be very costly. A good capital investment decision process systematically addresses the core funding questions of which projects?, why?, at what level?, and when?, while assisting the organisation in striking a justifiable balance between capital and operations budgeting, and between renewal and expansion demands. More fundamentally, a good capital investment decision process provides a comprehensive and rigorous decision framework against which these questions can be addressed - thereby providing staff, board, and customers with a high level of confidence in the quality of the investment decisions rendered.

All utility-based capital improvement programmes are ultimately constrained by the fiscal context of the parent utility and of the community that utility serves. It is critical, therefore, that the capital improvement programme (CIP) be developed in such a manner that the current and future financial condition of the utility is clearly capable of supporting the revenue obligations created by the bonded indebtedness and by the operating requirements of the additional facilities. The implications of the proposed CIP for the utility's financial condition, operating policies and system requirements must be carefully examined by management and the elected policy board, with the CIP so structured as to meet customer/stakeholder and regulator demand within rate schedule limits acceptable to customers. This requires reducing the CIP 'needs list' to that which the community is willing to pay for, then convincing the stakeholders that investment in the proposed CIP is in their own best interest. The Strategic CIP Business Plan process is an effective way to accomplish this.

What is a Strategic CIP Business Plan?

The Strategic CIP Business Plan is a core tool in the advanced asset management tool bag. It incorporates a 'whole-of-business' perspective, ideally interfacing with and supporting classic enterprise-wide asset management plan (AMP) methodology (demand analysis, setting of level of service, condition assessment, life-cycle valuation/costing, failure mode analysis, determination of remaining economic life, risk-consequence assessment, etc.).

A Strategic CIP Business Plan can be viewed as a sub-process and sub element of the AMP. Its focus, while strategic in nature, is more immediate - what is a politically acceptable and functionally feasible balance between immediate capital requirements (including both expansion and renewal) and rate increases triggered by those capital requirements? A Strategic CIP Business Plan provides for the systematic accumulation, preparation and - most importantly - presentation of key strategic material in the form of a business plan that identifies:

- The current state of the utility's infrastructure systems
- Its current financial condition
- The context for and the 'demand drivers' of the need for capital investment
- The financial capacity of the utility's rate base to support a proposed CIP.

It provides for a systematic projection of revenues and expenses under the current rate structure in order to identify the magnitude of impact of CIP investment under various reasonable CIP scenarios. This projection reveals which of the several rate components (volume charge, connection charge, etc.) must be modified to support the CIP funding requirements in an equitable and legal manner. These elements are then reconciled into a clear 'blueprint' statement - an action statement - detailing which projects will be funded, why they have been selected, what the impact on the utility and the community would likely be of not doing each project, in what manner they will be funded, on what schedule, and what the expected impact on the long-term financial condition and system performance capabilities of the utility is expected to be. The financial ramifications (including risks to the utility) of the proposed action are clearly enumerated: which components of the rate structure will be adjusted (eg. volume charge, hook-up charge), in what manner, and when (eg. 'a 5% increase in volume rates effective immediately and for each year through 2007, plus a one-time immediate 10% increase in capital connection charges'). In short, it makes a clear business 'bottom line' case for the collection of projects in terms of sustained service to the community, at a level of service and risk that the community is asked to support through rates paid for services.

The Strategic CIP Business Plan is intended for use by both management and the policy-setting board in determining which projects will be included and how much the community is willing to pay for - including a clear understanding of the business risk to the utility emanating from those projects not included in the CIP. In this sense, the business plan is as much process – bringing together divergent parts of the organisation (Board, public and management) as it is substance. Simply stated, the Strategic CIP Business Plan defines and rationalises the best 'business case' CIP for the community - those projects (and only those projects) that make good, solid business sense for the community. Most importantly, the plan is intended to give confidence to the commission and the county that the CIP makes good and prudent business sense, and that the management team/policy board are indeed acting as good stewards of the c ommunity's assets.

The Strategic CIP Business Planning Process

The Strategic CIP Business Plan process:

- Identifies the core 'failure mode/demand drivers' driving the CIP list
- Associates each project on the list with those demand drivers
- Quantifies the business risk addressed by each project
- Rank orders the projects according to the risk mitigated by each project
- Cumulates the associated cost of the ranked projects
- Identifies life-cycle costs associated with the projects
- Assesses the revenue and expense streams (Net Operating Income) necessary to meet all utility obligations over a long term (for example, ten year) planning horizon
- Identifies funds available for capital investment, currently and over the planning horizon
- Quantifies capital funding alternatives (debt service or 'pay as you go') into alternative funding scenarios
- Depicts the impact of those scenarios on the various rate components, and
- Serves to facilitate closure by the management team on a funding strategy that provides for long-term sustainable utility performance at a level of risk that the community is willing to accept.

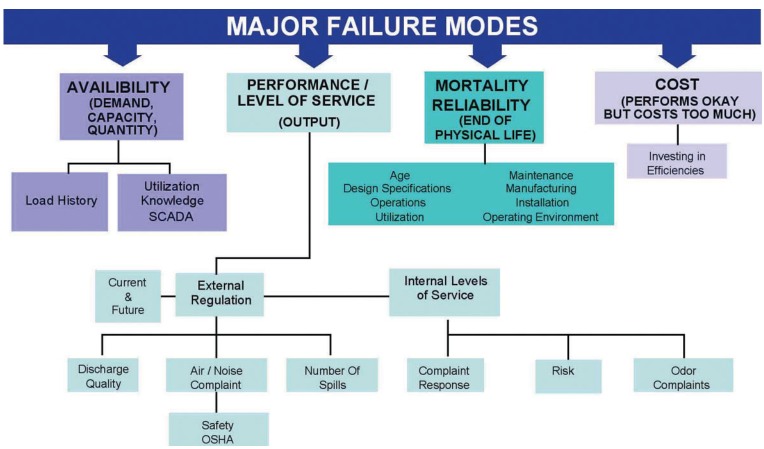
'Failure mode' is a rather new term to the US water industry. As the term implies, it articulates the manner in which an asset can fail, the major implication being that understanding the likely nature of failure substantially affects the decision on how best to manage the failure. Our consulting practice identifies four core failure modes as depicted in Figure 1 below.

The Project

To illustrate the process, this paper outlines the application of the strategic CIP business planning process to a major CIP effort undertaken by the Fulton County (Georgia, USA) Water Services Division. It documents the process of developing and applying the principles and processes outlined above from the inception of the CIP list to adoption of the CIP Strategic Business Plan by the County Commission.

The Business Plan was the result of a collaborative effort over several months among multiple departments of Fulton County. The CIP Team included senior managers from Public Works, Finance, Environment and Community Development, and the county manager. The CIP Team met weekly throughout the project. The agency is just taking its first steps into formal advanced asset management processes. Initially, a list identifying potential projects was compiled by the utility's management team based on the recommendations of previously prepared facilities plans, engineering studies and technical reports. This initial list identified $647M in water and wastewater capital project needs for the period 2003 to 2009. The

Figure 1 Major failure modes



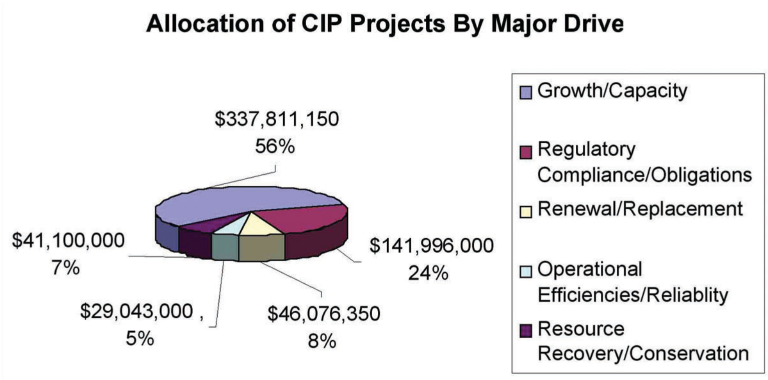


Figure 2
Allocation of CIP projects by major driver

immediate question posed by the county's senior management team was 'can we afford this project list?' The initial response, especially from the Finance Department, was a resounding 'No: the rate ramifications could be political dynamite'. How then to systematically pare down the projects list? And down to what level – what level of rate impacts would the County Commission be willing to withstand given the potential political impacts of not undertaking the projects (the business risk exposure).

To address this question, it was necessary to understand what factors were driving the CIP list. What were the 'failure modes' the county was facing that required action? The CIP team applied the four classic failure modes to a detailed analysis of the CIP 'wish list', to which a fifth (resource recovery) was split off into its own category due to an intense commitment on the part of the organisation:

- Regulatory requirements and other obligations
- Growth/capacity
- Physical mortality/renewal
- Operational efficiencies
- Resource recovery

Each proposed project was analysed to identify and subsequently quantify the drivers at work compelling the project (Figure 2). Each project was assessed as to its business risk exposure - what were the ramifications to the organisation of not doing a given project now?

Given the need to eliminate or defer projects, it became readily apparent that an understanding of the timing of demand was key to sizing and staging the CIP list. Population projections, growth data and development commitments were pulled together and mapped over the service area to assist in determining the timing and sizing of the improvements (Figure 3).

The compelling focus was to reduce the CIP to a 'just in time' capital investment strategy – that is, to identify only that plant and collection system investment that was necessary to achieve regulatory, growth and other strategic goals and commitments, eliminating 'excess capacity' except where compellingly cost-justified due to economies of scale (Figure 4). The CIP Team agreed upon a systematic prioritisation model and ranked the projects accordingly.

Introducing 'Dynamic Financial Scenario Modelling'

Traditional CIP financial analysis is rather static in nature, typically calling for an analysis of financial impacts at the conclusion of the CIP process as if the engineering analysis and financial analysis were virtually unrelated elements. The CIP Team recognised at an early stage that to earn political support for the CIP, a much more dynamic interface between the various project scenarios (mixes of projects) and the impact of those scenarios on the financial condition and rate requirements of the utility would have to be developed. The contrast in approaches is depicted in Figure 5.

A computerised financial model was developed to reflect actual and projected revenues and expenditures for the county's water and sewer utility for a ten-year planning horizon. This model was used to evaluate many different CIP alternatives and funding scenarios. The financial model is based on the county's financial reporting system and uses actual financial operating data to create the baseline condition. Ten-year projections of customer growth, revenues, utility rates, expenditures, interest rates, bond terms, etc. were incorporated into the model in order to project as nearly as possible future conditions and financial results when evaluating each alternative or scenario.

Several major determinants converged to frame the funding environment for the CIP. These included:

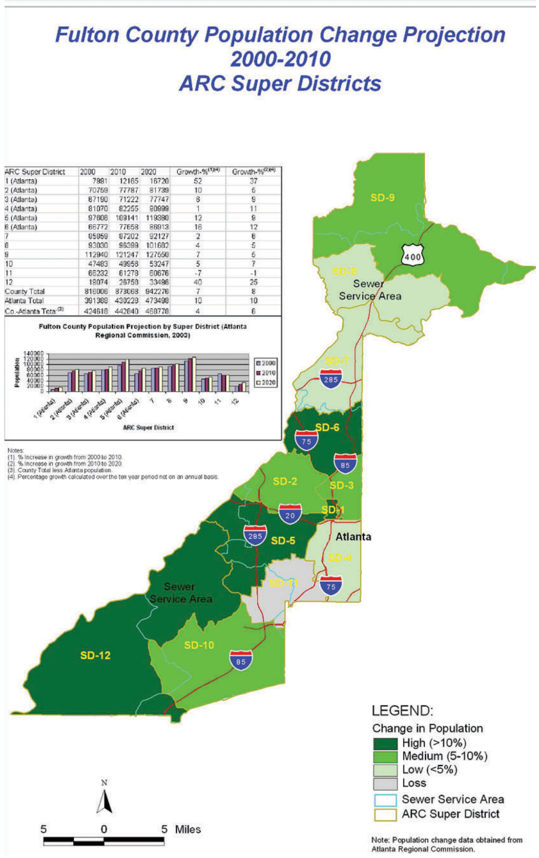
- Current financial condition of utility funds, including available reserves and uncommitted capital projects funds (this required a detailed reconciliation of every capital project funded for the past ten years)
- Projected demand for new service, including location, size and timing of projects in the CIP
- Anticipated growth in the revenue base (number of and average consumption per customer)
- Anticipated required expenditures to sustain the utility over time, including impacts on operations and maintenance of expanding the capital base, anticipated higher levels of regulatory compliance, renewal of older facilities and incorporation of operational efficiencies
- Projected changes in rates within the various rate components.

These factors interact to ultimately determine the capital funds necessary to support the CIP. Each of these factors was incorporated into various scenario worksheets.

Framing the 'Window' of Feasible Scenarios

The task of developing any funding strategy for a CIP program boils down to a balancing between sizing the CIP (through determining what is on the final list of funded projects and what is not) and evaluating the business risk exposure and fiscal impact on the organisation of each alternative CIP list using different funding devices (bonding versus 'pay as you go', rate changes, timing of projects, debt service mechanics). However, the list

Figure 3
Fulton County population change projection 2000-2010 ARC Super Districts



of possibilities to assess and evaluate are virtually unlimited. To reduce the number of alternatives to evaluate, the following four scenarios were developed. Each served as a 'feasibility boundary' for the identification and consideration of more focused alternatives. Collectively, these scenarios served to 'frame' the universe of reasonable alternative strategies.

Scenario 1. The 'Current Funding Capacity' scenario
This scenario addressed the core strategic question, 'what can the county afford if it elected to not raise volume rates no earlier than 2006?' That is, what could the baseline projected cash flow and currently available cash reserves alone fund (within financially prudent limits)? This scenario served as the 'baseline' against which all others were bench-marked.

Scenario 2. The 'Full CIP' scenario
This scenario asks the question, 'what would the rate impact be if the full $647M were funded immediately?' While it was intuitively clear from the outset that such a scale would not be politically feasible, this scenario served as the 'outer boundary' for all others.

Scenario 3: The 'Modified Debt Service Cash Flow' scenario
Various bond mechanics that can be structured into the bond covenant can be used to define the stream of obligations accruing to the county in terms of size and timing of resultant annual debt service. These mechanics move around the stream of interest and principal payments and their respective amounts. This approach allows for a 'fine tuning' of the bond package by timing payments to better match income and expenditure patterns of relevance to the county.

Scenario 4. The 'Phased Capacity' scenario
This scenario focused on addressing the question – 'what minimum package of water and sewer projects must move forward now to reasonably assure adequate capacity through the year 2009?' Here the issue is a technical engineering 'phasing' question; given projected growth in the county and the additional capacity needed to accommodate that growth, what is the best combination of projects that delivers the capacity (water and sewer treatment and transmission/collection) when it is needed and where it is needed? Treatment plants (both water and sewer) may be built in stages. Distribution and collection systems may be built in stages commensurate with desired paced and sustainable growth. Although total costs for a given

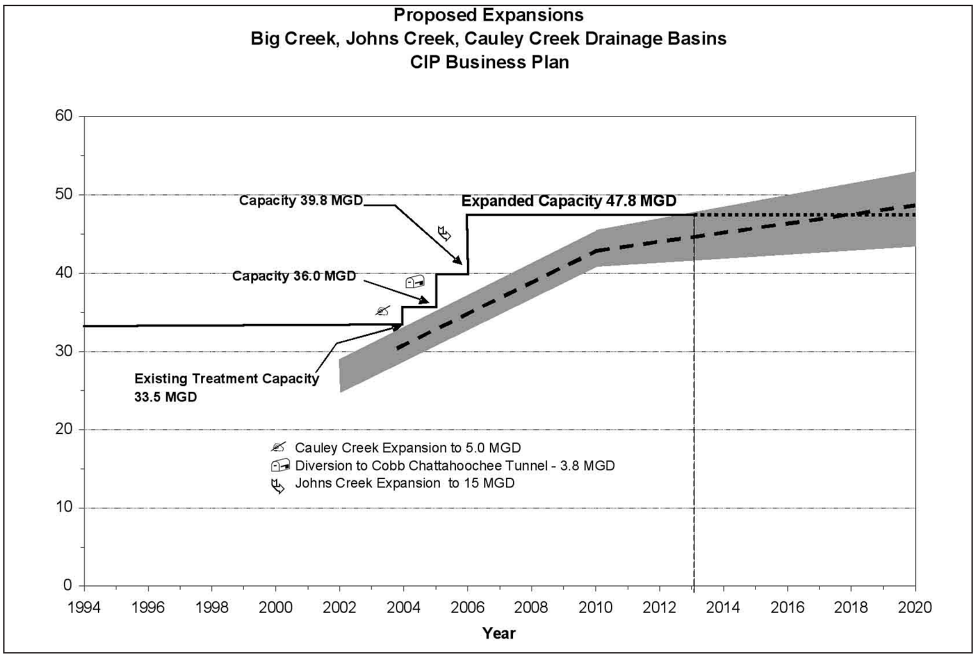


Figure 4
Proposed expansions

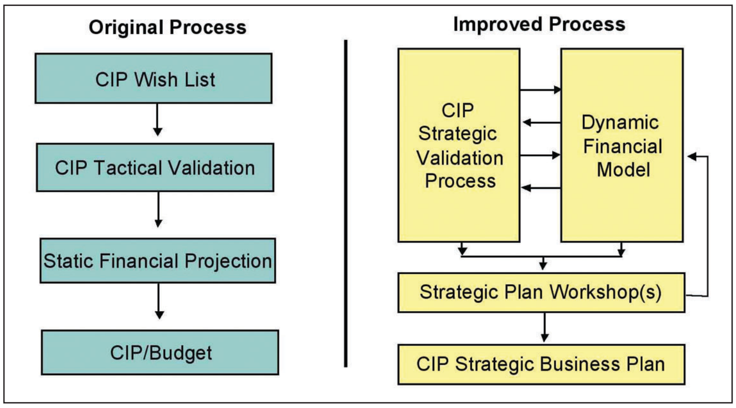


Figure 5
The full strategic CIP business planning model

Figure 6
Core scenarios

Scenario	Gross Bond Amount (millions)	Net Bond Proceeds (millions)	Annual Debt Service (millions)	Notes
1. No rate increase	$215.0	$193.5	$15.4	Current 201/203 available cash balances pay for current 203 projects for all scenarios
2. Fund all $600 million initially	$668.4	$601.5	$47.8	30 to 35% immediate rate increase
3. Staged Debt Service	$250.0	$225.0	$9.4 $17.9	3 years of interest only
4. "Just in time" capacity, obligations	$230.0	$207.0	$8.6 $16.5	3 years of interest only; meets "bottom line" capacity requirements and commitments

facility are likely to be modestly higher for the same 'build once' option, the costs are spread over a longer period, thereby 'freeing up' CIP dollars that would otherwise be tied up in order to provide more distant future capacity; these dollars are redirected toward addressing a broader range of facilities within a more immediate time-frame than otherwise would be the case. The funding question here is quite different in nature than those posed above. In this scenario, we are searching for the 'best' funding solution to fund a given amount of capital needs, where those needs are based on a 'just in time' phasing. 'Just in time' was defined by the five drivers identified above, together with the attendant detailed analysis that examined the timing issue.

Converging on the supportable scenario

Of course, these scenarios are not mutually exclusive: the best funding solution is crafted using all of the tools in the tool bag – debt mechanics coupled with modest, staged rate increases.

Review of the scenarios then led to consideration of another relevant 'framing' question: approximately how much net operating income would be generated in any given year by a five percent rate increase? A ten percent increase? A fifteen percent increase? An increase in impact, connection or service fees? (see Figure 6).

The model allowed for the staging of different rate increases in any given year in any of the major components of the rate structure (volume, connection, field services).

With the decision framework boundaries now defined by the four scenarios, attention turned to testing various refined alternatives within the now-defined framework. Substantial review, analysis and discussion of the four core scenarios by the CIP Team led to the iterative development of an incremental and 'emergent' set of 'most viable alternative' scenarios. These scenarios were built around the core projection worksheets used in the initial four scenarios, but introduced variable term lengths of the bond issues used to fund the projects and incorporated different combinations of project mixes.

Once staff had wrestled down the 'feasible scenarios' boundary, the county manager and county commission members were brought into the decision process. Various 'on-the-fly' modifications were made to the mix of projects as the commission wrestled with the business risk of deferring or excluding certain projects (given their commitment to orderly and systematic growth) and the requirement to raise rates to pay for most of the scenarios.

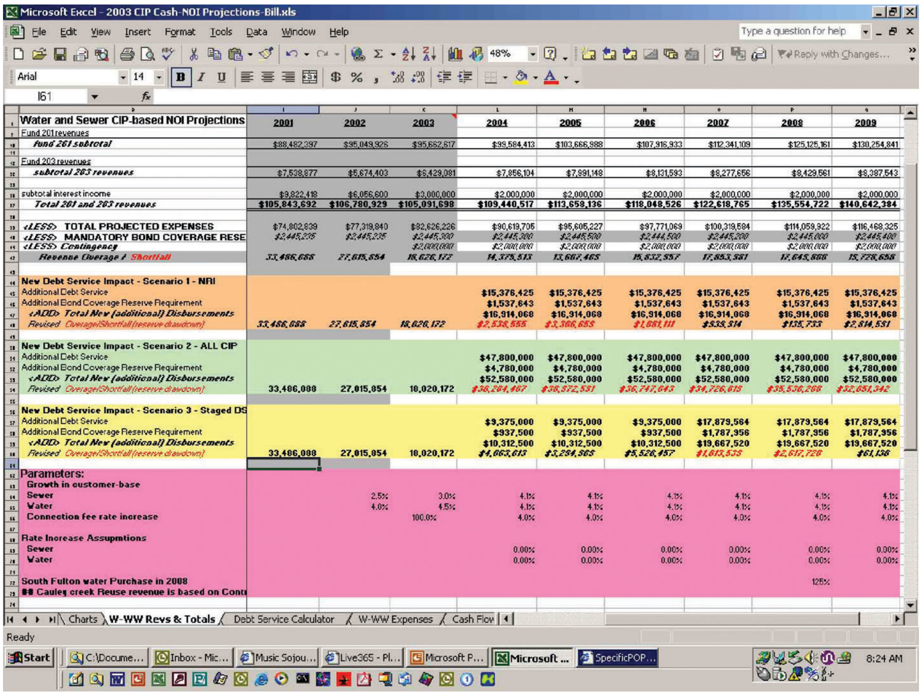


Figure 7
Spreadsheet model example

After much systematic iteration, deliberation and collaboration among senior officials – including the county commission finance committee – a final consensus strategic business plan emerged and was taken into public review and to the full commission for consideration and adoption. By its nature, the business plan made the case for the CIP investment in clear 'business case' terms – 'what, why, how and when' and 'what is left unaddressed for future consideration'. The business pan is far from a finished and robust asset management plan. But while rate increases were called for – which are never politically popular – the commission had confidence that what was being proposed was the best current trade off between rate increase and business risk exposure. And more fundamentally, the utility has a firm perspective on how the application of advanced asset management techniques can raise the level of confidence in the political arena that the staff and commission are truly acting as prudent stewards of the customer's asset base.

Summary

Developing a major CIP program on behalf of the customers of the Fulton County Water and Sewer Utility was a major undertaking. Many factors and forces had to be carefully and systematically considered in developing a prudent course of action for the utility as it struck a balance between the need to accommodate growth, regulatory requirements, physical mortality of its assets, resource recovery, and changing technologies with the very real political need to keep rates down. To effectively serve its stakeholders, the implications of the proposed CIP on the utility's financial condition, operating policies and system requirements had to be carefully and systematically examined by management and the county commission, and the CIP so structured as to meet customer and regulator demand within rate schedule limits acceptable to customers.

This CIP strategic business plan has provided for the systematic accumulation, preparation and presentation of key strategic material that identified the current state of the utility's infrastructure systems, its current financial condition, the key drivers and failure modes compelling the need for further investment, and the capacity of the utility to support a proposed CIP. It also provided for projection of revenues under the current rate structure to identify the magnitude of CIP investment required under reasonable assumptions. The recommended CIP strikes, in the estimation of the CIP team and the county commission, the best balance among the various needs of the organisation, system, ratepayers, regulators and the community.

A major reinforcement to the validity of the CIP business plan process was the high level of acclaim awarded by the bond ratings industry to the effort, when the plan was presented to the ratings agencies in the bonding phase. ●

WERF wastewater inspection and performance reports available from IWA Publishing

IWA Publishing has released two new titles in the WERF Report Series. The first publication, *An Examination of Innovative Methods Used in the Inspection of Wastewater Collection Systems*, brings together a body of information on the characteristics of the wastewater pipe network and the most common defects encountered. The authors identify the technologies and methods in use by utilities to investigate these defects for the purposes of condition assessment, together with the perceived unmet needs, and provide a comprehensive review of the current state of the art of investigation technology. Innovative investigation technologies are reviewed under five sections:

- Inspection of internal pipe surface
- Inspection of pipe wall condition
- Inspection of pipe wall condition and external condition
- Inspection of external condition
- Leak detection

The report identifies seven technologies for gravity pipe investigations and two for force main investigation as demonstrating potential for application in the wastewater industry. Using a structured approach, each of the chosen technologies is reported in detail with information on details of the technology, its performance including field requirements, role of the operator, and costs. Where possible field monitoring was undertaken this is reported.

Also likely to be of interest to asset managers working in the water industry is the second new report: *Developing and Implementing a Performance Measurement System for a Water/Wastewater Utility*. The primary purpose of this research was to provide methods and tools that enable a water/ wastewater utility to develop and implement a performance measurement system based on a demonstrated proven approach. To achieve this purpose, the research was conducted in three phases:

- Core research on existing and applicable frameworks for performance measurement with experience from utilities and other government organizations, as well as outside business and industry, on leading practices in performance measurement. Steps to develop and implement performance measurement that uniquely fit water/wastewater utilities were defined to be piloted by selected utilities in Phase II.
- Demonstration pilot projects for developing and implementing performance measurement were carried out over a 12-18 month period at four water and wastewater utilities that were selected from a group of over a dozen utilities that applied to be pilot demonstrations, based on a mix of utility type, size, and experience with performance measurement.
- Research results from the pilots and 'lessons learned' were applied to adjust the piloted process. Transfer of the knowledge and methods from these projects was previously shared in WERF/WEFTEC workshops and a web-conference.

A process (seven-step methodology) was developed based on a Balanced Scorecard approach to develop and implement performance measures both at the enterprise (utility-wide) level and team-based level. Ways to align and coordinate measures throughout the organization were defined for process-based and initiative-based scorecards. The testing of this approach through the utility pilots led to further recommendations for involvement, education, communication and commitment of utility participants for successful performance measurement.

An Examination of Innovative Methods Used in the Inspection of Wastewater Collection Systems (CD)
WERF Report: Collection Systems (01-CTS-7)
Authors: J Thomson, L Grada
January 2005; 200 pages
ISBN: 1843397315
IWA Members Price: £77.25 / US$124 / €116.25;
Non Members Price: £103 / US$165 / €155
Available to order online now at: www.iwapublishing.com

Developing and Implementing a Performance Measurement System for a Water/Wastewater Utility
WERF Report: Managing Utilities and Assets (Project 99-WWF-7)
Author: Terrance M Brueck
July 2005; 146 pages
ISBN: 1843397323
IWA Members Price: £77.25 / US$124 / €116.25;
Non Members Price: £103 / US$165 / €155
Available July 2005. For more information on new titles, visit www.iwapublishing.com.

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Author: Sveinung Saegrov

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Publication Date: July 2005;
180 pages; ISBN: 1843390914
Paperback
IWA Members Price: £45.00 / US$90.00 / €67.50
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Performance Indicators for Water Supply Services - Second Edition
Editors: H Alegre, W Hirner, JM Baptista, R Parena

The new edition of this acclaimed publication provides guidelines for the establishment of a management tool for the water supply utilities based on the use of performance indicators. The publication comprises the text and a CD-ROM with the software SIGMA Lite, which incorporates the performance indicators assessment system. The focus is on those performance indicators considered to be the most relevant for the majority of water utilities, to be used on a routine basis at senior management level.

Performance Indicators for Water Supply Services will be invaluable to all those concerned with managing the performance of the water supply industry including those in water utilities, policy-makers and regulators.

The title belongs to Manual of Best Practice Series

Publication Date: August 2005;
192 pages; ISBN: 1843390515;
Hardback
IWA Members Price: £48.75 / US$97.50 / €73.50.
Non Members Price: £65.00 / US$130.00 / €98.00

Water services management book includes focus on asset management

Water Services Management
Author: David Stephenson

David Stephenson devotes an entire 30-page chapter of his new book, *Water Services Management* (IWA Publishing, 2005), to the practice of asset management and its place at the forefront of leading thinking on water services maintenance.

The chapter opens with a brief introduction, in which Stephenson ascribes one reason for the importance of asset management to 'the fact that water services have lagged behind the manbuilt environment in many ways, [due to which] a formal method for evaluating the industry is required'. The chapter goes on to set out in some detail the applications and benefits of asset management, with sections covering:

- Assets
- Benefits of asset management
- Best practice (worldwide, UK, Australia and New Zealand)
- Data management
- Methodology for AMPs (Asset Management Plans)
- Life cycle asset management
- Asset management registers
- System definition

David Stephenson is a professor at the University of Gabarone, Botswana. He says that the book as a whole is intended to educate engineers to manage and improve water services, instead of just designing and constructing treatment works and distribution systems. The text covers water supply and drainage from the hydraulic and economic points of view. Although design and construction practices are reviewed, the focus is on improving existing systems and turning the industry into an attractive business.

The subject matter of the book includes potable water supply, sewerage and stormwater drainage. Hydraulic management embraces storage, peak flow attenuation and pumping. Water quality is considered including standards, pollution control and treatment. Infrastructure management includes rehabilitation, reconstruction, upgrading and maintenance. Topics relevant to economic efficiency are asset management, privatization, and risk analysis. Efficient use of energy and construction project management are also ways of improving economic viability.

Characteristcs encountered in developing countries are also considered , including low cost sanitation, water supply standards and off-grid energy sources. Capacity building and appropriate technologies are particularly appropriate. Financing, operation and benchmarking are also relevant topics for these areas.

Water Services Management
D Stephenson
April 2005. 368 pages.
ISBN: 1843390809. Hardback
IWA Members Price: £60.00 / US$120.00 / €90.00.
Non Members Price: £80.00 / US$160.00 / €120.00.

The chapter on asset management (chapter 11), will be available for purchase at IWA Publishing site www.waterintelligenceonline.com

New from IWA Publishing

water
asset management
INTERNATIONAL

New for 2005, Water Asset Management International is an international newsletter on asset management in water and wastewater utilities. The focus of the newsletter is on the strategic aspects of this developing field, providing utilities with international perspectives on infrastructure planning and maintenance as they seek to deliver cost-effective services to their customers.

Each issue of Water Asset Management International contains submitted papers from around the world, along with news, details of events and publications, and perspectives from water utility CEOs on the importance of asset management. Submission of papers of likely interest to an international audience and presented so as to be accessible to the general asset management community is welcomed.

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