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# Counting the cost of regulation

**Quantifiable evidence of the detrimental impact of the UK water sector's regulatory cycle on the supply chain is emerging for the first time.**

Initial findings from UKWIR's collaborative initiative involving British Water, the Society of British Water and Wastewater Industries (SBWWI) and industry regulator Ofwat, support a growing consensus that an inefficient boom and bust culture has been evolving unchecked within the supply chain since privatisation in 1989.

Conclusive findings from a small cross-section of sector suppliers have prompted UKWIR to repeat the exercise right across the industry with a revised questionnaire to generate an even more representative response.

While the preliminary results demonstrate that some businesses experience minimal adverse impacts over the course of the five-year cycle, for others the impacts are shown to be devastating. It is also clear that the pressure on small suppliers at the 'sharp end' of the supply chain is greatest, with the potential to significantly undermine the supply chain as a whole.

In what is being regarded as the best opportunity yet to instigate far-reaching policy change to the five-year Periodic Review cycle, senior industry voices are urging the sector to respond to UKWIR's study, The Regulatory Cycle and its Impact on the Efficiency of the Supply Chain.

According to UKWIR Director Mike Farrimond, the impacts of the regulatory cycle on suppliers have always been anecdotal with the focus on damaging peaks and troughs leading to inefficiencies; lost opportunities; lack of innovation; low morale; skills shortages; and loss of talent to other sectors.

'Ofwat, the water companies and other key industry bodies are now working together and tackling this important issue. For the first time there's a real sense that something can come of it. Crucially, what we need now is more evidence to support the project and that means more companies responding to the second phase survey,' he said.

'There's been a lot of talk in the past, but this is the first real opportunity for the water industry supply chain to influence the policy makers and make a difference. It's a case of speak up now and help instigate change or miss out altogether.'

Kay Webb, Senior Analyst/Engineer at Ofwat's Network Regulation Division, welcomed the UKWIR initiative as the best way to influence policy change in the future. She urged all sector stakeholders to respond to the questionnaire and make their issues and recommendations known:

'Since privatisation we've seen a roller-coaster expenditure profile which has been cited as a significant cause of inefficiency in the industry's supply chain. We're committed to supporting a project like this because we need to ensure the industry is equipped to deliver the capital programme now and in the future.'

'Until you start to ask these questions to see what the actual costs and losses are and the difficulties, it's hard to see why there should be any change. That's why people need to respond to the survey,' she added.

The timing of the study was also welcomed. The intention is to include its recommendations within Ofwat's methodologies paper for PR09 due to be published in the autumn.

Copies of the questionnaire can be downloaded from UKWIR's website at www.ukwir.org/site/web/content/news. ● **LS**

# Approval for Great Lakes wastewater study

**The US House of Representatives has approved a proposal that would involve the US EPA in undertaking studies of wastewater treatment works discharging into the Great Lakes.**

The move follows a recent report from the Sierra Legal Defence Fund that accused cities bordering the Great Lakes of using them 'like a toilet'.

The Fund's Great Lakes sewage report card found regular storm overflows from elderly municipal systems. The 20 cities studied discharge over 90 billion litres of untreated wastewater, including chemicals from commerce and industry as well as pharmaceuticals, to the lakes annually.

The Water Quality Financing Act of 2007 authorises $14 billion over four years for the Clean Water State Revolving Fund, which provides low-interest loans to construct wastewater treatment facilities and other pollution- abatement projects. It is focused on funding for wastewater treatment programmes to foster cooperation between the US and Canada on water quality monitoring.

Fully funding the CWSRF is considered a critical part of the 2005 Great Lakes Regional Collaboration agreement, which is designed to end wastewater flows into the lakes by 2020.

The EPA will also have to propose ideas to improve monitoring of discharges and cooperation between the US and Canada, and would be required to consult with the State Department and Canadian government, as well as the International Joint Commission, which protects the boundary waters between the two nations.

Another water-sources bill, which was approved in the same week, authorises $125 million in funding for local governments, water agencies and NGOs. ● **Lis Stedman**

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EDITORIAL

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# UK industry fares well internationally, says regulator

**The water industry in England and Wales compares well against a wide range of countries in Europe, North America and Australia, according to a new Ofwat report.**

Standards of customer service are generally high, bills are in line with most other countries, and water consumption per person is around average for Europe, although much lower than in Australia or the USA.

The report, 'International comparison of water and sewerage service 2007', builds on Ofwat's work in comparing the performance of water companies in countries throughout the world.

It draws on data from a wide range of sources but cautions, however, that although generalised conclusions can be reached, accurate comparisons with other countries are often difficult because of the widely varying methods of compiling data and statistics.

Although customers in England and Wales generally pay around the same for their water as those in other countries in the study, there are some key differences.

The price of water is subsidised by the state in some other European countries, and low levels of infrastructure investment in Italy have meant that water there remains relatively cheap. By contrast customers in Germany are bearing the costs of major investment in the water and sewerage networks, although now much of this has been carried out, prices are rising more slowly than in England and Wales.

Although it has proved difficult to draw detailed conclusions from the comparison of prices in other European countries, a German report (3) last year said that if the industry in that country, England and Wales, France and Italy operated on equal terms of investment, subsidies and quality standards, prices would be broadly similar.

Few countries collect customer service data in as detailed a way as that collected in England and Wales but Ofwat is working with the industry in other countries to improve the comparability of customer service data. Valid comparisons show that standards of service are significantly better than those in Scotland.

People in England and Wales use an average 150 litres of water per day, a figure mid-way on the international scale. Americans and Australians are revealed to be the biggest users, with per capita consumption in the USA is more than double that in Britain. Within Europe, the Spanish are the biggest users while consumption in the Baltic states of Estonia and Lithuania is only two thirds of that in England and Wales.

Ofwat's Director of Network Regulation, Dr Melinda Acutt, said today:

'Customers will be pleased to learn that the service they get from their water company compares well with those in other countries. And we have found that companies in England and Wales are at least as efficient as their overseas counterparts.' ●

# *EPA approves California sludge injection plan*

**The US EPA has approved Los Angeles' permit to inject treated sewage sludge nearly a mile below the ground beneath its Terminal Island treatment plant in San Pedro, California.**

The permit allows the city, over a five-year period, to drill three wells – one injection and two to monitor the effectiveness of the project – pumping up to 400t of treated sewage sludge each day into the Tar, Ranger and Terminal formations to evaluate potential benefits of using 'fracture injection' technology.

This involves injecting slurry mixtures at sufficient pressures to hydraulically create fractures. The waste will undergo high-temperature, anaerobic digestion. The potential benefits of this experiment include safe disposal, generation of significant quantities of methane for future energy use and permanent carbon dioxide sequestration. This project will not affect drinking water supplies, says the EPA.

Work on the project is expected to begin in 2007. LA currently applies its treated sewage sludge to agricultural land in Kern County, where it is applied as a fertiliser for non-food crops.

The monitoring will be extensive, as set out in the 40-page permit – sampling and analysis from the offset monitoring wells will be used to quantify the minimum slurry placement, biodegredation rates, CO2 and methane separation, carbon sequestration and saturation in formation brine, free gas migration, commercial methane production potential and time frames.

Drilling at the nearby Wilmington oil field has led the EPA to believe that the predicted depths of the geological zones are likely to be found to be accurate in reality. Any changes required if the depths do vary will require EPA approval before they are undertaken, though the risks are considered minor.

A National Audit Office report has recommended that Ofwat should push harder for improved data on leakage and consumption from water companies, as well as taking a lead in ensuring reliable evidence for the effectiveness of water efficiency projects.

Sir John Bourn, Auditor General of the NAO, said that understanding the needs of consumers should be at the heart of the regulatory regime for water.

Dame Yve Buckland, chair of the Consumer Council for Water, welcomed the findings, saying: 'Consumer views and understanding of consumer behaviour must be at the centre of any future regulatory decision-making on water policy.

'We are happy to see the National Audit Office recognise this, echoing many of the statements we have made on water resources over the last 12 months.

'Emerging results from our Using Water Wisely research will help in providing the necessary evidence, but more work is needed on top of that to work out the costs and impacts of different water efficiency initiatives.'

Dame Yve added: 'It is crucial, if customers are to be asked meet extra costs at the next price review in 2009, that they pay only for the approaches that work best for different groups of consumers in differing supply scenarios. Otherwise, water companies may not deliver the options that are best value for money.

'Meanwhile, the message to consumers is to minimise waste and use water wisely, but the industry must also demonstrate what it is doing to take care of water resources, and how it can help consumers to be more water efficient. Customers are saying 'show me how' – the will is there, but they need help with the means.'

Key findings from the CCW's research show that 67% of consumers were willing to try water-efficient devices. But 55% of consumers would be more likely to conserve water if water-saving appliances were cheaper. ●

# Spanish utility spreads disinfection research results

**Spanish utility Consorci de la Costa Brava has placed on its website a report on the combined use of UV light and chlorine for the disinfection of reclaimed water.**

Available in Spanish and English, the report is based on studies carried out in May 2006 in the utility's Blanes Reclamation Plant, Costa Brava, Girona, Spain.

The study was funded by the Catalan Water Agency. It was carried out by the technical staff of CCB and of Empresa Mixta d'Aigües de la Costa Brava SA (the company operating the plant), together with the research teams of Professor Juan Jofre and Francisco Lucena (University of Barcelona) and Professor Rafael Mujeriego (Politechnical University of Catalonia).

The report makes a number of recommendations. These include emphasising the value of achieving the highest possible quality for secondary effluent to maximise the performance of the disinfection process. Use of at least one operating UV module is recommended for the site. The researchers found that it would be appropriate to continue with systematic evaluation of the microbiological quality parameters used in the study in order to confirm the preliminary results obtained and strengthen the proposed operational criteria. The researchers also found that it would be appropriate progress with assessment of the use of sulphite-reducing clostridia spores and somatic coliphages as indicators of the effectiveness of disinfection and for the determination of the levels of disinfectant agents necessary for eliminating them and the other micro-organisms – both indicators and pathogens – used in the study.

The report was originally issued in the Catalan language and was then translated courtesy of the Catalan Water Agency so it can be shared with national and international colleagues.

The report can be downloaded at: **www.ccbgi.org/publicacions.php**. ●

# CDM wins $9.9M Egypt contract

**The US Agency for International Development (USAID) has awarded CDM a three-year, US$9.9 million contract to provide engineering services for the design and construction management of diverse water and wastewater infrastructure improvements in Egypt.**

As USAID's programme management partner, CDM, in association with Dr Ahmed Abdel-Warith Consulting Engineers, will develop facility designs, prepare environmental assessments, manage construction, and provide quality control on projects in six governorates.

The team's water and wastewater system design and construction management services will provide new treatment facilities and improve the performance of existing facilities, eliminate untreated discharges, and strengthen infrastructure reliability in Daqahliya; the Middle Egypt Governorates of Fayoum, Beni Suef, and Minia; in the oases of Kharga and Dakhla in the New Valley; and in Luxor City.

In addition, a watershed quality and management project at Lake Qarun, a valuable natural and cultural resource, will include full-scale wetlands treatment pilots, development of an integrated watershed/lake quality management plan, and implementation of priority management measures. An innovative groundwater lowering programme in the West Bank of Luxor – the site of the ancient city of Thebes and home of the renowned Valley of the Kings and Valley of the Queens – will help preserve some of the world's most treasured antiquities.

On all these projects, CDM will deliver sustainable facilities that meet critical environmental and archaeological mandates, prioritising those locations where improvements can go online quickly, maximising the use of local expertise, and providing strong programme management. When complete in 2009, the programme will have provided significant improvements in water and wastewater service for an estimated 400,000 people.

● **www.cdm.com**

# *H2O Networks cut congestion using the sewerage system*

**The sewerage system is providing an environmentally friendly way for UK organisations to set up their own IT and telecom networks. H2O Networks has developed a new system that provides fibre optic cables to be laid through the sewers without digging up the roads.**

Digging up roads for laying pipe and cable happens more than four million times a year at a cost of £1 billion ($2bn). A further £4 billion is wasted through the delays and inconvenience caused.

The Focus System allows the cable to be laid in the sewer network and can be installed 80% faster than traditional cabling methods – the network can be operational within weeks rather than months. Every city and town has ready-made ducts that can be used without causing disruption. H2O's revolutionary approach not only allows for quick installation is also can provide unlimited band-width at a fixed cost.

H2O's scheme is attracting much interest from water boards across the UK. Wessex Water Enterprises is one of the water boards that have signed up to the scheme, and Mike Peacey, commercial manager, comments, 'We've started the system in Bournemouth which is a town with a lot of industry as well as a lot of architectural heritage. Wessex Water Enterprises are actually really excited to be working with H2O Networks as it will allow us to use our assets to the benefit of local industry and the local environment.'

Elfed Thomas, managing director at H2O Networks, comments: 'There is also the advantage that as the cables lie at depths of up to 5m below the ground, compared with 450mm for conventional cables, it is also far more secure – especially in disaster recovery situations.'

● **www.focuss.net**

# Three Valleys Water improves work management using AMT-SYBEX

**AMT-SYBEX – a provider of asset management technology to the UK's essential industries – has provided Three Valleys Water with a unique, work management solution to help the water company increase operational efficiencies, minimise disruptions to supply and enhance levels of customer service.**

Designed primarily to replace a legacy system, the solution – which went live in May 2006 – is the first phase of an end-to-end require-ment that includes the delivery of work to the field, enabling staff to timetable site inspections, plan preventative maintenance projects and prioritise urgent call outs more effectively. It will also speed processes associated with forecasting for capital maintenance, compliance and aid Three Valleys Water's liaison with the regulator, OFWAT.

The new system utilises an asset repository of over 35,000 records created for Three Valleys Water by AMT-SYBEX in 2002. Based on Ellipse, AMT-SYBEX's enterprise asset management (EAM) software, the system contains information about the physical attributes of the water company's above ground operational assets. This includes essential details about the company's reservoir, water treat-ment, water tower and pumping station sites plus data on the lifecycle, quality and capacity of specific operational components.

Commenting, Steve Robinson, Head of Asset Management at Three Valleys Water said, 'Compliance, reporting and work management are high on our agenda. We are tasked with hitting increasingly exacting targets to deliver improved levels of service, and running more cost effective systems. Having access to accurate information about the condition, performance and maintenance of our above ground assets is essential for effective asset management, efficient operations, producing strategic business plans and for securing regulatory support.

'We chose to work with AMT-SYBEX because of its strong credentials in the UK water industry. Since 2001, we have built up a good relationship with the organisation in the development and implementation of our Asset Management Systems.'

AMT-SYBEX provided on-site consultancy on development, functionality, data management and training.

● **www.amt-sybex.com**

# A risk-based asset management tool for US drinking water infrastructure systems

This article presents a practical risk assessment methodology to provide drinking water infrastructure (DWI) decision-makers with an objective risk assessment tool. The purpose of this risk assessment tool is to maintain the desired level-of-service or systems reliability [r(f)], while managing the financial uncertainty of the expected budgetary impact within the capital improvement programme (CIP).

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**Under their current philosophy, drinking water infrastructure (DWI) decision-makers attempt to manage the risk of systems failure (R) through deterministic trial and error approaches that provide inefficient solutions (Wu et al, 2001). These deterministic trial and error approaches typically exclude uncertainty and access individual DWI component failures as a function of age, length, and service for a given distribution network configuration at a specific point in time (Silinis and Stewart, 2003). The algorithms for these methods generally use simple performance deficiency prioritisation rules to set up skeletal preventative maintenance (PM) programmes (Quimpo and Wu, 1997 and McKay et al, 1999).**

The lack of ability to actually estimate R within the existing DWI methods requires developing new methods that facilitate integrated solutions through systems and multi-objective decision analysis techniques (Stern & Kendall, 2001); incorporate complex environmental influences such as soil type, trench construction, water chemistry, piping material, and suchlike within existing methods (Franks, 1999); and optimise trade-offs between desired level-of-service or systems reliability [r(f)]and associated costs among competing DWI scheduled maintenance (SM) and emergency repair (ER) activities (Wu et al, 2001).

Accurately estimating R will provide DWI decision-makers with a time-dependent snapshot of the physical deterioration of the critical DWI components. This time-dependent snapshot ultimately provides decision-makers with an efficient maintenance and rehabilitation roadmap for reliable systems operations at the lowest possible cost (McKay et al, 1999).

Booth & Rogers (2001) concluded that few DWI decision-makers were interested in a probability formulation for estimating R. However, new financial rules, such as the General Accounting Standards Board (GASB) Rule 34 issued in June 1999, are changing their mindset. GASB-34 requires public services, such as DWI utilities, to develop viable asset management (AM) programmes. The purpose of these AM programmes is to preserve the life and function of critical assets by optimising the allocations of limited DWI operational, maintenance, and capital resources. The expected impact of viable AM programmes for DWI is a fiscal saving of 20% to 40% (Stern & Kendall, 2001).

These potential fiscal savings alone provide sufficient justification for DWI decision-makers to develop new AM programmes that incorporate attributes for uncertainty. This paper presents a practical risk assessment methodology for estimating R to provide the DWI decision-maker with an objective risk assessment tool. The purpose of this objective risk assessment tool is to maintain the desired r(f), while managing the financial uncertainty of the expected budgetary outcome within the capital improvement programme (CIP).

The magnitude of the expected budgetary outcome is managed through the DWI decision-maker's sensitivity to R, which is represented as the level of the system's rate of reinvestment (RR). The expected result of the proposed risk assessment tool demonstrates that by proactively managing R to maintain the system's r(f) will effectively manage the uncertainty of the DWI system's expected budgetary outcome within its CIP.

The limitations of the proposed objective risk assessment tool are that the underlying principles are applicable to only DWI. Additional theories would need to be evaluated for other industries; decision response alternatives only evaluate three discrete risk sensitivities rather than evaluating a stochastic distribution of risk sensitivities; and value is demonstrated through a generic example calculation rather than an actual case study. The objective risk assessment tool needs to be verified and validated through the application of extensive case study analyses.

The paper's discussions of the practical risk assessment methodology begin with an overview of the concepts of risk analysis. Next, the existing methods for estimating R are evaluated and combined within the proposed risk assessment methodology. Next, the applicable theories for estimating R and r(f) are formulated into the objective risk assessment tool. Finally, the value of the objective risk assessment tool is demonstrated through a set of example calculations for a conceptual DWI system to show the ability of the DWI decision-maker to manage the expected budgetary outcome within the CIP.

## Risk analysis concepts

Traditional risk analysis is undertaken to improve the quality of information that the decision-maker utilises by examining the uncertainty of decision response alternatives. The risk analysis is performed by calculating the magnitude of risk for an individual risk factor and/or cumulative risk. The cumulative risk is represented by the sum of the individual risk factors times the relative weight of the respective risk factors (Hastak and Baim, 2001). Ezell et al, (2000) and Haimes (1998) believe that a comprehensive risk analysis should quantitatively understand the risk factors, their intermediate/final impacts on cost and the actions to mitigate their impact in order to understand what can go wrong as well as its likelihood and consequences.

Hastak and Baim (2001) define infrastructure risk as the product of the probability of systems failure and associated costs of returning the system to service. This mathematical relationship is represented as: $R = p(f) \times C$, where R is defined as the risk of infrastructure systems failure; p(f) is defined as the probability of infrastructure systems failure and C is defined as the economic value of returning the failed infrastructure system to service. The economic value of a DWI's p(f) is calculated as the total service expenditure in terms of the equipment, material and labour costs that are necessary to return the infrastructure system to its normal operating condition.

The DWI infrastructure systems' uncertainty or R is defined as the probability that the DWI utility fails to provide water on demand to its customers. The DWI decision-maker either waits until critical DWI components fail and then expeditiously completes an ER activity, or performs SM activities on critical DWI components prior to their failure. These decision response alternatives provide the DWI decision-maker with the ability to balance the expected CIP budgetary outcome on an annual basis.

The decision response alternatives for the deterministic SM activities are the known or controllable costs that can be delayed by the DWI decision-maker in response to their effect on the expected CIP budgetary outcome. However, delaying SM activities on critical DWI components adversely affects the p(f) over the life of the DWI system. Correspondingly, as the p(f) rises, the level of the stochastic ER activities increases. Lauer (2001) found that balancing stochastic ER activities with deterministic SM activities is key to minimising the overall DWI maintenance and repair (MR) costs.

The decision response alternatives for the stochastic ER activities are uncertain or uncontrollable costs that are determined by the p(f). It is the randomness in the level of the ER activity costs that creates the R for the DWI decision-maker in terms of its cumulative affect on the expected CIP budgetary outcome. This situation is exacerbated further by the fact that ER activity costs are paid at overtime or premium rates. These premium rates are charged for the ER activities because they require immediate attention causing increased costs for shifting, expediting, and/or providing extra personnel, materials and equipment at a moment's notice. The C of the premium cost of the stochastic ER activity typically range from 1.5 to 2 times the cost of the deterministic SM activity.

The proposed objective risk assessment tool defines the DWI decision-maker's sensitivity to R by specifying corresponding levels of RR. A risk assessment is performed using three decision response alternatives that are based on desired risk-sensitivity in terms of low, medium, or high RR. The goal of the objective risk assessment tool is to demonstrate the value of estimating the DWI decision-maker's sensitivity to R. The objectives are to incorporate p(f) into the CIP budgetary analysis process and evaluate the effects of p(f) on the expected CIP budgetary outcome.

## Existing methods

Many professional and government agencies have published assessments and projections for the nation's DWI needs over the next 20 years (ASCE, 2001; EPA, 2001; WIN, 2001; Scharfenaker, 2001; and WIN, 2000). These need assessments have shown that the current DWI is in a state of general disrepair and substantial funding above the current levels will be required to maintain the DWI at acceptable r(f) through cost-effective CIP. To further compound the current needs dilemma, the DWI competes for limited resources with the other critical public infrastructures for transportation, schools, wastewater, solid waste, and energy.

Currently, the financial health of the nation's DWI is documented by the EPA's 1995 Nation-wide community water system survey, which was completed in January 1997. The results of the EPA (1997) survey revealed that the CWS sector spent \$32 billion from 1986 through 1995 on CIPs. On average, the 1995 CWS sector's AM activities spent approximately 20% on water quality (WQ) compliance, 30% on MR activities, and 50% on scheduled replacement (SR) improvements. On average, the 1995 CWS sector completed MR activities on approximately 2% of their respective pipe networks. In addition, the 1995 CWS sector completed SR activities on around 2% of their respective pipe networks. The WQ, MR, and SR activities within the CIP compete for the same AM programme dollars.

The ageing of the DWI system, along with increasing competitive pressures and customer demands, is forcing public water services to develop effective AM programmes as in the GASB 34 requirements for maintaining service efficiency and product reliability while meeting quality standards and containing service costs (Booth and Rogers, 2001).

The public water services are looking to AM programmes to provide integrated solutions that improve service efficiency and product reliability by balancing the MR activities as a function of the SM and ER needs (Stern and Kendall, 2001). It is generally accepted that as the DWI system ages the occurrence of stochastic ER activities increases due to the adverse impact of physical, chemical and biological deterioration. Additionally, as the frequency of stochastic ER activities increases, the SR improvements of the aging DWI system become the more viable option (Silinis and Steward, 2003).

The DWI needs may range from stochastic ER activities for maintaining the r(f) to SR improvements for creating new capacity for present and projected demand. The ability to pay may range from public drinking water utilities with strong bases of commercial and affluent users to those with large bases of government services

| Decision Responses | p(f) | Risk Sensitivity | Emergency Repairs |
|---|---|---|---|
| Null (Corrective) | High | Low | High |
| Traditional (Preventative) | Medium | Medium | Medium |
| Strategic (Proactive) | Low | High | Low |

*Table 1* - Description of the drinking water infrastructure (DWI) decision response alternatives as a function of the level of the probability of systems failure p(f), risk sensitivity of the decision-maker, and expected level of the emergency repair activities.

and low-to-moderate-income residential users. Managing the DWI requires decision-makers to manage the old as well as to build the new. They must know about governance, public health, engineering, operations, and politics as well as economics and finance.

The DWI problems discussed in the public forum are only 5% technical; 95% of the focus is on finance, public acceptance and environmental impacts. There are abundant opportunities in the DWI arena to take lead roles in defining issues, creating solutions, explaining to public and leading the holistic implementation process. Grigg (1999) and Means (2001) stressed that communicating the critical nature of DWI's WQ, MR, and SR activities under the CIP is paramount for the fundamental survival, public-health protection, economic development and quality of life of America's people.

Craun and Calderon (2001) emphasised the importance of adequately maintaining DWI systems. They found that since 1995 DWI deficiencies have been responsible for 45% of all waterborne disease outbreaks reported by the nation's 54,000 CWS. The DWI system deficiencies involved chemical and microbial contamination through cross-connections, back siphonage, inadequate separation, contaminated storage facilities, water main repairs, water main construction and meter installation (Craun and Calderon, 2001). To reduce the risk of waterborne disease outbreaks more attention needs to be placed on the preventing of contamination of the distribution system through an optimal combination of corrective, preventative and proactive maintenance policies.

The DWI system is ageing, which contributes to waterborne disease outbreaks and a reduced r(f). Sufficient CIP funds consisting of WQ, MR and SR budgetary components should be allocated for the routine inspection, repair, and expansion of water mains and storage facilities as well as the SR of the older infrastructure.

To reduce the potential for distribution system outbreaks and failures, drinking water utilities must maintain adequate water pressures, repair leaking mains, maintain chlorine residual, adopt cross-connection programmes, include inspection programmes, adequately disinfect after construction work and increase corrosion control efforts (Craun and Calderon, 2001). Failure to accurately predict the appropriate RR for the DWI system risks severe r(f) deterioration, adversely affecting the financial stability of the public drinking water utilities.

Optimising the financial tradeoffs between the competing corrective, preventative, and proactive maintenance activities of the AM programme, subject to minimising the adverse impacts on the expected CIP budget outcome, emphasises the importance of DWI system maintenance in the effectiveness of the overall system safety and reliability (Stern & Kendall, 2001 and Silinis and Steward, 2003).

Many quantitative analysis methodologies use mathematical representations to model the complex physical, chemical and biological deterioration processes that adversely affect the DWI's r(f) (Quimpo & Wu 1997; McKay et al, 1999; Franks, 1999; Wu et al, 2001; Stern and Kendall, 2001 and Silinis and Steward, 2003). These quantitative analysis methodologies provide objective and repeatable procedures to justify CIP budgets that effectively allocate dollars, extend asset life, and plan programmes to maintain the systems' r(f). However, they do not incorporate risk assessment into their respective quantitative analysis methodologies.

More recent quantitative analysis methodologies incorporate risk assessment and management techniques to facilitate decision analysis by highlighting tradeoffs among individual risks factors and associated mitigation cost impacts to effectively manage infrastructure assets (Hastak and Baim, 2001, and Ezell et al, 2000). However, the stochastic nature of the DWI systems' deterioration processes adds considerable complexity to these quantitative analysis methodologies, requiring substantial technical and modelling expertise.

While the required DWI system investment is daunting in size, it creates an opportunity to sensitise consumers and decision-makers to the opportunities of strategic risk management as communities differ in their DWI needs, ability to pay and ability to manage r(f). This article demonstrates an objective risk assessment tool for maintaining a desired r(f) while managing the expected CIP budgetary outcome. Managing r(f) by minimising the p(f) may require strategies ranging from instituting high reinvestment to no reinvestment due to limited budgets.

## Theory

Ending the current state of disrepair of the DWI system requires the prioritisation of corrective, preventative and proactive maintenance activities within the CIP budgeting process to ensure the effective allocation of limited resources (Li and Haimes, 1992). The DWI system is now nearly 100 years old, and at least 26% of the drinking water mains are constructed from unlined cast iron and steel pipe.

These mains have greatly reduced carrying capacities and are rated as being in poor condition, adversely impacting the current DWI system's r(f) (Kirmeyer et al, 1994). The prioritisation of corrective, preventative and proactive maintenance activities within the CIP budgeting process is the basis for the development of the DWI risk assessment tool.

The DWI risk assessment tool is characterised by three risk-sensitive decision response alternatives, which are described in Table 1. The Null or corrective decision response assumes that the p(f) is high and decision-maker's risk sensitivity is low because low levels of SM or preventative maintenance activities are planned to mitigate the p(f) due to infrastructure deterioration. The associated r(f) is adversely affected because the ER or corrective maintenance activities are performed only after the DWI system fails.

The Traditional or preventative decision response assumes that the p(f) is medium and decision-maker's risk sensitivity is medium because medium levels of SM or preventative maintenance activities are planned to mitigate the p(f) due to infrastructure deterioration. The associated r(f) remains stable since the level of ER or corrective maintenance activities is marginally reduced by the SM activities.

Finally, the Strategic or proactive

decision response assumes that the p(f) is low and decision-maker's risk sensitivity is high because high levels of SM or preventative maintenance activities are planned to prohibit the p(f) due to infrastructure deterioration. The r(f) increases since the level of ER or corrective maintenance activities is substantially reduced by the SM activities.

The basic relationships between an infrastructures' maintenance frequency (MF) and systems' performance is discussed in detail by Nelson et al (1999) in an EPA report entitled Optimisation of collection system maintenance frequency and system performance. These relationships are shown in Figure 1 and entail the following assumptions:

- the average infrastructure life expectancy is assumed to be 100 years with a salvage value of 25%. The average infrastructure unit value is assumed to be $100 per linear foot of pipe. The rate of the infrastructure's deterioration is assumed to be $0.75 per linear foot per year. Based on these assumptions, the rate of system degradation (SD) is represented by the following linear relationship: SD = $100 – ($0.75 * X), where the (x-axis) value is equal to the average age of the infrastructure network in years.
- the r(f) or associated (y-axis) value is assumed to be the percentage of the 'as-new' system's performance. The remaining system's value is a function of the average MF and the system age. The percentage of the 'as-new' system's performance is assumed to represent the infrastructure's current r(f). The infrastructure's MF is assumed to be the number of years to return the infrastructure to 100% or an 'as-new' system's performance level given a specific level of maintenance activities as represented by the chosen level of RR.
- the infrastructure's MR programme is defined as ongoing ER and/or SM activities that include actions that retard or correct the deterioration of the infrastructure system. The infrastructure system's level of maintenance or RR is defined as the percentage of the system rehabilitated within a given time period or MF.
- the infrastructure's RR is assumed to be the inverse of its maintenance frequency (MF). The RR or 1/MF determines the level of maintenance activities or percentage of the total infrastructure rehabilitated to return the system to 'as-new' condition in a given period of time. For example, a RR of 2% will return the system to an 'as-new' performance condition in MF = 1/0.02, which is 50 years.

Figure 1 is used to estimate the expected infrastructure system's r(f) given the average rate of system degradation (SD) and reinvestment (RR) assumptions that are specified in the EPA (1997) survey. The methodology steps include:

- drop a vertical line from the end of the 2% RR line to the corresponding point on the SD line
- draw a horizontal line to the desired level-of-service [% 'as-new' system performance or r(f)] axis
- note that the r(f) [y-axis] value is intersected at 65%, which represents the current infrastructure system's r(f). Therefore, given the assumed rate of SD with a 2% RR the overall infrastructure systems' r(f) is expected to perform at 65% of the performance level of a similar 'as-new' infrastructure system.

The basic infrastructure relationships defined by Nelson et al (1999) are applicable to critical infrastructures such as DWI systems. The r(f) for DWI systems may be defined as the probability that the DWI system operates correctly throughout a specified period of time given that the system is operating at the start of the time period (Haimes, 1998).

The p(f) for DWI systems may be defined as the probability that the DWI system fails during a specified period of time given that the system is operating at the start of the time period. The relationship between DWI systems' r(f) and p(f) values may therefore be expressed as the p(f) = 1- r(f). Given this simple relationship, the systems' r(f) or y-axis value calculated in Figure 1 can be expressed as the system's p(f) value over a given 1/MF or RR. For example, given the DWI's average rate of SD in Figure 1 with a 2% RR from the previous example, a DWI system's r(f) value is estimated to be 65% of the 'as-new' system performance level.

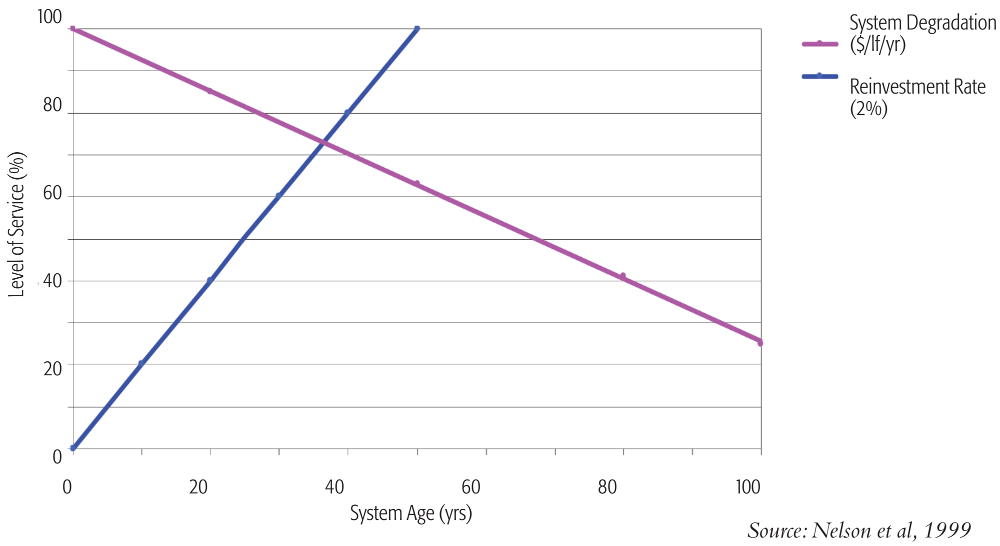
The system's p(f) value within the 50-year MF period is estimated to be 35%. This means that a DWI system with a 2% RR is operating at a r(f) that is 35% below the 100% system performance level. In other words, the DWI system has a 35% chance of failing to operate at least once throughout the associated 50-year MF period. Therefore, the level of financial reinvestment plays a crucial role in the maintenance of the system's r(f).

Guignier and Madanat (1999) found that, historically, the level of financial reinvestment through the infrastructure's CIP budget is broken down into competing maintenance and improvement activities. Additionally, the EPA (1997) survey found the CIP budget for DWI systems is broken down into WQ activities to meet the system's regulatory requirements, MR activities to meet the system's customer requirements and SR improvement activities to meet the system's economic development requirements within the AM programme.

The MR activities consist of CIP budgetary line items that are broken down as SM and/or ER activities. The ER activities retard and/or correct infrastructure deterioration after the system has failed. The ER activities are stochastic in nature and vary widely from one year to the next because they are based on risk factors such as infrastructure age, material, leakage, water quality and so on.

The WQ, SM, and SR activities consist of CIP budgetary line items

***Figure 1*** - **Graphical representation of the linear relationships between the DWI system's age (years) and level of service (% as-new performance) as a function of the system degradation and reinvestment rates.**




*Source: Nelson et al, 1999*

| Decision Response Alternative | SM = b | ER = 0.30 - b |
|---|---|---|
| Null (Low risk-sensitivity) | 0.10 | 0.20 |
| Traditional (Medium risk-sensitivity) | 0.20 | 0.10 |
| Strategic (High risk-sensitivity) | 0.25 | 0.05 |

***Table 2*** **- Three DWI risk-sensitive decision response alternatives as a function of the level (b) of scheduled maintenance, and associated level (0.3-b) of emergency repair activities within the maintenance and repair component of the capital improvement programme budget.**

that are compliance, maintenance and replacement activities that improve and/or functionally alter the infrastructure system returning it to an 'as-new' condition. The budgetary line item amounts for these WQ, SM and SR activities are determined by the DWI decision-maker for each budgetary cycle.

The DWI decision-making problem involves balancing the financial tradeoffs between the deterministic WQ, SM, and SR activities and expected adverse impacts from the stochastic level of the ER activities, while maintaining the current r(f). As explained earlier, the C element of the stochastic ER activities is quite expensive relative to the more cost-effective WQ, SM, and SR activities.

The DWI decision-maker must answer the following question: what is the optimum level of the SM activities that will maintain the current r(f), while minimising the adverse effects of the C from the expected level of ER activities on the CIP budgetary outcome? Therefore the DWI decision-maker must accurately estimate the expected level of ER activities relative to a chosen level of SM activities within the MR component of the CIP budget.

To answer the above question, a practical risk assessment methodology is used to develop an objective DWI risk assessment tool to estimate the impact of p(f) on the expected CIP budgetary outcome. The following CIP budgetary assumptions were made for a conceptual DWI system:

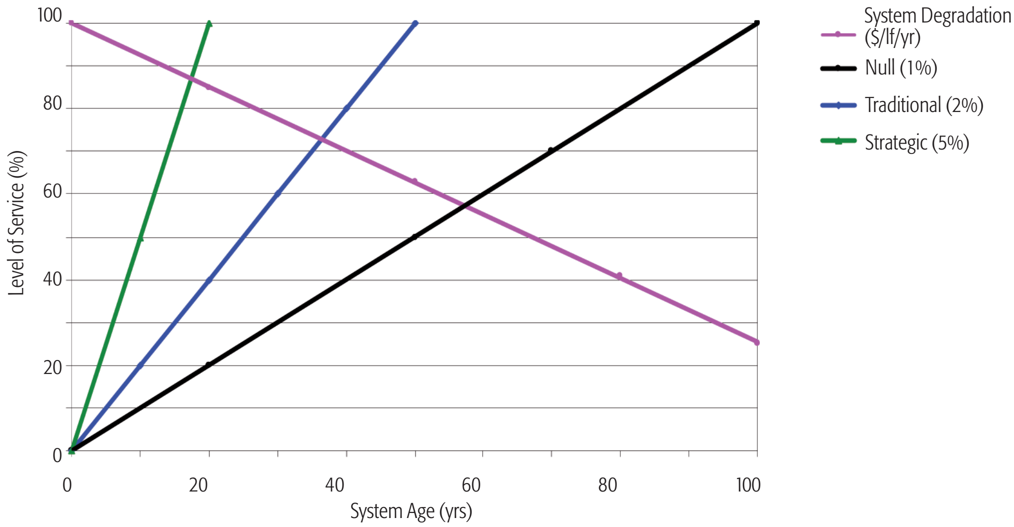
- annual water quality (WQ) compliance activity costs WQ ($/yr) = labour + material + equipment aspects WQ ($/yr) = ($/hr, $/lf, $/event) x (# hrs, # lf, # / events)
- annual scheduled replacement (SR) improvement activity costs SR ($/yr) = labour + material + equipment aspects SR ($/yr) = ($/hr, $/lf, $/event) x (# hrs, # lf, # / events)
- annual scheduled maintenance (SM) activity costs SM ($/yr) = labour + material + equipment aspects SM ($/yr) = ($/hr, $/lf, $/event) x (# hrs, # lf, # / events)
- annual emergency repair (ER) activity costs with C = 1.5 premium factor ER ($/yr) = 1.5 x SM
- average capital improvement programme costs with no risk assessment factors CIP ($/yr) = (0.20)*WQ + (0.3)*(ER + SM) + (0.50)*SR, where assumed component coefficients must sum to 1 for a balanced budget.
- annual maintenance and repair (MR) activity costs MR ($/yr) = 0.3 (ER + SM ), where coefficient constrained in assumption 5 MR ($/yr) = (0.3-b)*ER + (b)*SM, where b is the selected level of SM activity costs MR ($/yr) = (0.3-b)*(1.5*SM) + (b)*(SM) MR ($/yr) = [(0.3-b)*(1.5) + (b)]*(SM)
- probability of system failure as a function of system reliability p(f) = 1 – r(f)
- risk (R) from stochastic emergency repair (ER) activity premium costs R ($/yr) = p(f)*C ER ($/yr) = p(f)*[1.5*SM] ER ($/yr) = [p (f)*1.5*(0.3-b)]*SM, , where b is the selected level of SM activity costs
- average capital improvement programme costs with risk assessment factors CIP ($/yr) = (0.20)*WQ + (0.30)*MR + (0.50)*SR, where assumed component coefficients must sum to 1 for a balanced budget. CIP ($/yr) = (0.20)*WQ + (0.3)*(ER + SM) + (0.50)*SR CIP ($/yr) = (0.20)*WQ + (0.3-b)*(1.5*SM) + (b)]*SM + (0.50)*SR CIP ($/yr) = (0.20)*WQ + (0.3-b)*{p(f)*1.5}*SM + (b)*SM + (0.50)*SR CIP ($/yr) = 0.2*T +0.3*T + 0.5*T, where T represents the $/yr values of the WQ, SM, & SR components
- objective DWI risk assessment tool CIP (T) = (0.2)*T + [p (f)*1.5*(0.3-b)]*T + (b)*T + (0.5)*T, where T in $/yr

*(Equation 1)*

Equation 1, above, provides the mathematical foundation for the objective risk assessment tool. The WQ, ER, SM, and SR component coefficients for the conceptual DWI system's CIP budget are based on national averages from the EPA (1997) survey. Therefore, the assumed values of these coefficients are specific to the drinking water sector. Actual values for these coefficients for an individual drinking water utility will need to be verified and validated on a case by case basis. The WQ and SR component coefficients are assumed to be constant AM activities within the CIP budget of the conceptual DWI system. The ER and SM component coefficients of the MR component are assumed to be competing activities within the CIP budget of the conceptual DWI system.

The proposed objective risk assessment tool assumes that under normal conditions the DWI decision-maker will re-allocate limited financial resources between

***Figure 2*** **- Graphical representation of the three DWI risk-sensitive decision response alternative reinvestment rate (%) assumptions as a function of the system's age (years), level of service (% as-new performance), and rate of system degradation.**



| Decision Response Alternative | Rate of Reinvestment | r(f) | p(f) | SM | ER | SR | WQ | CIP Budget Impact |
|---|---|---|---|---|---|---|---|---|
| Null (Low risk-sensitivity) | 1% | 25% | 0.75 | 0.10 | 0.20 | 0.50 | 0.20 | 1.03 x T |
| Traditional (Medium risk-sensitivity) | 2% | 65% | 0.35 | 0.20 | 0.10 | 0.50 | 0.20 | 0.95 x T |
| Strategic (High risk-sensitivity) | 5% | 85% | 0.15 | 0.25 | 0.05 | 0.50 | 0.20 | 0.96 x T |

***Table 3*** **- Demonstration results of the DWI risk assessment tool for evaluating the impact of the three DWI risk-sensitive decision response alternatives on the expected total capital improvement budgetary outcome.**

the competing ER and SM activities of the MR component within the CIP budget of the conceptual DWI system.

The efficient allocation of the financial resources for the MR component is based on the decision-maker's understanding of the competing needs to maintain the current r(f) and balance the expected total CIP budget. The objective risk assessment tool allows the DWI decision-maker to set the RR in accordance with their level of risk-sensitivity (low, medium, high) and determine its impact on the expected CIP budgetary outcome.

**Example calculation**

To demonstrate the use of the objective risk assessment tool for the conceptual DWI system, as illustrated by Equation 1, three typical DWI risk-sensitive (low, medium, high) decision response alternatives are outlined in Table 1 and defined as follows:

- NULL (Corrective): the decision-maker's risk-sensitivity level is low and selects a RR of 1% that equates to a systems' MF of 100 years. Then using Figure 2, the y-axis value for the r(f) equals 25%. The corresponding p(f) is calculated as 1-0.25 = 0.75 or 75%.
- TRAD (Preventative): the decision-maker's risk-sensitivity level is medium and selects a RR of 2% that equates to a system MF of 50 years. Then using Figure 2, the y-axis value for the r(f) equals 65%. The corresponding p(f) is calculated as 35%.
- STRAT (Proactive): the decision-maker's risk-sensitivity level is high and selects a RR of 5% that equates to a systems' MF of 20 years. Then using Figure 2, the y-axis value for the r(f) is 85%. The corresponding p(f) is calculated as 15%.

Next, the DWI decision-maker sets the level (b) of SM activities and calculates the associated level (0.3- b) of ER activities relative to their risk-sensitivity. It is assumed that the more risk-sensitive the DWI decision-maker, the higher the level of SM activities within the MR component of the CIP budget. The three DWI risk-sensitive decision response alternatives with associated levels of SM and ER activity are shown in Table 2.

The selected level (b) of the SM activities represents the ability of the DWI decision-maker to manage the magnitude of adverse affects on the expected total budgetary outcome. The magnitude of adverse affects on the expected total budgetary outcome is mitigated by decreasing the expected level (0.3-b) of the ER activities within the MR component of the CIP budget. In other words, there exists a correlation such that as the selected level (b) of SM activities increases, the level (0.3-b) of expected ER activities decreases within the MR component of the CIP budget. By increasing the level of SM activities through a higher RR, the DWI decision-maker is effectively managing the system's r(f) by decreasing the expected level of the costly ER activities.

Finally, using Equation 1, as developed under the conceptual DWI system's CIP budgetary assumptions, the expected total CIP budgetary outcome is calculated for each of the DWI risk-sensitive decision response alternatives:

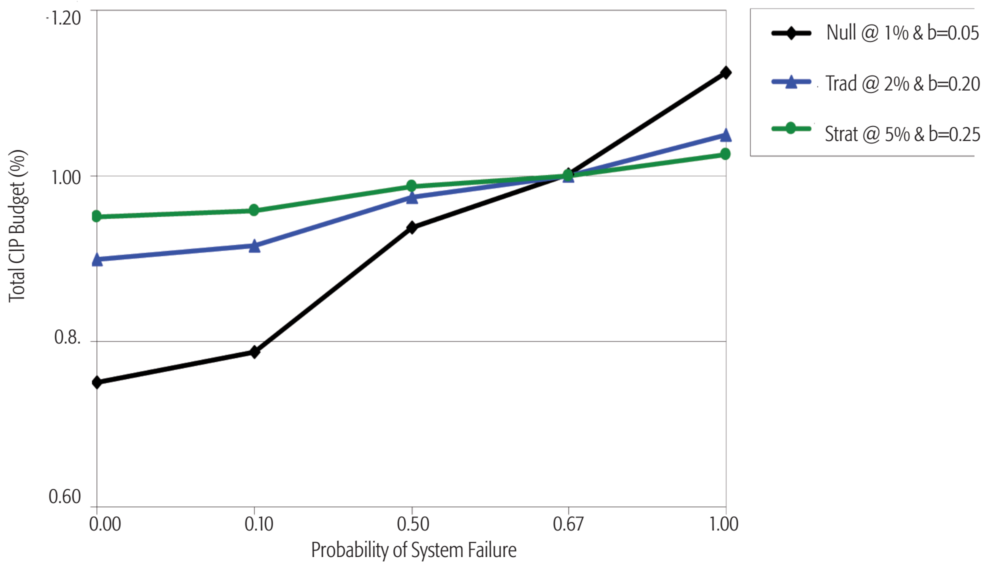
Expected total CIP budgetary outcome =>
T ($/yr) =0.2*T + [p(f)*1.5*(0.3-b)]*T + (b)*T + 0.5*T, given 0.0 < b < 0.3 (1)

The objective risk assessment tool calculates the adverse affects of three risk-sensitive (low, medium, and high) decision response alternatives on the expected total CIP budgetary outcome. The results of this demonstration of the DWI risk assessment tool are shown in Table 3.

**Discussion**

The results of the above demonstration reveal that the implementation of SM activities as part of the MR component can have a favourable impact on the expected total CIP budgetary out-

***Figure 3*** **- Sensitivity analysis for the DWI risk assessment tool showing the impacts of the probability of system failure p(f) on the expected total capital improvement programme budgetary outcome for each of the DWI risk-sensitive decision response alternatives.**



come. An important result to note from Table 3 is that under the DWI risk assessment tool, assumptions increasing the level of SM activities from b=0.20 to b=0.25 impose very little marginal impact 0.95 to 0.96 on the expected total CIP budgetary outcome.

This result suggests that a threshold level exists for which changes to the level of SM activities have an insignificant impact on the expected total CIP budgetary outcome. This result coincides with the Lauer (2001) rule of thumb, which suggests that the overall costs of the MR component can be minimised when the following breakdown is used: the MR component breakdown should be as two thirds of the costs for SM activities and one third for ER activities within the DWI CIP budget.

Intuitively, the DWI decision-maker assumes that as the level of RR increases, the r(f) increases and the p(f) decreases proportionately. However, in order for the p(f) to decrease, the expected level of ER activities must be managed to an acceptable level to have a favourable impact on the expected total CIP budgetary outcome. The DWI decision-maker manages R through optimal tradeoffs between the levels of the ER and SM activities within the MR component of the CIP budget.

The DWI decision-maker uses the drinking water sector's infrastructure and budgetary relationships as illustrated in Figure 2 and Equation 1, respectively, to assume different levels for SM activities for each risk-sensitive decision response alternative under constant r(f) assumptions. The DWI risk assessment tool clearly offers the decision-maker a practical risk assessment methodology to proactively manage the expected total CIP budgetary outcome.

Now suppose that the DWI risk-sensitive decision response alternative and associated level (b) of SM activities are held constant. How will the systems' r(f) and associated p(f) affect the expected total CIP budgetary outcome? This sensitivity analysis is graphically displayed in Figure 3.

The sensitivity analysis results show that under the DWI risk assessment tool assumptions, the p(f) does not negatively impact the expected total CIP budget outcome until the p(f) exceeds 0.67, indicating that a minimal r(f) of 0.33 should be maintained at all times. This phenomenon is explained because, as the p(f) approaches unity, the impact of the premium rates (1.5 to 2) from the expected ER activity costs become more significant, thereby offsetting the benefits of the risk-reduction through the SM activities.

Now suppose the system's r(f) and associated p(f) are held constant across the DWI risk-sensitive decision response alternatives. How will the DWI risk-sensitive decision response alternative and associated level (b %) of SM activities affect the expected total CIP budgetary outcome? This sensitivity analysis is graphically displayed in Figure 4.

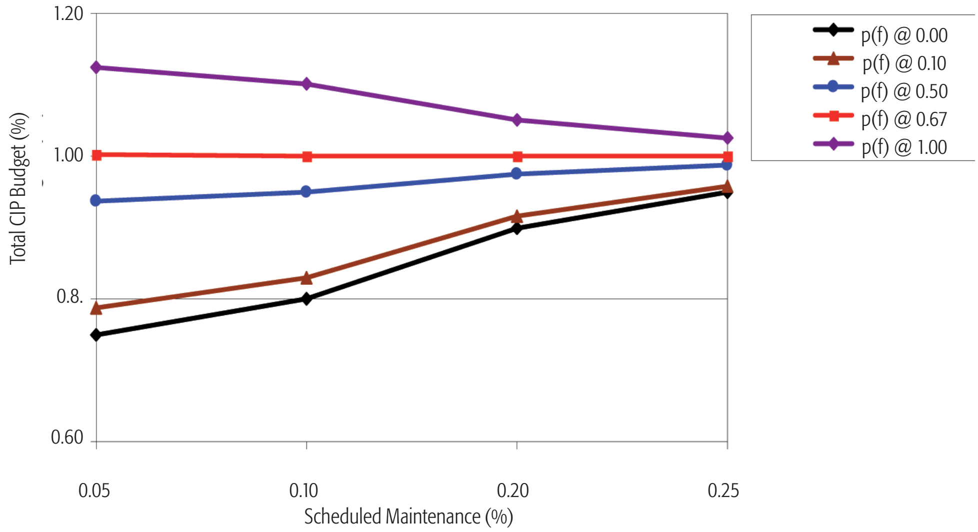



***Figure 4*** **- The sensitivity analysis for the conceptual water infrastructure risk assessment tool showing the impacts of the level of scheduled maintenance activities on the total capital improvement programme budget over the complete range of probability of system failure values for each of the risk-sensitive decision response alternatives.**

The sensitivity analysis shows under the DWI risk assessment tool assumptions, the impacts from the level of SM activity costs on the expected total CIP budgetary outcome over the complete range the p(f) values are partitioned by the risk-sensitive decision response alternatives. As the level of the SM activities increase within the MR component, the overall magnitude of the expected CIP budgetary impact stabilises over the entire p(f) range. This phenomenon occurs because the variability in the stochastic ER activity costs is mitigated by risk reduction through the SM activities.

Under the DWI risk assessment tool assumptions, the magnitude of the expected total CIP budgetary impacts can be migrated by increasing the level of SM activities within the MR component regardless of the p(f). In the same vein, the magnitude of the expected total CIP budgetary impacts can be migrated by increasing the overall DWI's RR regardless of the p(f). Therefore, the DWI decision-maker may elect to take either a 'pay now' or 'pay later' approach to ensure that the appropriate r(f) is maintained through an adequate RR throughout the life of the DWI.

## Conclusions

The goal of this article is to demonstrate the value of an objective risk assessment tool for estimating the DWI decision-maker's sensitivity to the risk. The purpose of the DWI risk assessment tool is to provide the ability for the decision-maker to maintain a desired level of service or reliability, while managing adverse impacts on the expected total CIP budgetary outcome.

The objectives of this article are to incorporate probability of systems failure into the CIP budgetary analysis process and evaluate the affects of probability of systems failure on the expected CIP budgetary outcome. The usefulness of the objective risk assessment tool is demonstrated by defining three risk-sensitive (low, medium, high) decision response alternatives that are encountered by the typical DWI decision-maker.

The paper concludes that the DWI system's level of service directly affects the probability of systems failure, which in turn affects the expected level of emergency repair activities. The DWI decision-maker can minimise their expected total CIP budgetary impact by maintaining a minimum level of service or maximum probability of systems failure threshold through the selection of an adequate rate of re-investment.

Optimising the associated trade-offs between the corresponding levels of emergency repair and scheduled maintenance activities within the maintenance and repair component will mitigate the adverse impacts of the expected total CIP budgetary outcome. When applied to the DWI risk-sensitive three decision response alternatives, the DWI risk assessment tool reveals that by selecting an adequate rate of re-investment to ensure an acceptable reliability, the decision-maker can anticipate the expected impact on the total CIP budgetary outcome.

DWI decision-makers must use practical risk assessment methods, such as the objective DWI risk assessment tool, as a means to effectively reduce risk by efficiently allocating limited financial resources. This means developing risk-avoidance positions through optimal tradeoffs among competing corrective, preventative and proactive maintenance activities within the context of an cost-effective asset management programme over the entire life cycle of the critical components of the DWI system.

Finally, the authors acknowledge that the proposed objective risk assessment tool needs additional verification and validation to assess its applicability at the systems level. ●

### Acknowledgements

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# ASSET MANAGEMENT IN THE CONTEXT OF OPERATION & MAINTENANCE CONTRACTS


This paper addresses the issues associated with asset management in the context of operations and maintenance contracts. The paper:

- identifies the key issues associated with the asset management function for services contracts
- outlines the various contractual approaches to asset management
- assesses how each approach deals with the key issues and risks
- sets out the advantages and disadvantages of each contracting approach
- and suggests an approach likely to maximise the value added to the asset management planning process by both parties



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## What are the key asset management issues?

In developing an operation and maintenance contract, a utility usually has a good grasp of the physical services that it wishes to include in the contract, such as network or treatment plant operation, burst main repairs, billing services and the like. The allocation of responsibility for these physical services between the contractor and the client utility is usually clear cut. When it comes to asset management, however, the allocation of responsibilities between the contractor and the client is not so straightforward, and careful consideration of this allocation is required in order to obtain an optimal outcome.

In considering how best to manage the asset management function in the context of an operation and maintenance contract there are a number of key issues that need to be considered. These issues are described below.

### *Defining what is maintenance and what is capital*

This is an area that needs to be clearly defined in any services contract, particularly in contracts where the contractor is responsible for maintenance activities (and receives a fixed fee for these tasks) and where the client is responsible for providing capital for new works, system improvements and major upgrades. The issue largely arises where part of an asset needs to be replaced (pump, length of pipe etc.). For options where the client is providing the capital, unless there are unambiguous rules set in the contract, the contractor has an incentive to claim capital work wherever possible, as this does not come out of the contractor's fixed fee.

### *Maintaining asset condition knowledge*

The level of asset condition knowledge held by the client can vary significantly depending upon the contract model adopted. Whether or not having a thorough knowledge of asset condition is critical depends on a number of factors including the organisation's strategic business objectives, the term and scope of the contract and the nature of the contract partner.

### *Measuring/specifying asset condition*

Contract forms that involve the contractor taking responsibility for renewal and capital investment decisions require a mechanism to ensure that the asset base is not being run down, particularly for longer term contracts. Specifying and measuring asset condition at the end of the contract period is extremely difficult and is compounded by factors such as:

- most of the assets being buried;
- an imperfect knowledge of the condition of the asset base in the

first instance;

- the age, material and condition of the asset base, and the influence of these factors on asset performance. For example burst rates in a particular area may increase over the life of the contract purely because of the age and characteristics of the pipelines, rather than because the level of service provided by the contractor has decreased; and
- the difficulty in determining (and measuring) what is an appropriate asset condition at the end of the contract.

*Optimising opex and capex solutions*
Achieving the lowest lifecycle cost is a key asset management objective. To achieve this a mechanism is required that links the operational implications of various investment decisions into the capital planning process. The cost of capital also needs to be considered, and particularly the difference in the cost of capital for the client and the contractor. For example, capital investment decisions made by the client may well be different to capital investment decisions made by the contractor purely because of the varying cost of capital.

*Capital programme management*
Determining how the capital program is managed, in terms of the delivery of the capital programme, is not a critical issue in determining how asset management planning should be carried out. Nevertheless the delivery of the programme needs to be consistent with the allocation of asset management planning responsibilities, and must dovetail with system operation. Further, one party should not be incentivised to maximise capital (as opposed to operational) solutions because of the subsequent fees received in managing the capital programme.

*Flexibility in varying the capital programme*
Business objectives, regulatory requirements and shareholder aspirations may change over the period of the contract. This may require flexibility in determining the amount of capital expenditure to be made from year to year. If flexibility to vary the capital expenditure on an annual basis is a business requirement then this needs to be taken into account in determining the contracting approach.

*Certainty of long term costs*
The opposite of flexibility is certainty of cost. For example a contract option that locks in expenditure over the long term into a fixed tariff provides certainty of costs over that term, which may suit a long term pricing model. Conversely, costs to the business will vary from year to year if the capital program is funded directly by the client, as the programme will rise and fall over time.

*Value adding*
The amount of potential value added to the business by the contractor is proportional to the contractor's role in business decisions, provided that the contractor is incentivised to act in the interests of the client. From an asset management perspective, for a contractor to be able to add value the contractor would need to be involved in the asset management planning process.

*Asset condition and serviceability risk*
The allocation of asset management planning responsibilities needs to follow the allocation of asset condition and serviceability risks. Asset condition and serviceability risks cannot be allocated to a contractor if the contractor is not responsible for asset management planning and determining the capital investment decisions.

*Asset cost risk*
Similar to the allocation of condition and serviceability risk, the allocation of risks associated with the cost of the assets in the long term (from an operations and maintenance perspective) must be consistent with the allocation of asset management planning responsibilities.

*Exit arrangements*
A final key issue that needs to be considered is the transition process and transfer of information at both the end of the contract and in the event of early contract termination. A potential loss of strategic knowledge (in relation to the assets) needs to be avoided.

### What are the options for asset management planning?

There are three broad options for carrying out asset management planning in service contracts, with these being:

- asset management planning being carried out by the client;
- asset management planning being carried out by the contractor; and
- asset management planning being a shared task carried out jointly by the client and the contractor.

Each of these approaches are outlined below.

*Asset management planning by the client*
This is the usual approach used in services contracts. Under this approach the client is responsible for asset management planning and capital program development. The contractor is required to identify assets where capital expenditure is required in order to allow the required service standards to continue to be met. If a need was demonstrated and the capital was not provided by the client then the contractor would be relieved of the appropriate performance obligation relating to the particular asset.

*Asset management planning by the contractor*
This approach can take two forms, depending upon who provides the capital for the renewal activities.

*Client supplied capital*
Under this approach the contractor carries out the asset management planning and capital programme development. Approval of the capital programme and the provision of funds is provided by the client.

Under this arrangement the client may still need to retain a strategic planning capability to deal with growth issues and the provision of services (new schemes) to any unserviced areas, as well as a capacity to review (and regulate) the contractor's proposals.

*Contractor supplied capital*
This approach is close to a full concession (where the contractor/ concessionaire is responsible for almost all aspects of the business, and bills consumers directly. Under a concession the contractor is typically required to invest capital to meet defined population coverage requirements). A modification, however, is that the contractor provides all capital for maintenance of the existing asset base, with the client providing capital only to meet growth needs or because of a need driven by a change in law (or change in service standard made by the client).

*Shared asset management planning*
Asset management planning can be treated separately to the provision of operations and maintenance services, and a joint asset management or technical services team developed. Funding of the shared team is through a separate payment structure to the provision of O&M services, however asset management planning still forms part of the contract. Funds for the capital programme, when developed, are provided by the client.

### How do these contract options deal with the key issues?

Each of the above contract options deal with the various asset management issues, discussed, in different ways. The way that the various options deal with the issues is summarised in Table 1, overleaf.

### Advantages and disadvantages of each option

The advantages and disadvantages of each option have been summarised in Table 2, overleaf.

From the various advantages and disadvantages and the material provided above, it can be seen that the shared asset management planning approach is likely to provide the optimum outcome. The other options each have positive aspects, however they each have significant drawbacks.

An approach that could be used to implement a shared asset management planning arrangement is outlined below.

***Table 1***
**How various contract options deal with asset management issues**

| Issue | How issue is handled | | | |
|---|---|---|---|---|
| | **AMP by client** | **AMP by contractor (client capital)** | **AMP by contractor (contractor capital)** | **Shared AMP with separate payment structure** |
| **Defining maintenance and capital** | Needs clear contractual guidelines – potential ongoing challenges to definitions. Need strategic review of replacement decisions. Maintenance risk on replaced plant and equipment. | Needs clear contractual guidelines – potential ongoing challenges to definitions. | No interface issues as contractor responsible for both maintenance and capital. Could be an issue where growth is concerned. Implications associated with differences between client and contractor costs of capital. Also transition issues with payout of unamortised costs. | Needs clear contractual guidelines. Potential for ongoing challenges to definitions, depending upon relationship. Creative tensions to optimise outcomes. |
| **Maintaining asset condition knowledge** | Client retains knowledge of asset base (contractor reports data but threat that there is no mechanism to turn data into useful information). Lacks operational link. | Prime knowledge of asset condition held by contractor. No resource within client to make use of data and/or information. Issue of strategic ownership of knowledge, particularly as time progresses. | Prime knowledge of asset condition held by contractor. No resource within client to make use of data and/or information. Client can take an audit role (and recover 'time slice' of information for rebidding purposes). | Client retains knowledge of asset base. Has an operational link into the planning process. |
| **Measuring/specifying asset condition** | Not a critical issue as client carrying out AMP. Requires oversight of contractor performance and maintenance plans. | Potential for asset condition to be unnecessarily improved to reduce opex. | Difficulty in ensuring asset condition adequately maintained. | Not a critical issue as client involved in AMP. Requires oversight of contractor performance and maintenance plans. |
| **Optimising opex and capex solutions** | Potential for client to refuse capital solutions because of competing short term considerations. Relief of performance requirements if contractor identified need (justified) not funded by client (contractor needs to nominate circumstances and outcomes of failure). | Potential for contractor to propose capital solutions to reduce opex. Relief of performance requirements if contractor identified need (justified) not funded by client (contractor needs to nominate circumstances and outcomes of failure). More emphasis on forward notice and justification for capital budgeting. Incentivate for optimisation. | Opex and capex will be optimised based on business case or performance standard outcomes. Optimised at contractor cost of capital, which may be different to client's cost of capital. | Opex and capex should be optimised if AMP team is balanced with mutual goals. Relief of performance requirements if contractor identified need (justified) not funded by client (contractor needs to nominate circumstances and outcomes of failure). More emphasis on forward notice and justification for capital budgeting. Shared assessment of risks. |
| **Capital programme management** | Could be by client or by contractor. Notionally better by contractor because of operational interface, however no flexibility if contractor not performing | Could be by client or by contractor. Notionally better by contractor because of operational interface, however no flexibility if contractor not performing. If carried out by contractor, contractor payment structure (and incentive to maximise capital solutions) becomes an issue. | By contractor. | Could be by client or by contractor. Notionally better by contractor because of operational interface, however no flexibility if contractor not performing. |

| Issue | How issue is handled | | | |
|---|---|---|---|---|
| **Flexibility in varying the capital programme** | Flexible. Would be an issue if capital not provided for a justified contractor business case. Reduced flexibility because of contractor cost outcomes (capitalisation of resources etc.) if contractor implementing the capital programme. | Flexible. Would be an issue if capital not provided for a justified contractor business case. Improved flexibility compared to AMP by client. | Inflexible. Contractor pricing based on anticipated capital spend and locked in for duration of the contract. | Fully flexible. Would be an issue if capital not provided for a justified contractor business case. |
| **Certainty of long term costs** | Relative certainty with regards to opex. Capex certainty at the discretion of client. | Relative certainty with regards to opex. Capex certainty at the discretion of client. Potential for lower opex because of contractor tendency to unnecessarily improve assets, however resulting capex higher. | Certainty of total costs. | Relative certainty with regards to opex. Capex certainty at the discretion of client. |
| **Value adding** | Contractor adds no value to the asset management planning process. | Takes advantage of contractor expertise in AMP but no skills transfer to client. | Takes advantage of contractor expertise in AMP but no skills transfer to client. | Optimises contractor and client expertise. Optimisation of resources to achieve high potential for adding value to client's business. Greater potential for skills transfer under a shorter contract timeframe. |
| **Asset condition and serviceability risk** | Risk retained by client. | Risk transferred to contractor provided that necessary (justified) capital provided by client. | Risk transferred to contractor. | Risk transferred to contractor provided that necessary (justified) capital provided by client. Better framework to avoid divergence. |
| **Asset cost risk** | Client retains risk of capex requirement, opex risk transferred to contractor. Issues with increased opex requirement for equivalent level of opex due to asset age profile. Cannot include any asset condition related KPIs into the contract. | Risk transferred to contractor provided that necessary (justified) capital provided by client. Issues with increased opex requirement for equivalent level of opex due to asset age profile. | Risk transferred to contractor. May require an interim sharing/transition of risk until contractor obtains a better understanding of the risk. | Risk transferred to contractor provided that necessary (justified) capital provided by client. Issues with increased opex requirement for equivalent level of opex due to asset age profile. Better framework to avoid divergence. |
| **Exit arrangements** | Not an issue as all information held by client. | Recovery mechanism required to enable information and skills transfer/ recovery. Extended transition and exit plan required. | Recovery mechanism required to enable information and skills transfer/ recovery. Extended transition and exit plan required. | Not an issue as all information held by client. Need a mechanism to ensure that some skills not solely retained by the contractor. |

## Approach to shared asset management planning

Asset management includes both an operations and maintenance (O&M) and a capital expenditure component. Day to day O&M would be carried out solely by the contractor, and the contractor would be responsible for routine preventative and breakdown maintenance to ensure that the assets are properly maintained. This paper is focussed on the capital expenditure side of asset management and ensuring that there is an appropriate link between this and the day to day O&M. The capital expenditure components that need to be addressed are:

- Growth – which includes both population/load growth within the existing serviced areas as well as system extensions as a result of new developments/developer works;
- Renewal – renewing/replacing existing above and below ground assets that have either reached the end of their useful life or unable to meet customer service requirements;
- Water and Effluent Quality – works required to meet new (or existing) water and effluent quality standards;
- Hydraulic (backlog) – works required to deliver the required water flow and pressure to the

| | AMP by client | AMP by contractor (client capital) | AMP by contractor (contractor capital) | Shared AMP with separate payment structure |
|---|---|---|---|---|
| **Advantages** | • Client familiarity with asset base and control of knowledge (provided adequate knowledge management system)<br>• Client familiarity with role Flexibility in setting capital programme<br>• No issues in contractor commencement and termination<br>• Clear allocation of responsibilities<br>• Does not limit potential market of suppliers | • Potential application of contractor knowledge<br>• Flexibility in setting capital programme<br>• Re-benchmarking of AMP process at each contract turnover (for short term contracts)<br>• Opex and capex considered concurrently<br>• Contractor ownership of outcomes<br>• Contractual drivers for delivering the AMP<br>• Clear allocation of responsibilities<br>• Removes master-servant relationship | • Removes maintenance and capital definition interfaces<br>• High certainty of costs to client for the long term but likely to be a premium paid for the risk transfer<br>• Well suited to price based regulation<br>• Potential application of contractor knowledge<br>• Opex and capex considered concurrently and forces optimisation<br>• Contractor ownership of outcomes<br>• Clear allocation of responsibilities | • No marking up across boundary – resource optimisation<br>• Potential transfer of knowledge and skills to client<br>• Opex and capex considered concurrently<br>• Capital programme has ownership of both parties<br>• Provides both verbal and written communication interface<br>• Client familiarity with asset base and control of knowledge (provided adequate knowledge management system)<br>• Flexibility in setting capital programme |
| **Disadvantages** | • Master-servant relationship<br>• Contractor is organisationally divorced from creation of the AMP and ownership of the outcomes<br>• Interface issue where contractor can nominate any amount of projects that require work but doesn't carry any responsibility for prioritising them<br>• Significant disconnect in considering opex and capex<br>• Potential communication problem as no process of engagement to understand actual issue<br>• Potential for capital plan to ignore operational implications | • Transition issues<br>• Contractor partially incentivised to reduce effort to increase margin<br>• Tendency towards conservatism (with focus on opex reduction)<br>• Client needs to maintain separate strategic planning capability | • Master-servant relationship reversed – client completely reliant on contractor<br>• Capital categorisation issues and scoping of risks<br>• Inability to effectively control asset condition at end of contract<br>• Client has no flexibility in capital spend<br>• Transition issues<br>• Limits field of capable contractors further<br>• Capital investment decisions based on contractor's cost of capital rather than client's<br>• No transfer of knowledge to client<br>• Increased political risk<br>• Client needs to maintain separate strategic planning capability | • Relies on maintaining relationships as no clear interface<br>• Potential declining contractor incentive late in the contract<br>• Lack of ability for contractor to reward himself |

*Table 2* - Advantages and disadvantages of different AMP contract options

existing population (vice versa for wastewater); and
- Improvements – works associated with safety, aesthetics, operational improvements, etc.

If the above areas were to be allocated to a single party (i.e. the client or the contractor) on the basis of the party in the best position to manage, then the allocation would be as follows:

| Client | Contractor |
|---|---|
| Growth<br>Water and<br>Effluent Quality | Renewal<br>Hydraulic<br>Improvements |

Such an allocation, however, ignores the linkages between the various works components. For example, a renewal or replacement activity considered on its own may not adequately address growth issues; similarly operational improvements in a particular area may avoid the need to spend a large amount of capital.

Therefore, for the assets to be managed appropriately and capital expenditure optimised, the AMP process requires input from both the client and the contractor. The potential for the development of optimal (and breakthrough) capex/opex project solutions will be enhanced if both parties are involved together in the AMP process. ●

# Developing a Master Asset Protection Plan: a road-MAPP for success

Are you utilising best practices? As stewards and trustees of multi-million dollar portfolios, we need to focus on adopting a long term asset management philosophy to help create a more organised and effective lifecycle team (i.e. planning, engineering, design, construction, O&M). An organised approach will lead to significant financial benefits. For the past eight years, the author's efforts have been focused on identifying and implementing best asset management practices. Currently and as a former utility manager (or practitioner), he is involved with local, national and international research and collaboration with various public and private industries. As a result, he has collected and tested tools and techniques in order to define a total enterprise asset management model called the 'Master Asset Protection Plan', or a road-MAPP for success.

**John W Fortin**
Asset Management Consultant
USA



**One interesting facet: whether we manage physical assets in utilities, academia, healthcare, or manufacturing, our roles are 90% the same and only 10% different. The difference is in the product delivered and the customers we serve. A successful Master Asset Protection Plan demands involvement from key business units: planning, finance, engineering, information technology, construction, operations and maintenance. Employing change management principles will ensure that your organisation adopts and integrates asset management best practices and reaps the associated long-term benefits. This article outlines fourteen core MAPP principles, along with explanations of each element based on first hand experience.**

*1) Asset Register – a master register/ inventory of building, plant and infrastructure assets maintained in the asset register. Each asset receives a criticality value and a unique identifier to use with supporting programmes/technology.*
The asset register should include all assets. A preventive maintenance programme should be assigned to each, whether it is an inspection, preventive or predictive task. Many organisations only capture equipment assets and forget about buried piping and the building envelope. If an inventory is needed, consider a cost-effective approach similar to one utilised at a large utility. Since a team of engineers were already slated to inventory each facility, they also tagged (with a unique identifier or 'smart number') and performed equipment condition assessments. Prior to embarking on this effort, an automated process was developed with off-the-shelf software technology which supported sequential, non-duplicated tagging and collection of condition data for timely use in the capital improvement planning (CIP) process as well as equipment data input into their computerised maintenance management system (CMMS). A future effort developed a criticality scheme that would be used in prioritising equipment for a maintenance optimisation programme, and would also be used in helping to prioritise projects against these assets.

*2) Condition Assessment/Monitoring – a programme that collects and monitors the condition and/or performance of all assets. Because data collection is expensive, a criticality/prioritisation process determines depth and frequency so that critical assets are monitored more frequently.*
Many organisations confuse condition assessment and condition monitoring terms. Traditionally 'condition assessments' are completed well into an asset's life and used to develop scope as part of a capital renewal project. This is a reactive and costly approach. The maintenance strategy should include regular condition assessment/ monitoring tasks for all asset types. The approach will vary quite a bit depending on the asset and its importance in meeting the organisation's mission. At a water treatment plant for example, continuous condition monitoring (on-line vibration) is used for high-speed critical equipment and a manual 'walk-around' programme is used for second tier, lower speed equipment. In addition to the five human senses, other condition monitoring techniques include oil sampling and infra-red scanning.

Building envelope assets (roofing, siding and windows) can be monitored through visual condition assessment/ inspection tasks. And since these decay at a lower rate than mechanical assets, the frequency could be extended to every 2-5 years, depending on where they are in their decay curve.

*3) Design and Construction Standards – a new projects programme includes O&M Readiness practices such as tagging/smart number coordination, maintainability reviews, maintenance plan development and appropriate technology purchases. These items are coordinated with the facility*

*management team leading to a smoother and cost-effective transition from the design/construct phase into the O&M phase.*
Design and construction standards need to keep the facility managers interest in mind. All too often the drivers for new facilities are cost and schedule., where management teams tend to focus on 'first costs' and not lifecycle costs. At one facility, detailed standards and procedures were developed with the facility management team that accounted for safe and easy access for serviceability, asset naming matched existing CMMS naming standards, vibration tolerances for high-speed equipment were detailed and a 'vibration signature' created at turnover as a baseline for decay monitoring.

The design process should also require a full facility lifecycle cost analysis. As part of this effort, team members should develop a maintenance plan that includes a list of active and static assets, appropriate maintenance plans, and a 10-year budget projection, including a staffing plan, to meet the PM programme's needs. While this is the correct (and often tedious) approach to fully fund the operation-specific facility, some owners, executives, and managers choose to ignore this and mandate a zero-budget increase.

*4) Maintenance Strategy – a mix of maintenance policies (determined through a criticality review) help monitor and maintain asset health. Policies must include preventive (PM), predictive (PdM) and condition assessment/monitoring practices managed through a Computerised Maintenance Management System (CMMS) and performance metrics.*
The time-based PM should be employed only when an adequate predictive technology to identify machine faults is not available. Studies have shown that approximately 10% of machine failures occur due to time or operations-cycle based wear. The other 90% of equipment failure modes have no equipment age to failure rate relationship, and therefore are said to be random in nature. This means that for most equipment failure modes, time-based PM inspections are inadequate for mitigating the occurrence of failure. In addition, inappropriate use of invasive PM procedures may introduce faults, or instability, in an otherwise healthy machine – exactly the opposite of the desired impact!

There are tools out there to help automate the maintenance process. Depending on the size and extent of your asset base, a computerised system should be employed.

*5) Renewal/Replacement Planning – Capital improvement planning driven by accurate condition assessment/monitoring and maintenance information with projects prioritised by a criticality framework. New CIP projects include O&M Readiness practices and a complete maintenance programme analysis to ensure proper staff and resource budgeting.*
If a comprehensive maintenance strategy is in place, our assets will live well beyond their expected lives. There also needs to be a connection point between the maintenance department and the planning and finance groups to ensure timely renewal of aging and problematic assets. At one organisation for example, a Project Identification and Prioritisation (PI&P) process was created to link the maintenance supervisor's needs to the capital budgeting/planning process. Sizeable maintenance projects were then identified and captured during the normal budgeting process ensuring renewal/replacement prior to catastrophic failure and cost impacts from secondary damage.

*6) Sustainable Financial Plans – short and long-term budgeting and funding strategies match asset management principles and programme requirements. Goals include proper funding levels to avoid deferred maintenance.*
As we know, each asset has a unique deterioration/failure pattern (See Figure 1). If the maintenance strategy accounts for this and there is a feedback loop to the budgeting process, then long term financial forecasts will be more accurate. At the same organisation noted above, the PI&P process connected the 'voice of maintenance' to the annual budgeting process. So the financial plan not only included budgeting for master planning and growth, but for cyclical rebuilt projects (i.e. large compressors) and renewal projects (i.e. VFDs that had a 10-year particular life). Once the financial plans are well understood, then rate/fee structures can be more appropriately set allowing for adequate funding. Sustainable financial plans now take into account renewal/replacement requirements helping to control deferred maintenance.

*7) Organisational Framework – departmental silos are minimised, MAPP programmes are designed, implemented and monitored at a corporate level, and MAPP principles are daily policy.*
With any large scale initiative, it is strongly recommended that a steering or guiding coalition be created with key department managers. This group should initially meet on a regular basis to ensure the MAPP is aligned with the organisation's business plan and that everyone agrees on which practices will be included in the programme. In one case, a large utility re-organised completely to meet new goals set in their re-aligned business plan. And in another case, strategic asset management positions were created along with inter-departmental task teams to help facilitate the adoption of new practices. In both cases, a corporate spokesperson/champion was assigned, linking the effort to the executive team agenda.

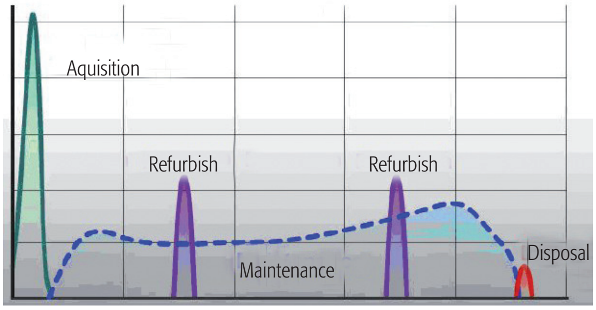


***Figure 1***
**Asset Life-Cycle Profile**

*8) Documented Policies/Procedures – asset management processes including planning/design/construction, maintenance, renewal/replacement, and associated MAPP policies are documented and reviewed annually.*
As change is made, new policies and procedures need to be developed and should be captured in a 'standards manual' managed by the asset or facility management department. Training on these new procedures is critical to timely adoption and change sustainability.

*9) Document Control – a programme where new asset documents (vendor cut-sheets, as-builts, and O&M manuals) and engineering programmes (CAD and standard specifications) are fully maintained and coordinated with facility management programmes.*
For this to be effective, the design and construction specifications need to include appropriate language and be coordinated with in-house facility management and information technology (IT) data standards. At one facility, a specification section was created for new construction projects that required electronic O&M manuals and a new 'smart number' naming scheme for as-built drawings and technology data standardisation (i.e. SCADA, CMMS and GIS). In addition, this facility created a formal technical information center (TIC) to help develop and control the lifecycle of these documents as well as manage the 'smart numbering' system.

*10) Technology and Data Management – a programme with the most appropriate technologies (CMMS, SCADA, GIS,* *EMS, financial) in place (and integrated, as appropriate) to support all MAPP principles. The programme must include appropriate staffing/budgeting levels to keep the technologies up to date and control data input for accurate reporting.*

The IT department needs to be part of the asset management organisational initiative and not out on their own. It is important that processes are documented on paper first prior to trying to automate them with technology. And once selected and implemented, there needs to be data entry control points. If not, the data quickly becomes contaminated and reporting less accurate. At one organisation, the maintenance team knew about the poor data quality, did not trust the reports and stopped using the programme, negating the return on investment opportunity. At another facility, IT staffing was cut and software upgrades/patches went unmanaged which led to an outdated and problematic system.

*11) Risk/Criticality Framework – an appropriate prioritisation process developed by key stakeholders that includes likelihood/probability and consequences of failure. The framework is a foundation element that applies to all asset prioritisation, maintenance programme selection, and renewal/replacement planning.*

Historically, prioritisation is usually given to those speak the loudest or who are 'connected' to decision makers. The use of a formal risk/criticality process can minimise the impact of such activities. It can be used to help prioritise capital projects and maintenance work.

At one large, complex facility, a prioritisation/criticality framework was used to prioritise which equipment assets would be included in a comprehensive Reliability Centered Maintenance (RCM) programme. RCM is a resource intensive effort which requires the most knowledgeable and experienced staff to collaborate in building a custom maintenance programme. Use of the criticality analysis helped break equipment assets into three categories that then received a different level of analysis. The outcome was a grouping of critical assets (See Table 1, above) that would undergo RCM; second tier critical assets would undergo an optimisation review and the low priority ones would remain with original equipment manufacturer (OEM) recommended maintenance tasks.

**Table 1: Is RCM for all assets?**

No. It is not appropriate for all assets, and it doesn't make financial sense. So, all equipment assets were prioritised using a criticality/risk model. Then the top 1/3 of the assets were selected for review under the RCM review process.

| Equipment | Maintenance Strategy |
|---|---|
| 1. Critical / Problematic (e.g. main water pumps) | RCM Review |
| 2. 2nd Tier Systems (e.g. back-up pumps) | Optimisation Review |
| 3. Support Systems (e.g. sump pumps) | OEM Recommendations |

*12) Performance Metrics – stakeholders use a variety of key performance metrics (KPIs) to drive change and manage performance.*

The glue that holds any programme together is the use of performance measures. The old adage, 'you can't manage what you don't measure' is very true. Sometimes called service levels, measures or metrics, they are needed to help set expectations and targets to meet a desired standard of performance. There are roughly three types of metrics; regulatory (i.e., air and wastewater discharge permits), customer (i.e., odour complaints, repair response time) and internal (time to complete maintenance tasks, cost and schedule for construction projects).

Monitoring initiative performance over time is important, but with multiple initiatives it can cloud results. So overlaying other initiatives to see their impacts can be helpful. At one facility, they monitored the percentage of maintenance work orders completed over time against the target of 90%. They also documented initiation of their RCM effort. As noted above, RCM involves maintenance staff and really considers their opinions as expert. So, as shown in the PM performance monitoring chart (Figure 2), once the RCM programme started the maintenance team felt valued and took pride in meeting (and exceeding) industry benchmark targets set by management.

*13) Training and Communication – active annual training programmes ensure that staff possess current knowledge of asset management principles. A Communication Plan regularly publicises MAPP performance and effectiveness.*

It is imperative that as best practices are adopted, regular training programmes are budgeted to keep staff proficient in those areas.

The Communications Plan is another essential component to a successful optimisation campaign, allowing connectivity between workforce members and business goals. Regular communication to staff, users and regulators can be done through simple means such as presentations and newsletter articles, or as extensive as developing an intranet site. There should be a focus on the status and results/benefits of project activities and their related impacts on business objectives, and rewards provided to those involved.

*14) Leading Change Effort – a corporate sponsor and guiding coalition/steering committee made up of key business unit leaders develop the programme's Mission and Vision including identifying and supporting internal change agents. Internal change agents should be well respected by their peers.*

Change management techniques should be adopted early and often when implementing a large scale management initiative. Models such as

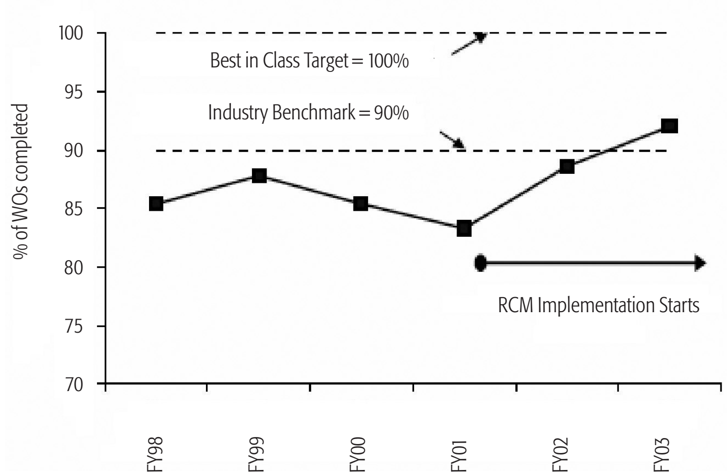


***Figure 2*** **Preventive Maintenance**

**Table 2**

| Kotter Steps | Large Public Utility Asset Management Programme |
|---|---|
| 1. Establish a Sense of Urgency | Rates increased significantly due to new plant<br>Threat of privatisation |
| 2. Create a Guiding Coalition | AM Programme Steering Committee created<br>Two dedicated Positions established |
| 3. Develop a Vision and Strategy | AM Programme mandated in Corporate Business Plan<br>Consultant Request for Proposals (RFP) developed |
| 4. Communicate the Change Vision | Implementation Concept Plan developed<br>Regular Presentations made and Meetings held |
| 5. Empowering Broad Based Action | Three Implementation Teams created<br>Site visits/collaboration meetings held |
| 6. Generate Short-term wins | Professional Association Award received<br>Project published in trade magazine |
| 7. Consolidate and Produce More Change | Created a multi-year plan<br>Expanded to seven Task Teams for new practices |
| 8. Anchor New Approaches in the Culture | Job Descriptions modified to include new skills<br>Promoted staff with new skills |

the 8-step process detailed by John Kotter in his *Leading Change* book is a viable option and should be considered. As detailed in Table 2, overleaf, one organisation mapped their facility asset management programme's success to the Kotter process somewhat verifying that this model is one to be considered.

### Summary

Embarking on a comprehensive management optimisation process like asset management takes time and diligence at many levels. Some clients have documented that successful implementations have taken between 24 to 60 months. So there is a need to plan accordingly and treat the endeavour as we treat a capital construction project: with a project manager and a multi-year budget. Benefits have been reported in both live and simulated scenarios to provide an average 3-year return-on-investment, making it an endeavor to strongly consider.

A successful asset management programme includes a combination of core principles, careful planning and a commitment of resources. This is a difficult task with pressures of normal workloads and competing corporate initiatives. Executive sponsorship, designated champions in each business unit along with a road-MAPP or model and continuous communication at all organisational levels can facilitate the change required to maintain a successful and rewarding asset management programme. ●

## AM DIARY

**A listing of upcoming asset management-related events and conferences. Send event details to WAMI for inclusion.**

*CNAM Workshop – Canadian National Asset Management*
**13–16 May 2007**
**Hamilton Ontario, Canada**
Over the past several years many Canadian Municipalities have made significant advancements in Right of Way (ROW) Infrastructure Asset Management practices. These advancements have created the need, in Canada, to seek a common understanding on ROW Infrastructure Asset Management Practices and to explore new ideas that will lead to sustainability. The workshop objectives are to disseminate knowledge on tools, techniques, philosophies and emerging practices; to develop consensus on asset management philosophies and future needs, and to establish an index of achievable strategic tasks which can be undertaken by municipalities within a 3-5 year period.
**Email: assetmanagement@hamilton.ca**
**Website: www.cnam.ca**

*2nd World Congress on Engineering Asset Management* and *4th International Conference on Condition Monitoring*
**11–14 June 2007**
**Harrogate, UK**
Recognised as the foremost international conferences in their fields, these events will bring together world leading technology and business practitioners and prominent academics.
The combined International Forum is organised by the Condition Monitoring and Diagnostic Technology (COMADIT) Committee of the British Institute of Non-Destructive Testing (BINDT) in partnership with the Centre for Integrated Engineering Asset Management (CIEAM). The interdisciplinary event wil feature:

- Industrial & academic papers combining scientific, technical & management perspectives
- Workshops & tutorials
- World leading forums for major industrial sectors
- Expert panel sessions
- Extensive exhibition & vendor presentations
- Case study presentations

World leading academics and technology specialists from industry and commerce will take centre stage to discuss the most important issues related to engineering asset management and condition monitoring.
Delegates to the three day Forum and exhibition will be able to investigate best practice and benefit from an international breadth of knowledge on topics including:

- Engineering asset management (EAM) & condition monitoring (CM) methods, techniques, systems & applications
- Risk & strategic asset management
- Knowledge management, optimisation & efficiency
- Diagnostics methods intelligent data & signal processing
- Maintenance & performance in EAM & CM
- Design & life cycle integrity

The forum will be of value to Heads of Asset Management, Condition Monitoring, Infrastructure Maintenance, Engineering, IT and Technical Services; IT Professionals, Asset Managers, Chief Engineers and many more…

For further information and to register for this event, visit **www.wceam-cm2007.org**

*2nd Leading-Edge Conference & Exhibition on Strategic Asset Management*
**17–19 October 2007**
**Lisbon, Portugal**
The 2nd Leading-Edge Conference & Exhibition on Strategic Asset Management will be focused on the techniques, technologies and management approaches aiming at optimising the investment in infrastructure while achieving demanded customer service standards. The conference will provide the perfect platform to discuss the developments at the leading-edge in this field to an audience of utility personnel, regulators and consultants.

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