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PAPERS

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IBM signs asset partnership with Yarra Valley Water

IBM has announced a business consulting and technology partnership with Australian utility Yarra Valley Water to enhance the management and functionality of its assets and customer service to over 1.7 million people and 50,000 businesses throughout Melbourne.

The partnership will see Yarra Valley Water consolidate several systems into a single platform. This includes approximately 19,000km of water and sewer pipes, 79 water pump stations, nine sewage treatment plants and two recycled water facilities. This holistic view will provide Yarra Valley Water with the ability to collect, combine and analyse data from across its asset portfolio.

These insights will improve customer service by enabling the issue to be more accurately diagnosed and prioritised on the first call, says IBM. The IBM solution enables the customer service desk to have access to all customer information on a custom-made, single screen that makes it easier to define the customer problem.

With all relevant data available in one place, the system will enable the company to analyse historical data from the entire water and sewerage network. With employee safety a key aspect of the company's operations, IBM worked with Yarra Valley Water to introduce a Permit Monitoring application in the control room, enabling teams to visually monitor active permits in the system and attain graphic alerts when an incident or event requires attention.

The new asset management solution has streamlined customer service in the Call Centre where representatives are now able to access information on a single screen as they respond to customer calls. The change has increased the efficiency of interactions with customers – saving time and improving satisfaction levels, says the company. ●

Study urges change to global standards for water and sanitation access

A recent study from The Water Institute at the University of North Carolina and the London School of Hygiene and Tropical Medicine has called for a new, rationalised global standard for improvements to household potable water and sanitation access.

The study, published in online journal PLOS ONE, explains that current access benchmarks established by the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP) treat water and sanitation differently, masking deficits in household water access.

The JMP will shortly be setting new targets for global progress in the new Sustainable Development Goals, which means the study is likely to be significant.

The problem is that existing benchmarks allow a potable water source to qualify as 'improved' if it is provided at community level, whereas for sanitation to be deemed 'improved' it has to be provided at household level.

Using the existing benchmarks, the figures suggest nearly three times as many people lack access to improved sanitation than to improved potable water sources.

The researchers recalculated the known progress using matching benchmarks, which showed that progress in sanitation outpaced water between 1990 and 2015.

Professor Jamie Bartram, of the Water Institute, said: 'Our findings have significant implications for how we measure progress towards universal access. Drinking water and sanitation are essential for good human health and the benefits are maximised when delivered at home.' ●

EPA drinking water report reveals 121 'at risk' supplies

The Irish Environmental Protection Agency has warned in its latest drinking water report that 121 'at risk' water supplies serving nearly one million people need investment to ensure they meet proposed future standards.

The 2013 drinking water report found that 99.8% of samples from public potable water supplies complied with microbiological limits, and 99.5% of samples were in line with chemical limits.

Among the 'at risk'... **(continued overleaf)**

water asset management INTERNATIONAL

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is a Dublin treatment system that serves around 130,000 people and the supply for the city of Cork, which provides water to 123,000 people. Both were identified as having 'treatment and management' issues.

Gerald O'Leary, the director of the EPA's office of environmental enforcement, warned that the good compliance figures masked 'the specific and serious problems occurring in some supplies and the significant risk of future problems.

'Investment is needed to improve the supplies where people cannot use their water and to reduce the risk of other supplies failing to meet the required quality standards in future,' he added.

The report provides a list of remedial actions that Irish Water must implement urgently across the country. These include improvements to disinfection systems, better management of water treatment and more investment in robust and resilient infrastructure.

The EPA also highlighted WHO's significant reduction of the threshold for lead in water and predicted that a new limit is likely as a result. Required actions would include removing lead pipes, which the report said should be a priority investment area.

In 2013 just 11 samples failed the old lead standard, but four times as many would have failed to meet the proposed WHO threshold, the report reveals. The EPA is also calling for a water safety plan to be implemented for every supply, which would include a preventive management framework. ●

Ghana and Togo sign drinking water pipeline MoU

The governments of Ghana and Togo have signed a memorandum of understanding (MoU) for the construction of an African Water Facility-supported pipeline to bring drinking water from the lower Volta River in Ghana to the city of Lomé in Togo and the Ghanaian communities along the water transfer route.

The AWF has offered a €1.4 million ($1.6 million) grant to Ghana to support the technical, legal and financial preparation of the Public-Private Partnership (PPP) project. In addition to AWF support, the African Legal Support Facility (ALSF) is providing a €0.7 million ($0.8 million) grant to help prepare the project.

The signing of the MoU in Lomé has paved the way for the launch of the project development studies, including a feasibility study as well as a social and environmental impact assessment, and the provision of a transaction advisory service. The MoU sets out roles and responsibilities between the two countries in the organisation and implementation of the project.

'The signing of the MoU marks the beginning of the realisation of an idea hatched in the 1970s to provide sustainable drinking water from Sogakope in Ghana to the residents of Lomé as well as the Ghanaian communities along the transboundary pipeline,' said AWF coordinator Akissa Bahri.

More than four million people in Togo and Ghana will benefit from access to improved drinking water when the preparation studies are completed and the project is executed. The AWF and ALSF grant will pave the way for the mobilisation of €100 million ($113 million) from the private sector for the water supply infrastructure investments under a Public-Private Partnership arrangement.

The Ghana Water Company Ltd shall act as the Executing Agency of the project.

Togo's groundwater supply sources for the city of Lomé and surrounding communities are on the verge of depletion due to overexploitation and their quality is deteriorating. Ghana's huge lower Volta River, emptying into the Gulf of Guinea, has ample source of fresh water to augment Togo's scarce surface water sources. The project is seen as strengthening sub-regional cooperation through the sharing of the resources of the transboundary Volta River. ●

Burkina Faso receives World Bank grant for watsan expansion

A new $80 million grant from the International Development Association (IDA) has been agreed to help Burkina Faso expand access to clean water and sanitation services for the poor in the urban communities surrounding the capital city of Ouagadougou.

The additional financing will be used to scale-up components of the ongoing Burkina Faso Urban Water Sector Project (UWSP).

Approved by the Board in 2009, the UWSP has already provided 434,000 additional people with access to piped water and 403,000 additional people access to improved sanitation services. The urban water sector reform supported by the project is also being successfully implemented.

'Working together with ONEA the UWSP project has made great achievements in increasing the distribution of clean water to urban areas, however Ouagadougou's recent population growth has created unanticipated challenges in providing water to its residents – many of whom are low-income families,' says Mercy Tembon, World Bank Country Manager for Burkina Faso. '[The] additional financing will build on the original project's positive momentum by helping to improve the city's water transmission / distribution system which is vital to expanding capacity to provide clean water for both new and existing customers.' ●

Reducing network rehabilitation costs through smart redesign

The replacement of networks within the framework of asset management plans will be a large investment for water companies in the developed world in the coming decades. Often the financial consequences of these investments are based on a pipe-for-pipe replacement approach, whereas in Secondary and Tertiary networks, a new approach to their development may yield significant cost savings. Jan Vreeburg, Henk Vogelaar, Ad Vogelaar and Mirjam Blokker discuss a new design approach and its application in the Dutch city of Sittard.

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Ageing underground infrastructure and its timely replacement is one of the biggest challenges drinking water companies in the developed world are facing in the coming decades. The drinking water transport and distribution network is the largest and most costly asset of a water company.

In general 20% of the length of the network has a transport function: this primary network connects the treatment locations with the larger conglomerates and conveys the water to the concentrations of demand such as small cities or neighbourhoods of large cities. The remaining 80% of the network can be characterised as distribution networks that primarily distribute the water to smaller concentrations of demand and to the individual connection points. In the Netherlands, for example, the drinking water network has a length of 117,000km, with 7.7 million connections (Geudens, 2013). This results in a 15.2m network for each connection. 80% of that network consists of the distribution network, which amounts to 12.2m of distribution network for each connection and 3m of transport network.

Typically, networks were constructed over periods of decades. In most European countries the biggest expansion of the network took place in the post Second World War period. During this period the insights into the design rules for networks changed and more parameters were taken into consideration, such as reliability and water quality. Master plans to develop large networks were hardly an option as growth and development over decades is very difficult to predict. That resulted in networks that have characteristics of organic growth expansion. The challenge of timely replacement now offers a unique opportunity to redesign the existing network with the complete set of parameters as they are known today: to make a master plan, or blueprint, for the replacement of the network.

To make a master plan three levels are to be distinguished in a network:

- The Primary Network consisting of mains with a regional transport function that connect the pumping stations / treatment locations with the large concentrations of demand, i.e. cities or parts of cities
- The Secondary Network consisting of mains with a local transport function that connects the Primary Network to the Tertiary Network
- The Tertiary Network consisting of the 'pipes-in-the-street' with the individual property connections

For each level of the network various design parameters can be used to optimally serve their purpose.

Replacement programmes, however, are usually based on pipe-for-pipe replacement. For transport mains this could be a reasonable assumption because they tend not to change much in hydraulic function, even over a longer period of time. Points of production and location of cities do not change and also the main layout of a city is relatively constant.

For the distribution (Secondary and Tertiary) network, however the pipe-for-pipe replacement approach will not result in an optimal investment. New insights in the interaction between the hydraulic behaviour of water and water quality, resulting in the concept of self-cleaning networks, have a great impact on the layout of a network. In this paper a systematic approach is laid out for the gradual transition from a traditional distribution network towards a modern, self-cleaning and more reliable one.

Design rules for drinking water distribution networks

For each of the three levels in a drinking water network specific design criteria can be defined, which will be described separately. The main design criterion for each part of the network is obviously to supply enough water at a sufficient pressure. Only for the pressure in the Tertiary Network are legal requirements in place. In the Dutch Drinking Water Act this is set at

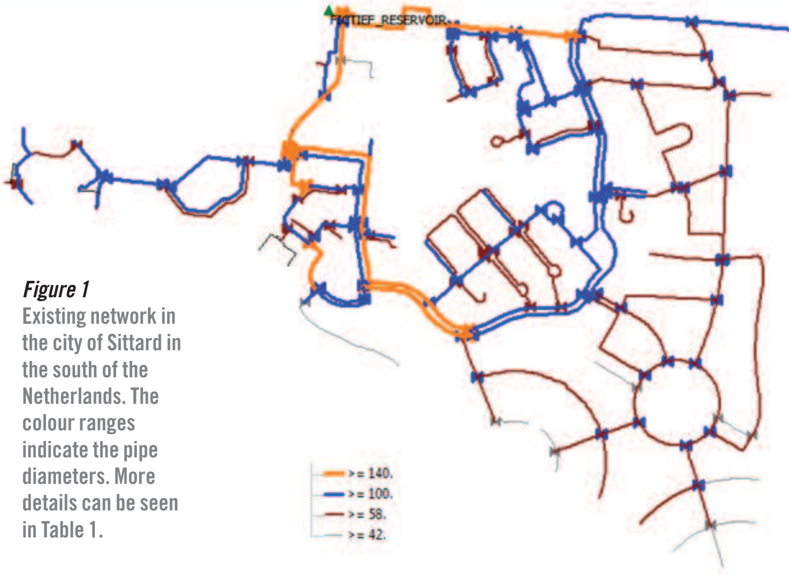

Figure 1
Existing network in the city of Sittard in the south of the Netherlands. The colour ranges indicate the pipe diameters. More details can be seen in Table 1.

150 kPa with a supply of 1000 litres in one hour. Note that this is different than a flow of 1m^3/h, which would be an instantaneous requirement. The Drinking Water Act requires a supply of 1000 litres in one hour in which the actual flow may fluctuate and be less than 1m^3/h, as long as it is compensated for.

The Primary Network in principal does not have direct connections supplying any individual connection. The network has a looped structure with an emphasis on security of the water supply (Beuken, de Kater et al. 2013). According to the Dutch Drinking Water Act, parts of the network may be isolated for repair after failure without an unacceptable effect on the drinking water supply. Practically, this means that the total supply to the connection points of the Secondary Network in 24 hours should be no less than 75% of the maximum daily demand in those points.

The Secondary Network is the connection between the Primary Network and the Tertiary Network. Its main function is continuity of supply, which is slightly different than the security of the water supply. The Secondary Network contains the majority of the valves, creating valve isolation sections. These sections can be isolated for repair or other reasons, restricting the number of connections without water. This determines the continuity of supply for individual connections. Failure of parts of the network may have a local effect on pressure, but only causes shut off of connections within an isolation section. Normally the repairs and consequential shut off will be no longer than 24 hours, but mostly shorter than eight hours. The emphasis in the design of the Secondary Network is thus on the location of valves dividing the network into sections with a certain maximum number of connections.

The focus of the Tertiary Network design should be on water quality. This means the network is designed as a branched, self-cleaning network (Vreeburg, et al., 2009). The branches are one-sidedly connected to the isolation sections of the Secondary Network and most of the individual connections are made onto these pipes. The length of the pipes is determined by the number of connections that may be shut off from supply during repairs. The diameters of the pipes are determined by the need to reach a self-cleaning velocity with a certain frequency. The characteristic flow with which the self-cleaning velocity is reached, is defined by patterns of realistic demand modelled with the pattern of the end use (Blokker, et al., 2010). The fire flows are supplied through hydrants, which are positioned in close cooperation with the fire brigades. The branched Tertiary Network has no function in the transport of water to other parts of the network.

The design criteria for the various levels of the network have evolved over the past decades. As mentioned, two of them are part of the Dutch Drinking Water Act: the pressure and flow criterion on connection level and the reliability criterion in the 'n-1 situation' (Vreeburg, et al.,1994; Beuken, et al., 2013). The pressure and flow criterion is literally defined as 'end-of-pipe' criterion and affects all levels. The reliability criterion is typically focused on the Primary Network, though the Secondary Network may contribute to the regional transport function in failure conditions.

The design criteria for the valve locations in the Secondary Network, the fire flow requirements and the maximum number of connections in a shut off section are defined at the company level. A systematic approach for valve location at the design stage leads to an optimisation of the number of valves and the effect of failure on the actual supply (Trietsch and Vreeburg, 2005). This effect is measured in Substandard Supply Minutes (SSM), which is a parameter on which Dutch water companies are benchmarked.

Transition towards a new approach

The application of the complete set of design rules will result in a network that is different from the existing networks, especially for the Secondary and Tertiary Network.

However, new networks are seldom designed in one stage with all conditions for the demand, location and developments known. Rehabilitation of networks, however, offers an opportunit to integrally reconsider the Tertiary and Secondary Network. The existing network has been functioning for a certain time and the built environment is more or less constant, which means that much of the boundary conditions are well known. The local (Secondary and Tertiary) network may be redesigned, resulting in a blueprint for the area. The actual time frame of rehabilitation may be spread over years or even decades, but during that time the boundary conditions will not change dramatically and the blueprint can be followed. In the period of rehabilitation the window of actual replacement of pipes may be flexible and aligned with rehabilitation plans for other urban service infrastructures in order to optimally share costs for street works, etc.

In this paper a methodology is presented for the redesign of the Secondary and Tertiary network, enabling a phased transition towards the new design.

Transitioning to a new network

The transition from an existing network into a new and better one is concentrated on the Secondary and Tertiary network. There are five steps in the process:

Table 1
Characteristics of the original and redesigned distribution network as presented in Figures 1 and 2 respectively

	Original	Redesigned
Mains length (m)	14,338	10,783
Number of connections	985	985
Total Pipe volume (m^3)	110	60
Average residence time (h)	7.3	4.0
Number of section isolation valves	140	26
Number of valve sections	96	25
Average number of customers per section	10.3	39.4
Number of loops	48	3

Setting boundary conditions

In this step the main pressure and flow conditions at the nodes of the Primary Network are determined either by network calculations or measurements. Other prerequisites are set such as the minimum pressure at the start of the Tertiary network (and thus the pressure drop over the Secondary network), the minimum and maximum number of connections within a valve section, the requirements for fire flows and the maintenance policy towards valves that determines the functionality of the valves. Restrictions on the range of diameters and pipe materials is also set in this step. The existing network is administratively split into the three levels (Primary, Secondary and Tertiary). This results in a basic model of the network and a checklist of boundary conditions.

Future water demand and external developments

Though the network is a reconstruction of an existing situation, the foreseeable developments that determine the water demand must be considered. Generally, there is a period of five to ten years in which the developments to the network in themselves form the opportunity to rehabilitate. This mainly concerns large reconstruction plans or changes in land use. Also, alternative pipe routes can be considered that might shape the Secondary Network. Usually the changes are not very large.

Conceptual design of the new structure

In this step the conceptual (re)design is undertaken. Starting with the existing network the layout for the Secondary network is identified. Logically, these pipes follow as much as possible the existing routes, which are available and already fit for pipe construction. Moreover these larger pipes in general have a longer life expectancy and the renewal rate tends to be lower. The sections for the Tertiary Network are also identified, mostly based on connection counts and length of the pipes (both restricted in step 1).

Actual design of pipe diameters and lengths

In the actual design phase of the Secondary and Tertiary Network diameters are determined through a mixture of experience and calculation. The design may be optimised with regards to the average number of connections per section, number of valves, location of hydrants, etc.

Checks and balances and fixing the blueprint

In this step the final check is made on all the boundary conditions set in step 1. Also interaction with fire brigades is crucial to verify the acceptance of the blueprint. Eventually the whole process needs to be recorded and stored for future reference. The rehabilitation of the network will be effectuated over a long period of time in which also boundary conditions may change. This calls for an easily accessible filing system with an active maintenance to check the validity of the target structure or blueprint of the network.

Case study of Sittard

These new design principles were applied to the redesign of an existing network in the city of Sittard in the south of the Netherlands. The characteristics of the original and redesigned network are compared to each other below.

The supply area in Sittard consists of proximally 1000 connections serving 2500 consumers. This is a relatively small Secondary network with a limited number of branches; a classic ‘dead end’ network. The present diameters are not very large, meaning that the Secondary network has a limited transportation function. Figure 1 shows the existing network. The boundaries that were set in the first step were that the pressure at the entrance of the Tertiary network should be at least 250 kPa. An extra criterion on reliability was set, in that if a section of the Secondary network fails and is shut off, the remaining pressure in the rest of the network during the repair should be at least 100 kPa. The maximum number of connections in one section was set at 100. This maximum number will not be used in many cases because the maximum length of the section is limited to 1km. There are also practical considerations, as the proximity of shut off valves may be of influence.

It is assumed that there will not be any dramatic changes in the area served in the future, so this aspect not considered in the redesign. It concerns an ordinary housing area with no industry and no structural growth is foreseen. Still, some extra demand was taken into account: an extra 10% was set on top of the historic maximum demand so the network has the ability to cope with an increase in individual water demand and possible changes in water use behaviour.

In the third step the conceptual redesign is made. In this case the Secondary network may be decreased in length, because a lot of the looping may be left out. At this stage local knowledge is of crucial importance to distinguish special connections like schools, nursing homes, shops, hair dressers, etc. to locate large demand, e.g. for fire flows. The Tertiary network is designed following the design rules for self-cleaning networks in the individual branches.

Figure 2 shows the redesigned network for the supply area of Figure 1. Table 1 summarises the characteristics of both networks. As can be seen in Table 1, the differences between the networks are considerable: the total length of the network decreased by 25% and the number of valves by 81%. The pipe volume of the network was decreased by 45%, which results in a reduction of average residence times. The unidirectional flows result in a significant reduction of maximum residence times.

Discussion

The construction of a network is a process that takes place over decades. Over these decades requirements change, as do the design criteria. The main structure of the network, the Primary network, is relatively stable and will not change much over time. Even if transport routes become redundant, they are kept for reliability reasons. Hardly any network has been designed as a total concept, which means that the present network is a combination of various concepts and insights.

The largest part of a network’s length consists of the Tertiary network. Only in the last two decades has there been an increased interest in the design and maintenance of this ‘small’ network. A change in concept for this part of the network, such as self-cleaning high velocity networks, potentially has a huge impact on the layout of the overall network (Vreeburg, et al., 2009). The pipe length and the number of valves are the most costly elements in a network. Reduction of length reflects linearly on reduction of total costs and the reduction in the number of valves also has a considerable effect. Maintenance costs reduce because cleaning is no longer necessary and valve maintenance is also reduced. In the longer-term a shorter pipe length also causes fewer failures.

Application of the self-cleaning concept in the Tertiary network enables a new approach towards reliability or the continuity of supply to clusters of connections in valve sections. In the new approach the Secondary network contains the majority of the valves and as such controls the supply continuity and reliability for the individual connections. Almost counter-intuitively the reliability of the supply in the Secondary and Tertiary network is higher than in a traditional looped network, despite the fact that a Tertiary

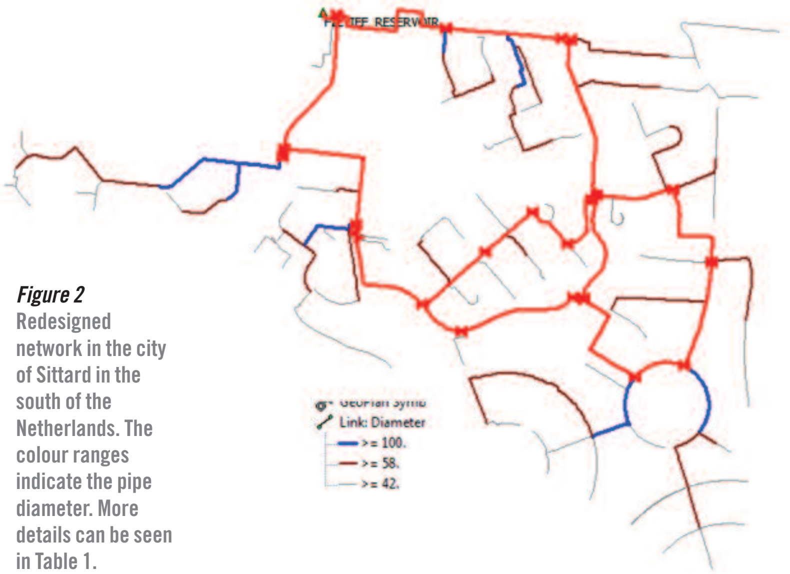

Figure 2
Redesigned network in the city of Sittard in the south of the Netherlands. The colour ranges indicate the pipe diameter. More details can be seen in Table 1.

branch is single-sided connected to the looped Secondary structure. The reliability at the level of individual connections is determined by the isolation of valve sections for repair – at that point the supply is interrupted. The size, i.e. the number of connections in a section, and reliability of the valves determines the total discontinuity of supply measures in Substandard Supply Minutes. In the new approach isolation is established by closing two valves in the Secondary structure. These are located in the 'arms' of the T-connection of the Tertiary branch to the Secondary structure. In fact, the reliability will be higher because the total time of closure is shorter: only two valves close by need to be closed and opened instead of four to five scattered across a wider area. Next to that, there is almost no danger of valves accidentally being left closed after repair, resulting in a more reliable network in general. Also, possible contamination in the Tertiary branch after repair or through another low pressure incident does not spread into the network.

It is remarkable that despite the crucial function of valves, the location and function of valves was hardly a design parameter in the conventional approach. Systematic analysis of valves in conventional networks showed frequent, very illogical valve configurations (Trietsch and Vreeburg, 2005). As in the case study (see Table 1) it shows that in the original situation the average number of connections in one valve section is just over ten. In the new approach the acceptable number of connections in one section is an actual design parameter, which needs to be within defined limits. Analysis of the effect of fewer valves (lower costs and less maintenance required) versus the amount of Customer Minutes Lost (or Substandard Supply Minutes) can now be made. The Watershare tool OptiValves was developed to undertake such a calculation, which enables objective decisions on the design parameters 'minimum and maximum number of connections in one section'. Obviously this may vary between companies and depends on local circumstances.

The positive effects of the self-cleaning principle on water quality have been confirmed several times over the years (Blokker, et al. 2007; Vreeburg, et al. 2009). In the Netherlands the principle has been applied by all of the water companies over the last ten years and has resulted in proximally 5000km of Secondary and Tertiary self-cleaning networks. A large threshold to overcome was the effect of the Tertiary small branches on the availability of fire flows. This has been a significant area discussion with fire brigades. A remarkable observation was that within the fire departments there was very limited insight into the actual use of water from hydrants during the practice of fire fighting. With the abundance of fire hydrants available, there was never a need to reconsider that. In the Netherlands the fire departments and the drinking water suppliers work together to achieve optimised situations in which sometimes alternative sources for primary fire flows are considered and found. In general the national organisation of fire brigades has adjusted their advice for the minimum capacity of a hydrant to half of the original value ($30m^3$/hour instead of $60m^3$/hour), largely based on a reconsideration of modern building codes and new fire fighting attack routines.

Asset management programmes developed by many water companies involve large-scale replacement of existing networks and appurtenances. This is a unique opportunity to redesign the network, keeping the existing Primary network as a backbone and much of the Secondary network for valve positioning. Application of the self-cleaning principle in the Tertiary Network (also contained in the Watershare tool SelfCleaningNetworks) shows the huge benefits that can be achieved with regards to reducing replacement costs and improving water quality. Developing blueprints for larger areas substantiates the more general approach of long-term asset management plans and enables a better alignment with programmes concerning other urban services such as sewerage, gas and electricity. Sometimes the hydraulic logic in the blueprint may even dictate the order and planning of rehabilitation of other urban services.

In the case study the prognosis of the investments costs for rehabilitation could be downsized by 30 to 40% because of the reduced length and the decrease in the number of valves. A counter effect is that the old pipes need to be excavated and removed, which reduces the effect of the shorter and smaller new pipes. More detailed calculations can only be made within the context of the actual replacement projects, but there will be an estimated 20% reduction in overall cost compared to the pipe-for-pipe approach. Considering this can be applied to 80% of the network, the general reduction over decades can be considerable.

The redesign of the network as described in this paper is not a static process. The actual replacement of the network will take some time and during this time the boundary conditions may change or be adjusted based on experience. The designs of the target structure or blueprint should be evaluated regularly, mainly in the first two steps of the methodology. A good recording of the designs together with the list of boundaries is a prerequisite to do this effectively.

Drinking water infrastructure is not the only urban sub-surface or surface infrastructure that needs to be rehabilitated in the coming decades. Gas companies, municipalities, electricity companies and so on also make plans to replace their networks. In practise that means in many cases that there is not enough time to redesign the network within the time limits set by the other parties. Making the designs in advance and having them stored gives flexibility in planning procedures and helps in prioritising rehabilitation projects.

Conclusions

The integrated approach towards the redesign of networks for rehabilitation combines several new insights into network design. It results in a new network that is 20 to 30% cheaper than a replacement programme based on pipe-for-pipe replacement.

Investments have to be made in redesigning itself and in the filing and maintenance of the new designs.

Within the Watershare suite several tools are available such as Optivalve, Water Use Info and Self Cleaning Networks to optimise the integral redesign of networks. ●

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iGPI and PGPI: national-scale cooperative R&D rollout of IAM planning methods and tools

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AGS, S.A., Sintra, Portugal

The National Initiative for Infrastructure Asset Management (iGPI) led by LNEC, IST and Addition, and its twin initiative PGPI, led by AGS, were collaborative projects through which a total of 30 Portuguese water utilities developed IAM systems and plans through a collective training, capacitation and R&D rollout programme (Apr 2012 – Oct 2013). Sergio Coelho, Helena Alegre, João Paulo Leitão, Maria Adriana Cardoso, Maria Santos Silva, Pedro Ramalho, Rita Ribeiro, Dídia Covas, Diogo Vitorino, Maria do Céu Teixeira de Almeida, João Feliciano and Rita Almeida discuss the projects and their outcomes.

The prevailing low levels of rehabilitation of water infrastructure in much of the world constitutes a major threat to the long-term sustainability of urban water services – a time bomb largely invisible to society and to policymakers, who are transferring an excessive burden to future generations. A paradigm shift in asset management infrastructure (GPI) is therefore urgently needed, given the restrictive context of availability of capital and the increasing demands from climate change and environmental protection.

As in many other countries, the rapid growth of public water service infrastructure in Portugal over the past 30 years has not been matched by adequate capital maintenance of either the older or newly constructed systems, giving rise to a sizeable deficit in infrastructure asset management (IAM). Significant measures have been undertaken in recent years to reverse the trend and help provide the country's utilities with the means to restore long-term infrastructural sustainability. Recent legislation requires an IAM system for water supply or wastewater management services serving 30,000 people and above. The national water services regulator followed up with technical guides outlining an integrated IAM methodology, published in conjunction with LNEC and the Tech. Uni. Lisbon (Alegre et al., 2013). Grounded on best practice and updated technical knowledge generated in Europe, USA, Australia and New Zealand, as well as amongst IWA's network of professionals, this methodology approaches IAM as a management process, based on continuous improvement principles and requiring full alignment between the strategic objectives and targets, and the actual priorities and actions implemented, thus embedding the key requirements of the ISO 55000 series standards on AM (Alegre & Coelho, 2012).

Widespread implementation of strategic IAM in urban water services requires a substantial mind-set shift for the water sector in most countries, as well for decision makers, politicians,

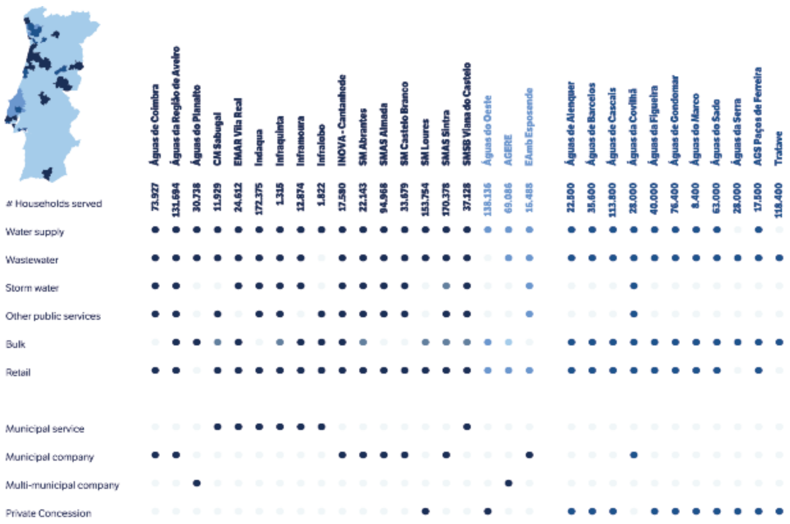


Figure 1
Utilities taking part in the iGPI and PGPI projects

the media, and society in general. iGPI, Portugal's 2012–2013 National Initiative for Infrastructure Asset Management (www.iniciativaGPI.org), was launched to help broaden the impact of those methodologies and products and reach out to utilities nationwide in a significant way. It utilised a collaborative format pioneered by LNEC in the last decade and aimed at assisting a representative sample of utilities of diverse size and context develop their own IAM systems and plans through a joint training and capacitation programme (Leitão et al., 2013). PGPI, a twin project simultaneously launched by the AGS group of utilities, expanded the reach of the programme and tested an even wider variety of organisational frameworks within the controlled environment of a corporate group.

Today, over 25% of the Portuguese population is served by 30 management companies that produced their strategic and tactical IAM plans under the iGPI and PGPI programmes. Applying the methodology and guidelines of the AWARE-P project, the widespread use of open source software has effectively created alignment and critical mass for much needed change. Outside Portugal, the methodology and software have been implemented by utilities in Spain and the USA, with pilots in Australia and Norway.

Project methodology

The projects followed a cooperative model involving a number of utility partners, with joint teams of research developers and users of the research products, 'working with' instead of 'working for'. In general, this provides scale and national visibility, contributing towards creating awareness and appetite for the theme. It also produces a networking effect and allows for the combining of strategic research with practical problem solving and opportunities to place it into practice within industry. Mutual validation and recognition from a peer group provides a greater comfort zone for early adopters. Developing nationally representative cases has significant leverage impact, demonstrating applicability and allowing for further learn-by-example training.

The utilities that took part in iGPI and PGPI ranged in the size of population served from 3000 to 390,000, as well as in service scope (water, wastewater, stormwater), organisational complexity and and nature (municipal, regional and private) (Figure 1). Maturity in terms of information availability, technical sophistication and management processes implemented was also diverse.

In the case of the public project iGPI, each utility paid approximately €20,000 as a participation fee. The total from the participating utilities covered 75% of the lead consortium's (LNEC and R&D partners) costs, who self-financed the remainder. PGPI was run by the privately-owned AGS group of utilities exclusively within its concessions, under an internal arrangement, distinct from the above-described terms for iGPI.

The project followed a 4x4-month phased schedule, with a total duration of 16 months. Each phase began with face-to-face training and the specification of the work to be developed by each participant. Training is complemented with e-learning via webinars and online materials. While the utility teams developed their pilot cases, LNEC analysed results and provided individual assistance to the utilities.

Results

The project's products included guidelines for developing IAM strategic and tactical plans, including MS Word templates, training materials (presentations slides, recorded webina-

CASE 1 - Midsize utility

Features: technologically developed utility; well trained staff; good inventory; complete, reliable GIS; good monitoring systems; hydraulic models available for the entire water supply system.

- The availability of a large amount of information, mostly reliable, including all-mains calibrated hydraulic models for the entire water supply system, allowed this utility to use more sophisticated and data-demanding metrics to address aspects such as pressure adequacy and flow velocity adequacy.
- Automated procedures have been implemented in order to calculate the selected metrics.
- Some metrics at the strategic level result from the aggregation of more detailed metrics adopted at the tactical level.
- Despite the technological maturity, the use of work orders information for reliability analysis revealed room for improvement. Non-infrastructural tactics were established to address this problem.
- With an IAM metrics system in place, the fact that a significant part of the process has been automated shortens the time and manpower needed for detail diagnosis, which allow this utility to work simultaneously with four pilot network sectors at the tactical level (two each for water supply and for wastewater) during the course of the project.

CASE 2 - Very small utility

Features: technologically aware utility at an early stage as an organisation, having inherited their infrastructure; capable but limited human resources available; good inventory; full coverage, recent GIS; runs other municipal services. Serves a seaside tourist area.

- Seasonality causes overcapacity of the systems for a good part of the year; the utility is particularly interested in exploring flexible solutions in their IAM plans.
- Dependency on tourism increases the utility's exposure to the economic crisis, which required the consideration of diverse revenue-generation scenarios in developing and analysing IAM capital maintenance plans.
- Successfully assessed and used the Infrastructural Value Index (Alegre & Coelho, 2012) as a prime metric for long-term scenario and intervention evaluation.
- After successful development of a strategic IAM plan for the water services, the utility decided to apply the same approach to the other services it runs (roads and public gardens).
- Due to the relatively small territory, a single stage was adopted in the tactical planning and the entire systems were the object of detailed analysis in the framework of the project.

rs, written materials), significant improvements in the AWARE-P software, a national visibility public event where the participants reported mid-term results (in March 2013 with around 200 attendees), and papers in industry publications. The main outcomes for the participating utilities are summarised in Table 1.

Central among the project results were the 30 sets of strategic and tactical IAM plans that the utilities produced; a rich and diverse first batch of cases creating a sizeable precedent for a broader roll-out. The way in which the several participating utilities developed their strategic and tactical plans, and implemented their IAM processes, was shaped by their context, resources, organisational maturity, information availability and the existence of other management systems or instruments. A large variety of cases illustrating the diversity of situations and solutions are available, two of which are illustrated in Table 2.

For the participating utilities the project has led to the effective harmonisation of the organisation' objectives among the various management systems in place, with considerable alignment between decision levels and management processes (e.g., harmonising kPIs cross-levels). The IAM strategic plans developed under iGPI are used as a central management tool by several of the participants; the project and IAM processes have been powerful drivers for improvements in data depth, quality, focus and integration, and many enhanced procedures for data collection, particularly related to work orders and surveying of buried assets, have been implemented.

The project has also had a major impact on the country's water industry, helping to raise awareness to the issue and making available software tools, documentation, planning templates, and a networkable community of IAM practitioners. The project provides the water services regulator with a workable basis to further develop the current regulatory framework and public policies.

The variety of cases covered demonstrates how, in actual practice, systematic and well-devised IAM processes can be tailored and successfully implemented in many different contexts. The collaborative project format has proven to be particularly suited to the task, enabling a quicker and more effective cultural change, technical uptake and process implementation.

Cases

The way in which the several participating utilities developed their strategic and tactical plans,

	Objectives	Outcomes
Phase 0 M0	Warm-up; project set-up; beginning of baseline data collection	• Detailed planning of activities; • Definition of teams and project managers for each participant water utility; • Definition of information to be collected.
Phase 1 M1-M4	**Strategic** & **tactical** planning levels: Objectives and diagnosis	• Concise report containing: objectives, assessment criteria, metrics and targets to strategic and tactical planning (macro) levels; • Strategic level diagnosis; • Data survey priorities.
Phase 2 M4-M8	**Strategic** & **tactical** planning levels: Plan development	• Full version of strategic IAM plan; • Prioritization of network sectors at the tactical intervention level.
Phase 3 M8-M12	**Tactical** planning level: Formulation of IAM alternatives for pilots	• First draft of the detailed IAM tactical plan containing: – objectives, criteria, metrics and goals; – diagnosis of priority area(s); – identification of infrastructural and non-infrastructural alternative solutions.
Phase 4 M12-M16	**Tactical** planning level: Evaluation and comparison of alternatives	• Full version of tactical IAM plan, including detail tactical planning for the priority (pilot) area(s); • Procedures for the collection, organization and quality control of data relevant to IAM: e.g. GIS, work orders, condition assessment / inspections, accounting data.

Table 1
The iGPI programme: objectives and outcomes

and implemented their IAM processes, was shaped by their context, resources, organisational maturity, information availability and the existence of other management systems or instruments. Table 2 shows some cases illustrating the diversity of situations and solutions. Utility size is classed as follows: Large utility – above 100,000 households served; Midsize utility – above 40,000 and up to 100,000 households served; Small utility – above 15,000 and up to 40,000 households served; and Very small utility – up to 15,000 households (not legally required to have IAM programmes). The national average household occupancy is 1.8 persons, although with some significant regional variations.

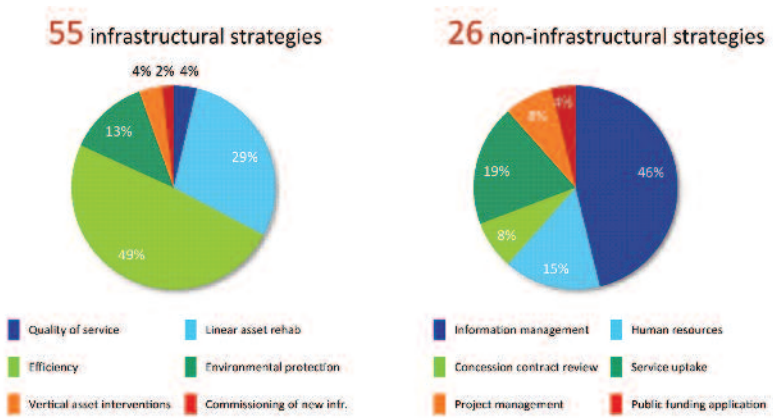
Conclusions

Although there is still a long way to go, the authors believe that Portugal is progressing rapidly and with steady steps in terms of IAM of urban water services. Having recognised the need for change in this field, LNEC and its partners initiated the process by developing a well-structured IAM approach, supported by technical guides, training courses and leading-edge open-source software (aware-p.org, 2008-2012).

Learning from leading know-how and practice, LNEC partnered with other R&D organisations, software developers and utilities in the AWARE-P project to jointly develop a ground breaking IAM planning methodology, supported by technical guides and a professional-grade, innovative software, plus e-learning and demo cases. A rollout and application stage implemented through twin national-level initiatives, led by LNEC and by AWARE-P utility partner AGS, allowed the methods and software to be validated and refined while supporting the effective, on-field development and implementation of IAM methodologies by over 30 utilities.

Today, over 25% of Portugal's population are served by utilities that have produced their corporate strategic and tactical IAM plans based on the AWARE-P methodology and templates – endorsed by the national water services regulator ERSAR – with widespread use of the open-source software, effectively creating alignment and critical mass for much-needed change. This has been supplemented by two utilities in Spain and one in the USA, with a pilot starting in Australia

Figure 2
Digest of infra-structural and non-infrastructural strategies included in the IAM plans in the utilities taking part in the PGPI project



CASE 3 - Small utility

Features: technologically developed utility; capable human resources available; good inventory; mature BSC management system; quality of management certifications; full coverage, reliable GIS for the whole area; good monitoring systems.

- The existence of certified management systems was felt to be an advantage in terms of maturity, but also a challenge, given that the existing systems did not address the long-term effect of managerial decisions.
- Top management agreed to review the BSC and introduce some small but critical changes. Due to the management's committed efforts and the small size of the utility, by the project's midterm a considerable harmonisation of all existing management systems had been successfully implemented, with an adequate consideration to long-term sustainability, previously not present.
- The IAM planning approach is being applied to the other services this utility is responsible for.
- The detailed analysis of the water supply pilot area was thought to justify a hydraulic model. LNEC assisted the utility in generating a basic model file from the GIS and loading nodal demands in a simplified but effective way for planning purposes. This allowed for a sound diagnosis and assisted the development and comparison of intervention alternatives. The process and results achieved showcased the solution for the other utilities in a similar situation.

CASE 4 - Large utility

Features: the utility is the result of the recent merger of several municipal water and wastewater services; very diverse contexts, challenges, and data availability and quality among the municipalities; certified BSC management system; GIS reflects the municipalities' disparity in data availability, depth and quality.

- The programme was seen by the utility as a golden opportunity to help establish sound organisational processes.
- One of the challenges for this utility was to prioritize the municipalities with higher rehabilitation needs, in a sound, transparent and accountable way, in a context of local political sensitiveness where consensus-driven negotiation is crucial. The results from iGPI helped respond to this challenge, particularly through a sound IAM metrics system.
- The existing BSC implementation did not address the long-term effect of the managerial decisions. Although changes are more difficult to implement given the size and complexity of the organisation, several new metrics have been included and a transition process has been devised towards a fully satisfactory BSC implementation.
- iGPI also gave rise to multiple new data collection procedures, particularly related to GIS, work orders, and harmonisation among information systems.

CASE 5 - Very small utility

Features: an inland region municipality with the lowest population density in the project, with one main town and several dozen small rural villages scattered across a large expanse, several hours away from the country's main metropolitan areas. Small but capable and very motivated team. Strong mayor support for the project. In-house GIS implementation, based on open-source software.

- This utility is challenged by their limited human resources, who must share their time among multi-service responsibilities, and by the high time and cost of any operational or maintenance intervention outside of the main town. The utility took part in the project because they have long recognised a vital need for streamlining and maximising efficiency, due to the resource limitations, as well as supporting their priorities on a sound basis. They also perceived that the collaborative format of the project would provide them with access to experiences, assistance and networking which would be unattainable in other circumstances.
- The project allowed this utility to establish clear priorities in terms of intervention needs and start addressing the most problematic cases, related to aged networks and very high non-revenue water. Infrastructural and non-infrastructural tactics have been established and a short-term action plan is being under way.

in 2013, while the AWARE-P software has over 1000 registered users in five continents. IWA's LESAM 2013 singled out Portugal's IAM programme in its conclusions, while WERF and USEPA (USA) are promoting uptake of the innovative methodology and further development of the software in the USA, and the World Bank's Danube Water Program has expressed an interest in the rollout formula utilised in the project. Given the diversity and representativeness of Portugal's water market, this project provides a valuable blueprint for similar development elsewhere. ●

Acknowledgements
The authors wish to thank the outstanding efforts and contributions from all the utilities, organisations and individuals that took part in iGPI and PGPI.

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This paper was presented at the 2014 IWA World Water Congress, held 21-26 September 2014 in Lisbon, Portugal.

Managing green assets for environmental and infrastructure sustainability

Installation of green infrastructure is a rapidly growing component of water and wastewater utility regulatory compliance and sustainability initiatives. These programmes are being driven, in part, by many factors including alignment with overall city sustainability initiatives, collaboration with environmental regulators, and desire for programmes that support community and economic development. These programmes also offer cost effective alternatives to traditional 'grey' infrastructure, while providing significant positive community and social benefits. David Sklar and Fernando Pasquel discuss the challenges these natural assets pose for engineers, operations and maintenance managers and the need for new asset management strategies.

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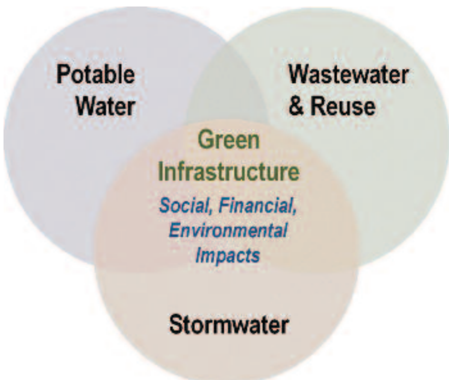
As the installation of green infrastructure (GI) continues in the water and wastewater industry at a rapid pace, many organisations are just now facing the challenge of how to manage these assets throughout their lifecycle to ensure they provide the environmental benefits they were designed to achieve. In addition to delivering a balance of positive triple bottom line (TBL) – social, environmental, and financial impacts, GI assets are often also directly tied to consent order obligations and regulatory requirements. From this perspective, ensuring that assets are properly maintained from the beginning is critical in delivering on commitments made to ratepayers and stakeholders. In addition, achieving programme milestones and performance targets ensures continued programme support.

Drivers, trends and strategies

Across the industry and around the world there are very different drivers for GI. Depending on regulatory, service level and community needs, utilities are placing a different emphasis on specific components of GI strategy, which can drive very different outcomes and benefits. Some of the more significant and common drivers include:

- Integrated Planning Frameworks (IPFs) for consent orders (USEPA, 2012) – in the United States, regulatory authorities are encouraging utilities under consent orders to embrace a balanced approach to wastewater and stormwater planning in order to best meet human health and water quality objectives under the Clean Water Act. They have specifically called out GI as a significant strategic component of this approach.
- Cost efficiencies vs. typical grey infrastructure – in the case of large GI programmes, significant justification has been made for large-scale investments in swales and green streets to partially offset extensive capital investments in sewer capacity upgrades, such as tunnels and large storage facilities. This approach is particularly common for utilities with large combined sewer overflow (CSO) issues where GI can have a significant impact on stormwater infiltration.
- Neighbourhood and social enhancements – as GI infrastructure often has significant social benefits, it can more easily be added as part of planned streetscaping and other neighbourhood improvements. Aesthetic improvements are easy to 'sell' to the community and can also have a positive economic impact in terms of property values and overall economic development.
- Stormwater, flood control and water quality – in areas that face a high risk of stormwater flooding, GI can have a significant benefit in reducing the risk and impact of flooding, including critical infrastructure such as railway stations and roadways.
- Alignment with sustainability initiatives – GI infrastructure is an important part of overall city- and utility-wide sustainability initiatives, including improvements to nearby water bodies as well as potable water reuse and urban rooftop gardens.

Figure 1
GI Investments should be considered in the context of balanced investments across TBL and asset categories



With such a wide variance in approaches, the costs, benefits and business cases for GI are also likely to differ. Many large urban utilities like New York City DEP and DC Water in the US are integrating GI heavily into their formal regulatory commitments and consent orders, and are looking to demonstrate a strong business case vs. grey infrastructure to drive reduction in CSOs. Therefore, the main driver is environmental benefit, but at a lower cost than traditional engineering methods. Utilities that are taking a more cautious approach through moderate investments in GI are employing a more limited or focused application in specific neighbourhoods or sewer basins. In these cases the main drivers are neighbourhood and aesthetic enhancements and alignment with overall sustainability initiatives. Therefore, the main drivers are social benefits, although there are also typically smaller-scale environmental benefits as well.

In all cases, utilities must examine the balance of stormwater, wastewater, potable water and reuse strategies and decide what level of commitment they want to make to GI to help cost-effectively meet regulatory and service level objectives. For those that decide to make some level of commitment to

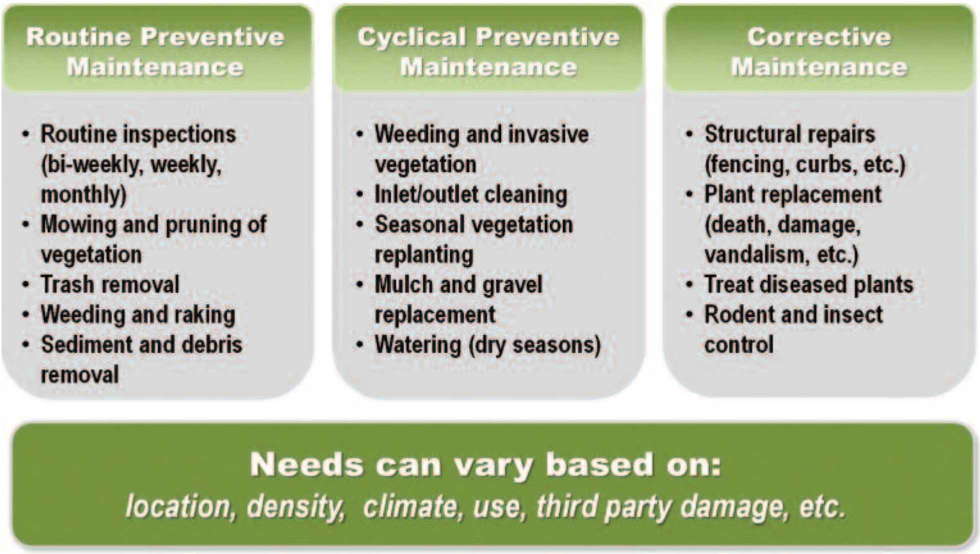


Figure 2
Typical GI O&M activities

GI, there are critical questions that must be asked in developing an appropriate strategy:

- Where to locate infrastructure – should there be a focus on development as part of city permitting requirements or should the focus be on retrofits to existing neighbourhoods?
- What type(s) of GI – should there be a commitment to significant investments in a single technology such as swales and permeable pavement or a balanced set of investments across many categories to limit risk? Should investment focus on blue (storms) or green (everyday) infrastructure?
- How much to build and desired speed of impact – should a utility take an aggressive implementation posture to drive significant quantified benefits such as SSO and flood risk reduction or more gradual investments over time?
- What balance of public vs private participation – should investments be funded via public infrastructure by water / wastewater / municipal rate payers or should the focus be on private developers and property owners?
- What types of public grants/ incentives to offer and how to fund – should grants for public infrastructure be funded with significant commitments and how should they be administered to create wider incentives?
- How to build business cases and track impacts – how should utilities justify and report project impacts and through what data, systems and key metrics?
- How to develop organisational skills, competencies, and tools – what is the best approach to recruit additional skill sets, establish new teams / structures, manage work and make strategic insourcing vs outsourcing decisions?

To answer the above strategic questions requires taking the time to establish a formal business plan and strategy, as you would for any new venture. However, this should not be a new exercise for most utilities and the same strategic planning and asset management policies that are employed for water, wastewater, and stormwater infrastructure can also be applied successfully to GI.

Challenges of managing GI

Proper maintenance of GI infrastructure poses unique challenges to organisations that are much more experienced with traditional treatment, pumping, collection, and distribution assets. GI assets such as swales, greenstreets, green / blue roofs, and rain gardens face more common and frequent day-to-day maintenance challenges such as vandalism, litter / debris, third-party damage, pest / animal control, vegetation maintenance, and other seasonal requirements.

Another key consideration is how those assets will be owned and maintained. In many cases, there is a mix of public and privately owned infrastructure and maintenance responsibilities must be clearly documented and followed if assets are going to have their intended impact. Furthermore, many utilities require that design and construction contractors take some responsibility for maintenance during an initial period, but often this is difficult to track without clear contract language and the staff to perform proper inspections.

Another challenge is developing the proper budgets and resource requirements to maintain and rehabilitate assets on an ongoing basis. Performing a true life-cycle cost (LCC) analysis can be difficult as the assets and design specifications are so new. It is much more difficult to obtain empirical data on what these assets will require over the long-term. While fixed costs are easily determined through competitive bidding and several years of bid tab data, variable costs for maintenance are still in question and will take a longer time to develop with an acceptable level of certainty. Adding to the challenge is that there is a lot of GI going into the ground quickly before formal processes and tools are in place to properly capture data.

Maintenance of GI infrastructure is outside the purview of historic water and wastewater utility engineering expertise and requires staff and skills more typical of other city and municipal departments such as Public Works and Parks and Recreation. With industry standards constantly evolving and new infrastructure going into the ground at a frantic pace, the larger challenges of managing GI portfolios include:

- Implementing consistent maintenance standards and updating SOPs as design, construction techniques, and materials continue to change and evolve.
- Keeping up-to-date asset inventory records as diverse assets and locations are added on a monthly basis.
- Managing a diverse portfolio of spatially scattered assets with a mix of public and private ownership.
- Recruiting and training new staff including project managers and specialised maintenance crews.

While it is easy to make some broad assumptions to estimate what typical O&M activities and costs will be, actual experience suggests that they will vary quite dramatically.

Figure 3
Key Activities in developing a GI asset management strategy

Something as simple as inspections and trash removal can vary from several times a week in heavily urbanised locations to every two to four weeks in other areas, which has a significant impact on costs. Also, many GI assets are in industrial areas that require much more maintenance than developed residential areas where they may be more likely to be informally looked after by residents. Areas with harsh winters and constant rainfall require much more maintenance and snow can cover an entire swale for much of the season, leading to significant vegetation damage.

Overall, the challenges faced for GI vary greatly from grey infrastructure and require different skills, processes, and monitoring techniques to address. Unlike grey infrastructure, with GI:

- Poor maintenance can inhibit function quickly
- Aesthetics are equally important, as assets are a visible part of the community
- O&M costs are much higher as a percentage of LCC than for most grey infrastructure

Developing a comprehensive GI strategy

Utilities at any stage of their GI programmes can benefit from following several key steps in developing a comprehensive asset management programme and ensuring a successful LCC strategy is put in place. One of the most fundamental elements is to develop a formal business strategy and asset management plan that defines the goals and objectives of the programme in clear terms and establishes formal asset life-cycle plans that are properly funded and implemented through consistent SOPs. Other key thoughts in developing a successful GI strategy include:

- Investing in formal IT systems and tools to maintain up-to-date asset inventory and maintenance records
- Developing and training specialised internal and external resources to manage the design, construction and maintenance of GI assets
- Maintaining and updating formal design standards, building from valuable lessons learned in the field and benefitting from other 'early adopter' utilities
- Ensuring that ongoing maintenance is properly funded from the start so that asset condition is maintained and systems can deliver designed results
- Measuring and tracking lifecycle operations and maintenance cost so that future maintenance and capital budgets can be realistically set
- Establishing a transparent set of key performance indicators so that programme benefits are quantified and strategies can be refined over time
- Proactively communicating with internal and external stakeholders including public outreach and education and issue formal quarterly and annual reports

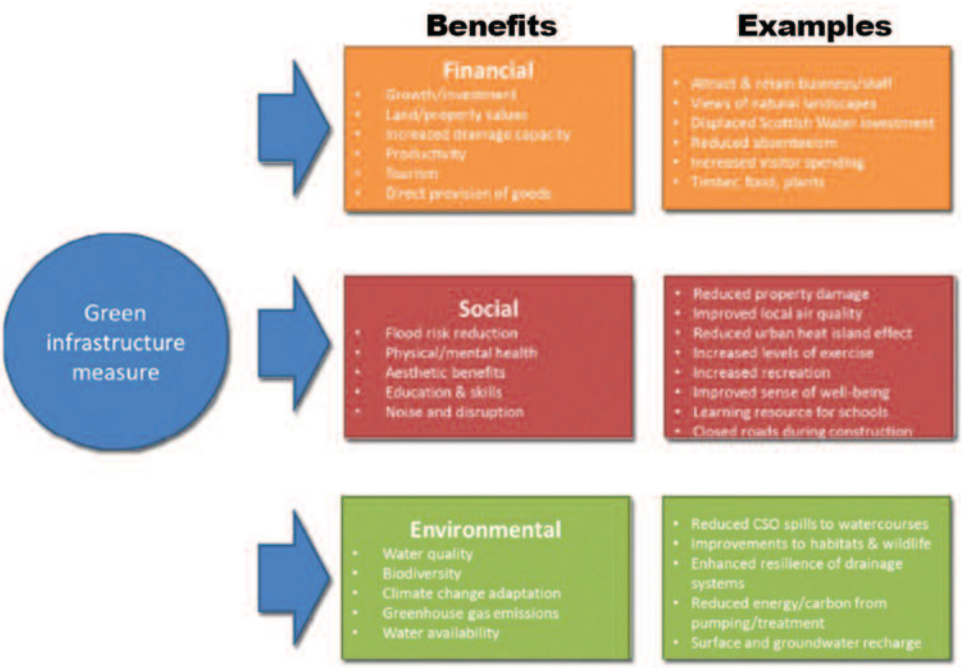


Figure 4
Significant TBL criteria examined

Finally as part of the business plan, utilities need to develop a solid staffing strategy to ensure the organisation is properly equipped to effectively operate and maintain these assets. Once again, there are some significant differences from grey infrastructure that must be considered.

- GI requires forestry, horticulture, and landscaping expertise vs. mechanical, electrical, and structural qualifications – need to recruit different skill sets
- GI requires a primarily field based workforce vs. mix of facility and field-based staff – need advanced mobile workforce tools
- GI requires extensive management and coordination of outside resources for specialised tasks vs. in-house efforts – additional co-ordination and work sharing with contractors and other city / municipal departments
- GI inspections are required for third-party infrastructure vs. utility owned assets – need inspection skill sets and mobile workforce tools

Industry case studies

As this is an important initiative for our industry at a critical point in its early development, there is mutual benefit in sharing best practices amongst peers and practitioners. Brief case studies provided for both Glasgow City Council (UK), and SFPUC (US) will help to foster common applications of asset management principles to allow utilities and municipalities to gain a better understanding of the optimal long-term strategies to operate GI assets most effectively.

Glasgow City Council (UK) embarked on its GI programme as a key component of a city centre surface water management plan. As such, the primary drivers were to reduce surface flooding, improve climate change resilience, mitigate heat island impact, reduce CSOs and improve aesthetics. A key component of this effort was an up-front analysis to establish a framework for triple bottom line (TBL) assessment to help identify the projects that are most likely to have the largest cost / benefit ratio as part of the programme. As a first step, the most impactful costs and benefits incorporating social, financial and environmental impacts were developed including a library of specific tangible examples. A follow-up step was to develop a library of TBL factors to document how they can be accurately quantified. Once each of these factors were quantified (for example greenhouse gas emissions, water quality, and aesthetic benefits), a monetised analysis could be completed to specifically measure the impact of various projects and objectively prioritise them for implementation. As part of this effort, whole life O&M costs estimates for various technologies (i.e. swales vs permeable paving) were developed to help evaluate the right application and

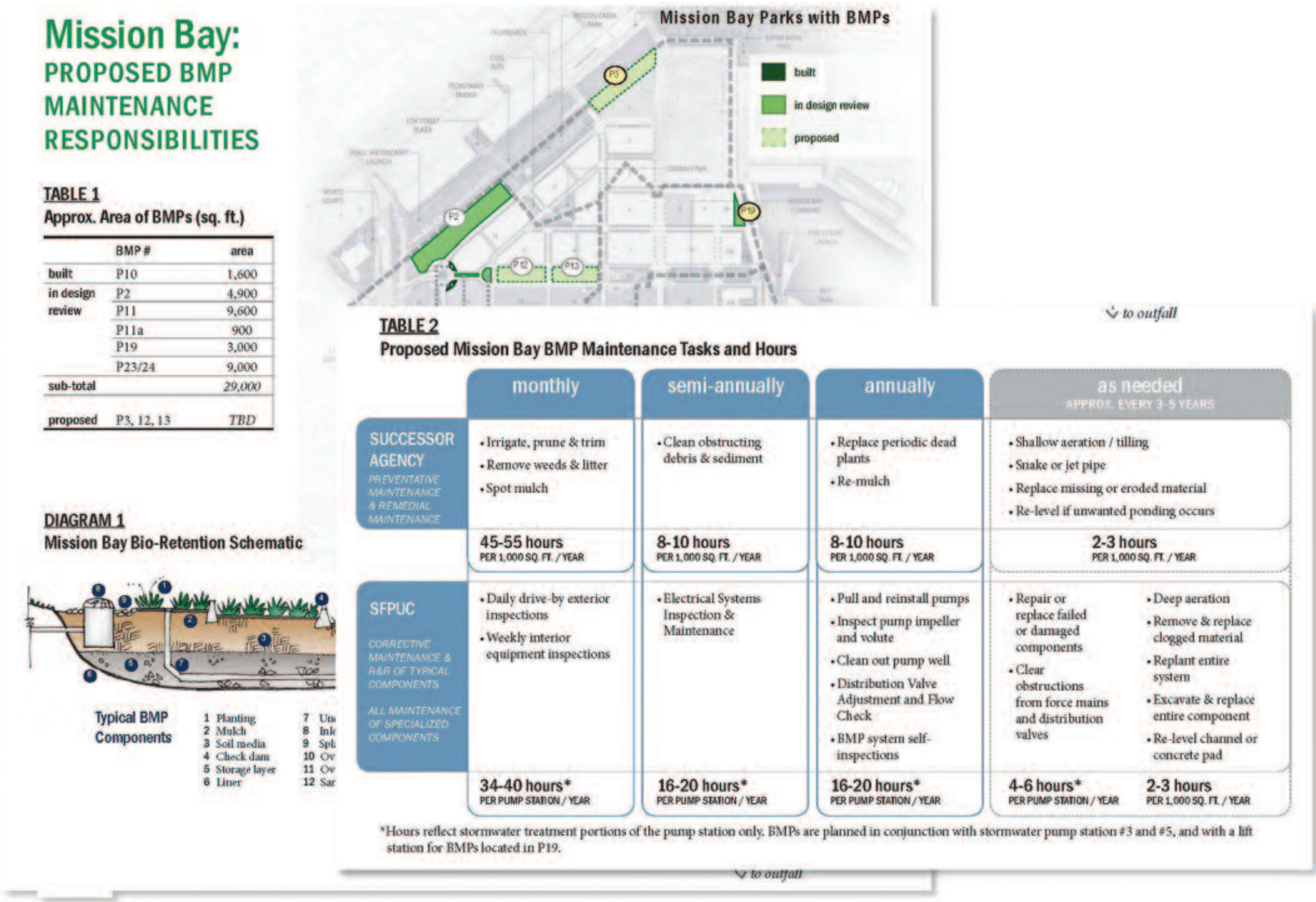


TABLE 1
Approx. Area of BMPs (sq. ft.)

	BMP #	area
built	P10	1,600
in design review	P2	4,900
	P11	9,600
	P11a	900
	P19	3,000
	P23/24	9,000
sub-total		*29,000*
proposed	P3, 12, 13	*TBD*

TABLE 2
Proposed Mission Bay BMP Maintenance Tasks and Hours

	monthly	semi-annually	annually	as needed APPROX. EVERY 3-5 YEARS	
SUCCESSOR AGENCY *PREVENTATIVE MAINTENANCE & REMEDIAL MAINTENANCE*	• Irrigate, prune & trim • Remove weeds & litter • Spot mulch	• Clean obstructing debris & sediment	• Replace periodic dead plants • Re-mulch	• Shallow aeration / tilling • Snake or jet pipe • Replace missing or eroded material • Re-level if unwanted ponding occurs	
	45-55 hours PER 1,000 SQ. FT. / YEAR	**8-10 hours** PER 1,000 SQ. FT. / YEAR	**8-10 hours** PER 1,000 SQ. FT. / YEAR	**2-3 hours** PER 1,000 SQ. FT. / YEAR	
SFPUC *CORRECTIVE MAINTENANCE & R&R OF TYPICAL COMPONENTS* *ALL MAINTENANCE OF SPECIALIZED COMPONENTS*	• Daily drive-by exterior inspections • Weekly interior equipment inspections	• Electrical Systems Inspection & Maintenance	• Pull and reinstall pumps • Inspect pump impeller and volute • Clean out pump well • Distribution Valve Adjustment and Flow Check • BMP system self-inspections	• Repair or replace failed or damaged components • Clear obstructions from force mains and distribution valves	• Deep aeration • Remove & replace clogged material • Replant entire system • Excavate & replace entire component • Re-level channel or concrete pad
	34-40 hours* PER PUMP STATION / YEAR	**16-20 hours*** PER PUMP STATION / YEAR	**16-20 hours*** PER PUMP STATION / YEAR	**4-6 hours*** PER PUMP STATION / YEAR	**2-3 hours** PER 1,000 SQ. FT. / YEAR

*Hours reflect stormwater treatment portions of the pump station only. BMPs are planned in conjunction with stormwater pump station #3 and #5, and with a lift station for BMPs located in P19.

Figure 5
Sample GI maintenance SOPs

narrow down list of 'best' options. To develop a final list of recommended and prioritised projects a six step approach was used: 1) determine economic baseline; 2) assess impacts of potential measures; 3) quantify impacts of measures; 4) value impacts of measures; 5) perform whole-life calculation; 6) apply sensitivity testing.

San Francisco Public Utilities Commission (SFPUC) (US) embarked on a GI programme as a component of its Sewer System Improvement Program (SSIP). In addition, it was a key mechanism to implement Stormwater Design Guidelines in public spaces and construct green streets as part of the City's 'Better Streets Plan'. SFPUC faced some unique challenges in developing maintenance strategies as it had to deal with different GI asset ownership structures including public, private, and multi-agency. Unlike other utilities in the US, the programme is not being driven by regulatory mandates but by proactive commitment to sustainability and a plan to build green corridors within the central business district. As part of its overall effort SFPUC has proactively developed long-term maintenance strategies for its GI projects and infrastructure. Although still in early programme stages, SFPUC have made some key decisions that were documented through a formal business plan. Their business plan addressed key issues such as labour union strategy, training, job classifications, career path, and defined tasks / activities. Most importantly, SFPUC's approach included proactive development of maintenance strategies during the design phase of major projects. This was critically important as contractors may be responsible for maintenance for initial period and there needed to be a clear understanding between the different agencies involved including SFPUC and the Department of Public Works (DPW). The maintenance documentation was comprehensive including identified work categories, activities, frequency and cost estimates including labour, equipment, materials. Additional activities that are still in progress include the development of planning level estimates for city-wide green infrastructure including maintenance strategies over a 20-year period.

Conclusions

While this paper has provided some broad strategies and approaches for effectively managing GI, many challenges remain. As it is still a new field in the early stages of development, utilities should continue to exchange ideas and lessons learned from others and evaluate the specific costs and benefits of GI based on local circumstances. As design standards, approaches, and technologies evolve, utilities will be better equipped to manage risks and ensure effective investments in GI that can offer cost effective social and environmental benefits in parallel with traditional grey infrastructure. There are several fundamental components to any GI strategy that utilities should proactively address.

- Develop overall business plans and trategies for staffing, materials / equipment, IT systems, data collection, and analysis to provide a strong organisational foundation
- Ensure that long-term maintenance strategies are developed in parallel with design and construction so that utilities have a solid plan from the day assets are commissioned
- Apply LCC and TBL analysis to validate realistic long-term budgets and ensure that assets are properly maintained and operated to achieve their desired impact
- Always be prepared to review and re-evaluate strategies frequently as a lot of the information is new and programmes will see significant evolution over the next several years ●

This paper was presented at the 2014 IWA World Water Congress, held 21-26 September 2014 in Lisbon, Portugal.

Water loss reduction and asset management: A practical illustration from French stakeholders

France has been undertaking efforts to reduce water losses from its drinking water networks from 21.9% in 2008 to 15% in the short-term, and to 5 to 10% in areas of high urbanisation. Developing a detailed description of all drinking water systems is the first step that is necessary to be able to develop and implement an effective action plan to reduce water losses. Sylvain Charrière, Eddy Renaud and Caty Werey discuss the recommendations laid out in the guide to the establishment of this description of drinking water systems laid out by the French Scientific and Technical Association for Water and Environment (ASTEE), which covers asset management guidelines and how effective asset management starts with the good knowledge of the drinking water system.

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In France, drinking water management is based on a decentralised model. In fact, the General code of Territorial authorities (CGCT) establishes the principle of compulsory municipality competencies in terms of drinking water supply. However, the production, transport and storage of drinking water are optional competencies for the municipalities. Accordingly, these competencies can be transferred to inter-municipalities in order to pool technical resources and streamline water management costs.

Each municipality is therefore the organising authority of its drinking water supply system and establishes objectives in terms of level of service. This may occasionally result in local significant disparities in the management of the service and the price of water. A tangible example of these disparities resides in the regulatory indicators such as the performance and asset knowledge index of transport and water supply infrastructures. Consequently, certain organising authorities exhibit a poor level of asset knowledge and a very significant level of loss from their network.

In light of this, the French government and notably the Ministry of Ecology, Sustainable Development and Energy provided articles in the legislation[1] in terms of reducing losses from drinking water systems and imposed obligations for the establishment of a minimum baseline of asset knowledge, together with financial penalties for non-compliance.

The Ministry of Ecology commissioned the French national agency for water and aquatic environments (ONEMA) to provide practical guidelines to accompany the introduction of an asset management approach across all French water services. Accordingly, work groups combining several bodies created three guides:

- 'Drinking water supply asset management plan: Development of a detailed description of transport and distribution of water infrastructures'. Containing Levels 1 and 2 of asset management.' ONEMA / ASTEE[2] / AITF[3] 2013.
- 'Guide for the development of an action plan for the reduction of losses in the drinking water distribution networks.' ONEMA / IRSTEA[4] / ASTEE 2014.
- 'Investment policies and asset accounting: Framework and good practices. A vision crossing technical, accounting and financial points of view'. ONEMA / ASTEE / AITF 2014.

Another volume aimed at helping local authorities to develop software tools and methods for asset management of drinking water networks is being developed. Its release is planned for 2015 under the name 'Level 3 of asset management.'

After a review of the French regulations and objectives for asset management in drinking water networks, this article will present the three asset management levels defined in the above guides.

French regulations

The National Commitment Act for the protection of the environment (known as Grenelle 2) sets a performance goal for drinking water networks based on regulatory yield. This yield:

$$R = \frac{\text{Volume consumed authorised + Volume sold}}{\text{Volume produced + Volume purchased}}$$

must be greater than or equal to the smaller of the following two levels R_1 and R_2 (ILC = Linear Consumption Index):

$$R_1 = 85\%$$

$$R_2 = R_0 + \frac{ILC}{500}$$

with R_0 = 65% or 70% if the samples taken from resources subject to distribution rules are over 2 million m^3/year.

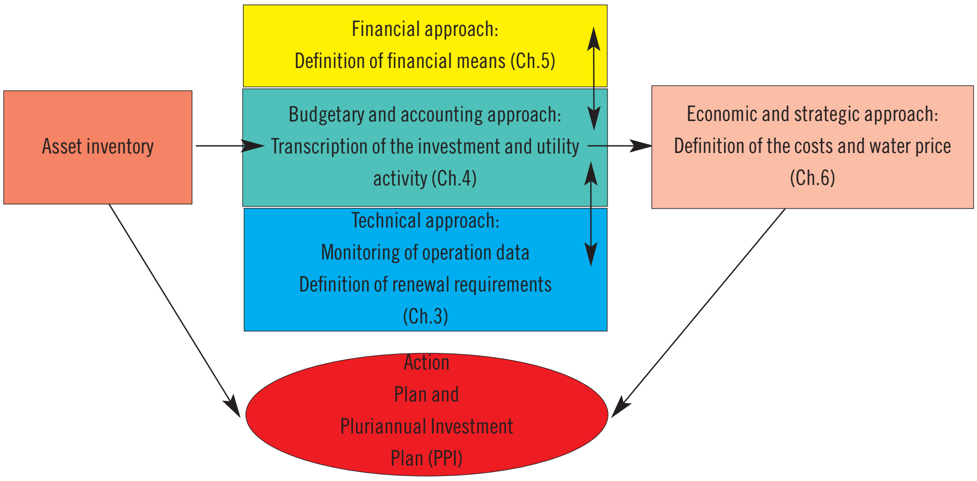


Figure 1
The development of action plans and PPIs

Water services not reaching this threshold should develop an action plan to reduce water loss.

In addition to this performance objective, the French legislation requires that organising authorities carry out a detailed description of their networks. This description reflects the need for each local authority to acquire a minimum knowledge base of their asset. This threshold is reflected in the ONEMA / ASTEE / AITF guide by the implementation of the Level 1 of asset management.

These regulations shall be subject to financial penalties. These incentive sanctions occur in the form of a doubling of the levy on 'drinking water' resources perceived by water agencies in accordance with article L. 213-10-9 of the Environmental Code.

The objectives of asset management

Asset management is a long-term approach that takes into account the state of assets throughout their life cycle in order to ensure the required performance level with a given risk factor, in a challenging economic environment.

In the case of a drinking water supply system it can be defined as a planning process for the optimisation of the design, supply and conception of infrastructures, the evolution and maintenance of the entire system the decommissioning of these infrastructures, and results in a set of actions to be undertaken in the short-, medium- and long-term to complete and maintain in the long-term a good level of water service performance while ensuring acceptable water prices for consumers. This process must constantly adapt to:

- Regulations
- User expectations
- The status of water resources
- The budget and financial environment including access to loans and grants
- Agreements and / or delegation contracts
- The likely consequences for future generations

Given the diversity of management services, and consequently the objectives fixed for the managing service by the organising authority, the content of an asset management policy cannot be uniform.

The objectives relating to asset management can be grouped as described below.

The quality of tap water

The primary function of the water supply system is to deliver water suitable for human consumption to the tap of each consumer. In certain circumstances the network is liable to local degradation of the water quality, which can be caused by structural problems (pipe material, leakage) and functional causes (initial water quality, retention time in the infrastructures and the network, water temperature).

An asset management strategy focused on maintaining the quality of water should therefore identify the causes and implement corrective actions such as the meshing or un-meshing of the network, the renewal or rehabilitation of pipes or connections, and so on. On the other hand, the satisfaction of health constraints can lead, for example, to the establishment of purges, enabling the reduction of the time the water remains in the distribution network. This solution, if there is a short-term economic advantage, induces additional water consumption and possible additional treatments.

The continuity of supply

Continuity of supply consists of ensuring at all times the availability of water service to all users, especially to sensitive users (hospitals, retirement homes, nursing homes, etc.). An asset management strategy aimed at maintaining or improving the continuity of supply incorporates several types of actions:

- Ensuring maintenance and network monitoring
- Managing the level and variation of pressure
- Establishing the technical analysis of the interactions between materials, stray currents...
- Renewing the most critical infrastructures (which exhibit a high probability of failure)
- Securing the network by meshing the pipes or by doubling strategic pipelines

This network performance is measured using the rate of unplanned service interruptions.

Asset management focused primarily on the continuity of supply would tend to maintain a high level of network security. Accordingly, pipes prioritised for renewal will be those who in case of rupture would deprive water sensitive users of a supply and / or affect a significant population.

However, certain security actions such as the meshing of the network can lead, for example, to an increase in the time the water remains in the network and therefore increases the possibility of degrading water quality.

The environmental impact

Water losses are an additional and often unnecessary levy on the resource. Their origins are varied: they can be physical (leaks from pipes, connections or other structures) or commercial (water theft). The steps taken to limit these losses should arise from an analysis of their origin, taking into consideration the context and surrounding issues.

In relation to physical losses, the asset management policy will consist of the joint implementation of:

- Operating actions to limit the volume of losses such as location and repair of leaks or pressure management
- Renewal of the most leaky piping and / or connections. Asset management based on the objective to reduce the volume of water loss should focus on the renewal of the most leaky pipelines.

These actions may require the establishment of an effective and sustainable segmentation of the water system. This aspect of the network performance is measured in particular with regular monitoring of the volume distributed to different nodes and regulatory indicators 'Linear index of unaccounted volumes,' 'Linear index of losses on the network' and 'Performance of the supply network.'

However, actions related to the fight against water loss can have an impact on the time the water remains in the network and the risk of freezing.

In addition to the impact on water resources, water loss has an impact on the energy consumption of the drinking water supply system. Pumping a quantity of water that will then be lost means unnecessary use of electric power.

Through the localisation of networks or the need to keep infrastructure operational, interventions are often a source of disruption. Certainly, whether it is service disruption or the disruption of road traffic, maintenance and network maintenance can disturb the environment. These disturbances being easier to manage when they are planned, it is sometimes advisable to anticipate some maintenance actions.

Synthesis

In the context of a drinking water asset management system, the organising authority will clearly need to make compromises between all of the above points.

For each organising authority this will involve defining key focus areas as well as concentrating efforts on each objective (level of information detail to be collected, investment to be provisioned, allocation of human resources...) in order to develop a policy of sustainable asset management derived from an integrated approach to each asset and its environment.

The various levels of asset management

Level 1: Developing an inventory

Level 1 of asset management enables meeting the elements required by law (Section D. 2224-5-1 of the CGCT). Accordingly, each organising authority must generate:

- A plan of the network indicating the location of monitoring equipment in the main water supply service infrastructures (catchment structure, treatment plant...).
- An inventory of networks, including: the length of the pipes; the year, or failing this the period, of installation; the category of the infrastructure: 'sensitive' or 'not sensitive' (in relation to Article R554-2 of the Environmental Code); the accuracy of the information used: Class A, B or C (in relation to Article R554-23 of the Environmental Code); the information available on the materials used and the diameters of the pipes.

This detailed description must be updated and completed annually. This level does not actually correspond to asset management, but it nonetheless constitutes the basic core of knowledge necessary for its implementation.

Level 2: Best practices

This level of information consolidation exceeds the French regulatory framework and moves towards the recommended best practices for effective management.

In addition to all elements in level 1, the guide ONEMA / ASTEE / AITF sets out that for level 2 to be achieved, the utility needs to generate detailed plans for all of its major infrastructure and its technical characteristics, including:

- The location of all equipment: valves, suction cups, drainage pipes, shut-off valves, regulators (e.g., pressure reducers), poles and fire hydrants, metering points, fixed leak detectors, etc.
- The main features of the infrastructures: reservoir volume, embankments and overflow tanks, total flow rates and discharge heads of pumping systems and recovery stations, etc.
- The location of out of service pipelines
- In the absence of accuracy, the alignment of the pipe under the road (left, right, centre) or footpath (right or left)
- The localisation of easements, which are essential in the planning of interventions within the network. For example, it enables emergency intervention on private land without the owner's permission.

At this level, the management of all plans by computer in order to facilitate the changes, updates and reproductions is prescribed.

Synoptic overviews of the infrastructures, planimetric mapping (simplified network mapping) and altimetry are also necessary for better understanding of the network's operation and its optimisation. Interconnections with neighbouring networks (existing or foreseeable) must be analysed.

Concerning the pipes, it is necessary at this stage to identify diverse information such as the function (supply of raw water, supply of drinking water, etc.), the depth, altimetry of the land, type of seals, date and reason for abandonment, etc.

Data relating to connections cannot be ignored here, as they are often the site of leaks. In addition it is very useful when repairing a pipe in order to anticipate the impact on users during decommissioning of the pipe. All pipe features are therefore also required for each connection.

Finally, special attention should be paid to the management and archiving of failure data in order to implement decision support tools. This information must be dated and the location logged, and must specify the type of breakdown, its probable cause and how it was detected, etc. During their repair these breaks are also an opportunity to control or enhance the data on the sections where they are located. This information must be retained for use in breakdown prediction models, even if the sections have been renewed over time.

Level 3: Advanced asset management

<u>The relevant data</u>

For levels 1 and 2, the research, storing and archiving of certain functional data from the drinking water network and connections is recommended (material, diameter, and year of installation, or failing that the installation period, length of the section, type of seal, etc.).

For level 3, it is suggested to supplement this functional data with contextual data, such as:

- Type of soil
- Traffic conditions
- Electrical environment (stray currents)
- Service pressure
- Criticality of the section, etc.

<u>Drinking water GIS: the foundation of asset management</u>

For levels 1 and 2, the use of paper plans or computer aided drawing (CAD) was a possibility to ensure the storage and analysis of data relating to drinking water networks. For level 3, it is imperative to structure information using a Geographic Information System (GIS).

Asset management at level 3 is based on the use of GIS. It is a computer application used to organise, manage, combine and analyse information from various sources, associated with their mapped location. This primary function of GIS is the technological support required to develop the foundation of an asset management strategy: control of knowledge.

The advantages of GIS are multiple:

- GIS provides a visual dimension for the connection of spatial data and structured alphanumeric data in databases, displaying them as a map
- GIS manages databases and allows you to store and organise a significant information mass attached to graphical objects
- GIS manages information in layers for cross-checking and grouping of similar information at the same 'level' for easy viewing and analysis
- GIS is a dynamic tool facilitating the continuous updating of the basic information that it contains
- GIS is an analytical tool capable of querying the database with generic criteria or spatial criteria and to cross-reference several details

- GIS provides advanced capabilities to facilitate the network operation

The level 3 guide details the important concepts to be taken into account in the design of a 'drinking water' GIS. Coupled with the use of an Excel spreadsheet, it is possible to perform an initial analysis on the state of the network. However, to perfect asset management, it is essential to rely on decision support tools. According to their nature, they enable improvement of the hydraulic understanding of the network or prioritise sections for renewal, with a view to optimising the investments related to the rehabilitation of pipes.

Hydraulic understanding

At level 3, the hydraulic understanding of the drinking water system must be based on the deployment of hydraulic modelling tools. The modelling of a drinking water network corresponds to the representation of the network's functionality and its components in space and time. Hydraulic modelling enables simulation of scenarios to test the responses of the model (flow and pressure) and ultimately that of the network.

The advantage of modelling is therefore multifaceted, enabling:

- Understanding of the hydraulic operation of the network and accordingly identification of the points of potential improvement: an area of extreme pressure (high or low), time spent in certain pipes, etc.
- Diagnosis and optimisation of infrastructure operation: pump uptime, reservoir drawdown, etc.
- Simulation of network operation under unusual conditions: fire protection, pipe rupture, etc.
- Estimation of the potential for network scalability to meet increases in water requirements: urbanisation, extensive sale of water, etc.
- Planning future infrastructure: pipelines, pumping stations, reservoirs, etc.

The hydraulic operation of a network can directly influence the structure of an asset management plan by enabling the characterisation of the criticality of each section, the pressure at each point and the residence time. These data are analysed in multi-criteria decision support tools.

Prioritisation of sections to be rehabilitated

For over 20 years, consulting firms, operators and researchers have developed a variety of decision support tools. Through using detailed network diagnosis and breakdown data it is possible to model the behaviour of each segment (breakdown prediction) and consequently develop a pipe rehabilitation strategy (multiple criteria tools).

The guide seeks to define the conditions of use of the various decision support tools. Tools for break prediction are used to estimate the break risk for each section based on the history of recorded breakdowns. Multi-criteria tools are used for associating other technical and economic aspects with these breakdown predictions, such as the environment of the pipe, the hydraulic criticality of the sections or the maintenance costs in relation to the rehabilitation costs.

Finally, the guide also introduces the concepts of long-term rehabilitation planning.

Asset management of other infrastructures

The detailed knowledge of a drinking water network must involve the entire production / transmission / distribution chain. Accordingly, the drinking water system infrastructures must be established and described in a structured information system.

Asset management of superstructure infrastructures (pumping stations, reservoirs, production plants, etc.) is inherently different to network asset management. Unlike the latter, it applies to a limited number of units and is more easily comprehensible without statistical tools. In addition, these infrastructures are often directly accessible; the data characterising their nature and condition are for the most readily available without complex investigations, unlike an underground network.

The guide suggests a method to investigate these infrastructures and to analyse their deterioration.

Investment policies and capital management

Current management of drinking water services is often based on the establishment of a renewal / rehabilitation programme, carried out using employee experience and knowledge of the network or from decision support tools using operation and investigation data. This is what we call the 'technical' approach to asset management; defining the requirements. Then there is the matter of how to finance these needs and how to stagger them better over time. This is what we call the 'financial' approach; defining the financial resources through appropriate accounting rules for transcribing the service activity and capital management approach. In particular, the value of capital assets as well as the depreciation periods used by different utilities may vary. These diverse functions are generally separated within the utility and use different methods and vocabularies. The notion of 'action plans' and 'Pluriannual investment plans' (PPI) make a first link.

Moreover, the notion of strategic and economic management requires consideration of both technical and financial approaches to create a link with the water price, within the framework of the pricing policy of the responsible organisation.

The guide 'Investment Policies and Capital Management: Framework and Best Practices' is based on the notion of action plans and multi-year investment plans.

Action plans

Action plans are a management tool for public action, which reflect the strategic direction (reducing leakage, quality of service, asset preservation, etc.) and policy goals, and define the necessary resources (operating and investment costs) to reach these objectives.

In this guide the action plan concept therefore covers:

- The actions for day-to-day operating and management of the service
- The actions resulting from medium-term programming plans (investment and management of the network)
- The actions associated or resulting from long-term programming / planning

Pluriannual Investment Plans

PPIs are an economic planning tool which reflects the cost of equipment and renewal projects and adaptation of technical assets. It is a prerequisite to the creation of any short- or medium-term economic projection. The investment choice has an impact on operating costs beyond the impact of the depreciation expenses mechanism.

The guide presents the various components involved in the development of action plans and PPIs (Figure 1). The guide also includes case study information from utilities of different sizes and a presentation of international approaches such as the OECD 3T issues (Tariffs, Taxes, Transfers).

Recommendations

It is key for water utilities to know their infrastructure in order to form a detailed inventory, as well as in terms of asset promotion to combine financial and technical approaches in order to build action plans and PPIs.

The accountancy nomenclature of fixed assets, conducted by component, will enable better understanding of the various lifespans and lead to the better allocation of costs. The extension of the accounting period adjusted towards the actual lifespan may only take place after a prospective financial analysis, taking into account its impact, particularly with regards to cost.

The valuation of assets conducted at their historic cost is an exercise performed by utilities under special circumstances. It is a useful approach, which contributes to the knowledge of assets and which can also become a governance tool to communicate with the economic regulator of water services.

The establishment of long-term approaches (+30 years) enables the development of a projection of necessary financial requirements to comply with investment / renewal requirements and financial strategies.

Accurate asset management is necessary in terms of intergenerational equity in order to maintain the water infrastructure capital. This raises the question of its impact on the water price and its acceptability by consumers. Will a formal debate with elected officials and consumers achieve the sustainability of water services in all economic, environmental and social dimensions?

The evolution towards integrated management and the consideration of the social and environmental aspects of the sustainability of the urban water management system will require opening up the system beyond the technical infrastructure and the concept of renewal.●

Notes

[1]*These include the articles L. 2224-7-1 and D. 2224-5-1 of the CGCT and articles R. 554-2 and R. 554-23 of the Environmental Code. Article L. 213-10-9 of the Environmental Code*

[2]*The Scientific and Technical Association for Water and the Environment*

[3]*The French Territorial Engineers Association*

[4]*The National Institute for Research in Science and Technology for Environment and Agriculture*

This paper was presented at the 2014 IWA World Water Congress, held 21-26 September 2014 in Lisbon, Portugal.

Sewer network monitoring in Athens

Water and asset monitoring specialist HWM has added GPRS data transmission to its Pressure Transient Logger.

The logger triggers a capture window around a transient event and transmits this data. Operators can send transient alarm information and a selectable window of fast logged data before and after an event via an event window selection feature.

The sampling rate on the logger's pressure transient channel extends to 100 times a second and operators can define sampling intervals and transient data capture trigger levels.

HWM has also added a secondary validation to its PermaNet leak detection system. This gives operators three secondary options to check for false positives prior to team deployment, consisting of remote correlation, remote retrieval of a detailed Aqualog noise graphic or listening to an audio file transferred to the host PC. Every component of the PermaNet+ system is installed in the chamber, removing the need for expensive and disruptive aboveground installations, says the company. With multiple secondary validation options, false positives are reduced and efficiency increased as teams are sent only to validated leak locations. ●

www.hwm-water.com

FCC Aqualia awarded Qatar contract

FCC Aqualia, a water management subsidiary of the Citizen's Service Group, has successfully bid for the management of the sewerage system in Al Dhakhira, Qatar, for the next ten years.

The €300 million ($352.8 million) contract represents FCC Aqualia's entry into Qatar following successful contracts in Saudi Arabia and the United Arab Emirates. The company is part of a consortium which also includes the South Korean company Hyundai. The contract covers design, construction, operation and maintenance of the wastewater treatment facilities, wastewater pumping stations, transfer pumping station and collectors associated with the city of Al Dhakhira, located on the east coast of Qatar, some 60 kilometres from Doha, the capital.

The new plant is expected to handle an average flow of 56,200m^3 per day and provide service to a population of more than 200,000 residents. It will incorporate the latest technology in sewerage and wastewater treatment, using more than 35 kilometres of pipes, with peak flows of 168,000 cubic metres and a wastewater tank with capacity for 84,000 cubic metres.

This new contract is the third for FCC Aqualia in this region, after the sewerage management contract in Abu Dhabi for the city of Al-Ain and a contract in Riyadh (the Saudi capital) for enhancing the efficiency of the supply network. ●

www.aqualia.es

Calais awards public services drinking water contract to Suez

Lyonnaise des Eaux, a subsidiary of Suez Environnement, has been selected by the French City of Calais for a public services drinking water contract covering a period of 12 years, commencing next month, and worth €79 million ($91.5 million).

The contract covers the preservation of water resources and improvements in quality of service to the citizens of Calais. Calais has been committed to a water preservation programme in the city perimeter for several years using Suez Environnement's Aquadvanced technology to measure flow, pressure and use of water as a means of identifying malfunctions. The system enables visualisation in real time in order to locate leaks and optimise repair operations. The data collected are processed and analysed to provide the municipality with a tool to support decision making in its investment policies.

Citizens of Calais will also be able to read their water meters remotely beginning in 2015 in order to further enhance leak prevention. Users will be able to monitor consumption in real time via a dedicated internet site and will in turn be better able to control their invoices. Remote meter reading is also useful when sending emails or texts rapidly where abnormal usage triggers suspicion of a leak. Lyonnaise des Eaux will also be setting up a programme to reduce the tang of chlorine in water as perceived by consumers. This will involve optimising quantities of chlorine to guarantee water quality by using the correct prescribed amounts of chlorine in the right locations at the right time. ●

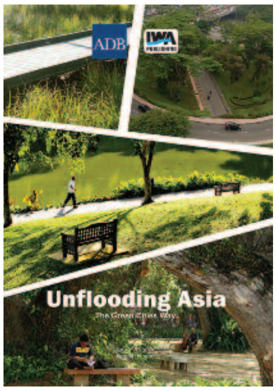
www.lyonnaise-des-eaux.fr

Unflooding Asia the Green Cities Way

Authors: Zoran Vojinovic and Jingmin Huang

A continuing increase in disasters triggered by floods occurs almost daily even though our technological capabilities have grown rapidly and global economic growth per capita has doubled. This paradoxical situation proves that our earlier ways of thinking are inadequate and that we must shift our way of thinking and working. It has become obvious that most flood-related disasters, although commonly referred to as natural disasters, are not the result of nature-related processes alone. Some of the early efforts in dealing with floods and flood-related disasters were only concerned with the construction of engineering structures (e.g., levees, floodwalls, dams, embankments, storage basins, diversions, etc.) without significant consideration of aspects which are nowadays regarded as equally important, if not more important. There is a great deal of natural, social and technological interactions that shape the vulnerability to floods. Realising that flood risk can hardly ever be completely eliminated, the traditional 'flood defence' culture has been replaced with the culture of learning how to live under flood risk and how to better respond to it. This renders purely engineering solutions inadequate.

Can the threats of more flood-related disasters provide an impetus to shift our mind-set towards an approach that favours not only sound technological innovations but one that also addresses the social, cultural, and wider ecological aspects of dealing with floods?



In this illustrated book, the Asian Development Bank (ADB) seeks to introduce a holistic thinking in dealing with urban floods by adopting the green cities development approach. Green cities development is a holistic approach which promotes multipurpose (or multifunctional) solutions that are not only technologically and economically efficient, but which are also ecologically sustainable and socially just.

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Case Study Application of Determining End of Asset Physical Life Using Survival Analysis Cincinnati and Milwaukeee

INFR2R11a

Author: Duncan Rose

Determining which investment strategy should be deployed for a given asset and when that strategy should change across the life cycle of the asset lies at the heart of asset management. Considerable progress has been made over the past decade, especially the last five years, in understanding how infrastructure assets actually fail. While much remains to be done, a body of refined techniques for assessing condition and predicting failure has emerged, based largely on the improved understanding of failure mechanics. This progress has focused on predicting remaining physical life.

The optimal investment strategy is directed at minimising total cost to the utility – including deferral or avoidance of the consequences to customers and community of failure (alternatively, maximise benefit to the community). This research draws on concepts and techniques from advanced risk analysis, the reliability sciences and microeconomics to provide for the development of a web-based tool to guide the asset management practitioner in meeting the challenge of developing an investment strategy that represents the best integration of maintenance, operations, and capital investment.

IWA Publishing April 2015. 40pp. ISBN: 9781780406770
To order, visit: www.iwapublishing.com

Transforming Our Cities: High-Performance Green Infrastructure

INFR1R11

Author: Marcus Quigley

Traditional approaches to stormwater management include construction of large, centralised end-of-pipe or interceptor solutions that can be extraordinarily expensive. The goal of this research is to look beyond conventional approaches to stormwater infrastructure and examine the effectiveness of various decentralised controls that use natural elements to dampen stormwater surges.

Specifically, the research team continues to develop highly distributed real-time control (DRTC) technologies for green infrastructure, such as advanced rainwater harvesting systems, dynamically controlled green roofs, wet detention basins and underdrained bioretention systems. Particularly, the objective is to demonstrate that these systems can play a critical role in transforming our nation's urban infrastructure.

IWA Publishing April 2015
200pp. ISBN: 9781780406732
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AM DIARY

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

IWA Specialist Conference on Water Efficiency and Performance Indicators / Benchmarking
19-25 April 2015, Cincinnati, Ohio, USA
Web: www.iwaefficient.com/2015

Cities of the Future - Transitions to the Urban Water Service of Tomorrow
28-30 April 2015, Mulheim an der Ruhr, Germany
Web: https://conference.trust-i.net

Regional Utility Management Conference Improving Performance in Emerging Economies
13-15 May 2015, Tirana, Albania
Web: http://utilityconf.al

9th IWA Symposium on Systems Analysis and Integrated Assessment
14-17 June 2015, Surfers Paradise, Australia
Web: www.awmc.uq.edu.au/conf/watermatex2015

IWA Regional Conference & Exhibition on Water Loss Management 2015
15-17 June 2015, Bucharest, Romania
Web: www.waterloss2015.araexpoapa.ro

Biofilms in Drinking Water Systems - From Treatment To Tap
23-26 August 2015, Switzerland

2nd Water Loss Turkey Forum
28 -30 September 2015, Istanbul, Turkey
Web: www.waterlossforum.org

LESAM 2015
17-19 November 2015, Yokohama, Japan
Web: www.lesam2015.org

For a full list of water sector events taking place in 2015, visit: www.iwapublishing.com