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UN stresses need to embrace right to water and sanitation

Top UN officials recently stressed the need to realise the human right to water and sanitation, saying that it is critical to a life of dignity and also to achieving progress in areas such as poverty reduction, improving child health and combating diseases. Assembly President Joseph Deiss explained to a plenary meeting that achieving the water and sanitation Millennium Development Goal targets is 'fundamental' to achieving other goals such as reducing poverty, boosting education and child health, and fighting HIV/AIDS and other diseases.

UN Secretary-General Ban Ki-moon told the meeting that the task at hand is to translate the commitment to provide access to clean water and adequate sanitation into action: 'Let us be clear, a right to water and sanitation does not mean that water should be free. Rather, it means that water and sanitation services should be affordable and available for all… and that states must do everything in their power to make this happen.

Adding that many governments have already included the rights to water and sanitation in their constitutions and domestic legislation, he urged those that have yet to do so to 'follow suit without delay'. ●

Research highlights benefits of watsan programme

Pentair in the US has announced the results of a multi-year research programme, Project Safewater-Colon, which suggest a holistic, low-cost 'micro-enterprise' model can effectively establish water and sanitation in unserved regions.

The programme was conducted in the remote district of Colon, Honduras, where nearly all of the region's 350,000 people lived without clean water and around 25% lacked adequate sanitation.

The work funded the installation of more than 200 water treatment systems and over 10,000 individual sanitation facilities and also encompassed widespread community education programme to increase awareness of the importance of safe, clean drinking water and the connection between good hygiene practices and health.

Project Safewater-Colon established a micro-enterprise business model, where the local community owns the water treatment systems and users pay their communities a nominal fee for potable water.

An independent study on Project Safewater-Colon's health impact was led by Dr Jeffery L Deal, director of anthropology and water studies for the Center for Global Health at the Medical University of South Carolina. He said: 'This is the first time conclusive evidence confirms what many have assumed for years – that access to clean, safe water directly reduces waterborne illnesses.

'This project has demonstrated that community-based water treatment systems can be done cost-effectively. Our findings provide us with a replicable, immediately deployable model to reduce the incidence of waterborne disease and save lives.' ●

Asian Development Bank report calls for further public private partnerships

A new Asian Development Bank (ADB) report assessing the private sector in the Philippines says that effective public-private partnership (PPP) implementation in the country can boost its competitiveness, as it brings better infrastructure quality and technical expertise.

In the Philippines, PPPs have typically been shunned by business because of unclear policy and regulatory frameworks, a cumbersome government approval process, and a lack of bankable projects, the bank says.

Other obstacles, such as controversial judicial decisions, have also constrained PPP growth, the report notes.

To encourage partnerships, the government should improve transparency in project selection, provide better accounting of revenues and expenditures, and have a higher-profile anti-corruption drive. ●

water
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INTERNATIONAL

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

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Development of a data filtration method for strategic data acquisition in sewer rehabilitation planning

Many of the current tools for sewer rehabilitation planning are too complex to be applied in practice, and in Austria for example, no standardised approach regarding sewer rehabilitation planning is currently available, making comparison between utilities difficult. In a three-year research co-operation between universities and sewer operators, suggestions for standardising performance requirements for sewer rehabilitation are being compiled, as well as a supporting data filtration method. In this paper, Florian Kretschmer, Hanns Plihal, Daniela Fuchs-Hanusch, Michael Moederl and Thomas Ertl describe the basic idea of the data filtration method, as well as the first results obtained regarding the definition of different performance indicators.

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Over the last 40 years about €22 billion ($31 billion) has been invested in construction and extension of public sewer systems in Austria. Today, these works are considered to be widely accomplished. In the future the main focus in urban drainage will concern rehabilitation activities to maintain long-term functioning and value of sewer systems. Figure 1 shows pipe jacking at a sewer rehabilitation site in Austria.

International research already deals with different aspects of rehabilitation planning (Milojevic et al., 2005; Le Gauffre et al., 2007; Ugarelli et al., 2007; Dirksen and Clemens, 2008; Alegre and Covas, 2009). Besides integrated rehabilitation planning strategies, publications mainly focus on conservation of the value of sewer systems or modelling of pipe deterioration. Several software applications for decision support are available. An overview of different modelling techniques for sewer deterioration is given in Ana and Bauwens (2010). However, in daily sewer system management practice the mentioned strategies, techniques and tools still seem to be rarely used. According to Ana and Bauwens (2007) a possible reason for the lack of practical applications can be found in the rather rigid and complex architecture of today's techniques and tools. Additionally, most of these (theoretical) modelling and decision support approaches require extensive datasets, which often are not available at utility level.

Due to the lack of standardised planning procedures at national level several Austrian sewer operators have started to develop 'in-house' sewer rehabilitation strategies. These strategies are based on the data commonly available in sewer practice. However, various planning approaches complicate the comparison of different utilities and thus the internal and external evaluation of a certain rehabilitation strategy. A standardised approach would help solve this problem. Additionally, it could serve as a planning guideline, especially for small- and medium-sized utilities, which often have not yet undertaken rehabilitation planning.

The standard EN 752 (2008) regarding drain and sewer systems outside buildings is considered to be a useful basis for the development of a national perspective regarding integrated sewer rehabilitation planning.

Strategic data acquisition

Functional and performance requirements

According to EN 752 (2008) drain and sewer systems have four different objectives (public health and safety, occupational health and safety, environmental protection, and sustainable development). Functional requirements, 13 in total, ensure that whilst taking into account sustainable development, drain and sewer systems convey and discharge their contents without causing unacceptable environmental nuisance, risk to public health, or risk to personnel working therein. To enable the evaluation of the performance of a system it is necessary to determine measurable performance requirements. EN 752 (2008) does not define any performance requirements but refers to different national organisations in the countries of the European Union.

Today, modern strategies in sewer operation and maintenance are more and more demand oriented and no longer only follow fixed intervals. However, to efficiently manage measures like demand orientated sewer cleaning and Closed Circuit Television (CCTV) for inspection, the availability of comprehensive input data is imperative. For instance, the analysis of cleaning protocols can give valuable information to identify sewer sections more or less sedimentation prone. Based on this information cleaning intervals can be applied more accurately (demand orientated). CCTV inspections do not only deliver information about the current state of the sewer pipes, but can also be used to optimise inspection intervals in the different sections of the sewer system (e.g. intensified observation of certain structural conditions). Due to changing boundary conditions demand orientated intervals have to be adapted continuously. A clear definition of related data needs, measurable performance requirements and service levels could support and catalyse modern sewer operation and maintenance. A standardised approach could serve as a pattern for sewer operators. It could support demand orientated adaptations of maintenance intervals and would increase transparency of demand orientated measures.

Another important task of sewer operation and maintenance is sewer rehabilitation. In Austria a research project dealing with strategic sewer rehabilitation planning is currently being carried out. The duration of the project is from January 2010 to December 2012. The project consortium comprises three Austrian Universities as well as five of the largest Austrian sewer operators. One major objective of the project is to suggest measurable performance requirements and related service levels, which can be used on a national scale in accordance with EN 752 (2008). On an international level performance indicators are already discussed in Ashley and Hopkinson (2002) as well as in Matos et al. (2003). Performance indicators shall be structured in a rather simple way and shall only depend on input data commonly available or at least easily accessible in sewer practice.

In a first working step the sewer operators participating in the project identified those functional requirements quoted in EN 752 (2008) most relevant for their daily practice:

- Protection from flooding
- Protection of groundwater
- Structural integrity and design life
- Maintaining the flow
- Protection of surface receiving waters
- Inputs quality

The sewer operators also defined an additional functional requirement: minimisation of operational efforts.

The next step and the current focus of the project work is to check the availability and applicability of existing national (and international) standards related to the different functional requirements mentioned above. If a standard is available and considered appropriate to a certain functional requirement, it can be applied directly. In this way the related performance requirements (performance indicators and service levels) are already defined by the existing standard.

If there is no standard available for a certain functional requirement, the project team (universities and sewer operators) will work out adequate performance requirements. In the process of compiling representative indicators, the availability of the needed

Pipe jacking at a sewer rehabilitation site in Austria. Credit: Thomas Ertl.

input data is brought into focus as well. As a result, a set of SMART performance requirements will be provided to serve as a basis for a standardised evaluation of functional requirements according to EN 752 (2008). Thereby SMART means that the requirements formulated are Simple and Measurable. They should be Accepted all over Austria and Relevant for the utilities. Due to increasing standards relating to increase in prosperity, the requirements are Time-oriented. Hence, by referring to these requirements, comprehensible and comparable sewer rehabilitation planning methods can be adapted.

A crucial point related to performance requirements is the availability of input data needed to determine performance indicators. Prior knowledge of input data requirements is essential for strategic data acquisition and thus for successful practical implementations of certain planning techniques.

Data filtration method

To support the practical application of the suggested performance requirements in strategic sewer rehabilitation planning a data filtration method will be developed within the current research project. The aim of this method is to enhance strategic data acquisition procedures. As mentioned before, according to EN 752 (2008) performance requirements have to be derived on a national level. However, in this context, from a practical point of view, two different aspects are of importance. On the one hand it is necessary to know exactly what kind of information is gained from a certain performance indicator (allocation to a certain functional requirement). On the other hand it is essential to have preliminary information about input data requirements for the calculation of a specific performance indicator. Based on this information a sewer operator can decide whether a certain functional requirement and therefore performance indicator is relevant for their current planning process, and a sewer operator can assess whether it is possible to calculate a certain performance indicator with the input data available. As a consequence, missing data can be collected systematically. Prior to extensive data collection work a cost-benefit analysis might be advantageous. The systematic approach of the data filtration method is shown in Figure 1. Functional requirements, service levels (and therefore performance indicators), evaluation methods and input data are the cornerstones of this method.

The data filtration method comprises a reverse and a forward approach. To assess the performance of a system regarding a certain functional requirement, one has to focus on the related service level. A service level is used to describe the degree of target achievement (e.g. accordance with the functional requirement). It defines which performance indicator has to be applied for the assessment. The way of calculating the performance indicator is given in the evaluation method. Each evaluation method requires a certain and predefined amount of input data. Thus, the data filtration method will directly provide the information on input data requirements for the assessment of a certain functional requirement (reverse approach).

Focusing on the available input data, the data filtration method gives an overview of the applicable evaluation methods and thus performance indicators and service levels to be derived from the existing input data. The 'derivable' service levels will give information on which of the functional requirements can be assessed directly from the available input data (forward approach).

For all existing and suggested performance indicators the input data requirements have to be listed. In several cases there will be analogies in the data requirements. However, a summary of all performance indicators including the related input data requirements will eventually be available.

First results

In the following the first results, regarding the collection and development of performance indicators related to the different functional requirements, are presented. The functional requirements are assigned to the four different aspects of integrated sewer management: structural, hydraulic, environmental and operational performance (EN 752 (2008)). The detailed description of service levels is not part of this paper.

One functional requirement concerns the structural condition assessment of sewers. Structural integrity and design life, amongst other aspects, specifies that sewers have to be maintained to ensure structural integrity. Sewer inspection is a common practice to observe the structural condition of sewers (and to a certain extent the hydraulic and environmental condition as well). Today, apart from different national and international standards (e.g. RLOOE 1992, DWA M 149-2 2006), EN 13508-2 (2008) is used as a visual inspection coding system in Austria. Further, EN 13508-2 (2008) will replace all national standards in the EU countries in near future. For the assessment of sewer conditions different national and international standards are available (e.g. ISYBAU 2006, DWA M 149-3). Most of the current methods are already based on the EN 13508-2 coding system. Methods for structural assessment as well as input data requirements are given by the available standards.

Regarding service levels all standards have four to five structural condition grades representing the priority of sewer rehabilitation measures. However, from a practical point of view in sewer rehabilitation planning it might be more appropriate only to use two structural condition grades (short-term rehabilitation measures needed or not). Sewer operators would also recommend the implementation of some kind of 'rehabilitation grade' performance indicator including appropriate service levels to be used in combination with sewer condition grade assessment. In this new performance indicator the design life of a sewer pipe might be considered as well. Matos et al. (2003) present a full listing of performance indicators for wastewater services. Here certain performance indictors are related to sewer system rehabilitation (e.g. wOp21 to wOp23 (sewer rehabilitation, renovation, replacement in % per year)).

Another functional requirement concerns the hydraulic performance of sewers. Referring to 'Protection from Flooding', EN 752 (2008) states that flooding events shall be limited to nationally prescribed frequencies. Matos et al. (2003) define flooding related performance indicators (e.g. wOp37 to wOp39 (floodings/100km sewer*year)). In the Austrian guideline OEWAV RB 11, flooding frequencies are already defined and categorised according to local boundary conditions (rural areas, domestic areas, city centres, transport facilities, etc.). Hydrodynamic models have to be adopted to prove compliance with prescribed frequencies. Data requirements are defined by the applied model. Currently another guideline dealing with sewer maintenance (OEWAV RB 22) is under preparation. In this guideline five hydraulic condition grades (service levels) shall be defined. From a practical point of view two hydraulic condition grades (compliance or non-compliance with the prescribed flooding frequency) again seem to be sufficient for sewer rehabilitation planning, as public pressure to immediately solve hydraulic problems (flooding) is high.

Two functional requirements concern the environmental performance of sewers. The most reliable way to confirm 'protection of groundwater' is to test the watertightness of sewer

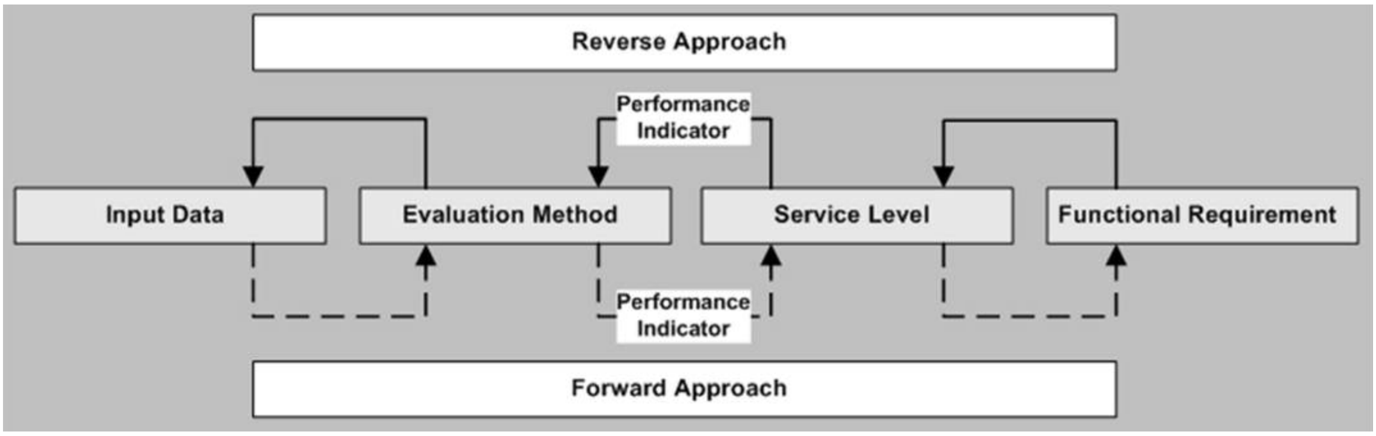

Figure 1
Data filtration method – reverse and forward approach

pipes. Therefore the functional requirement 'protection of groundwater' is considered to be on a par with the functional requirement 'water-tightness'. EN 1610 (1998) and the Austrian standard OENORM B 2503 (2004) define all required methods and related input data. Currently, both standards are being revised. However, EN 752 (2008) states that only new sewers have to be in accordance with testing requirements of EN 1610 (1998). Watertightness of existing sewers shall be in accordance with local or national testing requirements. This is a very important point, as conventional tightness testing according to EN 1610 (1998) and OENORM B 2503 (2004) is a very difficult task in operating sewer pipes. Information about the water tightness of sewer pipes can also be gained through indirect methods such as visual inspection (optical tightness), quality measurements in the groundwater (residues of pharmaceuticals) and tracer measurements.

Fenz et al. (2004) for instance describe the monitoring of concentrations of the anticonvulsant carbamazepine to quantify sewer leakage. These indirect methods seem to be very appropriate tools and thus shall be part of the new national guideline dealing with sewer maintenance (OEWAV RB 22). Quality and tracer measurements can be connected with additional and complex work (groundwater modelling, sampling, etc.), but as a result direct statements regarding the groundwater quality can be made. From a work expenditure point of view visual inspection to prove optical tightness of sewer pipes seems to be more favourable (excluding water protection areas) as it can be combined with the observation of the structural integrity. Obviously a high quality of inspection data is of tremendous importance. Additional data such as groundwater level, hydraulic conductivity or type of circumjacent soil can also support the evaluation process (e.g. risk analysis). Regarding service levels a two graded scale is considered to be sufficient for sewer rehabilitation planning (sewer tightness confirmed or not). In Matos et al. (2003) this functional requirement is address in performance indicators wOp30 to wOp33 (inflow, infiltration, exfiltration (m^3/km sewer*year)).

Regarding the 'protection of surface receiving waters', EN 752 (2008) states that surface waters shall be protected from pollution within nationally prescribed limits. In sewer operation and maintenance (and thus in sewer rehabilitation planning) surface waters will be mainly affected by combined sewer overflow (CSO) spills. The national guideline OEWAV RB 19 (2007) defines operational requirements (efficiencies) for CSOs. According to wastewater treatment plant design capacity a minimum share of the annual wastewater quantity in a catchment has to be conveyed to the local treatment plant. To prove compliance with the prescribed efficiency rates, hydrological or hydrodynamic models have to be used. Again data requirements are defined by the applied model. However, input data will at least be partially equal to the functional requirement 'protection from flooding'. Regarding service levels for sewer rehabilitation planning here again a two graded scale is considered to be sufficient (efficiency constraints met or not).

Three functional requirements concern the operational performance of sewers. Generally, EN 752 (2008) suggests assessing operational performance by the number of operational incidents or failures. The functional requirement 'maintaining the flow' is mostly affected by the occurrence of sewer blockages (sewer collapses, sedimentation, etc.). Therefore, proactive sewer operation and maintenance is the most appropriate approach to maintain the flow (periodical or demand orientated). In Austria this approach is considered to be state-of-the-art. In international literature the performance indicator 'sewer blockages' is cited (e.g. wOp34 (No. of sewer blockages/100km sewer*year) in Matos et al. 2003). However, in Austria from a sewer operator's point of view any incident or failure in sewer operation should be avoided. Sewer operators participating in the research project have less than 0.03 blockages/100km sewer*a. For this reason the use of the 'sewer blockages' performance indicator is of only very limited significance. For sewer rehabilitation planning it is most important to know which sewers need the most maintenance. In this context the definition of a novel performance indicator (including data requirements, evaluation method and service levels) such as 'operating expense' could be more appropriate.

With regard to contents it is obvious that the additional functional requirement 'minimisation of operational efforts', defined by the projects participants, is mainly related to 'maintaining the flow'. As mentioned before, operational activities, such as sewer cleaning and sewer inspection, are important measures to maintain the proper functionality of the sewer system. If the work carried out is documented appropriately (strategic data acquisition), essential information for sewer rehabilitation planning can be derived (e.g. cleaning intervals of certain sewers, etc.).

Regarding the functional requirement 'inputs quality', EN 752 (2008) states that the quality of non-domestic inputs shall be controlled, so that apart from further requirements they do not compromise the integrity of the pipe material. In Austria the national regulation IEV (2006) provides discharge and control requirements for non-domestic wastewater. All sewer operators are requested to assemble a register of all relevant discharges. As certain wastewater qualities can have negative effects on the fabric of the system, detailed information about non-domestic discharges can support sewer rehabilitation planning.

Conclusions and outlook

International research is already dealing with different aspects of sewer rehabilitation planning. Several strategies, techniques and tools are available, but due to their complexity many of the available approaches are not applied in practice.

In Austria, currently there is no standardised approach available regarding strategic sewer rehabilitation planning. Therefore several sewer operators have developed 'in-house' strategies. This complicates the comparison of different utilities and thus the internal and external evaluation of specific rehabilitation strategies. In a three-year research co-operation between universities and sewer operators, investigations on standardised performance requirements (performance indicators and service levels) regarding sewer rehabilitation (and maintenance) planning will be worked out. Current project work regarding performance requirements shows that for functional requirements regarding the structural, hydraulic and environmental performance of sewer systems national or international standards (including performance indicators, evaluation methods, etc.) are available. However, in specific cases additional and more significant performance indicators and service levels would be appropriate. Regarding the operational performance of sewer systems no suitable national or international standards exist.

Comprehensible strategic sewer rehabilitation planning requires the definition of appropriate structural, hydraulic, environmental and operational service levels and applicable performance indicators.

To support the practical application of incorporating performance requirements into rehabilitation planning processes, a data filtration method is derived, in the first stage of the mentioned research project. This method shall enhance strategic data acquisition. A sewer operator shall obtain direct information regarding the kind of input data needed to evaluate the accordance with a certain functional requirement (reverse approach), and as well as this an overview shall be given, indicating which of the functional requirements could be addressed, using only the data available (forward approach). A standardised approach could also serve as a planning guideline for small and medium-size utilities, which often have not yet begun their rehabilitation planning.

The upcoming project steps are a further development of the performance requirements (definition of performance indicators and service levels) according to specific functional requirements. Based on the performance indicators and the required input data, the data filtration method will be developed. Subsequently, the applicability of the method will be tested in several case studies in the course of the project. ●

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Sustainable asset planning in Sydney Water

Australian utility Sydney Water has a strong focus on asset management, creating plans for future growth and management of existing assets. In this article, Greg Kane discusses Sydney Water's approach to managing the utility's assets.

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Sydney Water is being challenged with servicing population growth and city expansion while managing the existing asset base and customer service in a sustainable manner. Future customer needs, behaviours and demands will change, and climate change will have a concurrent impact.

The Australian water industry generally has become a leader in sustainable asset management through its strong focus on:

- Responding to change and continuous improvement
- Investing for the long-term
- Understanding risk
- Adapting to climate change
- Questioning the status quo
- Providing superior customer service
- Protecting people's health and enhancing the environment

This paper describes how Sydney Water uses asset planning methods for managing some of these challenges, and how it has produced two key types of asset plans: area plans for growth and asset management plans for the existing asset stock.

Asset planning challenge

The population of Sydney is expected to grow significantly over the next 20 years. During this time, past experience tells us that customer demands and expectations of services and products will undoubtedly change; and most likely the movement will be in the direction of being more demanding and with higher expectations, underpinned by the desire for and availability of information about services (for example through the use of data from smart meters). Customers and shareholders will continue to seek efficiencies and value for money. It is expected that climate change will affect the (frequency, extent and variability of) 'extreme' or 'abnormal' events, and also will produce an underlying change in the (day-to-day) operating environment for assets.

The assets in the urban water industry generally have the following characteristics:

- Many of the assets are buried and out of sight, which makes visible assessment of asset integrity very difficult and costly.
- Water industry assets are generally expected to operate over long lives
- Long lead times are required to plan and build new water industry infrastructure
- There is a high degree of connectivity between service levels to customers and prudent asset management practices

Though many of the infrastructure assets have long lives, a great number were built some time ago and are aging. New models for competition will change the business operating environment, and a range of suppliers of different products are likely to emerge.

Against that backdrop, Sydney Water is facing two concurrent challenges: existing assets and how to manage them into the future; and building new assets for future services and customers.

A sustainability approach is the clear way forward for the Australian urban water industry. Our industry has stewardship of AUS$110 billion (US$115 billion) of assets used to provide safe clean drinking water and wastewater services to protect and enhance the environment.

Education and awareness, and a strong shift in attitudes, culture and moral codes for sustainability are already prevalent and growing in the industry and the community in general. However, while this is important, we have decided that it also requires an approach that more systematically incorporates and integrates a sustainable approach in our planning and decision making processes.

Discussion and analysis

Sydney Water defines asset management as: 'A business discipline for managing the life cycle of assets to achieve a desired level of service and financial return within an acceptable risk framework.' Most definitions of strategic asset management would indicate that is inherently a sustainable approach.

In discussion with its members, the Water Services Association of Australia (WSAA) has adopted a similar definition: 'Sustainable asset management is a risk-based process to manage infrastructure to achieve the optimal whole of life cost, which provides a desired level of service now, and into the future, taking into account environmental, economic and social considerations.'

The author observes that the 'future' view has been consciously included to emphasise the longer-term view and some sustainability aspects have been more explicitly described.

Sydney Water's asset management policy supports the company's approach to sustainable asset manage-

Sydney Water's desalination plant. Credit: Sydney Water.

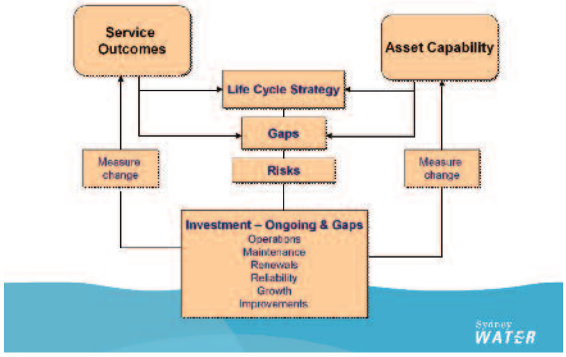


Figure 1
Asset planning process

ment. It includes a requirement for the Corporation to implement a set of principles in the development and management of Sydney Water assets that include actions to:

- Consult with relevant stakeholders to define requirements for service delivery
- Deliver a level of service that drives customer and stakeholder satisfaction and willingness to pay
- Consider both asset and non-asset solutions before settling on the proposed approach
- Pursue lowest whole of life costs at an agreed level of risk in delivering the services
- Apply a triple bottom line approach to life cycle costs, including the externalities of social, environmental and economic impacts
- Use Sydney Water's Sustainability Planning Manual in decisions relating to sustainable planning
- Apply agreed management practices throughout an asset's lifecycle for informed decision making

The asset planning process

Sydney Water's asset planning process is illustrated in Figure 1.

The first step is to understand the requirements of customers, shareholders, stakeholders such as interest groups, the community in general and its regulators. One of Sydney Water's major regulators is the Independent Pricing and Regulatory Tribunal (IPART) that assigns an operating licence for the Sydney region and then monitors performance against it. IPART also determines the prices that may be charged to customers. For Sydney Water many of the company's service expectations are reflected and captured in the operating licence and in the associated customer contract with each of our customers (for example, levels of service in relation to discontinuity of potable water supply services, and for the water pressure provided to customers). Other service levels set by regulators include water quality related requirements by the Department of Health, and environmental outcomes set in system licences by the Department of Environment, Climate Change and Water (on matters such as the quality of treatment plant outputs and frequency of sewage overflows). Beyond regulation, Sydney Water researches customer demands to establish levels and standards of service. This step also includes action to translate those requirements into potential 'specifications' for assets. At this stage (of the planning process) not all of the requirements are set and agreed, but will be compared against the capability of the organisations asset systems.

The assessment of asset capability includes monitoring in the current timeframe and more importantly in trends for parameters such as condition, performance, and capacity. The assessment of the asset system is not only the asset themselves, but the management and enabling systems that support it e.g., people management, financial management, risk management, logistics, and IT and quality management systems.

The above steps inform the establishment of the service levels. These may be set by regulatory direction, or collaboratively by negotiation, consultation or internal decision-making.

The life cycle strategy for the asset (types, groups and / or systems) is then developed from a comparison and assessment (trade-off) of the requirements of various stakeholders and the capability of Sydney Water. This will be a trade-off of lowest life cycle cost, risk and customer levels of service. So, for large water mains where the consequence of failure may be significant community impact, costs to the utility and disruption to customers' service, an avoid fail or preventative approach is identified. Conversely, for some small mains where the impact of failure is low and asset systems are in place for rapid response, rectification and minimisation of consequences and impact then a run-to-fail (or plan to repair) approach is a more appropriate life cycle strategy.

This analysis then provides the basis for estimating the resourcing needs to continue to provide that level of services in that approach. This includes a forward forecast of capital needs for new and renewed assets and for expenditure on operations and maintenance.

This 'first pass' of the planning process effectively establishes the baseline of a life cycle strategy and the resourcing needs to deliver to it.

The planning process is repeated annually where the inputs and assumptions are reviewed and confirmed. It is also during this 'pass' of the cycle that any existing or future potential gaps are identified – for example trends of product performance, asset reliability, conditions, etc. These are risk assessed for significance and for those where a decision is made to reduce or control the risk, the options are assessed and adjustment made to the resourcing needs.

Asset plans

Sydney Water has two main types of asset plans arising from this planning process.

Area plans are Sydney Water's strategic servicing strategy for the city. The purpose of these plans is to determine the most sustainable way of servicing an area. Sustainability includes economic criteria such as lowest lifecycle cost, but also reflects community and stakeholder views on environmental and social values. A strong emphasis of the area plan is to integrate plans for the water, wastewater, recycled water and stormwater systems, and (initially looked) to maximise potential recycled water projects and other water conservation measures. The plans necessarily focus in on geographical areas (hence the name area plans). The initial priority for preparation of these was to focus in on locations with greatest potential recycled water markets, such as areas with high population growth or large existing water users. The output of the area plans is a high level water cycle plan covering the sources of water supply, the range of products and services to be provided to customers (such as the extent and grade of recycled water provided) and any discharges to the environment.

The highest level of area plan also looks at natural resource management (water balance, demand / supply balance, etc.) that is a major consideration in sustainable asset management. This has been an area of considerable focus for Sydney Water, but this paper does not describe or explore that other key area.

Asset management plans describe the asset lifecycle strategy to manage different asset classes, such as pump stations, pipes and treatment plants. The plans define the target levels of service and the optimum way to meet these considering (life cycle) cost and risk. The plans describe the way assets in each asset class will be managed through their life cycle and include decision frameworks for how decisions will be made on aspects such as when to renew versus continue to maintain. The plans include an overarching approach to the renewal of assets using a risk based methodology and asset condition assessment. The plans define short- and long-term demands for capital investment by driver, identify consequential changes to operating costs, and provide justification for renewals, maintenance and operations expenditure.

The asset planning approach above applies to both forms of asset plans. In effect, the plans represent the capture of the assumptions, process and the outcomes of two focused forms of asset planning.

Sydney Water carried out the initial asset planning to prepare asset management plans in 2005 and has repeated cycles since to update the asset plans for each of its major categories or classes of infrastructure assets:

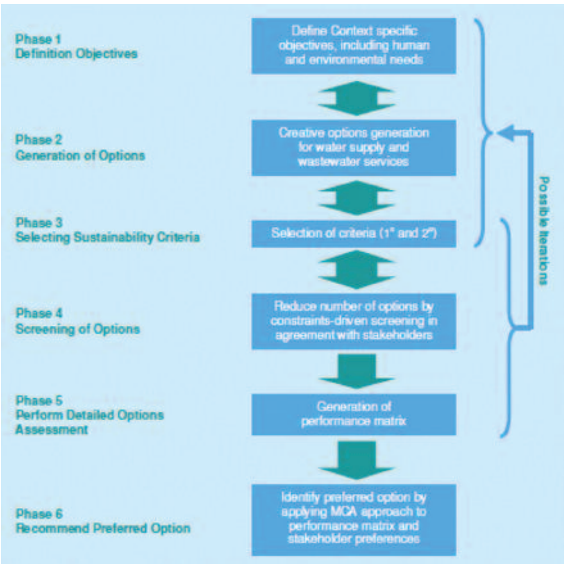
- Wastewater treatment plants
- Water treatment plants
- Sewage pumping stations
- Water pumping stations
- Reservoirs
- Water pipes
- Sewer pipes
- Stormwater pipes

These plans are updated annually as a part of the business planning cycle and the outputs are aligned to the cycle. Area plans have been in place since 2009.

The asset plans are used as the basis of the submission to the pricing regulator, i.e. they validate the prudency and robustness of investment decisions and expenditure allocations, and thus underpin the sustainability (of funding) for the organisation to continue to provide services.

The outputs of the asset plans are projections in three time horizons – quite precise and detailed in year one estimates, a detailed forecast for five years, and longer-term predictions and forecast for 30 plus years. The longer-term view is one key element to sustainable asset management. We have found that scenario planning is a key tool for developing this longer-term view and that a range of scenarios need to be produced and assessed because of the uncertainty of inputs to the planning process. The variability and uncertainty comes in the inputs such as growth, customer values and demands, climate change, technology developments, market forces, asset deterioration and aging, etc.

Figure 2
Six phases of the decision making process and framework



Decision frameworks

To support the implementation of the (derived) asset life strategies, Sydney Water has also developed decision frameworks. These were developed to streamline the management of known work such as major periodic maintenance and asset renewal. A decision framework clearly defines how decisions on identifying assets for work are to be made. These represent the thinking, the approach and the 'how' of certain asset management decisions (i.e. relevant factors and how they will be considered and used). For example, how to decide when to stop maintaining an asset and renew or dispose of it (at the end of its economic or service life); or, as another example, when to apply major periodic maintenance to a type of asset (such as the relining of the interior coating of water reservoir tanks).

In some decision frameworks, aspects of sustainability have been more explicitly and transparently included and reinforced. For example, the inclusion of social and community impacts in the asset life cycle decisions for the renewal of water mains. Or for example, the strategy for leakage, which targets reduction to the point where it makes sustainable business sense (the economic level of leakage based on the marginal cost of water).

In the development and management of these decision making frameworks, Sydney Water's approach and intent is for the following to be achieved:

- Safety and efficiency are key considerations in the company's asset management decisions
- An effective decision making framework exists for each major asset class
- The frameworks are flexible and adaptable over time
- They are successful in balancing economic, environmental and social outcomes

Document support tools

Sydney Water has also developed a sustainability planning manual as a planning support tool – this was built on earlier cooperative work of members under the overview of WSAA and underpins sustainable decision making and planning. The decision making framework assists in dealing with complex issues, sustainability requirements and licence compliance for Sydney Water. This approach integrates sustainability into decision making frameworks, and includes principles such as: a 'project' should be 'financially, environmentally, technically and socially sustainable'. Stakeholders, community, etc. need to be able to understand, participate in and accept decisions.

The manual outlines a decision making process and framework in six simple steps (phases) and provides supporting guidelines, resources and tools. The six steps are illustrated in Figure 2 and include definitions of objective, generation of creative options, selection of (sustainability) criteria, screening of options, detailed options assessment (with a multidisciplinary team and including engagement of stakeholders) and recommendation of a preferred option by applying a multi-criteria approach, as a robust and transparent method of ranking options.

Asset management framework

Asset plans represent a snapshot in time of the asset planning process. They are just one element of a strategic asset management framework in Sydney Water, that includes:

- Policies – for asset management, asset creation and maintenance
- Processes – plan, create, operate, maintain, renew, dispose
- Asset plans
- Life cycle management strategies
- Decision support tools
- Risk management framework
- (Quality) management system
- Models and information systems
- Competencies in asset management
- Benchmarking, for continuous improvement in asset management processes

Sydney Water also prepares a State of the Assets report annually. This provides a snapshot of aspects such as asset condition and performance, and the outcomes of previous investment, for example, how that has changed risk profiles. Importantly it also provides an assessment of the organisation's asset management capability and of any improvement plans in place or proposed to improve the asset management capability. ●

This paper was presented at the Australian Water Association Sustainable Infrastructure and Asset Management Conference, 23-24 November 2010, Sydney, Australia.

Acknowledgement

The preparation of the asset plans drew on a range of expertise in asset planning, operations and maintenance, and finance and economic skills inside Sydney Water and from its planning partners.

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Adaptation of Norway's water supply and sanitation systems to cope with climate change

Climate change can have impacts in all areas of the water industry, including quality and availability of water sources and water and wastewater infrastructure robustness. Today's choices, particularly regarding investments in infrastructure, will significantly influence the ability of the water industry to react to the climate change impacts of tomorrow. In addition to the need to plan investments, new issues related to water supply, health safety and environmental protection will also have to be accounted for. In this article, Sveinung Sægrov and Rita Ugarelli highlight the need for evaluating the relationship between expected climate changes in Norway and their impacts on urban water components.

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Expected climate change effects such as increased rainfall / runoff, temperature rise, and rise in seawater level will influence the water infrastructure in Norway in several ways. If we consider the urban water system from upstream water source to downstream receiving water, climate change in Norway will influence runoff patterns to drinking water sources (i.e. lakes or rivers) and thereby affect raw water quality, longer drought periods will challenge reservoir capacity and consumption patterns, organic compounds in water may lead to increased biofilm growth and corrosion in water pipes, and changes in freeze / thaw patterns may cause more frequent pipe bursts.

On the wastewater side, increased frequency of extreme runoff will be a challenge for the existing wastewater network and operation of treatment plants. More frequent CSO (combined sewer overflow) outflow may disturb the water quality of receiving bodies, and storm runoff combined with a higher sea water level may affect downstream sections of the wastewater system, for example by flooding CSOs and pumping stations and by submerging lower parts of the gravity network. Norway's cities will experience the effects of climate change in different ways, depending on the type of water sources used and the catchment area, whether they are situated inland or on the coast, and the current capacity of their water supply and wastewater systems.

To avoid these potential problems, several actions have to be taken that are based on local circumstances, so a careful analysis of expected local impacts of climate change is therefore necessary. Based on these, legal actions and regulation can constrain building on flood plains, and bring into place stricter requirements for treatment plants, etc. Drinking water treatment plants may need to be upgraded to cope with more organic substances in raw water, as well as emerging micro pollutants. Weak parts of the drinking water network may need to be rehabilitated to maintain system reliability, and controlling stormwater at source may reduce extra hydraulic load on wastewater networks. Energy recovery from wastewater flow and wastewater treatment processes is also important in order to obtain a carbon neutral urban water system. These potential actions need to be planned within a holistic scope, based on comprehensive risk analysis. A national programme 'Cities of the Future', hosted by the Norwegian Directorate for Civil Preparedness in conjunction with the main water utilities in Norway, has been established in order to assist climate change planning in the cities.

Recent events in Norway

Several recent events show the kind of problems that are expected to increase in future.

For example, a severe flood incident occurred in Trondheim in 1997, when heavy rain fell on frozen, snow-covered ground and caused an immediate runoff response. Gullies connected to the stormwater network were clogged by ice, which increased the severity of the event (Milina 1999). Madsen (2007) similarly described and modelled the impact of potential flood events in the city of Bergen.

Some events have been brought to court to decide whether they are a municipal responsibility or to be paid by insurance companies. As an example, one court defines the municipal responsibility as 'all rainfall events that can be imagined', which has been interpreted as a return period of over 70 years. This is an enforced duty compared to current international standards (EN 752).

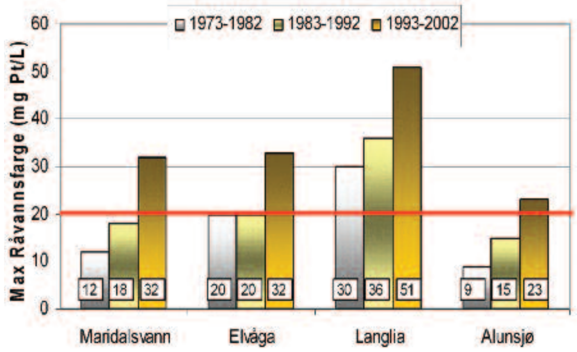
In 2010 and 2011 Norway experienced rather strong winters. This was shown to affect the weakest parts of the water infrastructure. The Norwegian main cities experienced double the number of pipe bursts compared to a normal year, with damage mainly occurring on old cast iron pipes.

Long-term trends in water quality

Norway has experienced a doubling or even tripling of colour in water reservoirs since 1970, as illustrated in Figure 1. The reason is not clear, but it is believed that it stems from the temperature increase that is documented over the last 40 years.

As well as this, an increase of organic matter in drinking water sources has also been measured in Norway and several other countries. This increase is expected to continue due to increased erosion in catchments of the lakes serving the water supply. Such erosion may happen as a result of more severe runoff situations. Increased content of organic matter may also increase the biological activity in water

Figure 1
Changes in reservoir water quality in Oslo (Eikebrokk et. al. 2004)



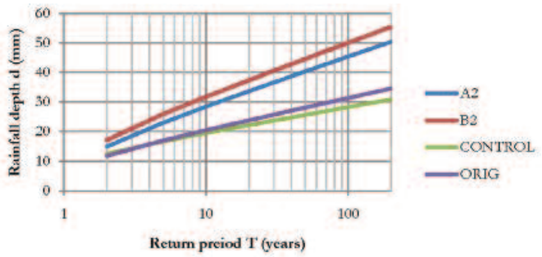


Figure 2
Impact of climate change on rainfall intensity – south-western Norway. Rainfall duration of 60 minutes. (Holvik, NTNU 2010)

distribution networks, with biofilm formation as well as bacteria / viruses in biofilm already being observed in distribution systems.

Scenarios for future precipitation

Scenarios for precipitation in the year 2100 have been developed by the Norwegian Climate adaptation programme and downscaled to urban areas (Hansen-Bauer 2004, Holvik 2010). As shown in Figure 2, which is of 60 minutes of rainfall for return periods of 2-100 years, a substantial increase should be expected. The control periods are based on statistics for the period 1961-1990. The A2 scenario refers to societal development 'business as usual' and B2 to a more environmental development.

It is obvious that increased precipitation will influence the performance of the wastewater networks. Calculations made for the city of Sandnes showed a tripling of weir discharge volume (Holvik 2010). Similar results have been obtained for other cities in Norway (Madsen, 2007).

At the same time, the utilities will also have to cope with sea level rise. The rise will vary from 0.5m to 1.0m, plus further increase driven by wind pressure during storm events. The downstream part of wastewater systems, including CSOs and pumping stations, will be influenced by extreme sea water level increases. Backflow may cause severe problems in downstream gravity driven networks, in particular if the event also includes heavy runoff from rainfall.

Figure 3 shows an example from Møllenberg in Trondheim (Holvik 2009). The shaded area will be submerged during high tide in 2100. However, the flooded area influencing pipelines are much larger. In this catchment, 30% of the network and 15km of pipes will be submerged during extreme sea water levels. It is obviously important to improve this network and reduce infiltration, as well as protecting buildings from backflow.

A particular issue in this area is the location of CSOs, which will be submerged during high tides. If the main wastewater system is to be kept, new types of weirs that can work during submerged conditions need to be developed.

Meeting the expected impacts

A full rehabilitation of the existing urban water service systems in Norway is estimated to cost €70 billion ($14 billion), which is not affordable for Norwegian water utilities. Therefore, we will have to stick to the existing infrastructure and make the necessary improvements to cope with climate change, as well as ageing of pipelines and plants, and increasing demand from customers. Some actions have already been taken to adapt exiting systems to the expected future needs. This also includes participation in major research activities within the European Union framework programmes, such as TECHNEAU, PREPARED and TRUST, as well as other programmes.

TECHNEAU was finished in 2010 and delivered technologies that help cities handle climate change. Examples are more robust and optimized water treatment methods based on coagulation / filtration, and operational capacity of membrane systems for treatment (Eikebrokk et al 2009, Azrague et al 2009). It also delivered methods to optimise maintenance of water distribution methods to avoid bacterial growth and sedimentation (Vreeburg 2010). These are methods and techniques that have been brought into use in the forefront water utilities in Norway.

PREPARED is a programme focusing on the adaptation of existing water infrastructure to the impact of climate change. It started in 2010 and will run to 2013, with the aim of making water and wastewater systems more robust and resilient. The programme includes the development of methods for risk assessment of the urban water cycle, methods for warning and prediction of potential hazards, and suggestions of permanent improvements that will increase the capacity of systems for better performance during extreme events, such as increasing dimensions of wastewater constructions. An overview of climate change effects that may impact the urban water cycle has been developed (Ugarelli et al 2011). The Norwegian capital of Oslo is heavily involved in this project, and other Norwegian cities will use the programme's findings as input to their planning to meet the climate change challenge.

Figure 3
City area of Møllenberg, Trondheim, which will be flooded if sea level rises (green shaded, Holvik, NTNU 2009).

TRUST is a recently started programme that deals with long-term sustainability, and will last until 2014. One of the core issues is the development of a metabolism model (Figure 4) for urban water cycle systems (Govindarajan 2011). This will be instrumental to show how the entire system and its components perform currently, and how they will perform under different circumstances. A prominent feature of the model is the ability to calculate use of resources and energy, the environmental impact of pollution in receiving waters, carbon emissions, and solid waste production. The TRUST programme also encompasses technologies for water and wastewater treatment, leakage control, rehabilitation of pipes, reuse of water, and energy minimization. Additionally, advice and software for the assessment of sustainable solutions will be developed. Norwegian cities are heavily involved in TRUST. They will use the programme for implementing carbon footprint calculations in their planning philosophy (selection of materials, technical solutions, etc.)

Strategies of Norwegian cities

Norwegian cities have begun developing strategies for sustainable development / production. In Oslo, for example, the following main objectives have been set (Milina 2010):

- Reduce greenhouse gas emissions
- Reduce energy use
- Increase resilience of city structures and infrastructure
- Implement the new EU Water
- Framework Directive
- Plan for green-blue city growth

Long-term plans with a time horizon of 10-15 years, as well as short-term rehabilitation plans, are being developed, supported by a number of tools for estimating future rehabilitation needs, failure prediction and risk assessment. Computer-based and geo-referenced information systems have existed for 25 years and are constantly being improved, which enable the cities to use advanced tools for condition assessment and condition prediction.

However, in spite of good plans and large investments, a temporary increase

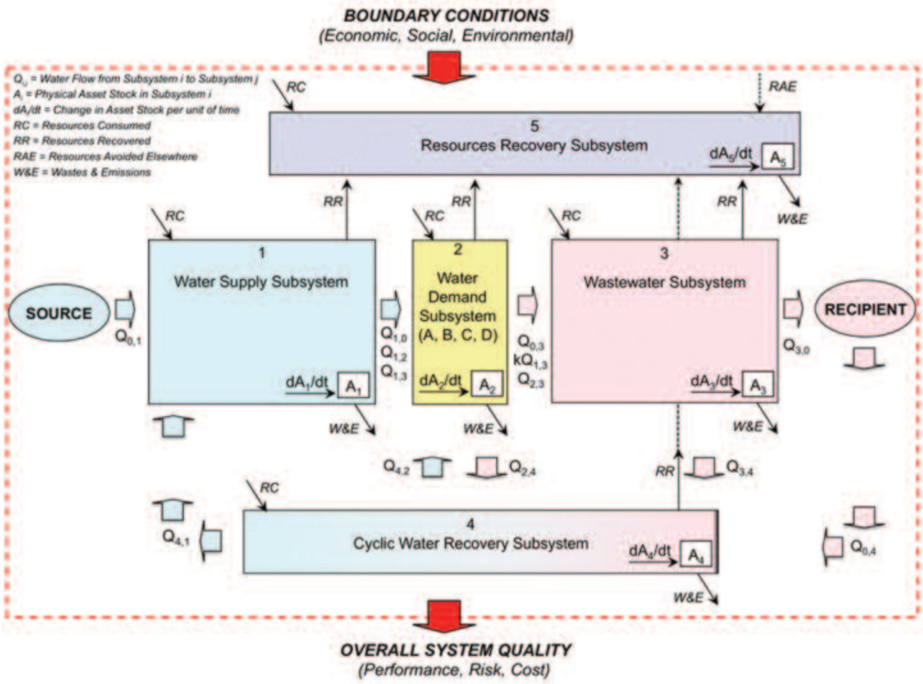


Figure 4
Resource flow model (metabolism model): material, energy and costs per consumption unit for urban water services, environmental impact (carbon footprint), Govindarajan, NTNU 2011

of pollution in the city's receiving water bodies, such as Indre Oslo fjord and the city's rivers, have been observed after major storm events. It is a concern that this will affect the public trust in the municipal water organisation and their willingness to pay for the necessary developments. Technological contributions to the improvement of the situation may include:

- Regional optimisation (several wastewater treatment plants working together, optimising the capacity of transport systems, modelling and online monitoring)
- Utilising the storage capacity of the existing network and new detention system (Ormen Lange), investigating potential hygienic (due to overtopping) and technological consequences of pressurizing the wastewater network
- Pollutant control in combined stormwater systems
- Separation of storm and sewage systems, source control and connection to 'green city development'
- Optimising wastewater treatment plant capacity to deal with flow and quality variations

Structural improvements are being made, for example with regard to local control of stormwater runoff and storage of wastewater, such as green roofs installed for local stormwater control in Haraldrud, Oslo, and the planning of a new wastewater tunnel, also in Oslo. A national guide for stormwater handling has been developed by the Norwegian Water Association (Norsk Vann; Lindholm et al 2005). Further, measures for adaptation to climate change in the water and wastewater sector have been studied in another recent report by the Norwegian Water Association (Muthanna et al 2010). Nie et al 2009 have also presented a review of research and development of climate change, risk management of urban flooding, and adaptation to climate change.

Conclusion

The water utilities of the main Norwegian cities will face substantial challenges over the coming decades due to the impact of climate change, as well as ageing of networks and treatment plants, and rapid population growth. It is beyond financial capabilities to replace major parts of the urban water systems, but continuous improvement of the existing system within a long-term planning horizon and the development of new techniques, such as improved renovation systems and planning methods, tools for financial planning, risk assessment and environmental impact, is expected to improve the cities' ability to handle future challenges. ●

Acknowledgement

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A three waters vision for Dunedin, New Zealand

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This paper presents an overview of how the Dunedin City Council (DCC) in New Zealand has restructured its water and waste business unit, developed a Strategic Direction Statement (2010-2060), and together with their consultant team, is developing an integrated long-term strategy for the future management of the three waters (water, wastewater and stormwater). By Dan Stevens, Tracey Willmott and Laura McElhone.

With the completion of a number of substantial water and wastewater infrastructure projects in recent years, which were the result of strategic decisions made in the early 1990s, the time has arrived when a new strategic direction is required for the City of Dunedin on New Zealand's south island.

The development of the Three Waters Strategic Direction Statement (2010-2060) was seen as a necessary tool to address an obvious lack of strategic and sustainable planning capability within the Council's water and waste services department. The statement outlines the principles, priorities and planning assumptions that will underpin decisions regarding water, stormwater and wastewater infrastructure and service delivery in Dunedin for the next 50 years.

Together with their consultant team, Dunedin City Council is continuing to develop a long-term strategy for the future management of the three waters (water, wastewater and stormwater). The strategy suggests an integrated approach to dealing with the decline in service performance that would otherwise be evident in a network of ageing infrastructure and is also expected to meet the new 21st century challenges of increased community expectations, a more stringent regulatory environment, and climate change.

Here is present a phased method of determining the appropriate capital and renewals response to ensure that the future investment in infrastructure is appropriate, optimised, sustainable and affordable, utilising a range of modelling tools and multi-criteria decision-making techniques.

Using a phased approach, starting with the development of a strategic three waters model, means that early benefits could be gained using existing knowledge complimented with an appropriate level of additional network data. The results of the first phase were used to prioritise areas of further study in subsequent phases, which involved more detailed investigations.

With the project nearing completion, the paper will describe the approach taken by the team to confirm levels of service, to build and calibrate hydraulic models and develop ten integrated catchment management plans for the city based on a framework developed during an initial pilot study.

The final stages of the project will include the preparation of master plans outlining a programme to address system deficiencies across the three waters for each of the future planning scenarios and will identify prioritised operational improvements and capital works using an integrated decision-making approach.

The project will answer many of the strategic questions posed in the Strategic Directions Statement (2010-2060) and provide guidance for further investigation where the questions cannot be answered directly by the Three Waters Strategy Study.

A business improvement strategy

In order to drive the necessary investment programme, Dunedin City Council (DCC) has developed an integrated asset management approach and has embarked on a business improvement project in order meet its capital and operational delivery targets.

The process has two main components. The first being to restructure the water and waste services business unit, and the second being to undertake a significant Three Waters Strategy Study that includes the development of hydraulic models to examine the entire water cycle within Dunedin's urban catchments, and to provide critical information on the performance of the networks.

A restructure of the business unit

Running in parallel with Phase 1 of the strategy study, the removal of the previously prominent operational 'silo' based structure and introduction of an integrated 'Three Waters' strategic structure was seen as key to the future success of the business unit.

The nature and requirements of the strategy study, and indeed the development of the Three Waters Strategic Directions Statement (2010-

Aerial shot of Dunedin. Credit: Dunedin City Council.

2060), would serve to reinforce this new approach and there is no doubt that this has helped to reshape the operating philosophy of the water and waste services business unit. This has perhaps been the most significant benefit of the project outside of the key project deliverables.

Integration and streamlining of business systems and processes has been a key objective of the restructure. There has been a real focus on developing integrated systems, ensuring consistency in data handling and adopting a common approach across the three waters.

A collaborative approach

Promoting a collaborative and inclusive approach was identified as key to ensuring the success of the Three Waters Strategy project. Given that tenders were received from six strong consortia, this proved to be a principal criteria used for selecting the consultant team to work with DCC on the project.

In December 2007 DCC appointed a consultant team lead by Opus International Consultants to undertake the project. The consultant team comprised Opus and URS New Zealand, and sub-consultants would be appointed throughout the project to undertake specialist tasks such as flow monitoring and stream assessments. Additionally, Metrowater (a council controlled organisation from Auckland) were appointed as 'industry advisors' to the project and Beca were appointed as 'project reviewers'.

As the water and waste business unit was being reorganised during Phase 1, a number of new and often inexperienced staff were joining the DCC team as the project progressed. It was essential that these new team members were able to draw upon and learn from the knowledge and experience of the combined project team, and a collaborative approach and willingness to share knowledge and advice was essential.

Guiding the project

A Project Control Group (PCG) was formed that would provide guidance and strategic direction throughout the project. The PCG would meet monthly and comprised key members of the DCC water and waste services business unit, together with representatives from the consultant team, the industry advisors and the project reviewers. Open discussion and a shared desire to achieve a successful outcome for the project have proved to be the hallmarks of the PCG.

Developing the strategic direction statement

The development of a Three Waters Strategic Direction Statement (2010-2060) was a key stage in the process as it effectively defined 'the vision' for the three waters for Dunedin up to 2060. The statement outlines the principles, priorities and planning assumptions that will underpin decisions regarding water, stormwater and wastewater infrastructure and service delivery in Dunedin for the next 50 years.

A process of inclusive community and stakeholder consultations provided valuable guidance in terms of setting meaningful goals, defining appropriate and affordable levels of service standards and clarifying the community's willingness to pay to meet these targets.

Project drivers

A number of key project drivers were identified for the Three Waters Strategy Study, which included:

- Reviewing and setting appropriate levels of service
- Developing an optimised investment plan for network renewals
- Building multiple redundancy into the networks where appropriate
- Optimising the operation of the three networks
- Investigating alternative water sources and demand management as water conservation tool
- Investigations of future water storage options
- Sustainable solutions and intergenerational equity
- Integrated catchment management planning
- Protect the environment and prevent sewer flooding incidents
- Answer strategic questions posed in the Three Waters Strategic Direction Statement (2010-2060)

A three phased approach

It was decided to adopt a three phased approach to the study.

- Phase 1 – Developing strategic level water and wastewater models, capital works master plans at strategic level, and a pilot catchment management plan
- Phase 2 – Detailed investigations, capital works master plans extended to reticulation level, complete remaining catchment management plans.
- Phase 3 – Construct projects and continued iteration and refinement of phases 1 & 2, improvement in accuracy of expenditure profiles

Using a phased approach, starting with the development of strategic level models, meant that early benefits could be gained using existing knowledge complimented with an appropriate level of additional network data – effectively quick wins that would provide confidence in the project and the investment by council.

The results of the first phase would prioritise areas of further study in subsequent phases, which involved more detailed investigations.

What is an integrated solution?

In the original Three Waters Vision statement it was established that the strategic objectives of the business unit could only be met by understanding the entire water cycle within the city environment, which would require an integrated approach to catchment management and infrastructure planning, as each of the three water states has an influence on the other in some way.

However, at the start of the Dunedin Three Waters Strategy Study it is fair to say that neither DCC nor the consultant team had a clear understanding of what 'integration' meant in practice, with respect to the project and for the wider operation of the newly restructured DCC Water and Waste Services team. A key outcome for the Dunedin Three Waters Strategy Study as a whole is to develop optimised and integrated solutions across the Three Waters as far as is practical – but what does this mean and what is practical? A series of workshops were held which resulted in a clearer understanding of the potential for the project to deliver integration across a number of areas. These were summarised under a number of sub-headings, including:

- Common business systems
- Growth and planning
- Modelling
- Innovative solutions
- Understanding interactions
- Common three waters issues

Significant progress has been made in many of these areas within a short space of time, through the business improvement process and as the Three Waters Strategy Project has progressed. Whilst the processes of integration in the context of the project are now better understood, the potential for a more integrated set of capital investment decisions would only really be possible during the later stages of the project. For example, as the team gained a better understanding of system demand, growth potential and the predicted effects of climate change on the principal water sources, the need for significant demand management, grey water reuse or stormwater harvesting were demonstrated as unnecessary and uneconomic.

Setting appropriate levels of service

One of the first defined objectives of the project was reviewing the agreed community outcomes, setting appropriate levels of service and detailing key performance indicators. The community outcomes were essentially defined by consultations and development of the Long Term Council Community Plan (LTCCP) and levels of service targets are to a certain extent driven by these agreed community outcomes, DCC's strategic objectives and the community's willingness and ability to pay. A wide range of activity management plans from other New Zealand territorial authorities were reviewed to determine typical levels of service adopted across the country. New Zealand and Australian benchmarking data was also reviewed, enabling DCC to set a target level for performance that would be both appropriate and affordable for the City of Dunedin.

In developing the capital works investment programme, the sensitivity to levels of service targets was investigated using the hydraulic models, enabling more informed decision making and providing surety in investment decisions and equity for the current and future generations.

Prioritisation and optimised decision making

A key part of the Phase 1 works was to develop an integrated decision making (IDM) process. This would allow issues to be ranked against a risk based framework and for resulting projects to be scored based on their benefit related to the agreed community outcomes and prioritised across the three waters. Indeed, if this process proved successful it was likely that this could form the basis for project prioritisation across the council as a whole.

'Issues' were identified in a number of ways. Firstly, detailed discussions were held with the system operators, who were encouraged to share their knowledge and experience gained from running the systems over many years. Secondly, system performance information was collated and analysed. This information included records of customer complaints for low or high pressure or poor water quality, bursts, sewer blockages, sewer / stormwater overflows, etc. These were geocoded and entered into the GIS system and imported into the hydraulic models for more detailed analysis. System deficiencies were identified through analysis of the hydraulic models under current and future demand conditions.

Once the issues had been identified the question was posed 'does this cause a problem (related to one or more levels of service criteria)?'. If no apparent problem was evident the issue was recorded in the system performance report and no immediate action was taken. If a problem was identified the issue went forward for a risk analysis.

The risk was assessed against an agreed scoring methodology and the problem was classified as 'manage actively' or 'manage passively'. For those classified as 'manage actively' a range of potential solutions were developed and discussed at workshops held with DCC operations and planning staff. Each option was scored in terms of their effectiveness to solve the problem and on their benefit related to the agreed community outcomes and the quadruple bottom line of the 'four wellbeings' (cultural, environmental, social and economic).

Finally, budget costings were developed for the favoured solutions, which could then be ranked across the three waters and a prioritised staged capital investment programme established. This staged capital plan would form the cornerstone for the future activity management plan (AMP). For the first time it will be possible for the water and waste business unit to create a single integrated AMP covering the three waters.

This prioritisation across the three waters marked a fundamental shift away from the previous policy whereby each of the waters was allocated a separate 'pot' of money. In the future, budget prioritisation can occur at an amalgamated level.

Integrated modelling

One of the most interesting aspects of the project to date has been the integrated approach to the hydraulic modelling. At the commencement of the project a review of the available hydraulic modelling packages was undertaken.

Key to the selection would be the ability of the modelling software to model water, wastewater and stormwater. An added complication was that modelling the raw water system was also added to the project, and this comprised a mixed pressurised and non-pressurised system.

It was also agreed that since a vast amount of system information was to be collated an asset management tool would be advantageous. The InfoWorks modelling platform was selected as the most suitable common modelling platform for the project, and this was complimented by the InfoNet asset management system.

A single integrated, user-friendly common modelling platform would also provide the best long-term solution for DCC as well as for the Three Waters Strategy project, since it was planned to have a small but flexible permanent modelling team as part of the water and waste services business unit.

Great care was taken to design the database architecture within the InfoWorks WS and CS models to ensure a co-ordinated approach was taken from the start. Good examples of this were developing a common node / asset naming convention and using a common set of data flags. Common background mapping was used and a single ground model developed. Essentially the look and feel of the models would be similar whichever of the waters was being modelled.

Throughout the modelling aspects of the study the modelling team would meet on a regular basis to discuss progress and ensure continued integration across the models. Additionally data and modelling results were to be shared, for example the total inflow into a zone and the calculated leakage from the water model were shared with the wastewater and stormwater modelling teams so that the inflow could be compared with the dry weather flow and inconsistencies could be flagged and further investigated if necessary. This level of co-operation and integration across disciplines is rare, perhaps surprisingly so, but proved to be very useful and once again demonstrated the benefit of the collaborative approach to the project.

Particularly close collaboration between the stormwater and wastewater modelling teams was also essential, as the 'separated' system proved to be less separated than the team had initially been led to believe! Workshops with the system operators and even the roading engineers helped to throw light on a number of issues, providing clarity for the modellers and the water and waste team, and once again demonstrating how a project of this nature asks questions of an organisation and helps break down barriers and encourage cooperation across council departments.

Climate change and sustainability

The long-term effects of climate change are the subject of much debate, but it was considered essential to factor the best available data for the Dunedin area into the optimised decision making progress for this project.

The expected effects of climate change vary across the three waters and developing integrated solutions that would balance these different effects will ultimately be a key factor in defining the success of the Three Waters Strategy project. It is expected that less rainfall / snowfall will be collected in the principal catchments used to supply water to the city, combined with increasing spells of hotter drier weather that could increase peak demands.

Key predictions for the stormwater system include potentially shorter storms of higher intensity, together with rising sea levels, which affect the discharge conditions. Additionally, sea water infiltration into the aging infrastructure in low lying areas would further reduce system capacity. Saline water intrusion into the wastewater system from rising groundwater levels would also impact on the capacity of the wastewater system and could significantly impact treatment plant operation.

High intensity storms would also impact the wastewater system as it is evident from initial flow monitoring that there is a significant stormwater inflow through direct connections and overland flow entering through manholes.

DCC has developed a corporate sustainability framework, which has recently been adopted as the basis for guiding / influencing all of DCC's core activities. Sustainability principles would therefore be integral to the capital works master plans for water and wastewater, and the integrated catchment management plans, which are the key output of the first two phases of the project. For example, strong emphasis has been given to developing operational rather than capital works solutions for problems wherever possible.

The treated and raw water models can also be used in future to identify sites where microgeneration may be possible. Generating power using surplus energy in the system is seen as desirable by a council wishing to provide leadership to the community.

Project progress

At the time of writing this paper, the Phase 1 works have been completed and the Phase 2 works are nearing completion. Strategic level capital works master plans have been completed for wastewater and water supply and the pilot catchment management plan has been completed. The final treated water report has also been completed, providing a 'source to tap' analysis of the current performance and future needs of the water supply system.

The Phase 1 works identified areas of the networks where detailed investigations were required in the water and wastewater systems. This formed the basis for the Phase 2 works, which are now nearing completion.

Development of a pilot catchment management plan and city wide catchment prioritisation led to the development of a staged delivery programme for the remaining nine catchments to be completed during Phase 2.

Benefits of the project to date

Though not yet complete, the Three Waters Strategy Project has already delivered a number of significant benefits to the DCC water and waste business unit in a number of key result areas.

Financial management

Improved economic outcomes are achievable through prudent infrastructure investments that are optimised to provide the best return on capital. The business unit is better able to develop compelling business cases to support investment in new capital projects.

Customer service

The project has enabled a clear line of sight between levels of service, community outcomes and the related costs. It also provides a genuine opportunity for the public and community groups to meaningfully engage in the planning processes for the three waters.

Organisational performance

From an organisational perspective, it has assisted in developing a robust and reliable strategic planning capability. It simultaneously addressed many improvement initiatives that had been identified in the activity management plans and the 2008 asset management process benchmarking project conducted by IWA & WSAA.

It has assisted the business along the path of developing advanced asset management techniques. A number of parallel and complimentary processes have been started, including developing a condition assessment policy and programme and a detailed criticality analysis of assets.

Environmental stewardship

In environmental terms the project has delivered some significant and immediate benefits in reducing the impact of sewer overflows to the city's living and marine environment. Water quality issues that impact on tangata whenua (people of the land) values and their traditional food gathering resources have been identified through the project.

People development

As far as the people involved in the project are concerned, it has provided an excellent training opportunity for new staff and captured knowledge that will endure within the business unit and our people.

Finally, the working inter-relationships developed through the project have been the catalyst for positive culture change within the organisation, which we hope will continue long after completion of the Three Waters Strategy work.

Conclusion

In order to drive their future investment programme, DCC has developed an integrated asset management approach and has embarked on a business improvement project in order meet its capital and operational delivery targets.

The process has two main components. The first being a restructure of the water and waste services business unit, and the second being to undertake a significant Three Waters Strategy Study that includes the development of comprehensive hydraulic models to examine the entire water cycle within Dunedin's urban catchments, and to provide critical information on the performance of the networks.

Now that the second of three phases of the Three Waters Strategy Study is nearing completion and the restructure of the water and waste business unit has been successfully implemented, a number of real and tangible benefits have already been demonstrated. This has provided DCC with confidence that the project is proceeding as planned and will ultimately result in improved operational performance and a prioritised and staged capital investment programme across the three waters that will be optimised, sustainable and affordable for current and future generations.

The project team are able to reflect on the success of the work to date and look forward with enthusiasm to completing the final tasks of this innovative and ambitious project. Meanwhile the restructured water and waste business unit continues to develop, based on the strategic guidance provided by the Three Waters Strategic Directions Statement (2010-2060) and a sound knowledge of the system performance, and needs developed as a result of the Three Waters Strategy Study together with more robust integrated business systems. ●

This paper was presented at the Australian Water Association Sustainable Infrastructure and Asset Management Conference, 23-24 November 2010, Sydney, Australia.

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Integrated planning for water infrastructure using sustainability principles

Selwyn District Council, New Zealand, is a small council with significant challenges that are centred on water resources. There are a plethora of segregated and independently-funded water supply, wastewater, stormwater, land drainage and stock water race schemes where infrastructure expenditure needs exceed affordability.

In this paper, Rob Blakemore presents a summary of a new approach to integrated planning across the '5 waters' in Selwyn, that culminated with the design of a prioritised expenditure programme for the entire district – to allow the Council to cut its cloth according to affordability from one year to another.

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Selwyn District Council (SDC) is a local authority situated in the South Island of New Zealand. Its core business includes delivery of water services. SDC is located in the heart of the Canterbury Region's groundwater zone (and surrounds the epicentre of the recent earthquake). The groundwater resource within this area is deemed to be fully allocated.

Selwyn District covers a diverse area, including rapidly growing urban centres on the periphery of the city of Christchurch, small rural towns, extensive agricultural land across the Canterbury Plains, and small alpine settlements (Figure 1). Availability of water resources varies across the district, and management of water resources in the coastal area must consider the significance of Te Waihora (Lake Ellesmere).

SDC sustains more than 70% or 26,000 people of its community via 30 independent and distinct community water service areas. Water service areas are a component of the 80 independent schemes within the 5 Waters Activity:

- Water supply (30)
- Wastewater (17)
- Stormwater (19)
- Land drainage (11)
- Stock water (3)

The use of water for human, agricultural, cultural and recreational needs is of considerable interest to Cantabrians and its rural economy. In planning the water management for this area, SDC had realised that there was little future in regarding the five waters as five separate activities. They all interact with the water cycle and all place different limitations on the future development of the area.

This paper discusses an approach taken to allow sustainable management of its five water services by regarding them as an integrated activity with priorities set outside any boundaries determined by specific schemes or specific utilities.

Context

Selwyn District – although small in population has a large geographic area with very different communities. Previous funding and expenditure has historically been allocated to each of the 80 '5 Waters' schemes, and priorities have been determined individually for each scheme. Although this approach does maximise local community input, it does not encourage efficiency – or integrated thinking. Local interests have less concern about long-term sustainability, especially over matters that are of little or no direct concern to them.

SDC was faced with a legislative requirement to revise its Activity Management Plans for the period 2009-2019. It also recognised that a ten-year funding window that displayed a ten-year vision was not going to serve the need to allocate expenditure across its 5 Waters infrastructure according to greatest priority within limited affordability, whilst taking account of significant natural resource and planning pressures that will impact long-term sustainability. A new approach was called for that can be summarised as a series of significant steps. The approach was to:

- Create and formally adopt sustainability principles that must be considered by the council for purposes of asset management and planning
- Define communities of interest within the boundaries of SDC for purposes of consultation (Figure 2)
- Prepare a strategic plan that specifically addresses influences external to the water infrastructure and SDC
- Adopt common levels of service for

Figure 1
Selwyn district

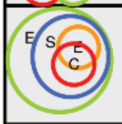
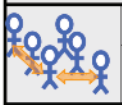
	**Principle 1: Make decisions based on the four aspects of well-being** Integrate environmental, economic, social and cultural considerations within Council decision making. Consider both the short-term and long-term effects of the decision.
	**Principle 2: Observe the Precautionary Principle to provide contingency and enable adaptability of our community** Err on the side of caution in the face of scientific uncertainty and a risk of serious or irreversible environmental damage.
	**Principle 3: Seek "intra-generational" and "inter-generational" equity** Improve quality of life and create opportunity for all of the current generation, without compromising the quality of life and opportunity of future generations.
	**Principle 4: Internalise environmental and social costs** Develop and adopt a system that recognises the true costs and benefits of protecting and restoring environmental/ecological, human, social and cultural resources affected as a result of the services that Council provides.
	**Principle 5: Foster community welfare** Support and encourage the region to prosper socially and culturally. Our assets are not just our built assets but our people, their skills and the connections between them.
	**Principle 6: Act to halt the decline of our indigenous biodiversity and maintain and restore remaining ecosystems** Conserve, and sustainably use and manage, the district's biodiversity, recognising the various services that ecosystems provide to humans as well as the environment's intrinsic value.
	**Principle 7: Consider, and promote the sustainability of our neighbouring communities and work with governing bodies for sustainable outcomes** Recognise that we are part of a whole globe system whether we can physically see the impacts of our actions or not.

Table 1 Sustainability principles

the waters
- Assign priorities to levels of service as expressed by the communities of interest
- Create a data base of all capital works projects and operational improvements for the '5 Waters'
- Prioritise projects and establish expenditure programmes

Activity management plans and changes needed

Previous activity management plans (AcMPs) had been prepared for water supply, wastewater, land drainage and stock water as separate documents. There was no activity management plan for stormwater. Driven by the Local Government Act 2002, SDC has to deliver a Long Term Council Community Plan (LTCCP) covering ten consecutive financial years. The AcMP is the vehicle for this detailed financial, asset, demand forecasts and risk assessment data. AcMPs undergo intensive revision on a three-yearly cycle. In New Zealand, AcMPs are developed using the 2006 International Infrastructure Management Manual (hereafter IIMM) guidelines and supporting documentation or guides. The Office of the Auditor general had already signalled that plans for 2009-2019 should have regard to sustainability.

Within Selwyn there was recognition that sustainable development for the district was not going to occur if it continued with previous practice – the preparation of five separate AcMPs for the five activities of water supply, wastewater, stormwater, stock water races and land drainage. Each activity interrupts the water cycle and impacts the water resources. Furthermore, there are often projects undertaken by the council that provide benefits to more than one of the five previously separate activities. Although there was no immediate intent to change the source and type of funding through the multitude of independently rated schemes, SDC realised that integrated thinking was required to justify expenditure and to prioritise improvement works. This approach led to the acceptance of the concept that there was only to be one plan produced – the 5 Waters Plan.

Sustainability principles – and the advantages of adopting them

The first stage to an integrated plan was to determine sustainability principles to be adopted by the council for purposes of asset planning. After considerable review of literature and internal discussion the council adopted the principles shown in Table 1.

Each principle is represented symbolically so that the council can be reminded of the relevance of any proposal it is considers to the principles in a simple and graphical way. This approach has meant that any subsequent report to council – whether involving policy or expenditure – can be directly linked to sustainability principles.

Common levels of service

Levels of service (LOS) have been redefined to reflect the adopted sustainability principles and have been worded in a generic way that ensures applicability across the five water services. The underlying premise of this AcMP is that all proposed works can be linked to and assessed against the levels of service such that improvements can be prioritised not only within a service, but across the 5 Waters Activity.

Prioritisation can never be determined unless there are common criteria against which there can be evaluation.

Perhaps this process is best described through metaphor. There is a common saying that says 'you can't compare apples with oranges'. Effectively, the project refutes this through a process that proposes: 'If you call apples and oranges fruit and then specify qualities of fruit that you may be looking for, you can then determine whether you want an apple or an orange by evaluating each type of fruit against their common qualities.'

Similarly for the five waters, it was decided that through the adoption of common levels of service that define the quality of the service you want in any of the five waters, priorities for projects of service you have already defined for your community can be established through evaluation of the contribution of the project to one or more of the levels of service.

The final nine levels of service that were adopted were:
- The community is provided with water services to a standard that protects their health and property
- Customers are provided and fairly charged for water services that meet their reasonable needs
- Nuisance effects of water services are minimised
- Water services are provided in a cost effective manner
- Problems with water services are addressed in a timely manner and prioritised according to risk and need
- Service capacity is provided to accommodate growing communities where this growth is sustainable
- Adverse effects of water services on cultural and heritage values are minimised
- Adverse effects of water services in the environment are minimised greenhouse gas emissions from the provision of water services are minimised

To ensure that management of the 5 Waters Activity reflects this diversity, five communities of interest have been identified. Consultation with these communities has allowed weighting of the levels of service to reflect local aspirations and priorities.

Communities of interest were defined to represent five distinct socioeconomic parts of the district in which it was believed that the people in the community may have different needs from the water utilities that serve them.

Using focus groups followed by local meetings and telephone surveys, we were able to attach weightings to these levels of service to reflect the relative importance the community placed on the nine different LOS. Importantly these were weightings to apply to each of the 5 Waters. It was therefore important for the community to understand the implications of losing the levels of service in each or all of the 5 Waters. The public consultation methodology of the work to establish these weightings was carefully thought through in advance of completion of the consultation. Ultimately the finally derived weightings were to be used to influence the priorities attached to improvement projects requiring capital or operational expenditure that would benefit their community.

An important benefit of this process is the early phase of public involvement that then reduces the potential negative impact from the community when faced with specific expenditure choices for project options. Justification of projects to a community becomes easier if they can be explained as contributing to specific levels of service that have been given weightings that reflect their views of importance.

Prioritisation of projects and affordability

One important final product of integrated asset management plans are expenditure programmes for the next ten to 20 years. However, the final outcomes of these programmes must be sustainable for successive generations and therefore we wanted to ensure they were connected to the sustainability principles. The principles were directly linked to the LOS.

Expenditure programmes have been developed for each community of interest that makes allowance for the relative importance of each LOS to each community.

The term 'project' is used to refer to any specific work item identified in relation to delivery of the 5 Waters Activity. A project may be a management task, system improvement, operational action, or construction of a new asset. The source of potential improvements may be derived from the strategic plan, from legislative requirements that have arisen since preparation of the last AcMP or because of changed community needs. There are also uncompleted improvements that were outlined in the previous AcMP.

The design of the prioritisation process has been based on a fundamental premise: no existing work, new work or system improvement should be undertaken unless there is identification of contribution to the retention or improvement of LOS for the whole or part of the community of interest that is serviced.

A project can provide a potential contribution to more than one level of service. Furthermore, a positive contribution in one area may be negated by loss of benefit in another area.

Renewal of existing assets is not considered within the prioritisation process, as a balanced, ongoing renewal strategy is essential to maintain existing levels of service for current and future generations. A 'prioritisation tool' has been developed based on the need to identify which performance measures are impacted by the proposed work (project). It does not attempt to quantity the specific benefits of any project because any project is part of a continuum of projects or work activities. If all projects are done the result will be to deliver levels of service to the targeted performance. It is more important to recognise which levels of service the projects contribute to and in what areas performance will be changed.

The score derived from use of the prioritisation tool can be regarded as an indicator of comparative community benefit and a comparative evaluation of the consequence of not achieving LOS if the project or improvement was not done.

Establishing the priorities

Before any project or improvement item can be prioritised there are a number of steps to work through.

Step 1 is to identify the LOS for the 5 Waters Activity.

Step 2 is to determine the relative importance of each LOS. This was determined for each community of interest through a consultation process and used to assign a weighting to each LOS against which projects are evaluated.

Step 3 is to identify performance measures – with scores and descriptors relevant to each LOS and each utility. There are a number of performance measures for any LOS. Some adaption of these measures may be required to allow 'scoring' of current performance. Each performance measure should be independent of the others. If measures are not independent there is a danger of 'double counting', biasing the prioritised work programme.

Descriptors have been developed to describe the range of impact on a performance measure – theoretically in the range from very positive customer benefit (5) to very low customer benefit (1). The long-term aim for SDC is of course to achieve positive customer benefit through improved LOS performance and achievement of associated community outcomes. It is, however, conceivable for a positive benefit to one LOS to be offset by a negative benefit in another. This aspect needs to be carefully considered in the evaluation process.

Step 4 is to define 'exposure levels' to reflect the extent of coverage of the proposed work. A simple way to think of exposure is as number of customers affected. For example a new water treatment project affects the entire community receiving the supply, but a new service connection benefits a single household.

However, there is a complication in that the impact of utilities may also be on the natural environment. It was therefore necessary to include a description of the extent to which the natural environment or other stakeholders are affected in the descriptors for impacts to LOS. This will have to be addressed when evaluating environmental impact of a potential project. Cultural impacts have been 'deemed' to always impact the entire community of interest.

Once a potential project or improvement action has been identified, a

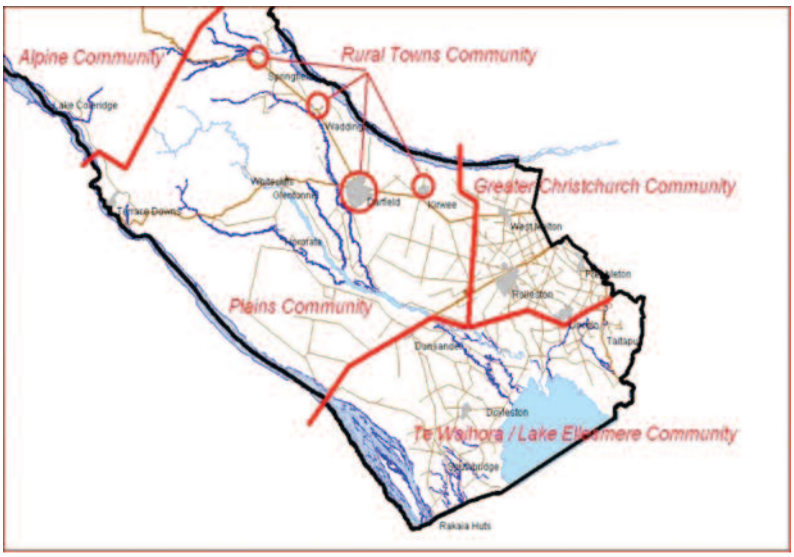


Figure 2
Communities of interest

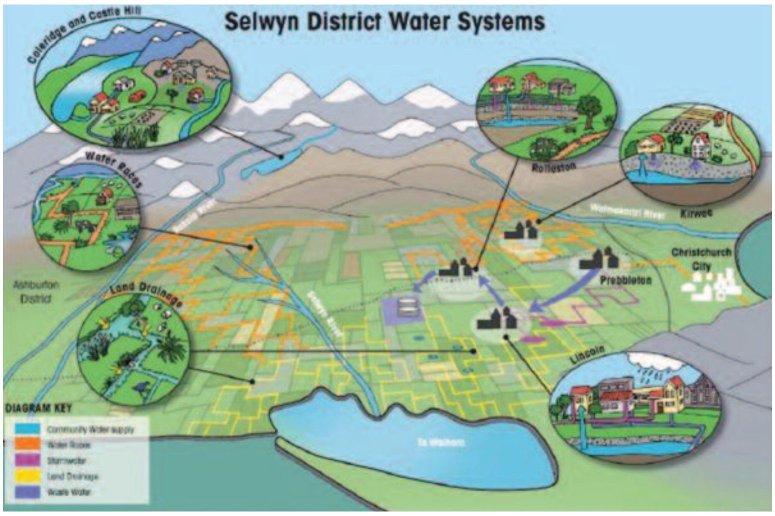


Figure 3
An integrated approach

further series of steps are worked through for each project:

- Identify which LOS are potentially affected by the project. These may be affected positively or negatively by the project or work
- Identify the most significant performance measure the project can impact. Only one performance measure should be identified for each LOS identified as relevant
- Assign a 'current status' performance measure score for each LOS in the community
- Assign a community exposure score for the project under consideration.
- Identify the aspired performance to which this project will contribute. This will usually be a score of 5.
- Calculate the prioritisation score. This is calculated as the sum of all identified performance improvements weighted by the associated LOS and exposure.

A database can be used to record project details and assumptions used to determine the prioritisation score. This allows ranked projects to be sorted by community of interest, and scheme and has provision for recording budget information to allow prioritised expenditure programmes to be produced.

Development of expenditure programmes

The derivation of work programmes and budgets for the 5 Waters AcMP is a multi-stage process. The prioritisation tool outlined above provides a useful foundation. However, it would be unwise to totally depend on the scoring process without a further assessment of practical details and extenuating circumstances that may result in a reprioritisation.

Typical examples factors that may justify a 'manual override' of the project priority score include:

- Coordination of construction activities with other works (e.g. roading or landscaping)
- Availability of external funding sources (e.g. MoH)
- Issues over community affordability because of current rating systems
- The need to sequence activities for practical reasons
- Projects where there are impacts to the same LOS but in more than one utility (e.g. a new telemetry system)
- Projects that provide benefit to the whole district or more than one community of interest – where efficiencies can be gained through widespread implementation
- Committed projects where funding is to be carried over from previous budgets

Draft expenditure programmes based on community benefit can then be reviewed with respect to funding capacity. Where funding constraints limit the amount of work that can be undertaken the lower priority projects are deferred to future years and a revised expenditure programme produced.

The outcome of this prioritisation process has been derivation of expenditure programmes that prioritise improvements according to community benefit for existing and future generations. The programmes can then be implemented according to affordability of the generations that will benefit from the projects. All project details that include the cost, project description and prioritisation score are permanently stored on a database until the project is completed.

Acknowledgement as good practice

In the publication 'Asset Management For Public Entities: Learning From Local Government Examples', this plan has been used as a good practice example. It states: 'Selwyn District Council has developed a system to ensure that its planned asset improvements are properly managed, monitored, and reported – showing that a good asset improvement plan need not be overly complex, but needs to be well structured and actively managed.

'Improvements are identified in each section of the plan and cross-referenced to a detailed projects programme designed to achieve the intended level of asset management sophistication. The improvements relate to matters such as sustainability, audit and monitoring, data collection, and criticality ranking. The plan identifies priorities (through a scoring assessment), responsibility, current status, and a cost programme for the project(s) in the next ten years. The Five Waters plan now appropriately accounts for the benefits accrued to different communities within the Selwyn district. Councillors have approved the finance required to implement the plan. The Council also maintains a spreadsheet of earlier improvement actions, which records and demonstrates the progress it has made.'

The plan was also a finalist in the IPENZ 2009 New Zealand Engineering Excellence Awards in the category; Sustainability and Clean Technology.

Conclusion

Integrated planning for water services is important for utilities that are managing assets in areas where water resources are under pressure. It is even more important for utilities where community affordability to fund improvements is under scrutiny and projects need to be prioritised according to community affordability. Common LOS that are strongly connected to sustainability principles have allowed Selwyn District Council to prioritise over 750 projects across the '5 Waters'. The system that has been adopted allows new projects and new ideas to be registered on a data base with uncompleted projects and then all projects re-prioritised at any time that budgets are recast. ●

Acknowledgement

This paper summarises the final outputs that were achieved through the collaborative efforts of my Opus colleagues and Selwyn District Council. In particular, I acknowledge Paul Carran, Greer Lees, and Hock Yeo of Opus and Hugh Blake-Manson, of Selwyn District Council.

This paper was presented at the Australian Water Association Sustainable Infrastructure and Asset Management Conference, 23-24 November 2010, Sydney, Australia.

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