ADAPTIVE WASTEWATER STRATEGY: UNCOVERING SECRETS

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ABSTRACT

Wastewater planning and modelling is based around assumptions such as growth and demand. Models enable asset owners to scope their projects and meet the financial planning requirements of the Local Government Act. The models can be used to test the impact of growth and demand changes tested against network performance standards too. How do you develop a strategy when there is no (or no fit-for-purpose) performance standard set? And how do you know if that performance strategy is affordable? What performance is being assessed, and what happens when there is little certainty about forecasting assumptions?

Kaitaia is a town representative of many towns in New Zealand, where little or no growth wasforecast in 2015 but has experienced population growth since. Regarding infrastructure planning, and specifically wastewater strategy, is this a blip on the horizon or a long-term trend that needs to be considered in current decision making? If the infrastructure is already at its limit, what do these demand variations do to the system? This uncertainty includes the impacts of climate variation such as increasing water leakage and pipe bursts over dryer summers; implementation of coastal retreat strategies due to extreme weather events; and changes in community willingness to pay following catastrophic events such as earthquakes.

Recent project examples are included to demonstrate that defining a wet weather performance standard for wastewater networks can grow a shared understanding of the network and justify and drive investment in wastewater infrastructure to reduce negative impacts on the community and the environment. Developing a wet-weather performance standard requires a good evidence base; enabling decisions to be confident and defendable. Collecting good data means models can be updated at regular intervals to reflect small or significant changes. With reliable network performance information, other data sets can be overlaid to demonstrate complex but important attributes of your infrastructure. The influence of flood events, receiving environment health, planning and development overlays, and social data sets can highlight trends that may affect infrastructure decisions.

This paper will also demonstrate that the way to achieve any agreed performance standard is through "adaptive wastewater strategy" including tools to ensure planning and improvement are possible in the face of uncertainty. Examples from projects carried out in the Far North, Queenstown and Tauranga will be used to show how these tools are being used to improve wet-weather network

performance. With the recent finalisation of the 2018 Long-Term Plans (LTPs), this is the perfect opportunity to examine current thinking and data on wet weather performance to be in forward planning mode rather than reacting to abatement notices.

KEYWORDS

wastewater, strategy, demand, adaptive, asset data

PRESENTER PROFILE

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1. INTRODUCTION

Wastewater overflows are an unpleasant and real side effect of the wastewater networks we use in all cities and towns in New Zealand. Put simply, robust, durable structures (pipes) are undermined with deteriorating joints and cracked pipes that let groundwater and (un)intentionally connect to the stormwater system. This multitude of failures means the piped wastewater network is not sealed from the environment. In fact, in many parts of New Zealand, the increasing demand placed on our wastewater networks is due in the majority from increasing stormwater and groundwater entering the wastewater network as it ages and only in some parts by 'real' demand caused by growth.

Understanding the quantum of wet weather demand on our wastewater networks is the first step to understanding the wet-weather performance of a wastewater network. Understanding how to cater for extra flow from uncertain growth and defining what the asset owner, stakeholders and the receiving environment is willing to "put up with", followed by planning affordable improvements to reduce wet weather overflows are the steps required to create a strategy for a wastewater network to effectively manage its wet weather performance.

However, it has been reported that few Councils are actively working to understand the wet-weather performance of their wastewater networks despite knowing they do have issues with wastewater overflows (Blake-Pearson 2018, New Zealand Herald 2018). For example, only one Council of 20 we reviewed reported against a level of service related to wet-weather performance of their wastewater networks. Is this because wastewater overflows are kept in the dark? Or does it indicate there is little strategic planning around wet-weather network performance? We propose this is largely due to the quantum of uncertainty involved with modelling and understanding the wet-weather hydraulics of a system. This uncertainty is discussed further in section 2.1.

Reporting the performance of a wastewater network has only recently been made more consistent across asset owners through reporting requirements (DIA, 2013a) and benchmarking (Water NZ, 2018) and is defined by dry weather performance and the number of breaches of any discharge consent(s). Performance of some wastewater networks under wet weather conditions came into the spotlight because of increasing media attention following wet weather overflows and resulting bacterial pollution, and less so because of network discharge consents being breached and enforced. In the event an abatement notice is received, decisions may be made in a reactive planning mode. In this mode, asset owners need to assess the costs of network improvements under time pressure and this may not allow time for solutions to be refined, as is possible in a proactive planning process.

When the spotlight swings on your dark (wastewater network) secret, what will enable you to confidently demonstrate the scale of the problem, what is being done to reduce wastewater overflows, how it's being implemented and what improvements have been achieved. A solid evidence base, a clear understanding of current wet weather performance, a proposed or agreed standard, and a strategy to meet the standard will help decisions to be made confidently and improvements to be implemented.

In the face of uncertainty, an adaptive strategy can be built on a solid evidence base, with crucial review hold-points over the life of the strategy to adapt to change as new information is available. Flexibility can be built into the implementation of the wastewater strategy and should be adopted as a principal where possible. This paper gives examples of Councils who are driving their wastewater strategy forward using three themes to make progress, despite the barriers. These themes are:

- Truly understanding wet-weather network performance (good evidence base, while improving data),
- Setting an (affordable) wet weather performance target, and
- Implementing an adaptive wastewater strategy including considering flexible solutions and review milestones.

The following sections gives examples of Local Government wastewater strategy development for improving wet weather network performance that is being driven forward despite the uncertainty inherent in wastewater network planning. Section 2.1 shows how understanding your unique network and its interaction with the environment are essential to communicating wet weather network performance and enables asset owners to plan for improvements. Section 2.2 discusses how setting a target and assessing its affordability allows for transparent decisions. Finally, section 2.3**Error! Reference source not found.** discusses how to be adaptive in planning, and how flexibility can be built into a wastewater strategy.

2. DISCUSSION

Most New Zealand Councils have design standards in place for new assets to meet an agreed performance. However, it has been reported that very few Councils are actively working to understand the wet-weather performance of their wastewater networks despite knowing they do have issues with wastewater overflows. Water New Zealand's (Water NZ) National Performance Review for the 2016/2017 put the spotlight on the issue of wastewater overflows to the receiving environment when it was released in early 2018 (Water NZ, 2018). The Water NZ Chief Executive John Pfahlert was quoted as saying "[t]hirty five of the 40 councils we surveyed had problems…where, in rainfall events, sewage is overflowing into the stormwater system and into rivers and streams", and that "[m]any of the councils don't have necessary design standards in place to prevent overflows, they haven't even undertaken a dialogue with the community about what might be considered acceptable," (Blake-Pearson, 2018). In our review of 20 New Zealand Councils (distributed geographically and by population), only one had a level of service for wet weather performance.

According to the Water NZ National Performance Review for 2016/2017 (Water NZ, 2018), only 13 Councils of 42 who responded have design standards for new sewers based on a containment return period, and the remaining were based on a multiplier of a dry weather flow, or no containment design standard was provided. We do note there is no local guidance or standardised reporting method for how to calculate and report on wet weather network performance. The Water New Zealand Inflow and Infiltration manual (Water NZ, 2015), provides guidance on how to measure and address Inflow and Infiltration and outlines benefits of having calibrated hydraulic wastewater models to understand performance but does not provide guidance for reporting wet-weather performance.

The dry weather overflow performance measure is one of the non-financial performance measures required for wastewater networks (DIA 2013a and summarised in Figure 1). The units are "the number of dry weather overflows per 1000 connections" and this is now reported across all Local Government organisations responsible for wastewater networks. Wet weather performance is not required to be measured and reported on, however abatement notices and the like are required to be reported (performance measure 2, figure 1) to reflect the impact on the environment. This may be a result of not being able to produce consistent data or units for overflow frequency across Councils.

Sub-part 2 – Sewerage and the treatment and disposal of sewage

(1) Performance measure 1 (system and adequacy)

The number of dry weather sewerage overflows from the territorial authority's sewerage system, expressed per 1000 sewerage connections to that sewerage system.

(2) Performance measure 2 (discharge compliance)

Compliance with the territorial authority's resource consents for discharge from its sewerage system measured by the number of abatement, infringement notices received by the territorial authority in relation those resource consents.

(3) Performance measure 3 (fault response times)

Where the territorial authority attends to sewerage overflows resulting from a blockage or other fault in the territorial authority's sewerage system, response times for attendance and resolution time.

(4) Performance measure 4 (customer satisfaction)

The total number of complaints received by the territorial authority about odour, faults, blockages and response times to issues, expressed per 1000 connections to the territorial authority's sewerage system.

Figure 1: Required wastewater network performance measures (summarised from DIA, 2013a)

Receiving an abatement notice (or the fear of it) may be a good motivator to make improvements in the wastewater network, however this creates a reactive environment where decision-making can become less strategic and can be driven by compliance (with the Resource Management Act). Compliance is mostly seen as a bottom line requirement expressed as a Level of Service. The target for all Councils for performance measure 2 is <1. These processes often leave the consequential “cost to comply” out of the equation. This keep-me-out-of-jail approach generally does not allow for the consideration of cost and benefits nor for a more comprehensive strategic approach. The costs to comply are likely to be higher with sub-optimal solution implemented. We also note that very few consent non-compliance notices were reported in the 2016/2017 year, only one abatement notice and seven infringement notices. (Water NZ, 2018).

The Local Government Act requires long-term planning and transparency around planned investment. And this planned investment is significant The National Performance Review (Water NZ, 2018) reports that almost $400 million was spent in the 2016/2017 year on wastewater capital expenditure among the 42 respondents. Whatever the exact amount, it is significant per Council and could be on average approximately $10 million per year. Understanding wet-weather performance of a network, and developing a strategy to improve performance where required, would be a fraction of the planned investment and would directly reduce the impact wastewater networks have on the environment. Savings using a proactive planning approach for a $500 million-dollar project in Auckland’s North Shore, compared to a reactive approach and assuming the same containment standard had to be met, have been estimated at between $100 and $450 million depending on the year of reference (Heijs & Brown, 2009).

2.1. UNDERSTAND THE HYDRAULICS OF YOUR UNIQUE SYSTEM, UNDER WET WEATHER CONDITIONS

2.1.1. BARRIERS

The main barriers to understanding the hydraulics of a wastewater network under wet weather conditions are; the significant amount of uncertainty involved; the lack of requirement for a level of service related to wet weather performance, and; the lack of guidance on methodology to understand wet-weather performance.

Uncertainty in wastewater planning can mean projects don’t get started ‘on time’, are deferred, or by the time they are implemented are based on old information. Compared to transport or community assets planning, the inputs to wastewater (and 3Waters generally) strategic planning holds additional uncertainty due to:

- The (perceived) expense of collecting data, modelling and planning
- The mistrust of monitoring and modelling,
- The integral relationship of the system with the environment (i.e. infiltration),
- The underground (invisible) nature of the assets and their condition, and

- The un-sexiness of the wastewater network: being-out-of-sight-out-of-mind, only prompting community concern and political willingness to act when things are really bad.

We propose there is an additional contributing factor to uncertainty which is much harder to account for: trust. This lack of trust could contribute to the resistance to invest in good asset data and modelling mentioned above and presents itself as a lack of trust 'in the numbers'. This could be due to many factors: a lack of trust in the black box nature of computer models; between a previous consultant and a new consultant; between internal and external stakeholders; and sometimes between old staff and new staff members where there hasn't been a good opportunity for handover (common when there is a lack of qualified staff), or there's a lack of calibrated or validated information to demonstrate that decision tools can be relied upon.

In the Water NZ National Performance Review 2016/2017, Councils identified the lack of qualified staff as the main reason that actual capital expenditure trailed budgeted expenditure by 70% over the last few years (Water NZ, 2018). A good evidence base which can be interrogated by new decision-makers to assess problems and proposed solutions against their own ideas, or when new information is available can assist in good handover between staff. This evidence base needs to include good data (or an understanding of data gaps), validation and calibrated results, quantification of uncertainties and assumptions such as growth predictions, and sensitivity to known factors (i.e. climate change) and unknown factors (i.e. sudden population shifts, changes in expectations or available funding). This evidence base can also be relied on and interrogated when there are other political upheavals (i.e. central and local government elections).

The barriers to understanding the hydraulic network performance in wet weather conditions include that:

- wet-weather network performance reporting is not required;
- wet-weather performance requires a reliable network model based on good asset data and real-time monitoring, which is perceived to be expensive and time consuming;
- the lack of guidance on best practice on how to calculate and report on wet weather performance;
- Fear for the outcomes showing that the network performance is not as good as communicated in the past; and
- decision-making is often stalled due to the lack of a shared understanding of the model results and their reliability (i.e. how uncertainty is dealt with).

The value of understanding and reporting against both wet and dry-weather performance measures is clear. A dry weather performance measure informs the network owner of the performance based on blockages and other disruptions. Metrics often include the number of incidents, response times and customer satisfaction. Reporting on this kind of performance can illuminate issues such as wet-wipes causing blockages in wastewater networks. Providing data on dry weather performance is relatively easy.

A wet-weather performance measure informs the network owner of performance during and following rainfall events that put the network (and potentially the receiving environment) under stress. Reporting on wet-weather performance requires the asset owner to understand the performance of their network during these events. This is a complex task and cannot be based on simply reporting on treatment plant or pump station inflows. In addition, the potential and often hard to see impacts on communities and the environment need to be recognised and communicated.

Understanding network performance (under wet and dry conditions) needs a reliable network model calibrated on real-time flow records and good asset data. A barrier can be that there is a distrust of 'the numbers' the model spits out (as mentioned above). This distrust can be reinforced by under-reporting of wastewater overflows (Heijs et al., 2017) which is due to many factors, for example the public not reporting them because they don't understand what's happening or are afraid this might reduce property value (through LIM reports). Sometimes the overflows are masked (by vegetation or floodwaters), and also may not be reported because people are unaware that their Council want to know about these events.

2.1.2. TOOLS

As discussed above, a reliable wastewater network model with good asset data, ground-truthed against real-time monitoring and local knowledge is required to calculate and understand wet-weather performance. With this, a shared understanding of the model and its reliability and (often local) limitations can be gained (as discussed in section 2.1.1). With this, solutions can be reliably formulated and uncertainty in the assumptions can be quantified using what-if analyses to understand sensitivity.

Once design solutions are formulated, the cost of altering a solution increases as a project progresses though the planning, design and implementation stages; therefore, any design variables based on assumptions should be tested and based on reliable model results. The biggest savings can be achieved at the start and in a proactive planning mode and there are cost-penalties for reactive solutions (Figure 2).

Models require gauging, monitoring, operational inputs, and ground truthing with local knowledge to validate 'the numbers' and be trusted by stakeholders. Once a model is developed, a shared understanding is required of the model results, the assumptions used for the model, and the areas or scenarios for which the model is more (and less) reliable. For example, using a long-term Time Series (LTS) to understand network operation during wet and dry periods has been shown to reflect observed network behaviour and characteristics (Heijs et al., 2017, Water NZ 2015), however, when a short time series of reliable rainfall data is available (i.e. less than 10 years), the results are less reliable in relation to less frequent rainfall events.

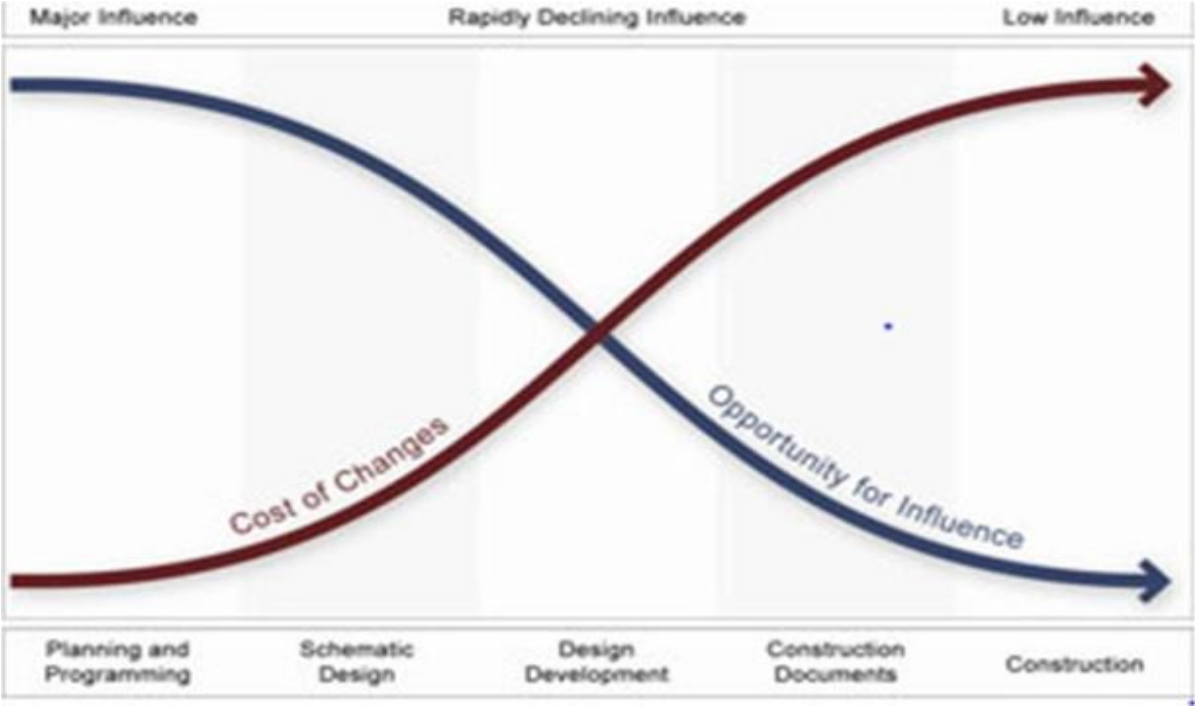
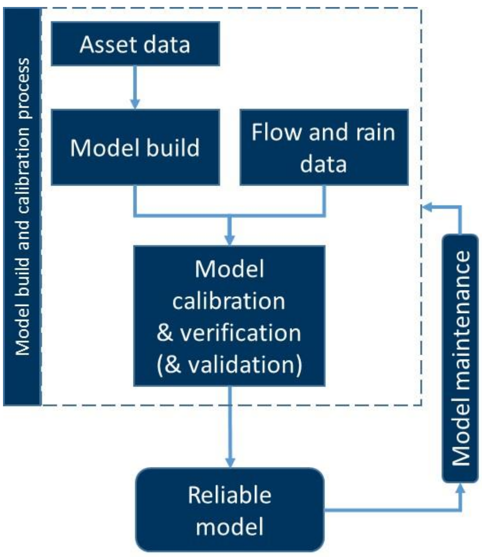


Figure 2 – Opportunity and cost of influence through project stages

Understanding wet-weather network performance means you're in a proactive rather than reactive planning mode – should an abatement notice be received or wastewater overflows become a local headline issue. This reduces the likelihood of having to implement solutions without a solid evidence base. For example, if a network overflows during a 10-year event in a network with a performance standard of 1 overflow per 2 years, this can be proven using a reliable model and an abatement notice can successfully be challenged.



To maintain and improve model results and to decrease uncertainty over time there needs to be model maintenance mechanisms built into business practices (Figure 3). Thinking of your network model as an asset is the best way to ensure it is maintained. This includes a commitment to:

- a data improvement programme,
- system performance monitoring (gauging etc.),
- model updates (changes in the network, changes in growth models) and re-calibration (including sensitivity), and
- regular reviews of improvement programmes

Figure 3: Network hydraulic model components and maintenance relationship

2.1.3. EXAMPLE

Communicating from a good evidence base can directly influence changes in community willingness-to-pay. For example, on the North Shore of Auckland where in the late 90's, wastewater overflows were recognised to be damaging the pristine beaches, residents were willing to pay the approximate $500 million project cost (2008 dollars) following a short but focussed consultation period. Thereafter the project was fully supported, funded and implemented by the North Shore City Council until the Auckland Councils were amalgamated in 2010 (Heijs & Brown, 2009). Recent issues campaigning through the media has created an environment where the spotlight can shift swiftly on to a local or national issue. It's worth noting that the same communication mediums also provide a platform for quality engagement with stakeholders through the communication of high quality model results.

Tauranga City Council and Far North District Councils are examples of wastewater network owners who have an understanding of the wet-weather performance of their wastewater networks. Although, the performance of the Kaitaia and Tauranga City networks are streets apart. Kaitaia has a modelled overflow frequency of around 20 overflows per year (at engineered overflow points) where Tauranga has a very low frequency (note: performance assessments are underway to confirm this). Both are working to understand their network characteristics, future growth scenarios, and the affordable solutions available to manage overflows. In the Kaitaia case the solutions will be to address wet weather overflow issues and in the Tauranga case to avoid this type of problem in the future.

As discussed above, models require good data, gauging, monitoring, operational inputs and local knowledge. During validation of the modelled Kaitaia wastewater overflow frequencies there was one known property affected by wastewater overflows but no customer complaints of overflows despite the fact the model said the engineered overflow points were activated 20 times per year and some uncontrolled wastewater manholes were overflowing 20+ times a year (Heijs et al., 2017). The overflow frequency at engineered overflow points were confirmed from observations by council staff through mapping of round-table discussion and comparing them to modelled locations (Heijs et al., 2017). This process also confirmed under reporting by the community.

In both locations understanding of the hydraulics of the network under wet-weather conditions has or will follow the process shown in Figure 3, building a solid evidence base to enable a better understanding of the actual wet-weather system performance and model reliability.

2.2. SETTING AN AFFORDABLE TARGET

The lack of a true wet-weather performance standard from most Councils means that communities are not being informed of the scale of the problem, or no conversation has been entered into (Blake-Pearson, 2018). The alternatives to the proposed investment are not being communicated to the community as identified by the Local Government Infrastructure Efficiency Expert Advisory Group, who stated that transparency of information in decision-making is lacking and alternatives and options for investment is needed (DIA, 2013b).

A network performance standard, often expressed as a Level of Service, is required to justify Council activities and to allocate funding through the LTP process required by the Local Government Act. As noted above, currently network performance is only defined by dry weather performance and abatement notices (Figure 1).

2.2.1. BARRIERS

Some of the barriers to setting a wet weather performance standard based on return period rainfall events (also called a containment standard) are:

- No targets have been set in the past and there is no priority to do that now (no current requirement for reporting performance),
- Targets have been set previously without knowledge of their true cost or effectiveness,
- Targets set but based on traditional design standards such as a multiplier of dry weather wastewater flows – not actual wet-weather network performance,
- Unable to justify a perceived expensive strategic planning project, including gauging, model build and calibration, performance analyses and a cost-benefit assessment (due to barriers above),
- Reluctance to change an accepted approach which might expose unexpected (inconvenient) performance problems, and
- Concern about cost of solutions once problem is quantified (overflow frequency and volume) and the need to justify these in already cash-strapped organisations.

A wet-weather network performance standard can be expressed as a spill frequency or have a (pipe) capacity as a target. Some network operators use a theoretical peaking factor as a performance standard, such as four times the Average Dry Weather Flow (ADWF). Others have no clear performance standards and as such may be operating in a reactive mode. Consequently, asset owners could be responding to perceived system failures, but without a benchmark to determine whether the failures are 'normal' or freak events.

Using a peaking factor can be appropriate when designing greenfield wastewater networks, however a modelled peaking factor provides limited information about the actual performance of an existing network, whether it causes overflows or whether it can cater for future growth. For example, some parts of the network might experience peaking factors of well over four, five or six times the ADWF, and don't have overflows or other capacity issues, while other parts of the network have overflows with peaking factors well below four times the ADWF and do cause issues. It is not uncommon that parts of the network have loadings well above their design assumptions but don't experience any containment issues. Even using a peaking factor in non-typical land-use scenarios such as areas with higher densities (e.g. infill growth) can lead to inaccurate assessments, mainly because the ratio of demand and pipe length is different (pipes letting stormwater in: the wet weather component).

The ‘traditional’ peaking factor of four or five times the ADWF is many decades old and is in need of a review. Shaw et al. presented a paper in 2008 called “Designing New Sewers to Account for Wet Weather and Infill Development” confirming this need for review, and reported that 10 to 19 times the ADWF was equivalent to the 2-year annual return interval event in some catchments they examined (Shaw et al., 2008).

2.2.2. TOOLS

It is important that a network performance standard is fit for purpose, achievable and affordable. A wet-weather network performance standard enables a wastewater network owner to benchmark performance and provide a transparent framework for reporting performance during or following rainfall events. This is required to avoid reactive and expensive network upgrades to address a problem that occurred during a rainfall event that the network was or was not designed to provide for. A wet-weather network performance standard also allows the network owner to justify capital works and help prioritise these works; to assess development applications and the ability of the network to service growth; and to use as the basis for a network discharge consent application. Regional Councils in New Zealand increasingly include a network performance standard in their consent conditions. The recommended cost-benefit approach to setting an affordable performance standard (Heijs et al., 2017) is in keeping with the Best Practicable Options (BPO) approach in the RMA and has been proven to be very useful in consent processes elsewhere.

Where such a large amount of money is committed to wastewater capital expenditure over the next 10 years (in the order of $7-$10 million per Council on average, see discussion above), an affordable target for reducing wastewater overflow frequency is important. Analysis of the costs and benefits of achieving a range of performance standards is important to ensure an informed decision is made when agreeing the wet-weather performance standard.

Once network performance is known and understood using a solid evidence base, a cost benefit analyses can be undertaken in which the cost to achieve a range of performance standards can be calculated and reported. Decision makers can make an informed choice, considering affordability and effects. Setting a target is essential to justify spending. The consequences of these choices are transparent and means stakeholders can assess the financial and environmental impacts of their preferences.

As in many cost benefit assessments, the law of diminishing returns has been shown to be applicable to wastewater network projects we have been involved with. Figure 4 shows a typical illustration of diminishing returns. The ‘effort’ is typically expressed in costs. Cost units that can be used are CAPEX and Net Present Value (NPV). The vertical axis shows the improved performance as a percentage. This can be overflow frequency but also other parameters such as overflow volumes or water quality. Because a percentage improvement is used, the shape of the curve will always have an asymptotic shape because more than 100% improvement cannot be achieved. Generally, a big return on investment is visible on the left of the curve and then diminishing as the curve moves to the right. The point of diminishing returns and hence what a community can afford will also be different for different networks.

In addition to looking at the monetary costs, other non-cost criteria should be considered, for example by using a Multi Criteria Analyses (MCA). This method is discussed in detail in Heijs et al. (2017).

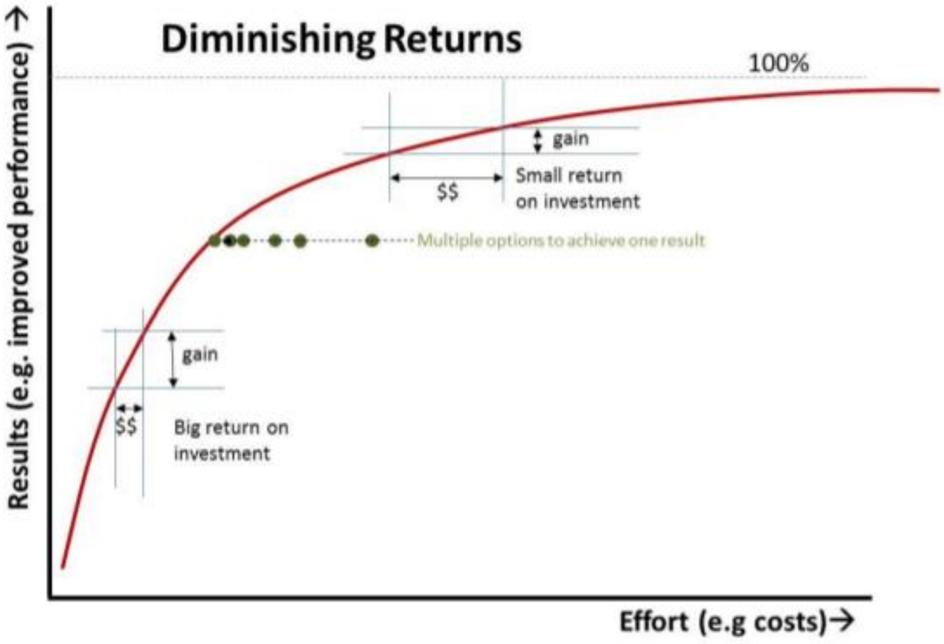


Figure 4: The law of diminishing return (Heijs et al., 2017)

Affordability, is also an agreed measure. It is consulted and agreed with stakeholders and it changes over time in some degree together with willingness to pay (discussed in section 1). However, this is something that can be reviewed throughout the life of the wastewater strategy, through the review process required by the LTP, and as a programme of continuous improvements, logically reviewing strategic direction as information changes. For example, a containment standard of four spills per year is accepted and a strategy is implemented based on that, but five years later a higher containment standard is agreed by stakeholders (at additional cost) based on solid grounds, affordability has changed. This is discussed further with reference to adaptive strategy and flexible solutions in section 2.3.

Other tools to enable an affordable target to be set include recognising that there is uncertainty with construction costs (as in any planned capital expenditure) and:

- Understanding that where pipe replacement is required, the biggest driver for cost is how much needs to be upgraded or built (e.g. length of pipe) not how big (e.g. the diameter of the pipe).
- Using the renewals budget to fund in part pipe replacement or targeted renewals at reducing inflow and infiltration.

- Implementing a large programme of work and/or renewals (over multiple years) will costs less than sporadic works. For example, in the early 2000's the price for renewal works in North Shore City reduced by about 50% because a constant volume of work created a competitive and more capable workforce as well as streamlined council processes (i.e. procurement) (Heijs & Brown 2009).

2.3. ADAPTIVE WASTEWATER STRATEGY

2.3.1. BARRIERS

Population growth, network deterioration and structural development changes are key drivers of infrastructure investment (DIA, 2013b). However, even these elements come with a high amount of uncertainty. As an example, in 2015 the population of Kaitaia was predicted to shrink over the next 30 years. Where, in fact, average house prices in the town have grown 16% is the last year, with an almost 30% increase in house prices in the last two years for the whole region (compared to only 9% in the preceding two years). Although house prices are not a great proxy for population growth, it does give an indication of demand and therefore population increase (assuming houses were lying empty). Kaitaia is a town representative of many towns in New Zealand, where growth was not predicted only two years ago! is this a blip on the horizon or a long-term trend that needs to be considered in current decision making?

It was widely reported that wastewater overflows increased 379% from the 15/16 year to the 16/17 year (Blake-Pearson 2018, New Zealand Herald 2018 from source: Water NZ, 2018). This increase was attributed to unusually wet seasons (Autumn 2017 being the wettest on record for parts of the North Island). If the water infrastructure is already at its limit, what do these demand variations do to the system?

Couple this uncertainty of population forecasts, network deterioration and structural development changes with the uncertainty of external factors (i.e. climate change) and internal factors (i.e. model uncertainties) discussed in section 1, and implementing any wastewater strategy seems impossible. Using an engineering standard is an easy option but developing an adaptive wastewater strategy and adopting flexibility as a principal where possible, will enable asset owners to improve network performance in an informed and cost-effective way.

2.3.2. TOOLS

Being adaptive in wastewater planning can be achieved by:

- having sound justification of future works through a good evidence base and understanding assumptions and their sensitivity (discussed in section 2.1),
- including review mechanism that enable data updates and reprioritisation based on the most current information, and
- Having flexibility as a principle of your strategy.

A review process is in part required by the LTP process but a programme of continuous improvements logically reviewing strategic direction as information changes is required. A basis for this is treating a network model as an asset to ensure it is maintained (see section 2.1.2). New information could include a re-calibrated model, changes in growth information, completed network upgrades and changes in available budgets. The review process also allows you to review your future works programme and related expenditure against new information and may mean solutions can be optimised further. Whether you wish to review the Level of Service every three years is unlikely once this target has been set (see section 2.2) but possible. Part of the review process could be to fine-tune the timing of network upgrades. Undertaking a work too late might result in wet weather overflows/exceeding a containment standard while delaying this upgrade because the rate of growth is lower than expected will defer this multi-million-dollar investment and reduce the impact on rates.

What does flexibility look like in a wastewater strategy? Two ways flexibility can be built into wastewater strategy are with a solid evidence base, and valuing flexibility in assessing design options.

A solid evidence base (a reliable and up to date model) enables flexibility. Although modelling of wastewater networks can be incredibly complex there is an opportunity with an up to date model to ask it a 'what-if question'. Such as how will my network perform if the Autumn of 2017 is the new normal (wettest autumn on record for parts of the North Island). As reported by The Local Government Infrastructure Efficiency Expert Advisory Group Report (DIA, 2013b), climate change data and scenarios chosen to plan for varied across councils. Having models that can be interrogated, new scenarios added and data inputs changed when it becomes available or standardized, is essential to adaptive wastewater strategy. Undertaking what-if scenarios also allow you to inform decision makers of the implications of changes such as deferring a major upgrade or a change in available budget.

The other aspect of flexibility in a wastewater strategy is choosing to implement design solutions that are more flexible than others. This can occur where multiple network solutions are available to improve the network performance. In some cases, a more expensive solution might be preferable because it provides more flexibility compared to the cheapest solution. What-if scenario's can help you understand the scope and cost consequences when testing the sensitivity of some of the assumptions. As noted above, that same flexibility can be provided through cost is often in the extent of network upgrade, not the diameter of the pipe. If there is an opportunity to go one step up in pipe diameter, this can give additional flexibility in case some of the assumptions (I/I, climate change, growth, etc) change or when a higher containment standard is required later.

2.3.3. EXAMPLE

In 2001 The North Shore Wastewater Improvement Programme was based on the best growth predictions available at the time. Six years later, the assumptions and models were reviewed. Total population estimates for the full catchment were spot on, however the location of the predicted growth had changed. In some network catchments the new data was more than 100% different. In this case growth was initially assumed to be more spread across the catchment as a result of infill but actual growth and new predictions showed developers were not interested in taking up growth capacity in existing brown field areas and moved to lower-risk green fields. The review process allowed the Council to make some changes to the remaining capital works programme to adjust to this new information, with the total cost of the improvement programme about the same (when excluding inflation) (Heijs and Brown 2009). When built-in review milestones are programmed into the strategy, the fact that the model and its inputs are not perfect is also bought to the fore, making it clear that none of the modelling (and supporting assumptions) is taken as the absolute truth, but a tool (or asset) that needs regular calibration to remain in service.

An integrated review process coupled with a data improvement programme is being used to create an adaptive wastewater strategy for Queenstown Lakes District Council (QLDC). QLDC are working to understand their wet weather network performance even though they have a very low occurrence of overflow. Due to the pristine nature of, and economic benefits drawn from, the receiving environment, the consequence of an overflow is extremely high. Although the probability of overflow is currently very low, rapid growth in some areas means the possibility of overflows may increase the risk of overflows in some locations. Anecdotally the overflows are very rare, understanding the mechanisms and contributing factors means that QLDC can create a strategy to minimise overflows. The strategy is based around the need to understand the current and future (do-nothing) wet weather network performance and overflow mechanisms first, while improving data.

The nature of the wastewater network in Kaitaia means that staged and flexible solutions to reduce overflow frequencies were investigated and developed to understand their costs and benefits, even though some were more expensive options. Non-cost criteria or life-cycle/operational costs were used to compare and value solutions that were more expensive. For FNDC, a staged upgrade approach was recommended so that an initial significant increase in network performance could be gained. With a relatively small investment. The staging also meant that following implementation of the first stage of construction, additional scoping and monitoring could be completed to better plan and cost the second stage of the improvements.

3. CONCLUSIONS

This paper has examined the barriers to developing a strategy to understand and improve wet-weather performance in wastewater networks. There is uncertainty inherent in wastewater network performance which can mean little is done to improve performance. Performance of a network is currently largely defined by dry weather performance and the number of breaches of consent of which there are very few reported each year, despite numerous known overflows (Water NZ 2018). According to Water New Zealand National Performance Review, many councils don’t know what their overflow frequencies are, the way these frequencies are calculated varies (Water NZ 2018) and what is published is very likely to be under-reported.

This demonstrates the non-financial performance measures currently required, dry weather performance and the number of breaches of consent notification (DIA 2013a) are not fit-for-purpose to reflect the impacts wastewater overflows are having on the environment. As discussed, by the time there's an abatement notice you're in reactive mode. Forward planning creates better outcomes and has lower long-term costs associated with it. Wastewater strategies are more successful if they acknowledge that the strategy will need to adapt over time (to improved inputs and changing community values).

The following table summarises the tools proposed in this paper to progress wastewater strategy to improve wet-weather performance despite the inherent uncertainty.

Table 1: Tools for developing of an adaptive wastewater strategy

Themes	Tools
Understand the hydraulics	Implement data improvement and network monitoring.
	Develop hydraulic model.
	Measure performance based on wet weather flows (and overflows).
	Maintain your model (like any other critical asset).
	Ensure stakeholders trust the network model(s).
Set an affordable target	Understand the costs to achieve a range of performance outcomes (financial, environmental and social).
	Communicate outcomes to decision-makers to arrive at an informed performance target. A cost-benefit analyses showing a diminishing returns relationship is recommended.
Adaptive Strategy	Use the good evidence base (model) for what-if scenarios to understand sensitivity to change in model assumptions.
	Build review steps into the strategy: - strategy inputs: model updates, network data, growth and demand data and gauging at agreed frequencies. - strategy outputs (works and implementation plan).
	Consider design solutions that allow for more flexibility in case assumption made change (future proofing).

The penalty of not looking after your network will be expressed in significant costs to fix high(er) overflow frequencies or greater environmental effects or both sometime in the future. There is also a need for industry guidance for wet-weather performance assessment to enable standardised assessment methodology and reporting.

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