APPLYING INTERNATIONAL BEST PRACTICE IN DRINKING WATER SUPPLIES. LESSONS LEARNT FROM HASTINGS DISTRICT COUNCIL.

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ABSTRACT (500 WORDS MAXIMUM)

In the wake of the Havelock North contamination incident in August 2016, the Hastings District Council undertook a comprehensive review of its people, systems, practices, and processes to enable the organization to respond to the outcomes of the Board of Inquiry investigation. Because of this review, they have adopted the World Health Organisation's preventive, risk-based approach to managing water quality and have been implementing a new strategy and business plan that aligns to a proactive risk-based framework as opposed to a purely compliance-based regime.

Two years later, HDC's management practices and systems for supplying drinking water look fundamentally different. Before 2016, HDC was focused on complying with all the requirements in the New Zealand regulatory space, namely the Drinking Water Standards for New Zealand and The Health (Drinking Water) Amendment Act.

However, after the scrutiny following the Havelock North incident, HDC looked to best practice around the world and this paper looks at the findings from this research. The findings from this major change in focus, detailed in this paper, include:

- The management frameworks used internationally provide comprehensive guidance about how to *manage* drinking water supplies, they do not just specify the end quality of the product. These frameworks include:
    - World Health Organisation Guidelines,
    - Hazard Assessment Critical Control Points,
    - Australian Drinking Water Guidelines and
    - Guidelines for Canadian Drinking Water Quality.
- The frameworks differ significantly in the approach to:
    - Multiple barriers, specifically active barriers
    - Critical Control Points
    - Risk assessments
    - Monitoring

Because of these findings, HDC has been progressively overhauling the management of its drinking water supplies, and developing long-term strategies and management plans for:

- Treatment and infrastructure options (considering capital and operating expenditure)
- Managing resource needs and staffing (both recruitment and training)
- Integration of systems and applying new technologies
- documentation development
- data management and reporting
- communication with stakeholders

The lessons learnt can be summarised as – there's more to adopting the World Health Organisation's preventive, risk-based approach to drinking water supply, than getting a tick for a Water Safety Plan every 5 years.

KEYWORDS

Water quality management, operations, international best practice, multi-barrier risk-based approach

PRESENTER PROFILE

Carly Price founded The Questioning Engineer, she is a water supply systems specialist, and a former water supply regulator in NSW, with 17 years' experience. She has been working with HDC since early 2017, to review HDC's practices and implement changes, including adopting internationally recognized preventive risk management processes.

Brett Chapman has been the 3 Waters Manager at HDC for 11 years. After 23 years' experience (including design, construction and asset management, treatment, and strategic planning), he has recently spent considerable time responding to the Havelock North event, presenting at the Board of Inquiry, and implementing a significant change process within HDC.

1 INTRODUCTION

1.1 WHAT HAPPENED IN AUGUST 2016?

Imagine you are the Water Group Manager for the local council. It's raining. Heavily. In fact, it's been called a weather bomb. How do you know your water supply will continue to deliver safe water and if someone asked, could you answer these questions?

1. Is the bore supply secure?
2. Is our compliance history exemplary?
3. Have we tested the water to demonstrate there is no water younger than 1 year?
4. Do we have an approved Water Safety Plan for our system?

If you answered yes to all the questions, then you are in the same situation that Hastings District Council was in August 2016.

As a result of sustained rainfall and significant overland flows, Campylobacter was drawn into the Havelock North water supply which was at that time untreated and not chlorinated. The ensuing contamination resulted in 6000 estimated cases of gastroenteritis and contributed to the deaths of 4 people. The investigations into the cause determined the most likely cause was from sheep faeces entering the Mangateretere stream and then into the aquifer via a direct pathway near the water supply bores.

Despite this, the Havelock North reticulation system was assessed as fully compliant in 2016/17 for the bacteriological requirements of the DWSNZ. Campylobacter is bacteria and the DWSNZ only requires 95% of bacteriological samples in unchlorinated reticulation systems to comply (Ministry of Health, 2008), (Appendix A1.8 Permitted Exceedances allows up to 5% of samples to fail). In the compliance reporting to the Ministry of Health, Havelock North reticulation system had 1 bacteriological transgression in 2016/17 with 1146 tests in the reticulation. So the reticulation system complied as 99.9% of samples complied. (At the time of writing, the Ministry of Health's Annual report for 2016/17 has yet to be released).

1.2 THE RESULTING RESEARCH QUESTION

After the scrutiny eased, HDC had time to think. Collectively the staff thought, if complying with the standards didn't protect our community, what else should we be doing to make sure the water we deliver is safe?

We set out to answer that question by looking at what water suppliers across the developed world do. Specifically, we looked at:

- World Health Organization Guidelines (WHO)
- Australian Drinking Water Guidelines (ADWG)
- Guidelines for Canadian Drinking Water Quality (GCDWQ)
- Hazard Assessment Critical Control Points (HACCP)

We considered these guidance documents and requirements because Australia and Canada are the English-speaking countries with the most similarities to the New Zealand water industry context. That is, in non-metropolitan areas, they both have low population densities with closer-to-pristine environments (relative to Europe and the USA). Canada is also a water-rich country, with a large proportion of the water supplies using groundwater sources.

2 FINDINGS

Our research resulted in findings about:

- the differences between the concepts and practices in New Zealand and other developed countries, and

- how to adopt these different concepts and practices in an operational water supply in a practical way.

2.1 INTERNATIONAL FRAMEWORKS' APPROACHES

There were some common concepts and practices in the international guidelines that are not in the New Zealand regime to the same extent, including:

- Multiple barriers for every system, and always having at least one active barrier.
- Critical Control Points
- Risk assessments cover more than microbiological and chemical hazardous events
- Monitoring for compliance isn't a box ticking exercise. It's a crucial part of understanding a system so it is managed properly

The differences between the DWSNZ requirements and the practices in Australia and Canada are outlined in the following sections.

2.1.1 MULTIPLE BARRIERS – INCLUDING ACTIVE BARRIERS

While the DWSNZ refer to the multi-barrier approach used in the WHO, ADWG and GCDWQ, the DWSNZ does not require every system to have multiple barriers. If a bore source is deemed secure, then no more barriers are needed. In fact, less visibility (i.e. monitoring) of the only barrier (the aquifer) is required.

Though in Australia and Canada, the exact interpretation of "multiple barriers" depends on the regulator for the specific state/province, there are no circumstances where only one passive barrier is accepted as the permanent, long-term scenario.

Implicit in the other guidelines is the assumption; to have multiple barriers you must have at least one barrier that is active. This introduces the concept of active and passive barriers:

- An aquifer is a **passive barrier** that prevents bacteria from entering the drinking water supplied to customers – it is an often-effective barrier, however, water suppliers have minimal control of performance or visibility of the integrity of the barrier and hence source water quality at any point in time.
- Chlorination is an **active barrier** that kills bacteria – you control the activity to ensure the barrier remains active. Active barriers are otherwise known as Control Points.

Under the ADWG, if you do not have robust mitigation of high risks like common pathogens, you must modify the process or add in a control point. A passive barrier is rarely considered a robust mitigation, because you can't adjust it to regain control if you lose the barrier's integrity.

So under the international guidance, the Havelock North system (or any "secure" bore supply) would not have been allowed to supply directly from the passive barrier without another barrier downstream. As a minimum, there would have had to be online continuous monitoring of the effectiveness of the passive barrier, so the moment it was compromised the water supplier was aware. But even then, could the problem have been arrested before consumers were affected?

An important point of clarification here is, that under all the guidelines, monitoring is not considered a barrier. Monitoring does not kill, remove or inactivate pathogens, it reports whether your barriers have been effective in pathogen removal/destruction/inactivation. So while monitoring is an essential component to a multi-barrier system, it does not contribute to the number of barriers a system has.

2.1.2 CRITICAL CONTROL POINTS

Critical Control Points (CCPs) are an activity, procedure, or process where control can be applied, and the control is essential for preventing hazardous events with high risks. In other words – if a standard operating procedure at this point in the process goes wrong (or doesn't happen) the customer might get unsafe water.

A CCP must have:

- parameters you can monitor to see if the control is working.
- critical limits set for those parameters that indicate the control is no longer effective.
- continuous online monitoring, often enough to show any failures in time for an appropriate response before water quality is impacted.
- corrective actions to resolve the issues that cause the process to be out of normal operating range while still providing safe water to customers.
- critical limits to shut-down a supply if the corrective actions fail to regain control and maintain safe water.

If you cannot monitor a barrier frequently enough to signal a problem, or if the only way to react to a problem is to cease supply to the customer, then the barrier cannot be a CCP. With passive barriers, such as aquifers, the operator cannot apply any measures here that control the risk, while still providing the customer with a service. So passive barriers cannot be CCPs under these international frameworks.

In many jurisdictions, regulators check or work with utilities to ensure the system has appropriate CCPs. Some regulators require data from the operational monitoring of the CCPs, others check the practice of monitoring and responding to CCPs through operational audits.

In Australia and Canada (the main jurisdictions where CCPs are used in drinking water supplies), the use of CCPs does not negate the use of multiple barriers. Even though a passive barrier cannot be a CCP, it does not mean that catchment management is not an important process to help maintain the effectiveness of that barrier. If a barrier is a CCP, it means a response to loss of control must be rapid; whereas for a non-CCP, the response may be less immediate.

2.1.3 RISK ASSESSMENTS

The DWSNZ and the Health (Drinking Water) Amendment Act require water operators to undertake risk assessments in the Water Safety Plans. The latest guidance (at time of writing) from the Ministry of Health on doing this is the January 2014 Water Safety Plan Guides (Guides).

The Guides' risk focus is on microbial contaminants and traditional engineering responses to the risks. This contrasts with the Australian and Canadian guidelines that provide guidance on how to do extensive risk assessments to ensure that risks (and the mitigation measures used to control them) are analysed beyond the traditional engineering responses.

The differences between the Guidelines may appear subtle, but the result can vary significantly. The following aspects are the areas of greatest contrast:

- Focusing on preventing the hazardous event, not the hazard, to reduce the likelihood in the risk rating.
- Identification of and addressing uncertainty as another aspect of assessing risks.

These aspects are detailed in the following sections.

HAZARD IDENTIFICATION

Separating out the definitions of hazards, hazardous events/scenarios and risks, ensures the assessment covers all the different ways an event can occur, rather than focusing on having a single preventive measure to prevent a hazard.

- A **hazard** is a biological, chemical, physical or radiological agent that has the potential to cause harm.
- A **hazardous event (or scenario)** is an incident or situation that can lead to the presence of a hazard (what can happen and how).
- **Risk** is the likelihood of identified hazards causing harm in exposed populations in a specified timeframe, including the severity of the consequences.

(National Health and Medical Research Council, 2011)

The following table illustrates how each jurisdiction uses different definitions.

Table 1: "Comparison of different risk assessment definitions"

Example	Australia	Canada	New Zealand
Campylobacter	Hazard	Hazard	Risk

Unsafe water at tap because chlorination failed.	Hazardous event	Hazardous scenario	Cause
Likelihood of chlorination failure when campylobacter present, leading to **consequence** of compromised public health	Risk	Risk	Risk

Why does this matter? The Canadian guidance explains:

> "The distinction between hazard and risk needs to be understood so attention and resources can be directed to actions based primarily on the level of risk associated with, rather than just the existence of, a hazard." (Canadian Council of Ministers of the Environment, 2004)

This means that the preventive measures identified in a typical Australian/Canadian risk assessment include more extensive non-infrastructure measures than in the typical New Zealand risk assessments.

For example, if you follow the New Zealand guidance for Water Supplies about the hazardous event where contamination enters a damaged bore casing, the preventive measure is the operator carrying out regular visual checks for damage. The only guidance for what to check on this preventive measure is the microbiological and chemical water quality.

In a typical Australian/Canadian risk assessment, as well as the visual checks, there would be other mitigation measures including:

- training of the staff that do the visual checks,
- further investigation to ensure the visual checks were able to pick up any issues, such as flood testing to see if a visually intact borehead is actually sealed,
- auditing of checks, including inspection logs, to ensure they are happening effectively and aren't just a box ticking exercise for the operators,
- regular preventive maintenance and
- planned renewals (planned according to the latest condition assessment).

The reason more preventive measures are identified is because the risk assessment is not focused on the *hazard*, eg. campylobacter (checking you have an intact borehead), it is focused on preventing the *hazardous event*, that is ensuring systems are in place to make sure barriers are working (so the solution is to focus on all aspects of ensuring the borehead is intact, not just checking that it is.) For example, flood testing in and around a borehead will replicate an event to the extent that you can see if the bore is safe or not.

Remember, the borehead at Havelock North had been visually inspected as required and was independently assessed as being secure. So we cannot assume that by having some preventive measures in place means the measure is fool-proof. By separating out the hazard, the hazardous event, and the risk, we can focus on preventing the hazardous event, not the hazard. It leads us to identify many more non-infrastructure preventive measures.

UNCERTAINTY

The place of uncertainty and its impacts on risk assessment are best described in the Canadian context:

> "The predictive nature of hazard identification and risk management dictate that substantial uncertainty will always be associated with these activities. An

> appreciation of the uncertainties in our scientific tools is an important part of a precautionary approach to managing risks." (Canadian Council of Ministers of the Environment, 2004)

Acknowledging the uncertainty provides another dimension to the risk assessment outputs. For example, having a relatively low risk rating for a very uncertain hazardous event, may require the same attention and resources as a well understood hazardous event with a medium-high risk rating. The attention and resources would concentrate on investigations to increase understanding of the hazard and hazardous event and reduce the uncertainty. This aligns with the precautionary and inquisitive approach that HDC has adopted since the incident in 2016.

Currently, in the New Zealand context, it is acceptable to rate a hazardous event as a low risk with very little evidence or data backing up the rating. That is, if a team nominates a low risk hazardous event with a high level of uncertainty, this is accepted. So the hazardous event is not considered further, as the priority is given to the high risk rated events.

In the Australian/Canadian context, it is far more likely that an investigatory preventive measure would be identified for the event, to reduce the uncertainty around the risk rating. While implementing this preventive measure would not be prioritized higher than a CCP measure, it would, nonetheless, still be resourced.

This is the fundamental step behind not assuming – not being complacent about unknowns.

Remember that the Havelock North incident occurred because it was assumed that the bore remained secure because it had been secure in the past. If a level of uncertainty had been assigned to the hazardous event of the aquitard being compromised, then resources may have been assigned to reducing that uncertainty. So, then HDC (with the help of Hawkes Bay Regional Council) may have investigated the integrity of the aquitard before the event. Being inquisitive and challenging assumptions is now the norm at HDC.

2.1.4 MONITORING

Data collection, analysis and reporting should be focused on providing decision-makers (even non-technical decision-makers like Councillors) with the information they need to have assurance that the water that is supplied is as safe as it can be.

The assumption behind all the guidelines reviewed is that compliance monitoring is a check after the fact, not a preventive management tool. Compliance data collection, analysis and reporting are a subset of the assurance-providing data collection, analysis and reporting. That is, assurance should be the focus, not merely compliance.

The Canadian guidance says:

> **Compliance monitoring** differs from operational or performance monitoring in that it is the minimum required by regulation or the operating authorization and is a legal requirement. **Operational or performance monitoring** goes beyond what is legally required and involves more in-depth and more frequent checks on the conditions that could affect the treatment, such as water alkalinity, pH, and temperature. It demonstrates how well the various stages of the multibarrier system are working. Performance monitoring can serve as an early warning system whereby process changes can be implemented before treated water quality compliance is compromised. (Canadian Council of Ministers of the Environment, 2004)

To provide decision-makers from the operators up to the Councillors, there are 4 types of monitoring that should be performed:

- **Operational/ Performance monitoring (Is it working?)**
  - **When** - usually continuous online (or high sampling frequency).
  - **What** – operational parameters that show what is being treated, and whether treatment will be effective; like pH, turbidity, electrical conductivity, freely available chlorine, ultraviolet transmissivity and intensity, filter pressure differentials, etc.
  - **Where** – each parameter will have different locations that are relevant, but generally throughout system, from source, between each treatment step, throughout the network.
- **Compliance/ Verification monitoring (Was it ok?)**
  - **When** – usually grab sampling daily/weekly depending size of population
  - **What** – pathogen indicators like e. Coli and protozoa testing, as well as disinfection effectiveness like FAC.
  - **Where** – Source, post treatment, and some of the reticulation system.
- **Validation monitoring (Will it work?)**
  - **When** – before a treatment technology is installed.
  - **What** - parameters determined by the authority, the most commonly accepted validation for off-the-shelf technology are the USEPA methods.
  - **Where** – in the manufacturers' facilities/ pilot plants.
- **Baseline monitoring (What is normal?)**
  - **When** – historical data, so frequencies will vary significantly depending on the parameters and systems.
  - **What** - parameters that indicates changes to the system, so suppliers are aware of possible issues, like pH, turbidity, electrical conductivity, FAC, etc.
  - **Where** – each parameter will have different locations that are relevant, but generally throughout system, from source through each treatment step, out into the reticulation system. For example, if FAC at the end of the reticulation falls well below the long-term average, there may be a backflow issue in the network.

Using a combination of these 4 types of monitoring, and not relying solely on E. coli monitoring is crucial for water suppliers to know they are supplying safe water. The reason for this is simple: **Significant issues are always preceded by some form of change** – you can't detect and understand the changes in your system if you aren't looking.

If the supply at Havelock North had operational monitoring at the time of the incident (such as online turbidity, electrical conductivity, pH), the change in the quality of the water may have been picked up earlier (by as much as 4-5 days) than the positive compliance result.

2.2 IMPLEMENTING THE BEST OF THE APPROACHES

Decision-makers, such as Councillors and Council CEOs, often have little experience in operational fields like water supply. To give them the confidence that the HDC Water Team is addressing the risks associated with supplying drinking water, we recommended assessing performance against management frameworks that are internationally recognized. By using these guidelines, the decision-makers could be sure the right questions are being asked.

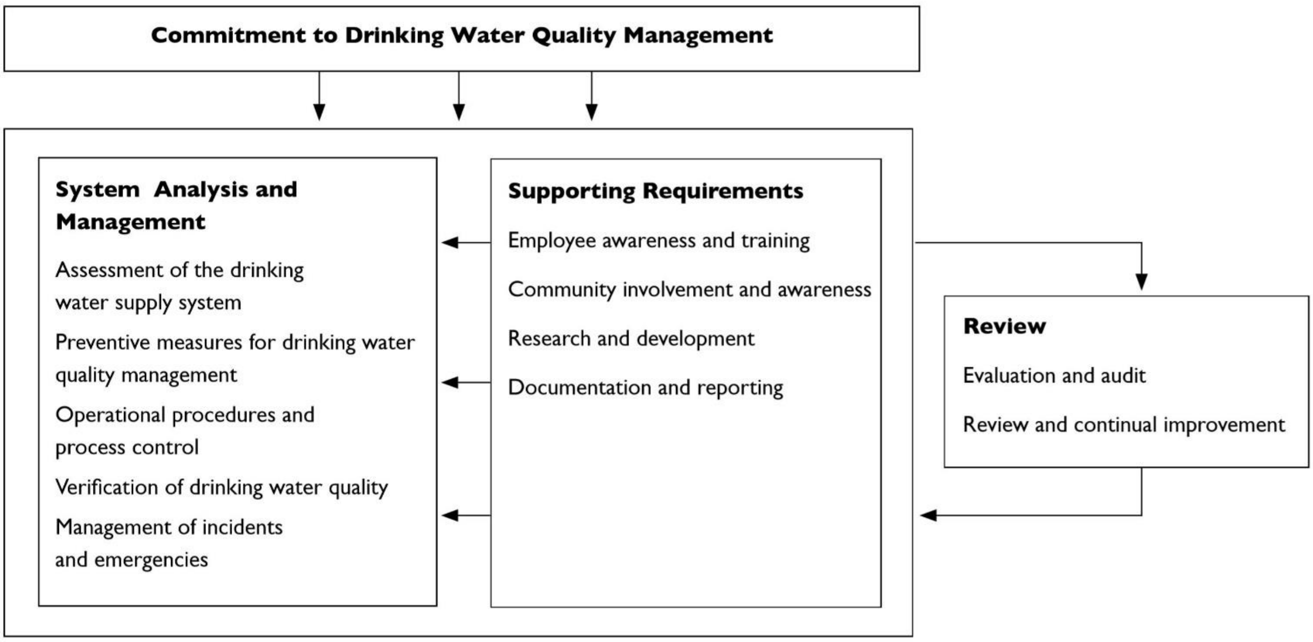
The different concepts and practices we found in the international frameworks were not easy to adopt in an operational water supply quickly. If we were starting from scratch, the implementation would have been far easier. But HDC had to keep supplying water, so staff had to prioritise operational tasks over system changes.

To make sure any HDC staff input for change was optimized, we did a gap analysis. That is we first assessed HDC's systems and practices against a chosen international guideline. From the gap analysis we prioritised the gaps based on risk and developed a roadmap for closing the gaps.

2.2.1 GAP ANALYSIS

We undertook a gap analysis against the 12 elements of the ADWG because it combines the management frameworks of ISO9001 and the food industry HACCP (ISO22000), while detailing it for drinking water supplies:

Figure 1: ADWG Framework for Management of Drinking Water Quality



(National Health and Medical Research Council, 2011)

The gap analysis findings in 2017 found very few true "gaps". Most of the areas of risk for HDC were "immaturities". There was a system or practice in place, but it was not mature enough to safely mitigate the biggest risks of hazardous events if they occurred.

The vulnerabilities HDC concentrated on minimizing initially, related to discrepancies between the practice in the field and the supporting systems (such as software tools, strategic frameworks, or documentation). Often practices were good, but systems didn't replicate or support practices to make it as efficient, consistent, and reliable as possible. For example, the day-to-day operation practices were good, however, there was minimal supporting documentation (such as comprehensive Operations and Maintenance Manuals).

Another significant risk identified was the practice of relying on spoken understandings with suppliers rather than established systems or legal agreements, including standards around quality and reliability of supply. By relying on goodwill with suppliers, (for example the laboratory services and chemical suppliers) HDC was in a vulnerable position. Historically, this had not been an issue, but with the changes in New Zealand's water industry, there are more suppliers requiring services from a limited number of organisations, which may not be able to provide quality services under increasing pressure.

From each significant gap or immaturity, we identified improvements and collated them into improvement projects. By implementing these improvement projects over 3 years, HDC can be confident of minimizing the risks associated with supplying safe water to its consumers.

2.2.2 IMPLEMENTATION OF IMPROVEMENTS

Improvement projects included:

- Change Management process – A team external to the 3 Waters team has overseen and managed many of the aspects of the significant change. This has ensured there is an independent process, allowing the 3 Waters team to continue operations while providing input into changes, but not having to manage the changes as well as regular operations.
- Drinking Water Strategy – Developing a vision for drinking water delivery with a prime objective of water quality and safety. The strategy includes new and redefined initiatives (involving both capital and operational expenditure) based on the latest modelling and science refined after the Havelock North incident. HDC will track progress against the vision, which outline targets and timelines in the Council's Long-Term Plan (LTP).
- Leadership Team development – Nearly doubling the size of the 3 Waters Team to introduce new roles around compliance, program delivery and operations management (as opposed to operators). HDC also established a new culture and leadership dynamic to the team by working with an experienced external consultant.
- Documentation Stream – Reviewing and documenting practices and procedures, including operational and communications corrective actions, by updating (or establishing) a Business Management Plan and Operations and Maintenance Manuals for all 3 Waters assets. This workstream is ongoing.
- Drinking Water Quality Management Plan - Develop an overarching document that is endorsed by Council and used as a communication tool both internally and externally. The song-sheet for staff and Councillors alike to talk to. This document is an information resource about the actual HDC water supply system.
- Data Management Reporting Strategy development - Reviewed all 3 Waters monitoring to optimize data collection, analysis and reporting to ensure it is representative, reliable, and timely. We thought strategically about all 4 types of monitoring (operational, compliance, validation, and baseline) together. Then assessed the existing data management tools to identify gaps. Improvements have been developed to make reporting more accurate and efficient, including formalising through the establishment of processes for regular reporting so the practice is standardized, efficient and has adequate quality control.

Though these projects were specific to HDC, the underlying theme of the projects is valid for all councils wanting to supply safe water – ALL the projects had a focus of managing risks. Not just microbiological risks, but the operational, financial, resourcing, reputational, and regulatory/ legal risks that may compromise HDC's ability to deliver safe drinking water.

3 CONCLUSIONS

Since August 2016, HDC has moved from being focused on compliance only, to establishing a preventive risk management framework using internationally-established practices. Through our evaluation of the difference between international practice and New Zealand's framework we found significant differences in the approach to:

- Multiple barriers, specifically active barriers
- Critical Control Points
- Risk assessments
- Monitoring

While the New Zealand framework used similar terminology to the Australian and Canadian guidance, the latter's guidance is more focused on managing the systems, knowledge, people and infrastructure used to deliver safe water. The result of the focus in the New Zealand framework on assessment against the Maximum Acceptable Values, leads to a traditional engineering approach, which only partially mitigates the risks.

HDC has started an overhaul of the management of its drinking water supplies, by developing long-term strategies and management plans for:

- Treatment and infrastructure options (considering capital and operating expenditure)
- Managing resource needs and staffing (both recruitment and training)
- Integration of systems and applying new technologies
- documentation development
- data management and reporting
- communication with stakeholders

By starting this process, we discovered the best way to manage risk is to understand:

- Significant issues are always preceded by some form of change – make sure you can detect and understand the changes in your system.
- Assumptions equal complacency. Just because it has always been done that way, or just because the standards say that's good enough, don't assume things are fine.
- There are many types of hazardous events that can cause risks to eventuate in drinking water supplies. Many different types of preventive measures need to be used to manage the risks, not just the traditional engineering measures that are typically considered in WSPs. A water supplier must think about all the systems, people, knowledge and infrastructure, not just the concrete, engineering solutions.
- Adding treatment infrastructure is only one part of the significant change process needed to make sure water supplies remain safe in the post-Havelock North water industry.

These lessons learnt can be summarised as – there's more to adopting the World Health Organisation's preventive, risk-based approach to drinking water supply, than getting a tick for a Water Safety Plan every 5 years.

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The 3 Waters Team at Hastings District Council.

The Change Management Team at Hastings District Council.

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