A water authority's experience with HACCP

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Abstract South East Water Limited (SEWL) is one of three retail water authorities operating in Melbourne, Australia. It was the first water authority in Australia to obtain HACCP accreditation for the supply of drinking water, in November 1999. This article presents an overview of the first two years' experience in developing and establishing a food safety management plan using Codex Alimentarius Hazard Analysis and Critical Control Points (HACCP) to ensure the water reaching customers is safe, aesthetically pleasant and meets operating licence requirements.

HACCP has improved the way in which our distribution and reticulation systems are managed, primarily through the refinement and optimisation of standard operating procedures. In addition, more consideration has been given to the development of contingency plans and the appropriate use of system redundancy to ensure quality of supply. Accreditation was only the beginning of a process. Once attained, there was an ongoing need to maintain and refine hazard measurement and reduction procedures. The major challenge for SEWL has been the integration of HACCP company-wide.

Spreading of HACCP was directly achieved through the involvement of operators, key personnel and subcontractors in the assessment of hazards and evaluating the appropriateness of critical control points. This not only assisted with improvements to the existing system, and the identification of system strengths and weaknesses, but was also an integral component in awareness training for HACCP. It was through assessment workshops and training that operators were able to see HACCP as primarily a summary of current practices, but with the focus of improving or maintaining water quality.

The net benefits of HACCP are difficult to quantify. Overall there is a greater understanding of water quality issues, more streamlined work procedures, and an improved response to customer enquires relating to water quality. This has been most clearly demonstrated by a net decrease in customer complaints over the two years since HACCP was implemented.

Keywords Food safety; HACCP; risk management; water quality

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Introduction

HACCP (pronounced "hass-up") stands for Hazard Analysis and Critical Control Point. It is a risk management system that identifies, evaluates and controls hazards which are significant for food safety. These hazards can be biological, chemical or physical.

A HACCP Plan has been developed for South East Water Ltd (SEWL) and implemented across all of its water operations from suppliers, distributors and retailers through to the customer to provide comprehensive system coverage from the interface with our wholesaler (Melbourne Water Corporation) to the customer's meter.

Since the implementation of the HACCP Plan, it and the associated processes and procedures have undergone several stages of streamlining for improvements.

Developing a HACCP plan

In May 1999, a multi-skilled team comprising representatives from the planning and operational divisions of SEWL, as well as key contractors and the bulk water supplier was established to develop the HACCP Plan using the process detailed in Figure 1. Operators and technical staff were enlisted to ensure that all aspects relating to risks and controls for each step and process in supplying water to the customers' meters were evaluated. This initial team comprised approximately 30 staff.

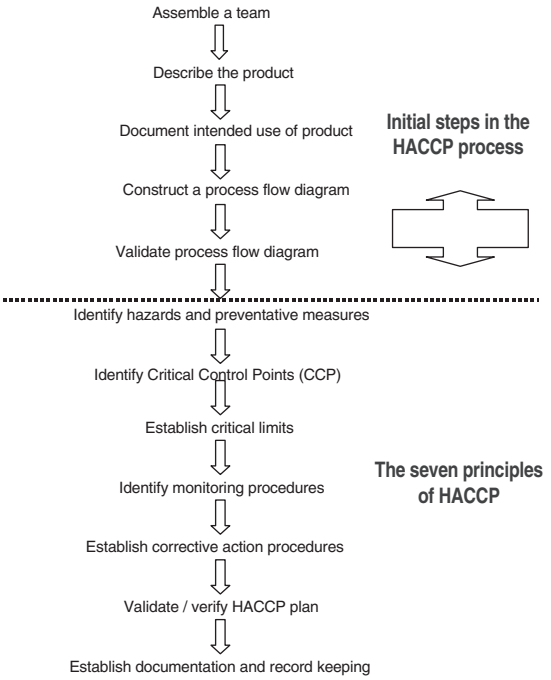

Figure 1 The steps involved in preparation of a HACCP plan

Since HACCP had been not formally been applied to a water distribution and reticulation system previously, SEWL enlisted the help of Australian Water Technologies (AWT) and Quality Assurance Services (QAS) to educate or train staff in the requirements of HACCP and how it could be applied to the risks associated with a water supply system. It was necessary to enlist the help of both organisations as QAS had extensive knowledge in the application of HACCP within the food industry but was not experienced with the uniqueness of hazards and risks associated with a water reticulation and distribution system. AWT supplied the expertise in relating it to water supply.

It should be noted that although SEWL undertook the development and implementation of a HACCP Plan internally, a consultant from the Department of Primary Industry (DPI) in Queensland was employed to oversee and provide guidance as necessary due to their extensive experience with the implementation of similar systems in the food industry.

The initial reaction by most staff to the implementation of HACCP was not favourable. Many staff took the view that the new system would mean extra work for little benefit.

From the training session, the distribution and reticulation system was divided into logical and manageable sections (see below) in order to enable a focused, more comprehensive risk assessment to be undertaken.

These five sections identified were:

- storage management (including the interface boundary with the bulk supplier);
- new mains (from new developments and renewals);
- disinfection (chlorinators dosing with sodium hypochlorite and including receiving and handling of chemicals);
- backflow (from properties or hydrants); and
- mains alterations (emergency and scheduled maintenance work undertaken on the water supply system).

SEWL team leaders who had undertaken HACCP training were appointed to coordinate each section based on their field of expertise. Each leader was assigned four to five staff

with knowledge and experience in the processes and procedures of that section. The groups then set about dissecting each step of the processes involved in the treatment, movement, storage and/or maintenance of water quality to identify and evaluate all potential risks that could occur and assigning a risk factor rating based on their likelihood and severity (Table 1).

Over 4 months, each group met for periods of 2–4 hours on four separate occasions. The risk factor for each identified hazard was calculated by determining the likelihood of the potential hazard occurring and multiplying this by the severity of the consequences should this hazard occur. The likelihood was listed on a scale from almost certain (being daily), to rare: occurring only once in five years (Table 1).

The severity rating for the consequence of an event occurring was determined by its effect on water quality and operations. An insignificant effect had no impact and was given a low rating of 1. Effects increased in severity from a customer complaint, through to an impact on the operating licence (major consequence) to a major public health event (catastrophic), which was given the highest rating – 5. The multiplied Risk Factor Matrix numbers are given by the large numerals in Table 1.

Hazards that were calculated to have a risk factor rating of 6 or greater (Table 1) were further analysed to determine if those steps in the process were crucial in preventing contamination of the water and thereby resulted in an "off spec" product. That is, was that step a Critical Control Point (CCP) or a Quality Control Point (QCP). A CCP is where the safety of the water is impacted on, whereas a QCP occurs when safety of the water is not impacted but the aesthetic quality may be. The severity of a QCP only ranges from insignificant to moderate.

An example of the process can be seen by following through how the "Mains Alterations Section" team assessed the process for using a peg to repair a burst or leaking water main (Figure 2).

The first stage of the process was to identify and evaluate potential risks. These were listed such as:

- physical hazards: dirt or debris entering the main when it is shutdown, the peg being forced into the main with debris on the peg (and/or parts breaking off into the main);

Table 1 Risk factor matrix

		Severity of Consequences				
		Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
		No impact / not detectable	***Customer complaint***	***Impact on customer charter***	***Impact on operating licence***	***Public health risk***
Risk Factor Matrix:		***Rating: 1***	***Rating: 2***	***Rating: 3***	***Rating: 4***	***Rating: 5***
Likelihood	Almost certain *Once a day* *Rating: 5*	5	10	15	20	25
	Likely *Once a week* *Rating: 4*	4	8	12	16	20
	Moderate *Once a month* *Rating: 3*	3	6	9	12	15
	Unlikely *Once a year* *Rating: 2*	2	4	6	8	10
	Rare *Once every 5 years* *Rating: 1*	1	2	3	4	5

Figure 2 The typical process of using a peg to repair a perforated water main.

- biological hazards: bacteria or pathogens from animal faeces or the soil surrounding the hole; and
- chemical hazards: such as petroleum products, particularly if the affected area collected road runoff, or a pump was placed in the Trench. Each potential hazard was assessed and by taking into account the preventative measures already in existence, a risk factor was calculated.

If the risk factor for the identified hazard was determined to be "severe", that is, the calculated rating was 6 or greater, then the Codex Decision Tree was utilised to evaluate if this particular step in the process was critical in maintaining the water safety or quality (a CCP or a QCP).

The Codex Decision Tree is a simple set of questions that is asked about the potential hazards that results in a "yes" or "no" answer (Figure 3). Depending on the response, you would follow one particular branch of the tree to the next question. Within four questions an outcome of "Not a CCP" or "CCP" is obtained (Figure 3).

An example of this decision process might be the evaluation of the biological hazard presented by the potential for faecal material entering a water main during emergency repair procedures. The following are the steps required to determine if this action and its associated procedure should be a CCP.

The likelihood of contaminant material entering a water main during a repair is low (ie classified as rare or unlikely); however if it did, the consequences could have an impact on our customer's health and/or SEWL's Operating Licence and is considered Catastrophic. Hence, the risk factor rating is $2 \times 5 = 10$.

From the Codex Decision Tree we obtain the following responses.

Q1 Answer: "yes". Control measures do exists as we use Quality Approved Contractors with procedures that have been approved for use by SEWL.

Q2 Answer: "Yes". The process can be specifically designed to eliminate or reduce the likelihood of the hazard occurring. The procedure can be designed so that it not only results in repair of the water main in a timely and effective manner, but also ensure it is free from contaminant material before the water supply is reconnected.

Hence the hazard is a CCP and possibly QCP. Additional analysis and information may be required, critical control limits would need to be established and monitored, and corrective actions specified to rectify the hazard when it occurs.

A portion of SEWL's HACCP Plan is shown in Table 2 and will be used to further explain these items. "Corrective Actions" are defined as "any action to be taken when

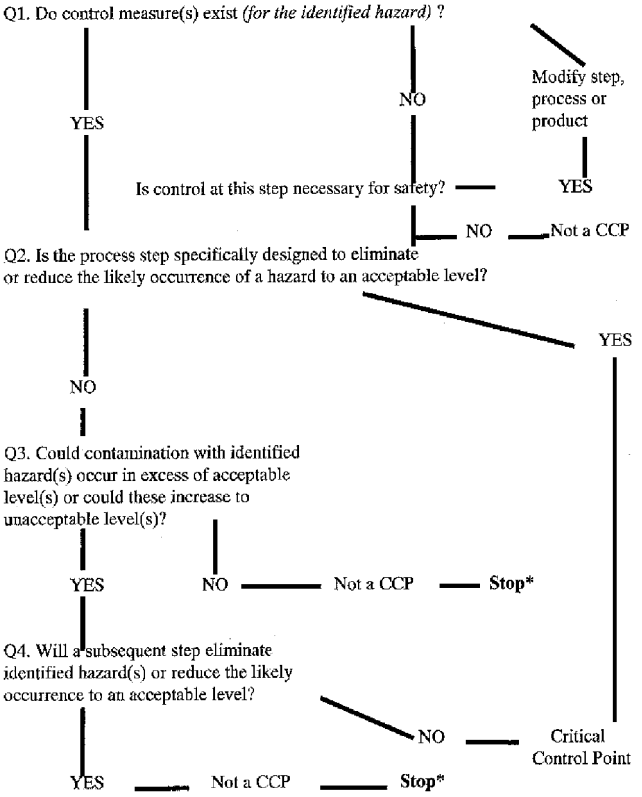

Figure 3 Codex Decision Tree used to identify Critical Control Points (CCP)

results of monitoring at the CCP indicate a loss of control". An example of a corrective action would be the removal of a physical hazard from the water main by flushing water from the main until the object/s or sediment/organic matter is expelled.

Where critical limits need to be monitored, procedures need to be established and records kept of the results observed. These records then become an essential part in analysing the water supply system to evaluate trends and the overall performance of water quality parameters and develop strategies to allow (or foster) continuous improvement.

Critical limits are determined based on knowledge and expertise, technical literature, regulatory guidelines and historical results.

Verification and validation procedures are then specified. A verification procedure is a means of ensuring that the critical limit you have specified is appropriate. Validation is a means of proving that the system complies or "works". For example – on-line chlorine analysers provide verification of adequate disinfection, whereas total coliform results provide validation.

Benefits of implementing HACCP

Since the implementation of the first HACCP plan, SEWL has experienced many benefits from the plan. The most obvious of these has been an overall increase in knowledge and understanding of the water supply system at all levels and an improved ability to identify potential risks to water quality or supply. Rotation of staff through the various HACCP sectional teams has resulted in a cross-pollination of ideas and the development of unique approaches to problems arising from the mix of backgrounds involved from both operations staff and contractors.

Table 2 Excerpt from SEWL's HACCP Plan

Step	Potential Hazard	Preventative Measure	Risk	Decision Tree	CCP / QCP	Critical Levels Target	Critical Levels Action	Monitoring Procedure	Corrective Action	Records
1st Reticulation / Distribution System	Pathogen contamination during storage and laying of new mains.	• Approved contractors. • WITS Manuals. • Capping of mains at end of shift. • Usage of exclusion caps at all times during construction. • Swabbing and flushing of all new mains prior to connection. • Chlorination of new mains > 150mm ϕ. • Dewatering of work trench. • Storage of pipes. • Adequate contractor construction process.	Unlikely/ Catastrophic 10	Y	CCP 3	0 Faecal Coliform CFU/100mL	1 Faecal Coliform CFU/100mL	The contractor undertakes sampling prior to connection on all chlorinated new mains. Independent company undertakes sampling to validate records produced by contractor. Project Managers and Inspectors from Asset & Engineering assess the findings and inspect not less than every three [illegible].	Contractor responsible for the water main renewal undertakes necessary corrective actions which may include: 1) Flush and swab mains to be connected. 2) Re-disinfect new mains. The contractor responsible for performing the works records corrective actions undertaken. Results	Contracts Supervision File. Contractor Performance Report (carried out bi-annually). Project Pre-Commencement Checklists.
1st Reticulation / Distribution System	Pathogen, physical or chemical contamination from failure of pressure reducing valves (PRVs).	• Scheduled Maintenance Program. • Safety relief valves.	Unlikely / minor 4	N N	No					

Risk Factor = Likelihood X Severity

The "Target' limit is the value or range which SEWL aims to achieve. The "Action" limit is the value that when reached, results in corrective actions being implemented to return the product to an "acceptable" state.

The number of staff involved in using HACCP has increased since the introduction of the plan. There has been a change of staff attitude that now embraces HACCP. This change has been brought about because of the greater understanding it has provided to staff, the ways in which it has streamlined their workflow and improvements to the way in which certain operations are undertaken. SEWL now has a greater understanding and control of the system as a result of improved record keeping and data collection. Record keeping has been simplified through standardisation (within the Quality Assurance system), and greater use can be made of the collected data to assess historical events and trends. Effectively a large amount of information that was related anecdotally is now stored in relational databases, which can be used to provide more efficient and informed analysis of water quality events.

In addition, the HACCP plan represents a schematic simplification of the water distribution and reticulation networks. Division of the network into specific sections such as treatment or storage tank or water main facilities has allowed detailed analysis of work procedures and practices, and their likely impact on water quality. One such area has been in the procedures for new mains renewal. This process was identified as a potential risk due to the need to disinfect and then neutralise all new mains prior to commissioning. The HACCP plan allowed rapid identification of potential risks through confirmation of this operation as a CCP. Rapid development of procedures to address this issue was then undertaken and the new process implemented. In addition, involvement of operators in the process has highlighted significant areas that needed review to minimise risks and facilitated the development of a more comprehensive plan that incorporated existing processes into HACCP that were not seen initially as preventing contamination (e.g. asset security and condition inspections).

Training in water quality issues has occurred for SEWL staff, contractors and sub-contractors and through the implementation of HACCP. A designated Water Quality Crew has been established to deal with issues relating to the safety and quality of the water being received at customers' meters.

Changes to operating procedures have occurred as a result of a greater understanding of the implications and potential consequences of actions executed out in the field. This made them more effective and developed a sense of discipline that ensured that the procedures were carried out correctly. Staff now have the incentive and ability to prevent and resolve water quality issues on site, through improved knowledge and understanding.

Audits against SEWL's Operating Licence are now easier and smoother due to the

increased record keeping. External HACCP audits are undertaken annually, with an internal audit undertaken between each external audit. These audits are seen as more of a productive improvement tool than a "what have we missed doing" concern. So far the audits have identified some 10 "Opportunities for Improvement" over the past 2 years.

Since the implementation of HACCP, SEWL has observed a reduction in the number of water quality complaints received from our customers. In the 1999/2000 financial year, over 2,000 complaints were received. For the following year (2000/2001), 1,800 complaints were received and this is expected to decrease even further in 2001/2002.

Enhanced relationships with our suppliers have also been formed from the utilisation of HACCP as a risk management system. Through HACCP, the bulk supplier has a greater insight into SEWL's requirements and the needs and concerns of its customers.

The future

Since the implementation of HACCP two years ago, SEWL is evolving and expanding the system to undertake an assessment of all potential risks across the entire water supply system from the catchment to the customers' meter. This will involve working even more closely with our bulk water supplier and strengthening our partnership with them.

As the amount of data increases, the accuracy of strategies being developed to maintain the water supply are continuously improving, resulting in more efficient and cost effective operating procedures.

Conclusion

The HACCP approach to risk management provides a level of confidence through independent audit, that the water supply system is being managed from the interface with the supplier through to the customer meter in such a way that it should remain safe and aesthetically pleasing. The key concept is controlling water supply hazards throughout the process and ideally at the earliest possible point during the product delivery process. The approach aids in identifying potential water quality hazards, and in defining working practices and procedures that are technically appropriate for preventing water contamination. It fosters a proactive approach to water quality management; at the same time it improves record keeping and information management to allow more effective service delivery to customers.