

Effective drinking water collaborations are not accidental: interagency relationships in the international water utility sector

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Abstract

The role that deficient institutional relationships have played in aggravating drinking water incidents over the last 30 years has been identified in several inquiries of high profile drinking water safety events, peer-reviewed articles and media reports. These indicate that collaboration between water utilities and public health agencies (PHAs) during normal operations, and in emergencies, needs improvement. Here, critical elements of these interagency collaborations, that can be integrated within the corporate risk management structures of water utilities and PHAs alike, were identified using a grounded theory approach and 51 semi-structured interviews with utility and PHA staff. Core determinants of effective interagency relationships are discussed. Intentionally maintained functional relationships represent a key ingredient in assuring the delivery of safe, high quality drinking water.

Keywords: drinking water, incidents, risk, public health, emergency management

1. Introduction

Public health protection must be the principal goal of a drinking water utility (IWA, 2004; WHO, 2011). The goal to provide safe drinking water in sufficient quantity and at good aesthetic quality (IWA, 2004) may be challenged by a plethora of natural and man-made adverse events and hazards, either in the catchment, or along the water treatment and distribution chain. These include drought, floods, fires, storms and hurricanes, spring melting and runoff, animal or human faecal contamination, algal blooms, chemical or radiological leaks, water treatment equipment failure, pipe breaks, operator error, vandalism, terrorism, and so on (Bartram et al., 2009; Emde et al., 2006; Herrick et al., 2006; Hrudey and Hrudey, 2004; IWA, 2004; Jalba et al., 2009; Pollard et al., 2007; USEPA, 2004b; WHO, 2011). For many utilities, the goal of public health protection is challenged by a wide range of other business risks. Water utilities must remain ecologically, environmentally and economically sustainable, as well as financially profitable and competitive for private water companies (CEC, 2000; Middleton and Saunders, 1997; Pollard et al., 2009; Pollard et al., 2007). Finally, as providers of an essential public health service, water companies must preserve regulatory as well as consumer trust, having to manage multiple perception risks, irrespective of their tangible health impacts (IWA, 2004; Mobley et al., 2006; Parkin et al., 2006; Parkin et al., 2004; Pollard et al., 2009). All these risks need to be assessed and integrated at corporate level, and the water utility must prevent and/or manage them to protect public health (Bartram et al., 2009; IWA, 2004; Jalba et al., 2009; Maxwell, 2004; Pollard et al., 2009; USEPA, 2004a; WHO, 2011; Pollard et al., 2013).

Trade-offs are a necessary requirement of drinking water management (Hrudey, 2004), but the clarity of strategic corporate objectives may suffer under the complexities of regulatory incentives, organizational structures, the debt financing of the asset base and split accountabilities (e.g. outsourcing) (Pollard et al., 2009; Pollard et al., 2007). Furthermore, risk factors that might compromise the overarching mission can lie undetected within organizations, acting as latent precursors for water quality incidents and other adverse events (Pollard et al., 2009; Reason, 1997). Managing risk, therefore, is more complex than just optimizing asset management, completing risk registers, ensuring compliance or managing chemicals in catchments; it requires vigilance at all levels within a utility, focused around unambiguous business goals (Pollard, 2008).

Some of these challenges can be addressed technically, for example, by installing better water treatment and upgrading infrastructure, developing new technological solutions for new and emerging pathogens or through better water quality monitoring systems (Rizak and

1 Hrudey, 2007; USEPA, 2005; WHO, 2011). Others are business-related and require
2 sustainable and environmentally responsible strategies, new ways to maintain profitability,
3 and to ensure occupational health and safety (Pollard et al., 2004; 2007). Others involve
4 responding to external challenges such as ensuring consumer satisfaction, collaborating with
5 stakeholders (including regulatory agencies) and through well-managed media relations
6 (Hrudey and Hrudey, 2004; Hrudey et al., 2006; Jalba et al., 2009). There are also challenges
7 for emergency management and catchment protection that involve a combination of
8 technical, business and external solutions (Bartram et al., 2009; Jalba et al., 2009).

9 We have previously identified six components that may be deficient in the relationship
10 between affected water utilities and their respective public health authorities (PHAs): (1)
11 proactivity; (2) knowledge exchange; (3) trust; (4) regular communication; (5) joint training;
12 and (6) a supportive regulatory environment (Jalba et al., 2010). We indicated that
13 international and national guidelines, supportive regulations, and local communication
14 arrangements do not, by themselves, guarantee effective interagency collaboration, though
15 they do present opportunities to develop meaningful (as opposed to cursory or superficial)
16 collaboration (Jalba et al., 2010). We distinguished a collaborative strategy (intent) from a
17 collaborative structure (for delivery). To be effective, any structure must adopt an agreed
18 strategy (Krames, 2008); that is, the relationship must have a defined purpose and a means of
19 achieving it.

20 Here, we report findings from in-depth interviews with senior drinking water and PHA
21 managers from a selection of reputable organisations from Australia, Canada, the United
22 States, and the United Kingdom, on the topic of achieving effective interagency
23 collaborations. Many of the participating organisations had been involved in managing
24 drinking water incidents that challenged their existing collaborative agreements and provided
25 lessons and opportunities to optimize their approach. To our knowledge, this is the first in-
26 depth study of this kind, and the research has broad international relevance for researchers,
27 practitioners and policy-makers seeking to strengthen water safety, business resilience and
28 risk governance in the international water sector.

29 Prior research has identified a number of drivers, tools and determinants governing
30 successful inter-organisational collaboration relevant to the area of drinking water. Rather
31 than explore failings, that have been addressed elsewhere by the authors, our aim here was to
32 identify effective practices.. Building on the work of Hrudey and Hrudey (2004), Parkin et
33 al.(2006), Cash et al. (2003), and Thomson et al. (2009), we seek to identify the critical
34 elements of interagency collaboration that can be integrated in the overall corporate risk

management approach of water utilities (Pollard, 2013) and PHAs alike, principally for the purposes of promoting a standard for meaningful interactions between utilities and agencies as a means of helping them discharge their mandates successfully. We offer insights to an international audience on (i) the critical institutional relationship deficiencies that may aggravate a drinking water and health emergency situation; (ii) the determinants of a successful effective relationship between a water utility and its respective PHA(s); and (iii) how an effective collaborative relationship can be integrated with the risk management culture of a water utility as an effective means of delivery.

2. Methods

2.1. Study rationale and participants

We employed a qualitative research methodology (Miller et al., 2004; Morse and Field, 1995; Silverman, 2001). An ethnographic approach would have unnecessarily broadened data collection, and participant observation. Observing single water professionals in public health risk management would have been unrealistic, since most utilities may not even experience one drinking water and health incident per year serious enough to warrant a significant interaction with their PHA. Drinking water and health incidents in affluent countries are rare and unpredictable; therefore, field research would have produced limited data. Our choice was to adopt a grounded theory method (GTM) adapted to the risk management focus of this research (Trochim, 2006). Participating organisations from English-speaking countries were selected based on being organisations: (i) covering various geographical areas, in terms of climate, water resources, cultural profile, urbanisation and socio-economic development; (ii) operating in various jurisdictions, with different laws and regulations relevant to the aims of the study (e.g. regulatory environment, regulatory agencies, emergency preparedness, specific safe drinking water legislation); and (iii) able to provide a water utility – PHA pairing. Interviewees (see Supplementary Information, SI-T1) were selected based on them: (iv) occupying key risk management positions in their organisation; and (v) working at the interface with other agencies in relation to public health risks. Atypical participants were accepted for comparison and contrast (e.g. former occupants of key positions).

2.2. Data collection and analysis

Using purposive sampling, we conducted 40 in-person, semi-structured interviews employing open-ended questions between November 2006 and March 2008. Overall, we

interviewed 51 professionals from Australia, Canada, the United Kingdom and the United States (SI_T1). Questions were organized in six sections (general institutional data, risk management policy and implementation, interagency relationships, past incidents and near-misses of public health relevance, emergency management, and training and assistance). Prior ethics approval for the study design, interviews and the handling of research data was secured through Flinders University Social and Behavioural Research Ethics Committee.

The research instrument was tested through a pilot interview with a typical participant, and reviewed before data collection began. Minor adjustments were employed to add clarity. Our analysis sought to identify current critical gaps and constructive processes that would cover the shortcomings recognized in the survey of past drinking water and health incidents described above. When opportunity occurred during interviews, additional incidents and unpublished aspects of some incidents identified through previous literature survey were clarified with reference to interagency relationships. Concepts were identified according to the lead author's (DJ) judgement. They were reviewed and verified with public health and drinking water experts. Purposive sampling may have limited the generalisation of our results to the water industry as a whole, but the consistency of our findings provides evidence of recurrent themes that segments of the water industry and PHAs ought to consider when seeking to improve interagency relationships. Our GTM approach was iterative (Goulding, 2002). Systematic analysis of qualitative data (e.g. interview conversations) sought to develop a supportable means of answering our research questions, and was achieved through coding, memo-ing, and concept mapping. Interview data was initially open-coded, with selective coding employed later as concepts developed. In addition to triangulation within the research team, study findings were reviewed by independent water experts from each participating country, including an US-based water industry expert panel who confirmed the relevance of critical data categories used during the analysis and validated study findings.

3. Results

Our findings present the high level principles that transcend national regulatory environments, operating structures, legal entities and local cultures. Where appropriate, divergent findings between similar organisations in different countries are reported. Our main results are presented and discussed below, with additional survey results presented in the Supporting Information (SI) online. The references section contains a full bibliography for the main text and SI and is intended a bibliographic reference to readers on this specific topic of interest.

3.1. Risk management culture

Most commonly, water utilities defined their mission as providing safe and aesthetically pleasant, high quality drinking water. Other aspects included cost-efficiency, excellent and reliable service, and environmental responsibility. PHA representatives most often defined their organisation's mission on drinking water as being to protect public health by ensuring safe drinking water and minimising human public exposure to drinking water hazards. Other aspects mentioned were being informed early of drinking water events that may affect public health, working with water utilities, and coordinating emergency response.

Interviewees were asked to self-assess the development of a 'risk management approach' to drinking water in their organisation. Half of water utility interviewees stated they followed a formal risk management approach to drinking water at all levels. Minority views included beliefs they were employing a risk management approach for individual water systems, but not at corporate level (one-sixth) or alternatively, that they *were* employing a risk management approach at corporate level, but not related directly to drinking water (one-sixth). Most notably, one quarter of interviewees reported not employing a formal risk management approach at all in their organisation; this view mostly expressed by the United States and some Canadian utilities. However, all interviewees reported having developed emergency response plans (ERPs) for their drinking water operations.

By contrast, over half of PHA interviewees reported not employing a formal risk management approach within their organisations; such responses came from PHAs from all participating countries. One quarter of interviewees, although not having a formal risk management approach for drinking water, were promoting water safety plans (WSPs) among water utilities in their jurisdiction, whilst the remainder reported employing a formal risk management approach at corporate level, but not specifically for drinking water. One quarter of total PHA interviewees, however, reported having developed 'vulnerability assessments' related to water security in their jurisdiction, most commonly in the US.

While most water utility interviewees affirmed they regularly apply risk management in taking public health decisions, in many cases this would refer more to having standard operating procedures (SOPs) or manuals rather than an explicit, risk-based approach to issues. The same applied to some of the PHAs interviewed, while the majority would typically refer to the public health precautionary principles and paradigm. Only a few PHA representatives expressed the importance of risk trade-offs when dealing with environmental health issues.

1 Most UK utilities and one Canadian utility reported having their risk managers focused
2 on business risks. These utilities have in place formal comprehensive risk management
3 programs for the whole business, whose focus is often on financial and commercial risk.
4 Public health risk is rarely elaborated explicitly, although most organizations would have
5 public health included in their mission statement and principles. In contrast, most US and
6 Canadian utilities did not have a centralised risk management program or a risk management
7 policy document at the time of interview (i.e. June 2007 and November 2006, respectively).
8 Their organisational culture seemed to be driven primarily by regulatory requirements that
9 promote compliance monitoring rather than overall risk management. Half of these utilities
10 practiced implicit risk management by adopting proactive programs to address certain high-
11 risk segments (e.g. cross-connections). Identified risk managers would usually focus on
12 emergency preparedness for potential terrorism and natural disasters, and on health and
13 safety.

14 The use of risk terminology does not necessarily imply a risk management ‘culture’
15 (Pollard et al., 2007) and the meaning that interviewees attributed to risk concepts seemed to
16 vary greatly. A consistent and mutually agreed application of risk management principles to
17 public health risks by both sides remains elusive and this may well lead to uneven
18 participation in decision-making, with one party having to more-or-less accept what the
19 ‘experts’ on the other side have already agreed on.

21 **3.2. Interagency relationships**

22 **3.2.1. Partner risk management approach**

23 Most utility interviewees considered their respective PHAs did not employ a risk
24 management approach in the activity of their own organisation related to drinking water
25 safety. In one US case, the interviewee believed their PHA would use risk management for
26 water security. Many utility interviewees regarded PHAs as being risk-averse, whereas risk
27 ‘management’ for a PHA might be interpreted as a need to weaken public health protection
28 standards. This seemed to relate to the precautionary paradigm that a typical PHA would use
29 (Emde et al., 2006; Jalba and Hrudey, 2006) reflected in these cases by a reluctance to
30 recognise explicit risk trade-offs. By contrast, two interviewees recognised that implicit
31 trade-offs remain a necessary part of providing a water service that need not compromise
32 overall public health protection.

33 Water utility answers were generally confirmed by PHA interviewees in paired
34 organisations. No PHA staff reported explicit risk management in their own organisation as

1 it relates to their own activity of supervising drinking water safety, although a few expressed
2 a belief that they practice risk management implicitly. The most common answer, of about
3 half of PHA interviewees, was that they do not know whether they use a risk management
4 approach. While the question of implicit risk management remains open, the PHA answers
5 clearly indicated their organisations had no systematic approach to risk management.

6 In paired organisations, half of the PHA interviewees believed their utility counterparts
7 follow a risk management approach, while most of the remainder affirmed ignorance on this
8 point. In two cases, the PHA interviewees expressed a belief that the utility follows a risk
9 management approach, whereas the respective utility representatives disagreed. Conversely,
10 a formal risk management approach was employed in a quarter of paired utilities, but their
11 PHA counterparts did not recognise this. In only three cases did both parties agree that the
12 respective utilities follow a structured, formalised risk management approach that was
13 confirmed upon further probing.

14 Many interviewees, particularly on the PHA side, were not very familiar with risk
15 management concepts and their application to drinking water safety. The language of risk
16 has often been employed liberally, to mean anything from emergency protocols to public
17 communication, but not necessarily to the adoption of a formalised risk management
18 approach to assure prevention, mitigation and control of drinking water incidents. The
19 limited recognition of the role of risk management in the area of drinking water quality may
20 help explain contradictory statements in paired organisations about what their counterpart
21 does on risk management. This finding raises doubts about whether the interactions resulted
22 in meaningful knowledge transfer and truly promoted prevention in all aspects related to
23 drinking water incidents.

25 **3.2.2. Quality of interagency collaborations**

26 All interviewees self-characterised their inter-organisational relationship as positive, in
27 varying degrees. To some extent, this may represent a sampling bias related to their
28 agreement to be interviewed for this research. Because participation in the study was
29 voluntary, professionals were more comfortable with their interagency relationships and may
30 have been more likely to accept participation. In some cases, interviewees from both sides
31 appreciated their relationship was somewhat restricted by the limited interest of the PHA in
32 drinking water issues, compared to other demanding public health matters (e.g, sexually-
33 transmitted diseases, illicit drug use, food safety, chronic illnesses, immunisations). Finally,

changes in the quality of the relationship, resulting from key staff changes, indicated that the institutional relationship was frequently immature and relied on personal connections.

The two sets of interviewees generally matched each other in terms of the reported intensity of interaction. In particular, approximately half from each side estimated they were in weekly contact with their counterparts. At the other extreme, a significant finding was that in a minority of participating organisations, the relationship is driven only by drinking water safety incidents, i.e. it is entirely reactive.

Identifiable results of institutional cooperation (such as joint emergency response protocols, other written agreements or joint projects) were reported by each side, with utility interviewees reporting activities in a higher proportion than their PHA counterparts. This is not necessarily surprising since not all organisations were paired in this study, and even in paired organisations cooperative activities were not always equally reported by both parties. However, the comparatively less frequent reporting by PHAs of concrete activities that demonstrate cooperation (beyond discussing compliance monitoring results), may suggest that issues beyond strict compliance are viewed as less important to their interaction. Actors engaged in a meaningful, as opposed to cursory or superficial, interaction would be more likely to recognise such activities as central to the purpose of developing a mature, stable institutional relationship.

As a further step in formalising the institutional relationship, several Australian utilities had developed memoranda of understanding (MoUs) with their state health departments. The content of these MoUs varied, but generally defined roles and responsibilities for each party during both normal times and in emergencies, formalised information exchange, and mandated regular contact and cooperation. Creating an MoU was a condition set in the operating licence for these utilities. Among interviewees from the other countries, there was only one identified case in the US, a tri-lateral agreement between the water utility, state and county PHA that defined roles and expectations during normal and emergency times. Another tri-lateral MoU was identified in one UK case between the water utility, water quality regulator and environmental regulator in relation to catchment management arrangements.

3.2.3. Relationship development

Several interviewees commented that before the 1990s, it was generally assumed that water utilities had all the expertise necessary to produce safe water, and they were expected to operate without much need for external input. This approach was not optimal for

1 protecting public health. For example, several Canadian participants (from both utilities and
2 PHAs) insisted that the deficient relationship between oversight agencies and the Walkerton
3 water system operators (O'Connor, 2002a) was typical for the kind of relationships that PHAs
4 had with water utilities during the 1980s and 1990s. Another participant stated, in this
5 context: *"In 1995 I went to a health inspectors conference in Ontario on the topic of water*
6 *and I asked the audience how many have visited a water treatment plant – nobody put their*
7 *hand up. In the 90s all that the health departments would do is look at the water results, but*
8 *never went to a water treatment plant to understand the system. To me that did not make any*
9 *sense, because you cannot judge the water only based on a 200mL sample"*.

10 Most interviewees indicated that relationships between water utilities and PHAs have
11 developed gradually in the past two decades. Various events helped shape that process,
12 providing more visionary managers with opportunities for strengthening the institutional
13 relationship (Table 1).

14 **[TABLE 1 HERE PLEASE]**
15

16 Most water utility interviewees reported the institutional relationship developing because
17 both parties had responded to a significant drinking water and health incident (Table 2).
18 Relationships between the two parties prior to the respective event were never reported as
19 antagonistic. In most cases, both organisations had been operating for many years, with
20 limited input from the other party. For some utilities the importance of having a meaningful,
21 ongoing contact with the PHA became clear after they 'came under fire' from media and
22 concerned citizen groups for failing to provide a satisfactory response to issues such as
23 protecting AIDS patients from exposure to *Cryptosporidium*, or children from lead
24 contamination in the water supply. In one case, political interference disrupted the incident
25 command process by adding pressure to an already stressful situation, by setting unrealistic
26 expectations (e.g. shorter timelines for lab results than can scientifically be expected, since
27 bacteria do not grow as fast as politicians may want them to), and by trying to influence
28 public health decisions.

29 The respective incidents nevertheless triggered, on both sides, a realisation of the
30 importance of establishing a regular relationship prior to incidents in order to improve future
31 responses. Generally, the critical incident was resolved without serious public health
32 consequences. However, difficulties occurred during the process relating to
33 misunderstandings, unnecessary mutual criticism, distrust and unnecessary delays resulting,
34 among others, from uncertainty about what the other party does or was intending to do.

1 Lastly, a role for relationship advocates (committed managers) emerged as a prominent
2 factor. Over half of the paired organisations recognised the role that committed managers on
3 both sides had over the years in seeking ways to connect, define, maintain and strengthen the
4 bilateral relationship. While the relationship was eventually formalised through bilateral
5 agreements in only half of the cases described in interviews, in all these cases the relationship
6 was regular and meaningful.

8 **3.3. Emergency management**

9 No systematic approach to addressing specific relationship components through targeted
10 scenarios was identified by participating utilities. Exercise scenarios seemed to be designed
11 and driven primarily by operational needs and the emergency concerns of the moment. The
12 purpose of developing relationship elements (e.g. trust) was not addressed, but either
13 assumed to pre-exist or expected to develop naturally in the course of operational exercises.
14 Furthermore, many utilities seemed to have formulated emergency preparedness plans, but
15 not actually tested them. Interagency relations were not always addressed in the planning.
16 Practising these plans by superficially going through the steps in the protocol provides little
17 assurance that the adequate organisational culture, institutional communication and support
18 systems are in place to support effective emergency response.

19 Organising more complex exercises or drills does require more effort, but meaningful
20 practise provides organisations with the opportunity to identify weaknesses and update their
21 plans. On the other hand, a passive attitude and relying on external bodies to organise such
22 exercises may leave many significant relationship gaps unmitigated. For example, scenarios
23 such as malicious contamination of the water source may be popular with emergency services
24 agencies but are unlikely to be representative for the typical challenges that utilities (and
25 PHAs) are confronted with more commonly in their efforts to maintain a safe drinking water
26 supply.

27 As an example of an ineffective way to organise an exercise, in one case the municipality
28 organized an emergency preparedness drill using a scenario of intentional contamination of
29 the source water with cyanide. The drill involved various city agencies and the local PHA,
30 but the city water utility was not involved in either the planning or execution stages. Thirty
31 minutes into the exercise it was realized that it was extremely difficult to introduce enough
32 chemical contaminant into the water supply to pose a credible health threat to the population;
33 thus the scenario made little sense. The exercise was abandoned. The scenario should have
34 been developed with expertise from the utility, and should have employed priority risks from

1 within their vulnerability assessment process. For optimal effect, the scenario should have
2 been designed in a manner that would challenge interagency relationships, such as when
3 available data on contamination is limited and subject to divergent interpretations from
4 various professional perspectives (e.g. water system engineering vs. public health). PHAs
5 were, in general, less involved in testing their emergency preparedness arrangements in
6 relation to drinking water than were utilities. This is consistent with earlier reported findings
7 about PHAs being less committed to the institutional relationship development in this area
8 compared to utilities, because of their competing public health priorities. All participating
9 water utilities would inform their respective PHA immediately if public health consequences
10 from consuming drinking water were suspected, such as from adverse monitoring results, a
11 water treatment barrier failure, or a source water contamination event. The same would apply
12 for security incidents, even if no contamination was detected. The utility would then seek
13 PHA input on assessing health risks. Most utilities indicated that they would prefer to take
14 proactive steps regardless of possible reputation damage, even to calling a boil water advisory
15 (BWA), thus demonstrating due diligence. One utility participant commented: *“Due*
16 *diligence approach means that we prefer to take action, e.g. call a BWA, even if uncertain. In*
17 *a court, I’d rather defend myself on the basis that as soon as we heard of this, we took action,*
18 *rather than explain that we waited for two weeks to tell the public – much higher liability!”*

19 Participants were also questioned on whom they would expect to lead risk
20 communication to the public in drinking water and health incidents. There was limited
21 consensus on this issue even in the same country, and not even in paired organisations.
22 Generally, water utilities would hope that the PHA takes the lead for public health
23 notifications and related public communication, but only a few utilities had formal
24 arrangements with PHA in this regard.

25 Research interviews included a section where the interviewer (DJ) introduced between
26 one and three scenarios based on past drinking water incidents and adapted to local
27 conditions and asked the interviewee to comment on aspects of their emergency response
28 related to institutional collaboration. On analysis of interview responses to these adapted
29 incidents, those interviewees from organizations with a formalised and structured approach to
30 their relationship with PHAs generally seemed to have better appreciation of the mutual
31 needs and the challenges that an incident would present to their relationship. By contrast,
32 interviewees from utilities characterised by a more improvisational approach to risk
33 management and interagency relations failed to observe potential relationship challenges (e.g.
34 miscommunication, conflicting interpretations of limited data available, political interference)

and sometimes projected an unwarranted over-confidence in their ability to manage relationships during an incident. Similar attitudes were present in the utilities involved in past incidents that experienced relationship difficulties. Unwarranted confidence, in particular, was noted previously in several incidents (Jalba et al., 2010).

3.4. Mutual expectations

To better understand relationship determinants, we explored the expectations of water utilities and PHAs in a drinking water incident from each others' perspectives. PHA expectations of the water utility are summarised comparatively to utility beliefs about the same in Table 2. Utility expectations and beliefs of the PHA are listed in Table 3.

[TABLE 2 HERE PLEASE]

[TABLE 3 HERE PLEASE]

The expectations in Tables 2 and 3 helped identify many grey areas where the responsibility is either shared, expected to be shared, or may be an overlapping area of interest that only becomes apparent in a more challenging incident. Prominent examples include dealing with unusual contaminants, public notification or linking epidemiological analysis with water system operational findings.

Many of the expectations listed in the tables are not easy to fulfil for every incident. The analysis of incidents presented previously (Jalba et al., 2010) indicate that utilities sometimes experience difficulties in relation to identifying and isolating the source of the contamination, unconditionally supporting a prolonged or 'blanket' boil order (i.e. precautionary covering many areas where the risk is highly unlikely, but cannot be entirely excluded), deciding what is the appropriate amount of information that needs to be shared with other agencies, or corroborating epidemiologically-derived indications of water supply contamination with evidence of possible water system barrier failures.

On the PHA side, there were equal indications of potential difficulties on expectations such as providing the location of cases (for privacy concerns); assessing population health impact; providing health education on water safety risks; justifying the epidemiological link of an outbreak to the water supply beyond reasonable doubt; presenting a unified front in public when there is disagreement or uncertainty related to the source of population exposure to a contaminant; judging the risk of transmission via water in comparison with other

exposure pathways; appreciating the potential of certain pathogens to be transmitted through the water supply; and even providing laboratory support for detecting pathogens that may be routinely detected in clinical samples but for which a detection method from water samples may not be available (e.g. emerging pathogens, or pathogens that are usually not transmitted through water). In particular, several PHA interviewees appreciated that typical medical and public health training often does not sufficiently cover drinking water treatment, environmental health risk assessment and risk management to enable public health personnel to respond appropriately to some of the above expectations, such as advising on water treatment improvements; treatment removal effectiveness for new or emerging pathogens, for pathogens that are usually not transmitted via water, or for new or unusual chemicals that may contaminate the supply; or providing a health risk assessment for some of the previously mentioned categories of chemicals or pathogens. Of note, most participating organisations failed to recognise many of the expectations that the other party may have for them. A reasonable matching of expectations was only identified in six cases of paired organisations (out of fourteen pairs).

4. Discussion

In a world of increasing interdependence, good inter-organisational collaboration plays an important role in fulfilling the mission for most organisations (Bardach, 1998; Gray, 1989). This applies to all players in drinking water, particularly water utilities and their oversight agencies (IWA, 2004; Parkin et al., 2006). While the technical task of producing drinking water belongs to the water utility only, the mission of producing “*good safe drinking water that has the trust of consumers*” (IWA 2004) requires the cooperative effort between a utility and its stakeholders, particularly public health agencies. In developing countries, institutional disagreements about this responsibility (WHO, 2000) represent a significant barrier to water supply management.

A critical aspect of institutional sustainability is the capability to manage risks. A comprehensive risk management approach can be achieved by including several risk categories (namely financial, commercial, public health, environmental, reputation and legal risks) along with operational risks (Pollard et al., 2004; 2013). An optimal relationship with PHAs aims to prevent not only public health, but also reputational and legal risks. Good relationships with water regulators are vital to building consumer confidence (IWA, 2004; Pollard et al., 2004). Developing an effective collaborative relationship with PHAs may be regarded as one of the critical tests of the maturity of the overall risk management culture in a

1 water utility (IWA, 2004; Williams and Hruday, 2007). Good interagency relations become
2 critical to the recognised stages of drinking water incidents (WHO, 2008). In the proactive
3 stage, regulatory agencies provide feedback, endorsement and verification of safety measures
4 taken. In the initial alarm stage, these agencies provide advice and verification that relevant
5 action is taken. In the management/control stage, they may continue to provide advice, and
6 undertake their own verification that objectives of the intervention are achieved. In the post-
7 incident stage, their role is to ensure that the initial risk is controlled, and that measures are in
8 place to prevent future incidents. The risk management process also recognises a proactive,
9 analytical phase (resulting in a risk estimate) as well as a deliberative phase which involves
10 stakeholders' input (Glicken-Turnley, 2002). Major stakeholders would include internal
11 stakeholders (various departments in the utility that may have a stake in the issue, e.g.
12 operations, water quality, risk management, public relations) as well as external stakeholders
13 (e.g. public health and environmental regulators, water resources agency, water vendors,
14 contractors, medical and health care professionals, consumer groups, community leadership).
15 Depending on the cause, severity and impact of the incident, other important stakeholders
16 include the Government emergency services agency, law enforcement, local politicians and
17 the media (Bartram et al., 2009; Jalba et al., 2009). Proactively developing good relations
18 with stakeholders during normal times is much easier than during an incident where time is
19 limited, stakes high, and communication cautious.

20 Establishing the safety of drinking water involves more than just water technology. The
21 subjective nature of risk engages perceptions, depending on the various meanings of risk held
22 by different stakeholders (Aven, 2010). Confidence in the safety of the water supply relies
23 on interpretation from various viewpoints, depending on trust, being up-to-date on emerging
24 pollutants and pathogens, and being well-informed. Events or developments that may impact
25 water quality reported in our interviews, such as human or animal bodies drowned in the
26 water source, toxic spills from accidents happening near the catchment (e.g. highway
27 accidents), or accidents happening during recreational, industrial or agricultural activities in
28 the catchment, highlighting the importance of having good relationships with stakeholders.

29 In the absence of pre-established agreements on incident management, multiple points of
30 contact with the media may result in conflicting messages being passed on from the various
31 actors in the management of the drinking water incident, which can easily fuel media and
32 public speculation about the real gravity of the event, the competence of responders or the
33 success of control measures (Jalba et al., 2010). Political interference may occur, and delay
34 or undermine the efforts of the incident control team if cooperation between stakeholders is

not well-structured and tested in advance (Hrudey and Hrudey, 2004; Scottish Executive, 2002). Lastly, poor public communication (Jalba et al., 2010) may aggravate the public health consequences of the incident (Hunter and Reid, 2005).

In a drinking water incident, regulatory agencies themselves are likely to come under pressure from public, media and politicians. Good institutional relationships, particularly regulatory trust, are important for maintaining a unified ‘front’ against cross-criticism. Regardless, regulatory agencies typically have the last word as to whether the incident response was optimal or not. A true partnership often includes joint weathering of adversity in the cases where there is public and/or political dissatisfaction to incident response.

4.1. What determines effective interagency relationships?

In a drinking water emergency, all players depend on each other for critical information related to incident investigation, contamination control and public communication (Parkin et al., 2006; WHO, 2011). Many study participants indicated a crisis is the most difficult time for building relationships. Because of public interest in the matter, this relationship has to withstand sustained pressure from public, media and politicians. We suggest an effective collaborative relationship must recognise a *preventive* framework similar to the multiple-barrier approach advocated internationally for managing drinking water quality, meaning that all six relationship components we introduced (Jalba et al., 2010) are necessary for optimal institutional relationships. A failure in any of these presents a relationship risk, even if the other components may eventually provide enough control to prevent an interagency incident (i.e. close-call). Moreover, the components must be achieved in a meaningful, not a cursory or superficial, way. For example, mutual understanding includes an understanding of regulatory roles and good personal relationships, but also understanding the other party’s working environment, their expectations, and even how to best present the information shared in a format that is most helpful to them. A collaborative attitude and top management support further creates the conditions for the continuity of the relationship. Finally, active implementation and structure firmly establishes the relationship, thus supporting consistency, preventing succession risks, and sustaining the relationship during crisis (Parkin et al., 2006).

4.2. Effective inter-organisational collaborations are not accidental

Developing relationships proactively takes time and commitment; there are often no ‘natural’ incentives in this regard for water utilities in affluent countries since drinking water incidents with public health consequences are rare (Hrudey and Hrudey, 2004).

1 Nevertheless, such incidents may occur regardless of the efforts to prevent them, and a crisis
2 is not the optimal time to ‘exchange business cards’. Without a platform of trust, sharing
3 information and expertise, and open communication between agencies, unnecessary
4 difficulties and additional risks are present during incident management (Jalba et al., 2010).

5 In contrast, with the poor cooperation examples reported in the incidents we analysed,
6 e.g. hiding or counterfeiting evidence, lying to regulators, or blocking media statements
7 issued by other stakeholders (Jalba et al., 2010), we uncovered little evidence indicating that
8 such behaviour would have been expected prior to the incident. In general, any prior contacts
9 between stakeholders seemed to have been professionally amiable even if technical concerns
10 might have been present. This was sometimes confirmed during study interviews. Mistrust,
11 poor communication, insufficient training and a suboptimal cooperation structure seemed to
12 have only become apparent at the time of the incident (Jalba et al., 2010). We learned that
13 improvements were generally implemented after incidents to prevent re-occurrences, as part
14 of the organisational learning process and/or under external pressure, i.e. Governmental
15 investigations (Badenoch et al., 1990; Laing, 2002; LIHAG, 1989; LIHAG, 1990; McClellan,
16 1998c; O'Connor, 2002b), or improved regulations (OMOE, 2003). This is commendable,
17 but reactive in approach.

18 Discovering the reality of institutional relationships during incidents is itself an example
19 of poor prevention. Among participating organisations, approximately a quarter of water
20 utilities and half of PHAs had not practised their emergency management arrangements in a
21 joint exercise at the time of the interview. Many of their representatives affirmed they
22 exercised their emergency arrangements ‘enough’ when actual incidents occur, and believed
23 that such an approach provides adequate practise for their needs. Most of these organisations
24 were found to lack any form of written bilateral agreements. Interviewees from these
25 organisations expressed confidence in the *status quo* based on their past incident management
26 experiences. However, the lack of formalised agreements, coupled with a lack of joint
27 practise focusing on interagency collaboration, leaves many potential relationship gaps
28 unrecognised. This makes them vulnerable to events that may challenge institutional
29 collaboration in the same manner as they did in the analysed past incidents.

30 While it is impossible to prevent all undesirable developments, it is clear from the above
31 that an informed, vigilant and inquisitive attitude regarding the quality of current interagency
32 relationships would benefit both consumers and organisations involved in the area of drinking
33 water. An adaptation of prevention principles (Axelrod, 1984) for drinking water safety
34 should recognise three stages of prevention, namely proactively promoting relationships,

1 periodically verifying the existing arrangements, and learning from collaboration challenges
2 when they occur.

3 Bardach (1998; 2001) addresses the question of whether successful inter-organisational
4 collaborations are achieved reactively or purposefully. Without negating the role of chance
5 interactions, a proposed “*craftsmanship*” model suggests successful collaborations are more
6 likely to be achieved through an active, rather than a passive, process. This process is often
7 conducted by visionary, committed individuals, skilled in the art of “*boundary spanning*”
8 (Williams, 2002).

9 The role of external pressures in developing institutional relationships among
10 participating organisations was clearly identified and the presence of relationship advocates
11 was correlated with a better recognition of the critical relationship components (Jalba et al.,
12 2010) than the average participating organisation, while the presence of external pressures
13 did not significantly correlate to such understanding.

14 Our findings clearly indicate that effective inter-organisational relationships are not
15 accidental. Good institutional collaborations identified among participating organisations did
16 not develop neither randomly nor naturally. In some cases, the appreciation of the value of
17 good institutional relationships may have occurred as a result of past incidents aggravated by
18 defective relations (Jalba et al., 2010). More often, such appreciation developed in less
19 dramatic circumstances, where an incident or close-call was eventually managed
20 successfully, but post-incident analysis revealed suboptimal relationships, which may have
21 delayed incident control and recovery. For example, political interference into the incident
22 command system process led participating organisations to formulate a better structure and
23 guidelines that would prevent politicians from disturbing incident response (Scottish
24 Executive, 2002). In some organisations, the presence of ‘enlightened individuals’ on both
25 sides catalysed the process.

26 Learning from experience is vitally important. For provision of drinking water, incidents
27 and close-calls (in one’s own organisation, or elsewhere) represent an important source of
28 learning that is often underused. Systematically learning from close-calls is at least as
29 important as analysing generic, catastrophic scenarios, yet often risk managers may focus on
30 the latter. While the importance of learning from close calls as a risk management tool was
31 advocated by many of the participating utility representatives, most PHA interviewees did not
32 seem to recognise the critical role that this approach can play in preventing drinking water
33 safety incidents. Their lack of knowledge about how utilities in their area approach this

1 aspect of learning is likely to limit the extent to which the PHA can encourage and support a
2 fully preventive risk management approach among their partners.

3 While each have their place in developing a risk management culture, effective
4 interagency collaborations are more likely to develop from jointly practising meaningful,
5 likely scenarios based on past experiences, rather than relying only on the odd generic
6 ‘Hollywood-type’ disaster management exercise. ‘Likely’ scenarios may also involve less
7 resources, can be organised regularly, and will provide multiple opportunities for interaction
8 between key people in both organisations. Past incidents with collaboration difficulties may
9 inform more meaningful and less repetitive scenarios whose practice will improve aspects of
10 institutional relationships components and determinants that are critical to their mission.

11 If developing an effective institutional relationship is rarely accidental, the same applies
12 to maintaining the momentum of the relationship, or ‘sustaining innovation’ (Schall, 1997).
13 An important challenge for participating organisations seemed to be keeping interagency
14 relationships ‘alive’ when disasters or major incidents do not occur. Relationships are
15 dynamic entities, tested in time by routine incidents (as well as lack of) with rotation of staff
16 in key positions.

17 Successful ‘boundary-spanners’ (Williams, 2002) are skilled at identifying ways to
18 maintain regular contact between organisations; this includes ‘orchestrating’ [artificial]
19 opportunities to keep the momentum going (Table 3). Creative managers find no shortage of
20 opportunities in the space between organisational barriers because they are less bound by pre-
21 existing patterns and routines. Such initiatives may include setting up ‘boundary
22 organisations’ or ‘boundary objects’ (Cash et al., 2003) in the form of interdisciplinary bodies
23 or collaborative projects that bring together organisations with the purpose of addressing
24 common interests (Tables 3 and 4). Cross-boundary entities filling gaps between
25 organisations are more likely to engage parties by increasing the salience of information
26 produced, credibility of initiative and a ensuring a more transparent process (Cash et al.,
27 2003). In the area of drinking water, possible examples include local/regional water quality
28 committees, organised seminars or training events on interdisciplinary topics of common
29 interest, joint research projects or formulating joint emergency response guidelines. Other
30 initiatives may include inviting key people to become familiar with their own organisation’s
31 operations, for example through a guided visit at the local water treatment plant.

32 Many participants in this study failed to recognise succession risks to institutional
33 relationships, particularly on the PHA side. As Schall (1997) notes, rather than relying on
34 key people’s immortality, responsible managers in charge of the institutional relationship

1 should use succession planning strategies. In more proactive organisations, managers are
2 actively looking for new potential champions of the relationship in their organisation,
3 delegating them on a rotation basis to represent them in key interagency activities (be that
4 regular communication, joint meetings, expertise sharing, or common projects), and investing
5 in their training. Creating multiple contact points between the partners establishes a wider
6 support within each organisation, thus enhancing resilience. Skilled managers also identify
7 opportunities to ‘hardwire’ the relationship in organisational procedures, such as embedding
8 interagency communication and interdisciplinary training in their culture. By engaging key
9 stakeholders in multi-agency activities, they establish a wider support in the community
10 (Jalba et al., 2009). Finally, by promoting recognition of the advantages of the relationship,
11 its discontinuation may later be perceived as a strategic risk (Schall, 1997). One could
12 hypothesise that employing an active, coordinated approach to preserving the momentum of
13 the relationship makes it difficult to cease even when confronted with difficult times and
14 competing priorities.

16 **4.3. Regulation is necessary, but not sufficient in isolation**

17 Adopting regulations and guidelines that require stakeholders to work together on a
18 common task (e.g. WSPs, ERPs) is a step toward promoting an environment where more
19 institutional contacts occur (Bartram et al., 2009; Jalba et al., 2009; NHMRC, 2004b;
20 USEPA, 2004a; USEPA, 2004c; WHO, 2008). Regulatory frameworks may encourage
21 interagency collaboration to complete their requirements; however there is less certainty
22 about what will happen once mandated documents are developed. Would introducing more
23 regulations that require agencies to connect take care of all institutional relationship
24 deficiencies noticed in past incidents? Will ‘indirectly mandating’ interagency cooperation
25 via requirements such as WSPs, ERPs, vulnerability assessments and so on ensure that water
26 utilities and their stakeholders will develop all necessary components of an effective
27 relationship? These questions raise the issue of whether effective interagency relations are
28 more likely to be achieved reactively or purposefully. This is complex and may require
29 further research; however some preliminary observations can be offered on the basis of this
30 study.

31 Prior to the development of a ‘risk management culture’, utilities and their oversight
32 agencies involved in the incidents did not operate in a legislative vacuum. During the last
33 three decades when these incidents occurred, regulations were generally in place to mandate,
34 for example, oversight of the safety of water supply operations, or empowering PHAs to

1 investigate and enforce public health protection if they suspected that the water supply is
2 unsafe. Indeed, relationships between key people existed in many cases even before the
3 incidents we studied (Jalba et al., 2010; Laing, 2002; McClellan, 1998c; O'Connor, 2002a).
4 What was missing, however, was an agreed standard of what a meaningful interaction
5 between agencies represented as a means to help them discharge their mandates successfully.

6 Both environmental and public health enforcement officers had a 'relationship' with
7 Walkerton water supply operators, which at that time was regarded as acceptable (O'Connor,
8 2002a; Perkel, 2002). The latent deficiencies only became apparent when the water supply
9 became severely contaminated with pathogens (O'Connor, 2002a). While the results of
10 regulatory inspections of both Walkerton and North Battleford water systems prior to the
11 incidents were inadequate (Laing, 2002; O'Connor, 2002a), it is easy to forget fearing a
12 problem that rarely occurs (Reason, 1997), and accept the *status quo*. The authority of
13 enforcement officers may have been real, but in the 'real world' there are many factors that
14 may limit their effectiveness. In the absence of a true collaborative relationship, both
15 persuasion and regulatory coercion are less likely to produce the desired changes.

16 Rather than increasing regulation, a different mindset may be required from water
17 utilities and oversight agencies alike (Pollard et al., 2009). A productive relationship differs
18 from a 'mandated' relationship. Should interagency relationships remain unrecognised as an
19 essential 'ingredient' of successful risk management in the area of drinking water,
20 development of WSPs, ERPs or vulnerability assessments may become another lost
21 opportunity. As Pollard et al. (2009) note, introducing new standards such as WSPs while
22 ignoring related human factors may not prevent them from becoming another cursory or
23 superficial exercise, i.e. something to produce, file and then move on doing things as before,
24 or even documenting under a new template what the organisation already does, rather than
25 stimulating improvements. Drawing from the experience of implementing the international
26 quality standard ISO 9000 and the introduction of the hazards analysis and critical control
27 point (HACCP) approach, Pollard et al. (2009) emphasizes that both meaningful and
28 superficial implementation are possible, depending on the organisational 'mindfulness'
29 culture.

30 If effective inter-organisational relationships are clearly recognised as important for the
31 successful provision of drinking water, they are more likely to be sought purposefully than
32 being left to chance. If organisations choose to pursue them in the same way that they pursue
33 other functions such as treatment operations, business opportunities, risk management or
34 public relations, then they may take steps to stimulate and 'hardwire' the collaborative

performance of their staff and of the organisation as a whole. Mindful organisations may choose to select, train and reward their staff based on their collaborative performance (Daley, 2009), such as interdisciplinary communication skills, engaging stakeholders, and building trust in their product. Mutual recognition of the importance of interagency relations between water utilities, oversight agencies, and other stakeholders, is also likely to encourage sharing of expertise and critical information.

4.4. Assessing relationship performance

Awareness, of the quality of one's organisation institutional relationships, as well as of the type of relationship gaps that aggravated past incidents and how they occurred is likely to be the most powerful motivator for developing effective interagency relationships. A systematic verification of effective interagency relationships was recommended in Pollard et al. (2009) based on research findings and guidance literature on inter-organisational relationship performance (Daley, 2009; ISO, 2007; OECD, 2003). The proposed framework for performance evaluation of institutional relationships was based on outcome and activity relationship performance indicators during both normal and emergency times. This framework was designed to ensure that all six relationship components we introduced are considered when water utilities formulate their local risk management strategy relating to cooperation with regulatory agencies.

4.5. Interdisciplinary training

Apart from in-house training, institutional relations may be promoted by involving the other party's representatives in common research and community projects by implementing interdisciplinary training for key people involved in the relationship, and by discussing issues of mutual interest such as monitoring and controlling emerging pathogens, or concerns over long-term effects of chemicals or disinfection by-products (DBPs). The related practical skills may be developed through incident and close call debriefing, case studies, joint exercises on emergency response plans, or responding to mutual assistance agreements with other peer organisations.

The success of such training is best tested using simulations based on realistic scenarios, preferably adapted from real incidents that happened in their organisation or elsewhere. The use of realistic joint simulations is likely to give a practical understanding of major training themes, such as each other's response protocols, how to identify resources, understanding which entities are likely to be involved in an incident, matching epidemiology findings with

1 distribution infrastructure, challenges of risk communication with a potentially distrusting
2 public, as well as limitations of water quality monitoring, of data interpretation and of the risk
3 assessment approach.

4 Finally, key people involved in the institutional relationship must have a practical and
5 realistic view of what the other party needs to know, can possibly know and can be expected
6 to be able to do in a drinking water incident, and what expertise and resources can be
7 expected from them. One of the findings of our research was that mutual expectations in
8 terms of training, expertise and ability to address concerns may not always match the
9 standard training provided for professionals on the other side, or even with what can
10 realistically be expected from them. This leaves many grey areas of expertise that may not
11 always be obvious during routine business, but which might become apparent during a
12 challenging situation.

13 Water operators may not always be able to: identify the source of contamination in the
14 water system (Carrique-Mas et al., 2003); unconditionally support a prolonged or ‘blanket’
15 boil order that as a precaution covers many areas where the risk is highly unlikely but cannot
16 be entirely excluded (McClellan, 1998a; McClellan, 1998b); decide what is the relevant
17 information that must be shared with other agencies (Laing, 2002); or corroborate
18 epidemiologically derived indications of water supply contamination with possible water
19 system barrier failures (Hrudey and Hrudey, 2004).

20 On their side, PHA personnel may not always be able to: justify the epidemiological link
21 of an outbreak to the water supply beyond reasonable doubt (e.g. South Devon
22 cryptosporidiosis outbreak in Hrudey and Hrudey, 2004), judge the risk of transmission via
23 water in comparison with other exposure pathways (e.g. Victoria toxoplasmosis outbreak in
24 Hrudey and Hrudey, 2004), or provide laboratory support for detecting pathogens that may be
25 routinely detected in clinical samples. This is because a detection method from water
26 samples may not be available, or because pathogens multiply in humans, but not in the water,
27 so the negative predictive value (probability of a negative result being truly negative) of the
28 method is much lower for water quality testing than for stool sample testing (Allen et al.,
29 2000).

31 **4.6. Study limitations**

32 Adopting a qualitative approach to studying the collaboration between water utilities and
33 PHAs has helped to identify a multitude of themes. At the same time, the generalisation of
34 findings of this study is limited by purposively sampling a selection of organisations in order

to investigate a variety of organisational cultures. Another study limitation relates to interviewing only the most experienced people as far as the institutional relationship is concerned. The relationship between better interagency collaboration and safer drinking water has been explored here only qualitatively but our findings reinforce the intuition that better collaboration has merit and is needed in most cases.

5. Conclusions

Would better institutional relationships have avoided the high profile water quality incidents of recent decades discussed in Hrudey and Hrudey (2004)? Even optimal interagency relationships cannot prevent contamination from entering the water supply, and no relationships can assure contamination-proof systems. Equally, no amount of collaboration (or technology, for that matter) can prevent unforeseen hazards such as a pathogenic *Cryptosporidium*-carrying rabbit infiltrating the waterworks (Chalmers et al., 2009) or a relief worker depositing treatment chemicals in the wrong place in the system (LIHAG, 1989), though certain technological and managerial improvements would have made such situations less likely.

On the other hand, with the Walkerton incident as an example, poor institutional relationships can result in excessive energy, time and resources being spent trying to obtain the right information about what went on, thereby severely delaying control of an outbreak, resulting in high public inquiry costs, and an expensive out-of-court settlement of a class-action lawsuit (O'Connor, 2002a). In the North Battleford incident, much time was unnecessarily wasted; by PHA investigators who were unaware of drinking water system problems (Laing, 2002). Poorly managed interagency relations in the Sydney incident led to a loss of institutional credibility and costs of several Government inquiries (Hrudey and Hrudey, 2004). In the Camelford incident, poor interagency communication led to a serious loss of credibility, costs of Government inquiries, psychological and psychosomatic suffering, and legal action (COT, 2005; DOH, 2005). So we conclude:

- (1) A responsible water utility fosters good relationships with their PHA counterparts. A responsible PHA is likely to respond in-kind.
- (2) An effective institutional relationship is often determined by the successful achievement of at least six relationship components: trust, communication, shared expertise, common interdisciplinary training, supporting regulation and proactivity.

1 Together, these components will act as a multiple-barrier protection from inter-
2 organisational conflicts.

3 (3) Some of the participating organisations in this study demonstrated practices that
4 sought intuitively to develop these components. However, most lacked a targeted
5 approach and, as a result, not all relationship components were found to be optimal.

6 (4) The use of risk terminology does not necessarily imply the existence of a risk
7 management culture, and meanings can vary greatly. A common risk management
8 paradigm may need to be formulated regarding collaboration between water utilities
9 and PHAs.

10 (5) The *pros* and *cons* of the interventionist versus naturalist approach to interagency
11 relations for drinking water may remain a subject for philosophical debates.
12 However, the study evidence clearly supports the adage that ‘prevention is better than
13 cure’. A ‘natural’, evolutionary, process of developing inter-organisational
14 relationships may well be advocated by ignoring the ‘red flags’ identified in this
15 study. On the other hand, proactively implementing the lessons from past incidents
16 and the successful current practices would clearly reduce inherent adverse
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Table 1: Opportunities for developing a relationship between a water utility and a PHA

Opportunity	Examples
<i>Legislation</i>	<ul style="list-style-type: none"> • Requirements to develop WSPs; • Regulatory requirement to develop a common MoU; • Working out joint incident response protocols; • Developing emergency response plans and vulnerability assessments (particularly after September 11, 2001);
<i>Incidents</i>	<ul style="list-style-type: none"> • Waterborne outbreaks (e.g. Cryptosporidiosis). • Successful management of a drinking water and health crisis that involved the PHA; • Desire to understand each other's business after suboptimal incident management coordination;
<i>Public concerns</i>	<ul style="list-style-type: none"> • Concerns about lead contamination in distribution; • Concerns about <i>Cryptosporidium</i> from the AIDS community, working on a common communication strategy; • Concerns on long-term effects of disinfection by-products (DBPs) or fluoride; • Health concerns over intensive agriculture projects that would impact source water quality;
<i>Requests for assistance</i>	<ul style="list-style-type: none"> • Uncertainties on interpretation of <i>Cryptosporidium</i> tests resulting in working out a common protocol; • Water utility requesting PHA to interpret recent studies on new DBPs; • PHA requesting assistance with water samples analysis for recreational water or other non-drinking water related issues; • PHA requesting assistance on borderline projects (e.g. lead contamination from building plumbing).
<i>Joint projects</i>	<ul style="list-style-type: none"> • Community drinking water safety educational projects; • Drinking water safety research projects;
<i>Other</i>	<ul style="list-style-type: none"> • Environmental regulator inspections that pointed out deficiencies, resulting in the involvement of the PHA in discussions over upgrading water and sewage systems; • Utility paying for PHA staff dedicated to drinking water quality.

Table 2: Views of both parties on PHA expectations of the water utility

Expectations category	PHA participants views	Utility participants views
<i>Incident management</i>	<ul style="list-style-type: none"> • Able to recognise when drinking water contamination occurs; • Will perform a risk assessment related to any contamination event; • Is able to correlate water quality testing results with operational conditions; • Provides recommendations for public health protection; 	<ul style="list-style-type: none"> • Able to provide assurance when the system functions normally; • Identify location of the system problem and isolates it from the rest of the system; • Explain issues, concerns and options from utility perspective; • Clearly define the area of service potentially affected; • Propose control options in the case of public health risks;
<i>Knowledge</i>	<ul style="list-style-type: none"> • Is able to describe the relevant properties of the chemical of concern (e.g. source, formation, removal options, and how it is regulated); • Has information on emerging pathogens; 	<ul style="list-style-type: none"> • Able to describe contaminant and know how to test for it; • Well-informed on common problems; • Well-informed on water industry best practices;
<i>Responsiveness</i>	<ul style="list-style-type: none"> • Provide timely and accurate information; • Respond promptly to PHA inquiries; • Provide timely notification of adverse results, investigations results and any incident control decisions; • Investigate for water system problems when suspicion is raised, e.g. by enhancing sampling and testing; 	<ul style="list-style-type: none"> • Provide PHA with adverse monitoring results and related technical and operational data in a timely, honest and transparent manner; • Prompt notification of any unusual events with potential public health consequences; • Prompt investigation of water system problems; • Enhancing water quality sampling and testing;
<i>Public support</i>	<ul style="list-style-type: none"> • Unconditionally supports PHA public notices (including 	<ul style="list-style-type: none"> • Will not remove or try to remove a boil water notice

	conditions to lift them); • Participates in joint media statements;	until the PHA is convinced that their water is safe;
<i>Partnership approach</i>	• Complete transparency in communication; • Invites PHA input in their investigation (e.g. sampling strategy), to discuss control options (e.g. treatment, system shutdown), and their consequences; • Participates in PHA investigation by describing the water system, current operating conditions and reporting recent system changes; • Participates in corroborating and interpreting epidemiological data within the context of their system; • Utility laboratory will cooperate with the public health lab to develop a pathogen detection method and serotyping techniques.	• Offers full cooperation throughout the incident.

Table 3: Views of both parties about utility expectations of the PHA

Expectations category	Utility participants views	PHA participants views
<i>Professional advice</i>	<ul style="list-style-type: none"> • Justify epidemiological connection of illness to water • Assess health risk from particular water contaminants • Treatment removal of unusual contaminant • Advice on public notification (e.g. high-risk groups) • Advise sampling locations based on case distribution; • Characterize unusual or emerging pathogens; • Advise on how to detect new chemicals and emerging pathogens in drinking water, and possible sources of contamination; • Advise on improving water treatment; 	<ul style="list-style-type: none"> • Assess health risks in an incident • Identify vulnerable populations • Decide if there is a public health emergency; • Help utility define effective control options • Describe the pathogen and its potential for transmission through drinking water; • Clarify whether an alternative water source is needed; • Interpret pathogen testing results for raw/treated water • Justify epidemiological link to drinking water • Advise on water treatment and control options for unusual chemicals and pathogens;
<i>Incident management support</i>	<ul style="list-style-type: none"> • Provide laboratory support; • Provide assistance with specific water tests (e.g. <i>Cryptosporidium</i> genotyping); 	<ul style="list-style-type: none"> • Enhance disease surveillance • Disseminate information quickly to the public; • Facilitate distribution of drinking water alerts to particular groups (e.g. dialysis patients), or businesses (e.g. industrial developments); • Provide resources to the ICS;
<i>Public support</i>	<ul style="list-style-type: none"> • Present a joint front during public communications • Provide health education to the public (including contaminant fact sheets on pathogens and chemicals of concern); • Protect water utility customer confidentiality; 	<ul style="list-style-type: none"> • Educate the public; • Mitigate rumors and public concerns about health risks; • Present a unified front in public;
<i>Partnership</i>	<ul style="list-style-type: none"> • Clearly outline their expectations and be 	<ul style="list-style-type: none"> • Provide location of cases

<i>approach</i>	<p>reasonable/realistic about what can be achieved;</p> <ul style="list-style-type: none"> • Notify the utility on potential waterborne disease; • Provide location of cases in an outbreak • Provide updates on population impact in a waterborne outbreak; • Place drinking water risks in the general public health context by weighting drinking water against other exposure pathways (e.g. nitrosamines in food); • Seek clarification when water monitoring and epidemiological data are incongruent; 	<ul style="list-style-type: none"> • Provide related disease statistics • Notify on potentially related cases; • Periodically update water utility on the public health investigation;
<i>Regulatory support</i>	<ul style="list-style-type: none"> • Advise on regulatory guidelines; • Issue public alerts (e.g. boil order) • Notify general practitioners in their area. • Assist water utility with reaching out to other Government agencies (e.g. catchment management); 	<ul style="list-style-type: none"> • Facilitate contact with local hospitals, other PHAs, and other Government agencies



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Effective drinking water collaborations are not accidental: Interagency relationships in the international water utility sector

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