Controlling CROSS CONNECTIONS and Preventing BACKFLOW

by **Caigan McKenzie**
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In May 2000, a city employee in Pineville, Louisiana, mistakenly connected a business' sewerage pipe to a six-inch water pipe. When company employees used the toilet, sewage was forced into the water line. It took officials two months to locate the source of contamination and to fix the problem. In the meantime, families from 60 residences in the area found toilet paper clogging their icemakers, washing machines, and dishwashers, and excrement flowing through their water heaters. This incident occurred because of an unprotected cross connection in the water distribution system and a backflow.

A cross connection is a physical link, such as a jumper connection or swivel arrangement, between a potable water supply and a source of contamination. A backflow is a change of pressure in a water pipe that forces water to flow opposite its intended direction, allowing contaminants to enter the potable water system through unprotected cross connections. Cross connections occur around the home as well as in municipal water systems and can involve low- or high-hazard contaminants.

Hazards of Cross Connections

"We have a long list of backflow contaminants that have been documented," says Ken Rotert, a microbiologist with the U.S. Environmental Protection Agency's (EPA) Office of Ground Water and Drinking Water. "Anything that is used in a commercial or industrial setting can enter the system as well as sewage." Contaminants that have entered the water system through unprotected cross connections have caused poisonings, chemical burns, illnesses, and even death. (Examples of these incidents may be found on American Backflow Prevention Association (APBA) Web site and EPA's Web site. See the end of the article for URLs.)

Types of Backflows

There are two types of backflow: backpressure and backsiphonage. Backpressure occurs when downstream pressure is greater than the potable water supply pressure. Some causes of backpressure are booster pumps and elevated plumbing.

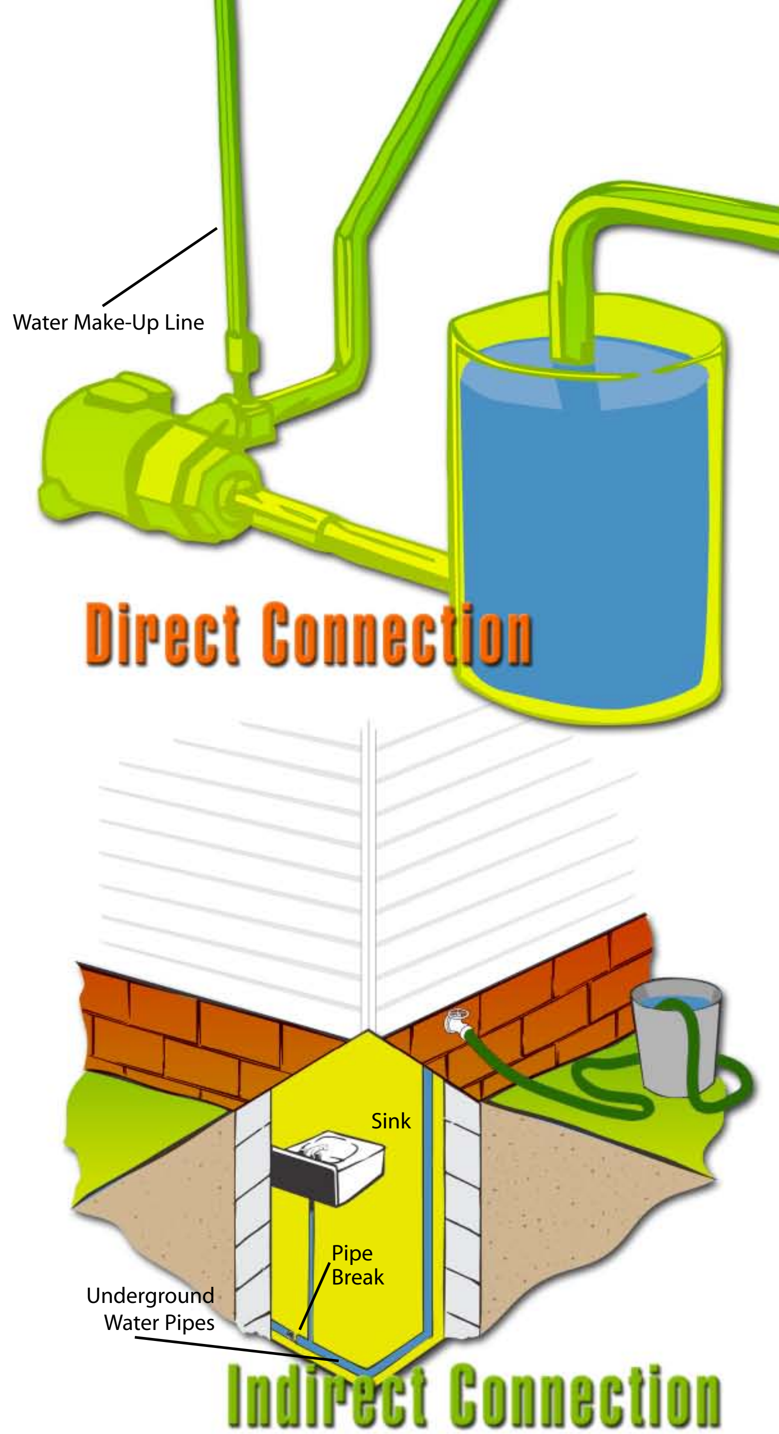
Backsiphonage is caused by a negative pressure or vacuum in a water system, just like when you suck a beverage through a straw. Some causes of backsiphonage are water line breaks and low pressure in a water distribution system because of fire fighting.

On Tap Online

For more information, see the *Tech Brief* "Cross Connection and Backflow Prevention" on the National Environmental Services Center Web site at *www.ndwc.wvu.edu*

Types of Cross Connections

There are two basic types of cross connections: direct and indirect. A direct cross connection can be affected by both backpressure and backsiphonage; an indirect cross connection is affected only by backsiphonage.



An example of a direct cross connection is the make-up water line feeding a recirculating system. This setup creates a direct pathway between the two separate systems, making it possible for backflow to enter the potable water system.

An example of an indirect cross connection is a garden hose connected to a water supply line and submerged in a bucket of soapy water. Other examples of direct and indirect cross connections are lawn irrigation systems, hot tubs, swimming pools, boilers, fire protection systems, film processors, and service wash basins.

Backflow Prevention Devices

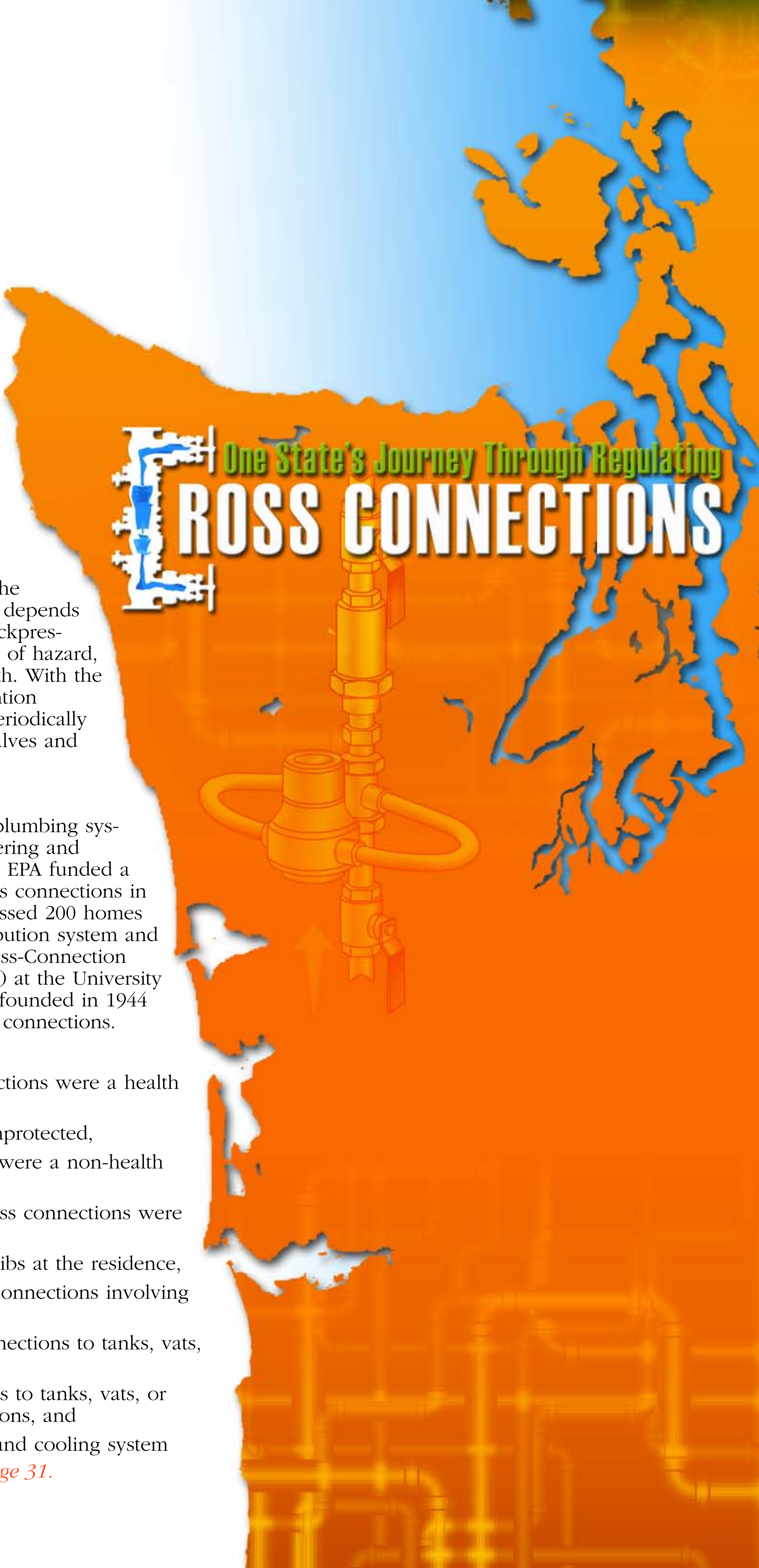
While public health officials say it is best to avoid using cross connections altogether, they recognize that there are cases where cross connections are necessary, for example, in boilers and injector units. However, cross connections often are installed by people who are unaware of the potential health hazards from this type of plumbing connection and who are unfamiliar with the correct procedure for choosing and installing backflow prevention devices. When cross connections are used, correctly installed backflow prevention devices stop contaminated water from flowing back into the potable water supply.

There are five basic types of backflow control methods and prevention devices:

- air gaps,
- reduced-pressure-zone backflow preventors,
- double check valves,
- vacuum breakers, and
- barometric loops.

(See the sidebar on page 31 for more information.)

The method or device used to reduce the contamination risks of a cross connection depends on whether the backflow is caused by backpressure or backsiphonage and on the degree of hazard, as defined by the industry, to public health. With the exception of the air gap, backflow prevention devices are mechanical and need to be periodically tested to ensure that the internal check valves and mechanics are properly working.



Prevalence of Cross Connections

Cross connections can be found in all plumbing systems, because they are convenient for altering and extending those systems. In January 2002, EPA funded a study to determine the prevalence of cross connections in household plumbing. The study encompassed 200 homes in Iowa that shared the same water distribution system and was conducted by the Foundation for Cross-Connection Control and Hydraulic Research (FCCCHR) at the University of Southern California. The FCCCHR was founded in 1944 specifically to work on problems of cross connections.

Results of the study showed that:

- 9.6 percent of all direct cross connections were a health hazard,
- 73 percent of all water uses were unprotected,
- 4.3 percent of all cross connections were a non-health hazard,
- 95.7 percent of direct or indirect cross connections were a health hazard,
- 91 percent were unprotected hose bibs at the residence,
- 61 percent were unprotected cross connections involving toilets,
- 5.9 percent of homes had cross connections to tanks, vats, or water softeners,
- 18.2 percent of the cross connections to tanks, vats, or water softeners were direct connections, and
- 43.6 percent of homes had heating and cooling system cross connections. *Continued on page 31.*

Washington State has long been a leader in water and wastewater issues, so it is no surprise that the state drinking water program has had cross-connection regulations for public water systems since 1970. "For a long time, our office had placed emphasis on the development of written cross-connection control program plans, but a survey of water systems in the mid-90s showed that while these plans had been developed, they had not been successfully implemented," says Terri Holderman-Notestine, cross-connection program manager with the Washington State Department of Health (DOH). "They were merely 'bookshelf' plans, because they sat on the bookshelves in purveyors' offices, but systems weren't doing anything that the plans said."

In 1996, DOH examined the cross-connection control regulations to identify their deficiencies. DOH made major revisions to the regulations and clarified jurisdictional issues between water purveyors and city or county building/plumbing officials that implement the state's uniform plumbing code. The revised regulations became effective in 1999. "Along with this effort, DOH shifted emphasis from systems developing written program plans to monitoring how well the water systems were implementing the written plans," Holderman-Notestine says.

Each water system must develop and implement a cross-connection program to protect the public water system from contamination. Water systems must incorporate their written program plans into their comprehensive water system plans or small water system management programs. Each plan must include the following 10 minimum program elements:

- legal authority,
- hazard surveys,
- approved backflow assemblies,
- qualified personnel,
- inspection and testing,
- testing quality assurance and control
- backflow incident procedures,
- consumer education,
- records, and
- reclaimed water requirements.

In addition, the revised regulations require all water systems to investigate and report backflow incidents to the DOH on the department's "Backflow Incident Report Form." This form includes information about the extent of contamination and the sources and types of contaminants. Using a standardized form helps ensure that reported data is consistent and complete and that it can be more easily analyzed.

"Another change to our regulations is the requirement for water systems to complete and submit annual summary reports (ASRs) to DOH on request," Holderman-Notestine says. "We use these to collect information about the status of the written program plans and implementation activities. Annual reporting helps to ensure that water systems are implementing cross-connection control programs and helps to identify any weaknesses in the cross-connection control programs statewide and system-by-system. Right now, our annual reporting focus is on the largest community public water systems in our state, those with 1,000 or more connections, because these systems serve the majority of the state's population and are most likely to serve high-hazard premises. Currently, 220 systems must submit ASRs." Purveyors submit their ASRs using DOH's cross-connection control web-based application.

Under Washington State's regulations, water systems that serve high-hazard premises are required to use premises isolation (also called containment) to protect the public water system from contamination. Premises isolation requires that an approved backflow prevention assembly be placed on the service lines of high-hazard premises so that the customer's entire plumbing system is separated from the public water distribution system. Examples of some high-hazard facilities include sewage-related, nuclear, medical, dental, veterinary, and interconnected auxiliary water supplies.

In 2005, the DOH began to take compliance action against purveyors serving wastewater and nuclear facilities that failed to meet the mandatory premises isolation requirements for high-hazard premises. Compliance letters were based on ASRs received for calendar year 2004. This year, DOH will base compliance on ASRs for 2006 and is expanding the list of high-hazard premises selected for compliance action. DOH plans to focus on water systems with unprotected medical facilities and any sewage-related and nuclear facilities that have not yet complied.

"We have seen steady improvement since we began to collect the data for the 2001 reporting year," Holderman-Notestine says. Records show that reclaimed and nuclear premises are at 100 percent protection, and wastewater pump stations and wastewater treatment plants are at nearly 100 percent. "We feel that we have some momentum going and are making real progress to improve public health protection in Washington State."

This is consistent with the state Office of Drinking Water's mission to protect the health of the people of Washington State by ensuring safe and reliable drinking water.

For more information on Washington State's cross-connection regulations, see DOH publication 331-355, November, 2006 and publication 331-234 at www.doh.wa.gov/ehp/dw *or contact Holderman-Notestine at* terri.notestine@doh.wa.gov.

Continued from page 17.

One of FCCCHR's conclusions was that small changes, such as adding a hose bib vacuum breaker or changing a toilet fixture, could correct many of the cross connections problems they had found. FCCCHR further concluded that additional studies need to be done throughout other areas across the country to include more homes with irrigation systems and homes with pools and spas.

Backflow Incidents Underreported

Typically, water purveyors become aware of backflow contamination from customers who complain about water's odor, taste, or discoloration, or because contact with the water has made them ill. Based on these reports, EPA has documented 421 backflow incidents, resulting in 12,093 illnesses, between 1970-2001.

"We don't have an accurate number because there is a lack of reporting and a lack of monitoring," Rotert says. "Events are typically short in duration; and water systems don't monitor for many of the contaminants that enter

Backflow Control Methods and Prevention Devices

An air gap is a physical, vertical separation between a potable and nonpotable system. Air gaps should be twice the diameter of the supply pipe, but not less than one inch. This method is one of the simplest and most effective for preventing backflow and backsiphonage.

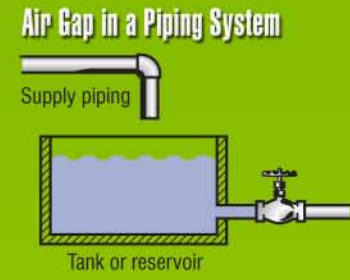
Air gaps can be can be used in all hazard levels and is the only acceptable method for protecting against lethal hazards, according to the Foundation for Cross-Connection Control and Hydraulic Research. They are commonly found in the standard design of household bathtubs and kitchen and bathroom sinks.

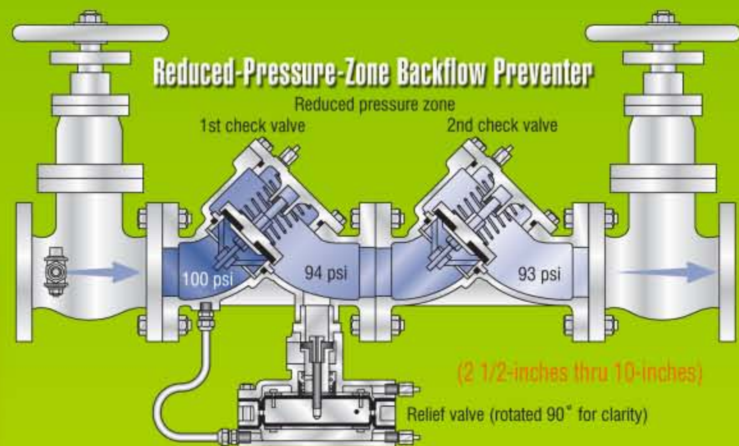
A reduced-pressure-zone backflow preventer consists of two spring-check valves separated by a pressure-relief valve that can vent to the atmosphere. This assembly is effective against both backpressure and backsiphonage and can be used in both non-health and health hazard situations, according to ABPA. They are often used to protect municipal systems from commercial or industrial connections, such as a hospital or factory.

A double check valve consists of two check valves coupled together in one body, test cocks to evaluate whether each check valve is watertight, and a closing gate valve at each end. Double check valves are effective against backpressure and backsiphonage but should be used only for non-health hazards, according to ABPA. They are used for low- to medium-hazard installations, such as lawn irrigation and fire sprinkler systems.

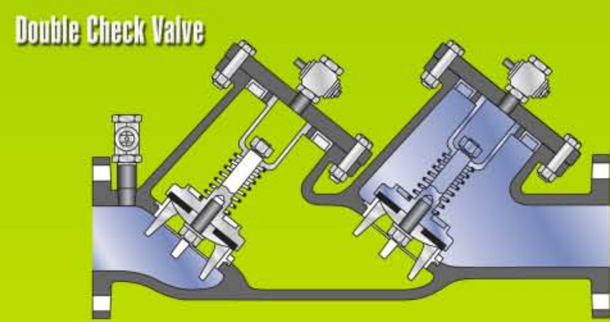
A vacuum breaker is an assembly with a check valve that seals the water supply entry and opens an air vent when the normal flow of water is stopped. These assemblies only prevent backsiphonage.

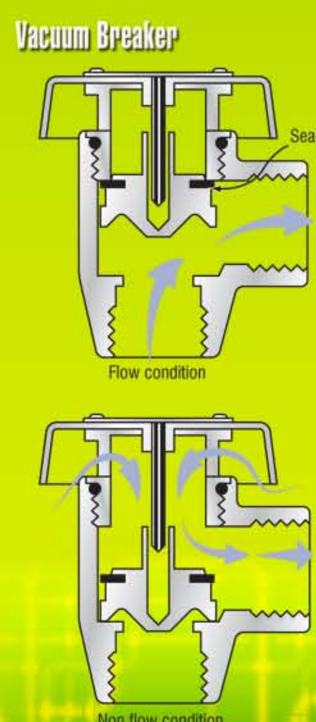
A barometric loop is "U" shaped and is 35 feet in height, allowing the water to flow over it. It only protects against backsiphonage since backpressure could drive water over the top of the arrangement.

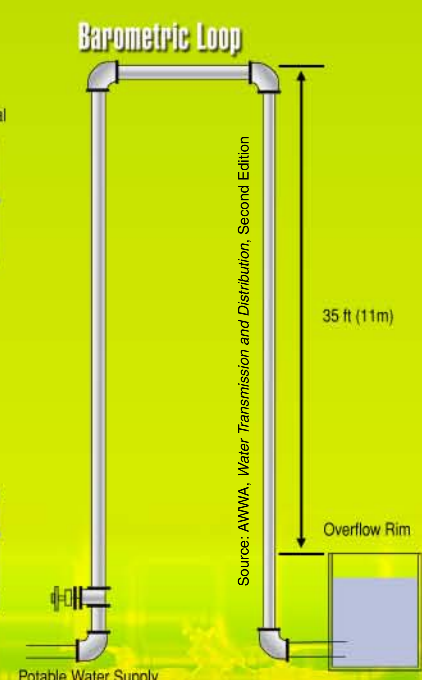




Source: U.S. Environmental Protection Agency, 2003. *Cross-Connection Control Manual,* Washington DC: EPA.







Source: AWWA, *Water Transmission and Distribution,* Second Edition the system due to these events, or in most cases, for the pressure that would indicate that events may have occurred. There is also a disincentive for systems to report these events because of a loss of consumer confidence and possible legal issues." Some other reasons for underreporting include water customers not linking their illnesses to backflow events, and not having a central location for housing all backflow reports.

EPA Stakeholder Workshop

Although lack of documentation has made it difficult for EPA to determine the level of risk to the public from cross connections and backflows, the agency does recognize that these issues may be a significant public health concern. "There are not specific mandates in the Safe Drinking Water Act that gives EPA the authority to regulate cross connections," Rotert notes. "In addition, we haven't been able to demonstrate significant public health risks associated with cross connections that we could use to warrant regulating them."

At the January 2007 EPA Stakeholders' Workshop, Rotert described an EPA-developed methodology that could potentially be used to estimate backflow contamination risks in community water systems. The methodology, based on existing frameworks, looks at both chemical and microbial risk assessments and the challenges associated with them, such as collecting meaningful data. "We thought there was a potential to model how often these events occur based on information that we have," Rotert says. "For instance, we looked at the frequency with which lower negative events occur, which is one of the drivers for backflow; and we looked at the frequency with which cross connections occur. So it was piecing together available information on the factors that lead to backflow."

The model comprises the following components:

- estimated number of service connections in the U.S. (total and by size category),
- occurrence of service connections with unprotected cross connections,
- proportion of service connections with unprotected cross connections that are considered high hazard,
- occurrence of low-to-negative pressure events,
- percentage of service connections that experience a pressure reduction that may result in contamination,
- estimation of the number of contaminated service connections per event, and
- estimation of the number of contaminated service connections annually in the U.S.

The model includes examples of calculations for estimating exposure, lists exposure aspects not included in the model, and identifies the future steps for assessing exposure.

Cross-Connection Control and Backflow Prevention Programs

According to data compiled by EPA and presented by the FCCCHR at the January 2007 EPA Stakeholder Workshop,

- all 50 states have some requirements for cross-connection control and/or backflow prevention;
- only 31 of these states require water systems to develop a cross-connection control and backflow prevention program;
- forty-two states require authority to implement a local ordinance or rule, 30 states require the ordinance or rule to include enforcement authority, and 23 states require authority for entry for surveys;
- forty-two states require training, licensing or certification of testers;
- and 17 states require the system to notify the public following a backflow event.

Currently, EPA is looking at revisions to the Total Coliform Rule (TCR), and during this review, may look at including broader issues associated with drinking water distribution systems. "Part of our effort in revising the Total Coliform Rule (TCR) is to look at pathways of contamination in the distribution system, and cross connections is one of these pathways," says Yu Ting Guilaran, branch chief of EPA's Office of Ground Water and Drinking Water. "But before we can decide if we should do anything about cross connections, we need to know what the benefit is. We have to answer the question, 'Do we have enough information yet to identify the risk level to public health?'"

More Information

For answers to frequently asked questions about cross connections and backflow, see the American Backflow Prevention Association Web site at *http://.abpa.org/faq.htm.* For a list of backflow prevention videos, see *www.nobackflow.com/videos.htm.* For an introduction to backflow, see *www.irrigationtraining.com/introtobackflow.html.*

Design manuals that address cross-connection control include the *University of Southern California's Manual of Cross-Connection Control*, 9th edition, available from the Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California *(www.usc.edu/dept/fccchr/)*, and the *Manual M14, Recommended Practice for Backflow Prevention and Cross-Connection Control*, 3rd edition, available from the American Water Works Association *(www.awwa.org).*

To view materials presented at the 2007 EPA Stakeholder Workshop, go to *www.epa.gov/safewater/-disinfection/tcr/regulation_revisions.html.* To download EPA's model for estimating backflow contamination risks, go to *www.epa.gove/safewater/disinfection/tcr/regulation_revisions.html.*

A member of NESC for more than eight years, **Caigan McKenzie**, has had a number of her water and wastewater articles reprinted in a variety of publications.