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Cross-sector emergency planning for water providers and healthcare facilities

WATER PROVIDERS AND HEALTHCARE FACILITIES MUST WORK TOGETHER TO DEVELOP EFFECTIVE EMERGENCY PLANS TO SUSTAIN HOSPITAL FUNCTIONS WHEN WATER SUPPLIES ARE DISRUPTED.

The US Environmental Protection Agency (USEPA) has issued guidance for water utility emergency response plans that identifies healthcare facilities and hospitals as particularly critical users (USEPA, 2004). In the context of emergency response planning, the practical implications of this critical user designation includes prioritized notification in the event of failure of the water supply system, prioritized service response in the event of emergency disruption, and inclusion of healthcare facilities in coordinated emergency response planning for either water system contamination or supply disruption. Recent experience suggests that performance in all three areas—notification, prioritized service, and coordinated planning—could be improved.

The twofold purpose of this article is to outline the critical nature of the water supply in sustaining the operations of healthcare facilities (particularly during periods of community emergencies) and to advocate for enhanced cross-sector support from water utilities in meeting this need. The intent of this discussion is to suggest avenues for enhanced coordinated planning for emergency water supply.

The information and ideas presented here were developed in the course of a regional project sponsored by the Metropolitan Washington Council of Governments (MWCOG) for development of emergency water supply operations plans for critical water uses in the Washington, D.C., area (see sidebar on page 77). This article is adapted from a presentation made at the

In the wake of Hurricane Katrina, a boat was used to ferry patients, including an intubated critical care neonate infant (far left), from the Louisiana State University Health Sciences Center to a waiting fire truck.

PHOTO: CINDY NUESSLEIN, CHILDREN'S HOSPITAL

2009 AWWA Water Security Congress in Washington.

WATER SUPPLY INTERRUPTION MAY SEVERELY COMPROMISE THE OPERATION OF HEALTHCARE FACILITIES

Hospitals' recent experiences during natural disasters underscore the need for better planning. Several recent cases have been reported of hospital crises brought on by water supply failures concurrent with natural disasters (Barkenmeyer, 2006; Perrin, 2006). Particularly notable was the fate of some New Orleans hospitals in the wake of Hurricane Katrina in 2005. Hospitals in the area typically made the decision to weather the storm and remain open to support their communities in the days before hurricane landfall. In addition, a determination was made for many patients that it was more dangerous to evacuate in the days before the storm than to shelter in place. In fact, most hospitals found that they could sustain operations during the hurricane thanks to the heroic performance of their staff, makeshift procedures, and onsite emergency power generators. However, when the municipal water supply eventually failed, it resulted in a cascading failure of other critical systems, such as the hospitals' central cooling systems. Ambient temperatures soared, and the hospitals found that conditions became intolerable for critically ill patients, particularly young children and neonates in intensive care. In some cases, these patients had to be evacuated the day after the hurricane under the most extreme conditions.

A natural disaster of a different sort affected the McAlester Regional Health Center in McAlester, Okla., which was without municipal water for two and a half days following an ice storm in December 2000. The hospital resorted to its Y2K plan of the previous year and obtained supplemental water supplies from the National Guard, the fire department, and a local water distributor (Kuchenmeister, 2007).

Other reviews of adverse effects on hospital operations during natural disasters have included discussions of the consequences stemming from loss of water. Researchers detailed the effect of the 2003 blackout in the northeastern United States on four inner-city hospitals (Klein et al, 2005). They reported on hospital equipment and operations that could not function because of lack of water.

- Sterilization equipment required water, as did some X-ray processing equipment.
- Computed tomography scanners and other equipment relied on water for cooling.
- Certain laboratory tests could not be conducted without water.
- Personal hygiene was compromised because staff members were unable to wash hands or equipment.
- Heating, ventilation, and air conditioning (HVAC) systems lacked water for cooling and heating.
- The cafeteria required water for steaming and cooking.
- Toilets could not be flushed, leading to unsanitary conditions.

A literature review of hospital experiences in such disasters as hurricanes, volcanoes, and floods reported similar consequences of water supply disruptions (Milsten, 2000).

Survey delineates hospital experiences during water shortages. As part of the MWCOG project, a written survey of hospitals in the Washington, D.C., area was conducted in summer 2006. The survey was sent to 31 hospitals in the region and included the following questions:

- What are the hospital's water supply sources?
- What is the hospital's typical water use, and what estimate does the hospital have of its emergency needs?
- What are the hospital's principal water uses, and what does it consider its critical water needs during an emergency?
- What specific plans has the hospital made for meeting emergency water supply needs?

The survey also requested copies of the hospital's emergency response plan (if any) and any applicable mutual assistance agreements.

Written responses were received from 26 hospitals, and telephone interviews were conducted with several. MWCOG also conducted a workshop in which survey respondents participated (TriMed, 2007).

In some respects, the 2006 survey was configured as a followup to an earlier survey conducted in 2002. On the basis of the earlier survey, it was reported that "the region's hospitals have an average of 5.8 days of energy generation capability and 2.5 days of water supplies" (DCHA, 2004). However, in both the 2006 telephone interviews and workshop, hospital participants acknowledged that the widely reported figures on water stockpiles supporting the 2.5-day-supply estimate were misunderstood. The 2.5-day supply number had been based solely on bottled water stockpiles intended strictly for drinking. In addition, in discussing their facilities' emergency response plans, hospital managers indicated that the plans had been developed internally, i.e., without substantial discussion with local water utilities.

The 2006 survey responses detailed hospitals' recent experiences with emergency water shortages that had severely stressed their capacities to maintain normal operations (TriMed, 2007). For example, Hurricane Isabel in September 2003 directly affected electrical power systems in the region, which in turn shut down operations for the major water supplier in northern Virginia. Several hospitals were without water for approximately six hours, which affected all consumptive uses and sanitation. Conditions were becoming critical before water was restored. One of the hospitals commented that loss of water supply resulted in a cascading failure of other systems (e.g., cooling, sterilization, and basic toilet sanitation) on which hospital operations are dependent. In contrast to the New Orleans experience during Katrina, temperatures in the D.C. region after Isabel were moderate, and engineers at the largest affected hospital were able to maintain building cooling operations by shifting water from six cooling towers to one unit remaining in operation (Keene, 2003).

Shortages may also result from breaks or other system failures. Another type of water shortage emergency was faced by a group of Washington hospitals as a consequence of a large distribution system main break in 2005. Because of difficulties in isolating the break, the entire distribution zone was affected, and four hospitals were

At Inova Mount Vernon Hospital in Alexandria, Va., emergency water carts are stationed at the stairwell standpipe to supply water for manual toilet flushing and other uses.

Ramps will be needed at traffic crossings to help protect temporary distribution lines such as aboveground hoses or piping.

without water for 12 hours. They reported that the operational consequences were extensive, and that the experience was an eye-opener for them because it emphasized how vulnerable they were to loss of this critical infrastructure (see photograph below).

> When the municipal water supply eventually failed, it resulted in a cascading failure of other critical systems, such as the hospitals' central cooling systems.

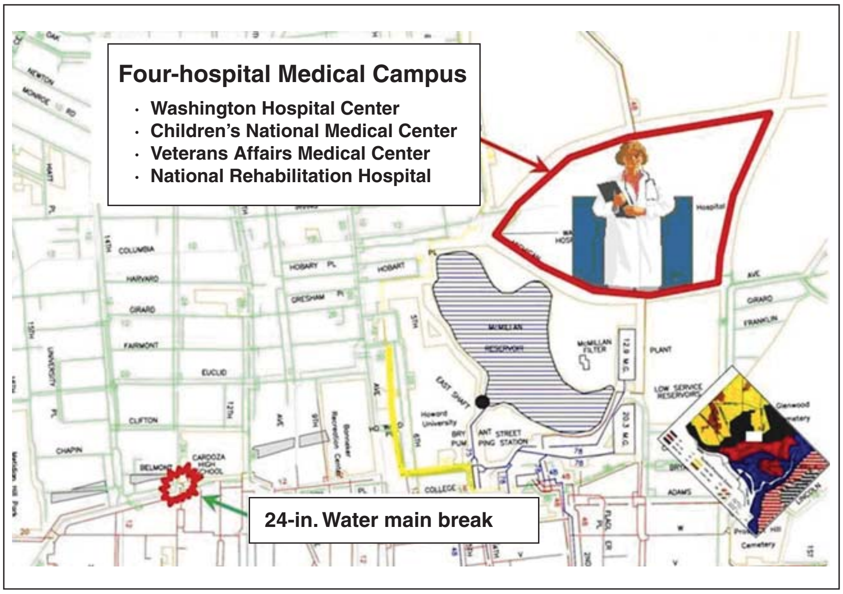
STANDARDS AND AUDIT HELP DEFINE WHAT'S NEEDED

Hospitals' recent adverse experiences highlight the need for more stringent standards for emergency preparedness. Prompted by accounts of the disruption of healthcare facility operations during natural disasters and other emergencies, The Joint Commission, the principal accrediting organization for hospitals and other healthcare facilities, moved to rigorously upgrade the emergency preparedness requirements for hospital accreditation. The Joint Commission's emergency preparedness provisions were revised in 2008 and again in 2009, with the current standard calling for a hospital's emergency operations plan to identify procedures in the event that that "the hospital cannot be supported by the local community . . . for at least 96 hours" (Joint Commission, 2009). This requirement is primarily intended to cover support from utilities providing such services as water, wastewater disposal, power, and heating fuels (Joint Commission, 2009; Wagner 2008).

In the 2008 version of the standard, when the 96-hour requirement was first introduced, a qualifying note stated that "an acceptable response effort would be to temporarily close or evacuate the facility" (Joint Commission, 2007). However, as mentioned previously, evacuation of a healthcare facility before an imminent natural disaster or in its immediate aftermath is in itself fraught with dangers to the evacuees and so is considered a contingency of last resort. Furthermore, communities affected by a natural disaster expect their hospital to remain open and effectively operational throughout an emergency period. Additional background information on the development of The Joint Commission's enhanced standards for emergency management is available elsewhere (Soloff, 2007).

Hospital emergency managers consulted as part of the MWCOG study stated that they considered emergency water supply to be the most intractable of the issues to be addressed in their emergency operations plans. Most hospitals have made provisions for onsite emergency power generators. For most consumable medical supplies, it is feasible at some cost to provide for emergency stockpiles. However, the volume of water required for hospital operations—even in a curtailed mode—is more than healthcare facilities have found feasible to address through onsite stockpiling. Hospital managers noted that in some hospital emergency plans the checkbox for emergency water is marked on the basis of a stockpile of bottled water, but they acknowledged that this constituted only a small fraction of their true emergency needs.

Audit zeroes in on water use. As part of the MWCOG study, an audit of water use was conducted at a major regional hospital in order to quantify and characterize each use on the basis of whether it could be intentionally curtailed during a water supply disruption and still support critical hospital functions (AH Environmental Consultants, 2007). Inova Fairfax Hospital in Falls Church, Va., is an 833-bed regional medical center, with a level-one trauma center and a level-three neonatal intensive care unit. The



A transmission main break in 2005 disrupted water service for 12 hours to one of two high-pressure zones, which included the four-hospital medical campus.

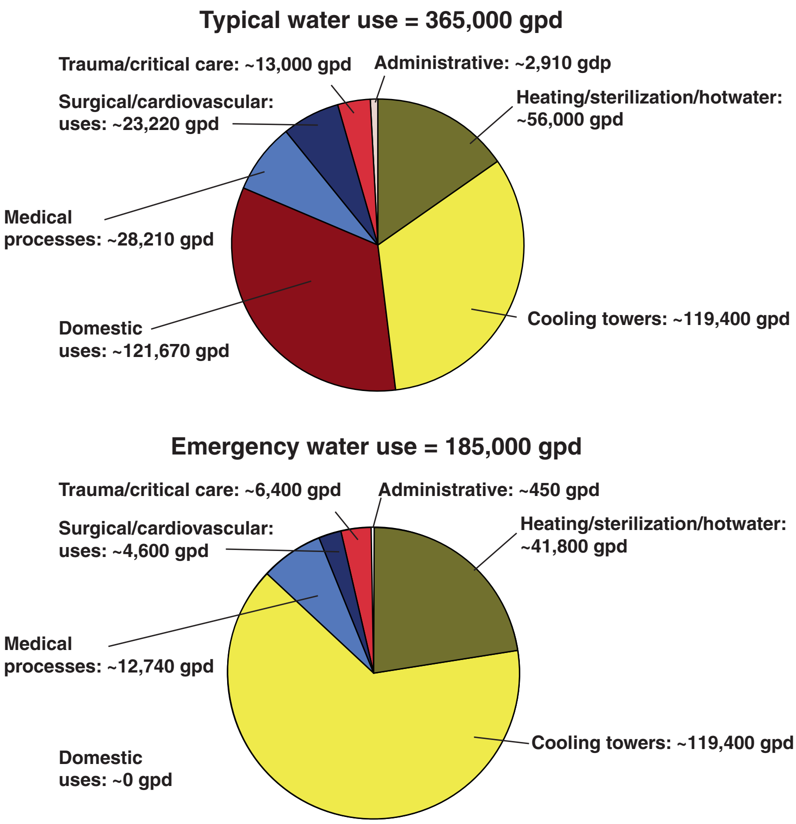


FIGURE 1 Comparison of typical Inova Fairfax Hospital (Falls Church, Va.) water use versus emergency water use (total of essential and critical functions)

hospital was particularly sensitized to the issue of water supply emergency when it experienced a significant disruption in the wake of Hurricane Isabel in 2003.

The water audit consisted of five principal activities: initial interviews with hospital engineering staff, review of water utility master meter records (records of 17 meters provided by Fairfax Water), inspection of fixtures and equipment to identify and characterize water use, installation of temporary flow meters in selected areas, and analysis of data and review with hospital engineering staff.

On the basis of hospital interviews, water uses were broadly categorized as

- domestic (e.g., toilet flushing, handwashing, bathing, showers, cafeteria and food service);
- medical processes (e.g., dialysis, sterilization, medical air compressors, liquid ring vacuum pumps, operating room cleanup, magnetic resonance imaging units, radiology coolant, laboratory); or
- building/industrial (e.g., steam, hot water, air conditioning).

Within each of these uses, the specific demands were then prioritized as either emergency (i.e., loss of life or threat of severe health would result within 6 hours for essential needs or within 6 to 24 hours for critical needs) or normal (i.e., loss would range from minimal effect on hospital function to inconvenient effects on sanitation, but no life-threatening consequences would ensue).

Typical water use at Inova Fairfax Hospital totaled 365,000 gpd (AH Environmental Consultants, 2007). The audit found that under emergency conditions, water use could be curtailed by about half (from ~ 365,000 to 185,000 gpd), depending on the season of the year (Figure 1). The most stringent building heating and cooling needs occurred in winter or summer, the seasons that could be considered to have greater potential for some kinds of natural disasters. The largest residual requirement was for cooling tower blowdown. Recommendations for further reducing water needs included providing treatment to the cooling tower water in order to increase the number of concentration cycles and replacing the existing liquid ring vacuum pumps and medical air compressors with models that do not require water for cooling or seals.

As a first stage in planning for emergency water supply, hospitals and healthcare facilities could look for ways to reduce demand through enhanced conservation or adoption of technologies that are less water-dependent, such as the practices and equipment changes proposed for Inova Fairfax. In addition, conducting an audit of water use of all types within the healthcare facility will provide insight into how much water is used (or wasted) and how much of this use is categorized as essential or critical. Additional details on protocols for conducting hospital water use audits are available in the forthcoming handbook to be issued by the Centers for Disease Control and Prevention (CDC) and AWWA (AH Environmental Consultants, in press).

VARIOUS OPTIONS FOR HOSPITAL EMERGENCY WATER SUPPLY ARE AVAILABLE

Conservation practices, adoption of technology that is less water dependent, and completion of a water audit only go so far. Healthcare facilities and hospitals must plan strategies to meet their residual water requirements after contingent conservation protocols are put in effect. The following sections discuss five approaches for providing an emergency hospital water supply.

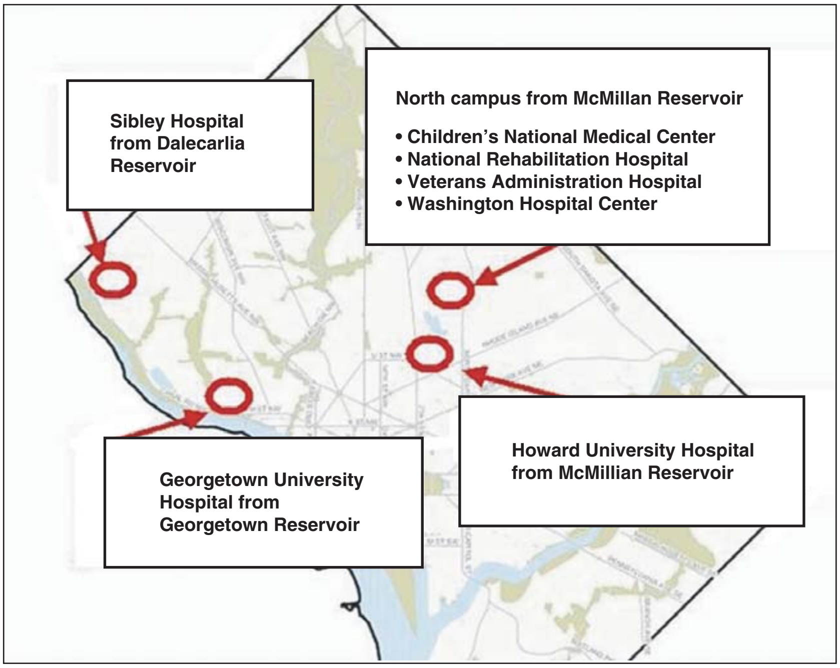
Independent water supply promises self-sufficiency but is not an option for every facility. An independent water supply is the approach that most addresses the issue of hospital self-sufficiency in the event of failure of the public water system and the hospital "cannot be supported by the local community" (Joint Commission, 2009). This approach was implemented by most of the hospitals in New Orleans following their Katrina experiences (Arendt & Hess, 2008). However, the option of an independent supply generally is limited to hospitals with reasonable access to a groundwater aquifer on site or in the immediate area so that a well can be economically drilled, which is often not the case for healthcare facilities in highly developed urban areas.

Inova Mount Vernon Hospital in Alexandria, Va., adopted a practical implementation of the independent water supply strategy with the use of an onsite groundwater well. Although the well was drilled as an emergency water supply, its primary use is for landscape irrigation. For emergency use, the piping is also connected to the building boilers and cooling tower systems. To avoid the potential for cross-connection hazards, however, there is no physical connection to the main hospital water systems or to the municipal supply. (Such a connection was considered in order to supply other hospital needs, but it was determined that the potential safety hazard and regulatory burden outweighed any potential benefit from connecting to an auxiliary.) Subsequent to the initial installation, the hospital extended the groundwater supply lines into the building where they are connected to standpipes in each stairwell. The standpipes are equipped with hose bibs on each floor so that water can be drawn into wheeled drums that can be rolled to individual bathrooms, allowing toilets to be flushed manually with buckets (see photograph on page 70).

Dedicated onsite water storage requires capital investment and attention to water quality. Another option for a hospital is to make a significant capital investment in an onsite water storage facility dedicated to emergency use. However, the implications of such a choice are significant. The hospital must coordinate closely with the public water supplier to determine the appropriate capacity and operating elevation of the storage unit to ensure coordination with the utility's distribution system operation.

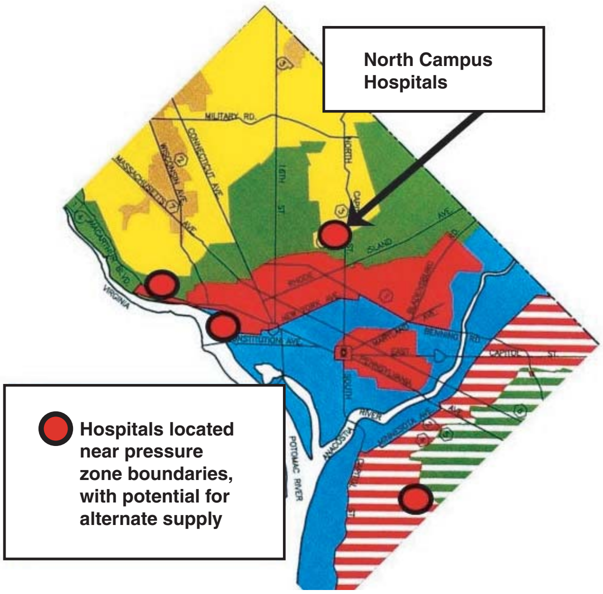
Like the utility's distribution system storage, the hospital's storage tank would need to have adequate turnover of the contents in order to maintain water quality, in addition to maintaining an emergency reserve. This could be accomplished by either constructing the onsite storage facility at an appropriate elevation such that the water surface fluctuates with the ambient distribution system pressure, or forcing the flow direction with one-way check valves or backflow preventers. If the tank's elevation is such that the contents can rise and fall with system pressure, the storage facility could be operated during normal conditions as an integral component of the utility's distribution system (with the understanding that under emergency conditions, the storage facility's valves would be positioned to direct the water solely to the hospital). The

Emergency planning also needs to address the issue of restoration of service after the emergency event, including the decontamination of water distribution systems should they be compromised.



A number of Washington, D.C., hospitals developed plans for providing backup emergency water supplies from nearby reservoirs with partially treated water.

FIGURE 2 Identification of hospitals with potential water service from adjacent higher-pressure service zones



A backup interconnection was established for the north campus hospital system (Washington Hospital Center, Children's National Medical Center, Veterans Administration Hospital, and National Rehabilitation Hospital).

hospital would need to take on the cost of regular maintenance of the storage facility (e.g., periodic inspection and cleaning), although this responsibility could be contracted out to the water utility or qualified contractors.

The water storage facility discussed here is envisioned as a permanent structure that would be operated during normal conditions so as to maintain an adequate reserve volume in case of emergency. Another type of storage for a hospital to consider is temporary storage (e.g., devices such as field bladders) that can be deployed in the event of an emergency. These devices would be operated in coordination with one of the alternative supply options, most likely the emergency tankers discussed subsequently. The hospital would have to develop operating plans for deployment of the storage bladder and schedule its regular inspection and maintenance to ensure it is in satisfactory condition when needed.

Reliance on emergency water tankers has limitations. Many hospital emergency water supply plans include provision for a precoordinated supply from commercial tanker trucks that would transport potable water from outside the affected area. This strategy, though appropriate, has significant limitations. First, the volume of such tankers is typically in the range of 2,500 to 5,000 gal, because tanker trucks of larger capacity would not be safe on roadways. A hospital would be hard-pressed to meet even a curtailed emergency water demand solely from the limited volume available by tanker.

Second, few companies or agencies have the required truck inventory (i.e., large tankers certified for portable water or food-grade transport), and the same providers often are listed in every hospital's emergency plan, as well as the plans of the local governments. In times of emergency, these local facilities and agencies end up competing for the same resource. To mitigate the problem, the hospital could have a prior contract arrangement in place, but it is still likely that an emergency condition that affects multiple hospitals would exhaust the available resources of water tank companies. In addition, traffic congestion during a regional emergency could hinder the timely delivery of trucked in water in sufficient volume.

A third consideration is the hospital's plumbing system, which would require modifications to receive and/or store delivered water. The Florida Department of Emergency Management describes a manifold system involving isolation valves, backflow preventer, and pump that it reports has been implemented at several hospitals in central Florida (Florida SERT, 2005).

Backup service may be available from adjacent public water supply service zones. Backup service is a well-known design element of water and wastewater facilities for providing backup electrical power supply from a separate source. The preferred backup electrical source is a wholly independent generation station, but it is still generally recognized as an improvement if the supply is from a separate substation and routed along a separate transmission corridor.

Healthcare facilities' adverse experiences in the wake of natural disasters and other emergencies have demonstrated their critical dependence on community water supplies.

The same concept could be applied to hospitals for water supply, often without excessive cost. Although not standard practice, backup service for water supply constitutes an opportunity for collaboration and partnership between hospitals and water providers to enhance overall emergency preparedness of critical customers. For example, a hospital water supply connection typically is obtained from a single service zone in the public water system, but there may be potential for establishing a backup supply from a nearby service zone at reasonable cost. Collaboration between the engineering staffs of the hospital and the public water utility would likely be able to identify opportunities that might not be evident to either group working alone, and a joint emergency action plan or memorandum of understanding could be put in place.

TABLE 1 Water use needs in healthcare facilities during water disruption emergencies

Potable Water	Bottled Sterile Water
Drinking water	Surgical scrub
Handwashing	Emergency surgical procedures
Cafeteria services	Pharmaceutical preparation
Ice	Patient-care equipment (e.g., ventilators)*
Manual flushing of toilets†	
Patient baths, hygiene	
Hemodialysis	
Hydrotherapy	
Fire prevention (e.g., sprinkler systems)†	
Surgery and critical care areas	
Laboratory services	
Laundry and central sterile services‡	
Cooling towers†§	
Steam generation	

*This item is included in the table under the assumption that electrical power is available during the water emergency.
†In this article, these items are suggested as potential areas for nonpotable water supply.
‡It may be possible for healthcare facilities to arrange contingency provision of these services from another healthcare provider, independent contractor, or other resource.
§Although some cooling towers use a potable water source, most units use nonpotable water.

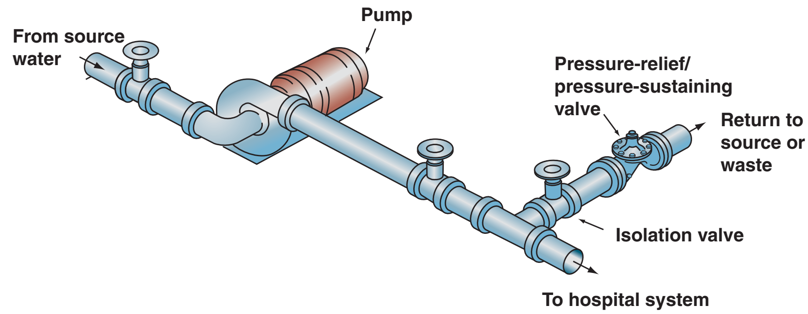
Source: CDC, 2003

In the MWCOG study, backup service from an adjacent pressure zone proved feasible for several hospitals. Through cooperation between the water utility (the D.C. Water and Sewer Authority) and several hospitals acting jointly, a backup service connection was installed to the adjoining zone (Figure 2). Making the backup connection operative required extensive preplanning by both the utility and the hospitals. The utility developed a plan for valve operations to isolate the hospital campus from the normal supply zone and then open the connection to the next higher pressure zone. This process involved operation of six major valves and would likely take two or more hours to be fully implemented in the field. The hospital engineering staffs evaluated the internal building plumbing systems to determine whether a higher pressure of the backup supply could be accommodated. After studies by both engineering teams, they jointly wet-tested their plans (during a less-critical time of day for the hospitals) and found them successful. The utility was able to transfer the supply without interruption, and the hospital infrastructure was able to accommodate the higher pressure.

Emergency supply can make use of both treated and untreated sources. The fifth option for alternative supply identified in the MWCOG study is to draw from any available surface water sources near the hospital. Depending on the intended use, some level of basic emergency treatment of the water may be needed. This approach was demonstrated during the Katrina emergency when the US Army and US Bureau of Reclamation deployed three Expeditionary Unit Water Purification (EUWP) systems for emergency duty, including provision of backup supply to the Biloxi (Miss.) Regional Medical Center (Stocks & Armistead, 2005). However, these deployments were of an opportunistic nature, in that the EUWP systems were not otherwise committed at the time. Typically, the military would not have such resources available because they would be committed in support of the primary defense mission. If a water's intended use requires that it be treated, the hospital might be able to prearrange on-call support from commercial vendors who have mobile treatment units in stock. Such systems may have sufficient capacity to supply a hospital's substantially curtailed water requirements.

The largest, most intractable water requirement for hospitals in an emergency situation is not for drinking or medical procedure uses. The more critical, high-volume needs are for nonpotable uses—building mechanical systems, toilet-flushing, and fire suppression—which may allow some compromise in water potability, provided the hospital's water distribution system can make isolation of these uses practical for alternative supply. In this case, the hospital may consider using reasonably high-quality sources that are untreated or partially treated for these high-volume demands and meeting drinking water and medical uses with supplies that could be stockpiled (i.e., bottled water). Table 1 summarizes CDC guidance on water quality require-

FIGURE 3 Typical piping system elements for temporary emergency backup supply



System includes a pressure-relief/pressure-sustaining valve for pumping into a closed distribution network. The piping system is connected to the hospital system on the customer side of the water utility backflow preventer.

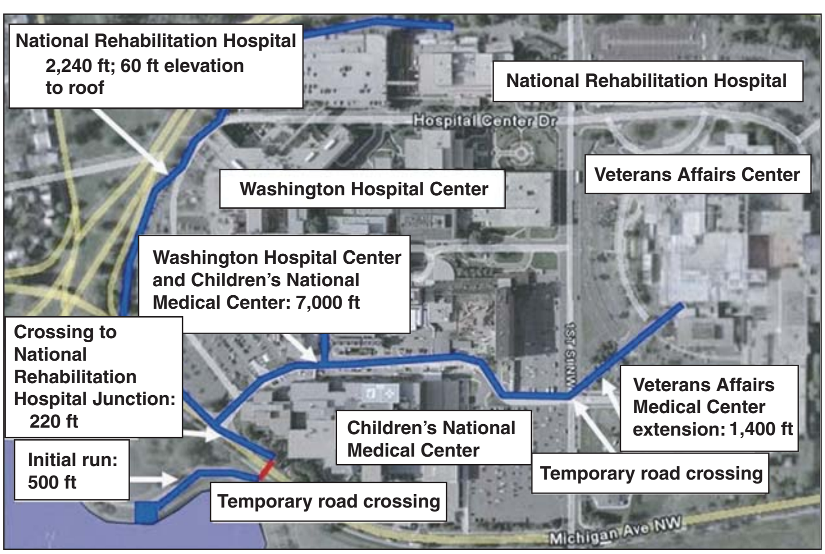
ments for various hospital uses (CDC, 2003). (The CDC reference indicates potable water for some uses that this article suggests can be met by water of lesser quality.)

The MWCOG study found that several Washington area hospitals are located near large reservoirs of partially treated water owned by the water treatment agency, the Washington Aqueduct Division of the Army Corps of Engineers (see photograph on page 73). In the event that a disaster disabled the public utility's treatment or distribution pumping facilities, water from these reservoirs could be made available for emergency hospital use. In the study, distribution layouts were developed for deployment of ground surface distribution hose from the reservoirs to physical plant locations at the hospitals (see photograph below).

Planning for use of the reservoirs entailed significant involvement by the hospitals, water utilities, fire department, and local emergency management agency. In recognition of the fact that an extensive level of field operations by either the utilities or fire department might not be available during an actual emergency, a recommendation was made to the hospitals that they contract with equipment rental companies with emergency asset deployment capability. Technical operational aspects that needed to be addressed in the operational plans included

- routing of aboveground hoses or temporary piping, including provisions for traffic ramps where the distribution lines would have to cross traveled roadways (see photograph on page 70);
- provision for disinfection of hoses, pipes, and pump apparatus not normally used for potable water purposes (depending on the intended water use); and
- special valve control capability for pumping into closed-pipe systems (Figure 3), which the rental contractor or fire department typically would not be familiar with in its normal dewatering or firefighting operations (Typical construction operations involving sewage bypass or dewatering pumping and a fire department's normal firefighting operations both involve pumping to open atmosphere. Pumping into a closed-pipe system would require special valving in order to match supply and demand rates. The water utility would be able to provide guidance on this issue. Another approach to the closed system supply problem would be the use of a hydropneumatic tank; however, the tank size that would be needed for a large hospital may be impractical).

Plans should cover recovery after the event. Emergency planning also needs to address the issue of restoration of service after the emergency event, including the decontamination of water distribution systems if they are compromised. Disinfection of water mains on the hospital campus should follow the procedures established in AWWA Standard C651-05 (AWWA, 2005); the water utility can provide



This schematic shows the locations of temporary distribution hose and/or pipe routing for emergency service to north campus hospitals.

essential support in this effort. To address decontamination of the building plumbing, the CDC has published information on repair of healthcare water systems after disruption of water supply as part of *Guidelines for Environmental Infection Control in Healthcare Facilities* (CDC, 2003).

CONCLUSION

Healthcare facilities' adverse experiences in the wake of natural disasters and other emergencies have demonstrated their critical dependence on community water supplies. In recognition of the importance of sustaining water supply during emergencies, accreditation standards for healthcare facilities have been raised to place more emphasis on emergency preparedness.

This study found that bridging this water supply need and developing effective solutions will require active cooperation and involvement on the part of both healthcare facilities and water utilities. Water providers can take a proactive role by engaging hospital managers in their service areas and working with them to develop effective emergency operation plans.

ACKNOWLEDGMENT

The authors thank Stuart Freudberg, director of the Department of Environmental Programs for the Metropolitan Washington Council of Governments, who directed the overall project. They also thank the following individuals for their assistance on various aspects of the project described in this article: Craig Deatley, Susan Eckert, and George Thorne of the Washington (D.C.) Hospital Center; Curtis Cochrane of the D.C. Water and Sewer Authority; Tim Gerhart of the D.C. Fire and Emergency Medical Services; Mel Tesema of the Washington Aqueduct Division, US Army Corps of Engineers; David Marra of Inova Fairfax Hospital, Falls Church, Va.; Pres Andam and Patricia Needham of Children's Hospital

Emergency Planning Tasks to Address Critical Water Uses

The work described in this article was accomplished as part of a larger project on regional water supply emergency operation plans sponsored by the Metropolitan Washington Council of Governments, the central coordinating organization for the 21 local governments surrounding the nation's capital. The project was funded through an urban areas security initiative grant from the US Department of Homeland Security.

The objective of the project was to engage representatives of various community agencies to develop specific operational emergency response plans (O'Brien & Gere, 2007). Agency coordination included water utilities, emergency management agencies, fire departments, hospitals, and others. The project scope was to develop model operational plans to address provision of alternative water supply in the event of emergency failure of the public water systems. Four critical water use areas were identified: potable water, firefighting, sanitation, and healthcare facilities. The following paragraphs discuss the tasks completed by various agencies for the first three areas of water use; healthcare needs are addressed in the main article.

Under the potable water task, the primary output was the development of fact sheets for point-of-distribution sites from which bottled water and other emergency commodities could be distributed, in accordance with guidance issued by the US Army Corps of Engineers (USACE, 2005). These fact sheets included diagrams of the sites with recommended traffic flow and inventory layout, site capacity, and logistic resources needed to operate the site at the specified capacity. This task also reviewed technologies and commercial availabilities for emergency water treatment systems.

Firefighting response planning was targeted at urban and near suburban fire departments and involved putting together site-specific fact sheets documenting access to alternative water-drafting locations (e.g., riverbanks, streams, and reservoirs). Development of site-specific utilization plans for such alternative sources is commonplace among rural fire departments, but such plans are typically not developed in detail for urban and near suburban settings.

The sanitation task took the form of development of public outreach literature describing sanitation measures the public could take in the event of a sustained water supply emergency. A brochure was prepared that could be distributed to the public by member governments.

National Medical Center in Washington; Steve Mabley of Veterans Affairs Medical Center in Washington; and Andrew Welter and Mike Bickerstaff of O'Brien & Gere in Landover, Md. There were also many other contributors, too numerous to list here.

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Date of submission: 09/02/09
Date of acceptance: 11/16/09

JOURNAL AWWA welcomes comments and feedback at journal@awwa.org.

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