

Aqua ut a Telum “Water as a Weapon”

By

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Introduction and History:

In recent years many articles, scholarly papers, opinion pieces and books have been written about how the growing shortage of resources, especially clean water, will eventually lead to conflict and perhaps even war. Whether or not any of these hypothetical scenarios of escalating conflict will play out is a matter of conjecture. While peaceful solutions to the problem of allocation will be difficult they are by no means impossible and can be worked upon and hoped for; however, one other aspect of water having to do with conflict may be even more difficult to avoid. That is the actual utilization of water as a weapon or weapon vector.

There is ample proof in the historical record, from all over the world, that attempts to thwart an enemy by denying them access to water or actively seeking to inflict casualties by adulteration of the water supply has been used by many groups as a tactic. The historical record of the use of water as a weapon goes as far back as 1000 BC when it is reported that ancient Chinese warriors used arsenic to contaminate the water supplies of their enemies.¹ History is replete with other examples. A few of the documented incidents are listed below. There are many more.

600 BC The Assyrians used ergot, a naturally occurring hallucinogenic fungus similar to LSD, to contaminate the wells of their enemies.²

590 BC Solon of Athens placed the purgative hellebore in the water supply of the city of Cirrah to disable the defenders with crippling diarrhea.³

300 BC Numerous examples of the use of dead animals for the contamination of wells and other water sources are quoted in Persian, Greek and Roman sources from this period.⁴

128 BC In Asia Minor the Roman army poisoned wells relied upon by the rebel Aristonicus and his troops so as to ensure a Roman victory.⁵

1155 The Holy Roman Emperor Fredrick I, also known as Barbarossa had human corpses placed in the city of Tortona's water supply. According to all reports this was a success, and the water supply was contaminated.⁶

1466 Vlad Tepes also known as Vlad the Impaler or Vlad Dracula (The basis of the Dracula Vampire myth) ordered the burning of crops, the poisoning of wells,

and the killing of all animals, so that the invading Turks would find nothing to eat or drink. Mahmud Pasha lamented, "*For six leagues not a drop of water was to be found. The intensity of the heat caused by the scorching sun was so great that the armor seemed as if it would melt like a lighted candle.*"⁷

- 1759 During the Machandal slave rebellion in Haiti, slaves with knowledge of herbs and their properties were able to poison the water supplies of a few planters and animals.⁸
- 1863 During the American Civil War, Confederate General Joe Johnson ordered the contamination of water sources by placing the carcasses of dead sheep and pigs in wells and ponds to slow the Union advance by depriving them of water sources.⁶
- 1904 In an attempt to exterminate the Herero and Nama peoples of South West Africa, The German military intentionally poisoned wells and other water sources.⁹
- 1939 The Japanese military poisoned Soviet water sources with intestinal typhoid bacteria in an area near the former Mongolian border.¹⁰
- 1945 The Desperate and retreating German Army poisoned a large reservoir in Bohemia with raw sewage.¹⁰
- 1946 In the final days of World War II, a group of Jewish resistance fighters hatched a plot to poison the water supplies of several major cities in Germany. The goal was to inflict over 6 million casualties. Logistics problems forced a scale back of the plan resulting in the poisoning of several thousand German POWs via poisoned bread.¹¹
- 1960's Yasir Arafat's Fatah movement orchestrated several bombing attacks on Israeli water infrastructure.¹²
- 1970 During the democratic National Convention in Chicago, the Yippie political movement threatened the city water supply with LSD requiring US Army troops and National Guard be called out to guard the reservoirs.¹³
- 1970 The Ku Klux Klan poisoned the water supply of a farm belonging to Black Muslims. 30 cows were killed.¹⁴
- 1970 Members of the Weather Underground plotted to obtain biological weapons from the US bacteriological warfare facility at Fort Detrick Maryland. They planned to use them to contaminate the water supply of several major US cities.¹⁵

- 1972 Neo-Nazis from a group known as RISE obtained botulinum, meningitis, anthrax and typhoid, which they planned to use to poison water supplies in Chicago and Saint Louis.¹⁶
- 1977 A reservoir in North Carolina was intentionally contaminated rendering it unusable.¹⁶
- 1980 In Pittsburgh a disgruntled employee intentionally injected weed killer into fire hydrants.¹⁵
- 1982 A man in Los Angeles was arrested preparing to poison the water supply of the city with a biological agent.¹⁷
- 1983 Investigation of a threat to poison water supplies in Louisiana revealed traces of cyanide.¹⁷
- 1983 The Israeli government reported a plot to poison Galilee water supplies.¹⁶
- 1985 In New York City investigation of threats to poison the water supply with plutonium showed increased levels of plutonium in the water.¹⁸
- 1986 The Covenant, Sword and Arm of the Lord, a Christian survivalist group, stockpiled large quantities of Potassium Cyanide with plans to poison water supplies of several major US cities.¹⁹
- 1987 In the Philippines 19 police recruits died and 140 were hospitalized after being given poison water.¹⁶
- 1992 The Kurdish Peoples Workers' Party (PPK) poisoned the water supply tanks at a Turkish Airbase in Istanbul with Potassium Cyanide.²⁰
- 1993 At a meeting of Islamic Fundamentalist groups in Tehran, Iran, one of the proposals discussed was the idea of poisoning the water supplies of major cities in the west as a response to Western aggression against Islamic organizations and states.²¹
- 1999 In an attempt to force Britain to withdraw troops from Northern Ireland, Adam Busby, threatened to poison the UK's water supplies with the weed killer Paraquat.²²
- 2000 A man was arrested for attempting to poison the water supply of Kurusaray, Turkey with insecticide.²³
- 2000 A water tank for a condominium in Singapore was deliberately poisoned with kerosene and turpentine.²³

- 2001 Abu Sayyaf, a Philippine terrorist organization, contaminated the water supply of the town of Isabella with a substance causing a gasoline taste and odor.²⁴
- 2002 Al Qaeda members were arrested in Rome with chemicals and plans to poison the water supply around the US Embassy.²⁵
- 2002 FARC rebels poison a water treatment plant in Pitalito, Columbia.²⁶
- 2002 Two Al Qaeda operatives were arrested in Denver with plans to poison US water supplies.²⁶
- 2002 Russian Special Forces uncover a plot by Chechen rebels to use a potent poisonous substance to poison the water supplies in Grozny.²⁶
- 2002 Boere Vryheids Aksie (BVA), a South African White Supremacist group, planned to poison millions of black South Africans by contaminating water supplies with tetranium, an agricultural poison.²⁷
- 2002 Al Qaeda operatives were arrested with plans to attack water supply networks surrounding the Eiffel Tower neighborhoods in Paris.²⁸
- 2003 Jordan foils an Iraqi plot to poison drinking water supplies feeding U.S. military bases along the Eastern desert.²⁹
- 2003 In China, a man is arrested after dumping a pint of insecticide into a reservoir. 64 people were ill and 42 were hospitalized after the exposure. The man was a seller of water purification devices, and his only motive was to increase sales.³⁰
- 2004 In April, a Sudanese man with Iranian intelligence contacts is captured carrying a very powerful poison in Iraq. The man was reportedly preparing to poison the water supply of Diwanayah a city 100 miles south of Baghdad.³¹
- 2003 FBI and Department of Homeland Security issue a bulletin warning that terrorists were trying to recruit workers in water plants as part of a plan to poison drinking water at the treatment plants.³²
- 2004 The Sudanese Government utilizes the practice of poisoning wells in their attacks on black civilians in the Darfur region.³³
- 2005 The reservoir in Kaikoura, New Zealand had to be drained after threats by environmental activists were made and compound 1080, a dangerous poison, was found at the site.³⁴
- 2006 A water tank in Tring, England was deliberately contaminated with weed killer.³⁵
- 2006 In Queensland Australia crops were deliberately destroyed by someone intentionally contaminating a water tank with glyphosate herbicide.³⁶

- 2006 Strychnine was intentionally placed in a Danish reservoir.³⁷
- 2007 A terrorist threat to poison water supplies led to a big security alert at reservoirs and treatment works across Britain.³⁸
- 2007 In China 201 people fell ill and 1 died when water intentionally contaminated with fluoroacetimide was used to make porridge.³⁹
- 2008 In Varney, West Virginia a man was arrested with 2 canisters of Cyanide and plans to poison the water supply.⁴⁰
- 2008 In California a water tank was intentionally contaminated with Mercury.⁴¹
- 2008 In China 60 school children fell ill when their water supply was intentionally contaminated.⁴²
- 2008 In Swaziland, a land dispute resulted in the intentional poisoning of an entire villages water supply.⁴³
- 2009 The water supply of a Burmese refugee camp (pop. 30,000) in Thailand was intentionally poisoned with weed killer.⁴⁴
- 2009 Moscow police warned of a plot to poison the city's water supplies.⁴⁵
- 2009 Water supplies were disrupted to the Auckland, New Zealand business district when a group calling itself the United Freedom Fighters made threats to use cyanide to poison the water.⁴⁶
- 2009 In the Philippines Moro Islamic Liberation Front (MILF) rebels poisoned water sources being used by government soldiers and local residents.⁴⁷

The above examples should indicate that water is indeed a target and can be utilized as a weapon or weapons vector. In the past Governments, The Military, Terrorist Organizations and Fringe Groups as well as Unstable Individuals have sought to exploit the vulnerability of our water supplies. Just what are these vulnerabilities?

Vulnerability Assessment:

Source Water and Reservoirs: When observing a typical municipal water supply system (Figure 1) it is natural to assume that the main point of vulnerability to an intentional contamination attack would be the introduction of an agent into the system at the source water (reservoir). Many sources are distant from populated areas and are spread over wide geographic areas making physical security methods difficult to implement. However; in order to create widespread casualties from an attack on the source water, the amount of contaminant required would, after taking dilution into account, be either too large to handle easily or be more expensive than other readily

available terrorist weapons. Within the water industry, this concept is summarized by the phrase *dilution is the solution to pollution*.

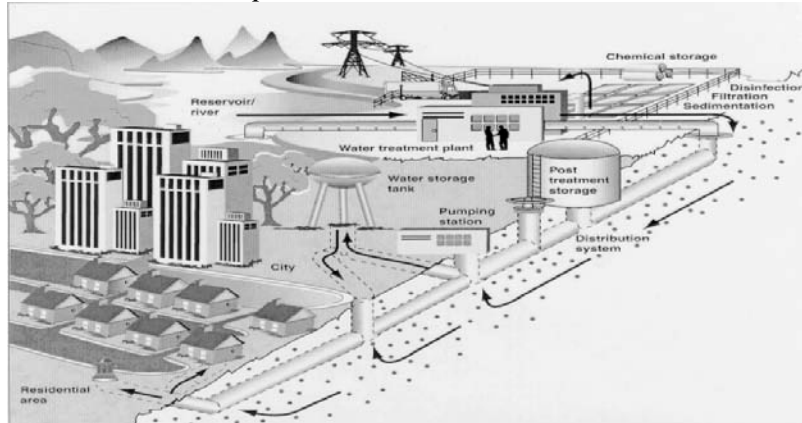


Figure 1 A representative municipal water supply system.

While an attack on source water is possible and precautions should be taken to monitor all sources for potential contamination, it is by no means the most vulnerable point in the water supply system. Not only would large quantities of contaminant be required because of dilution, but this point in the system is also exposed to natural conditions such as light that may significantly degrade some potential threat agents. Also, this point is pretreatment and many contaminants can be degraded or removed by conventional water treatment practices. The main threat to source waters is actually accidental or naturally occurring pollution rather than intentional attack.

Treatment Plants:

In many cases the treatment plant is the last barrier between natural, accidental or deliberate contamination and the consumer. The concept of dilution is vastly diminished by the time the water reaches the treatment plant. All of the water passing this point is destined for use and, the volumes are substantially less than source waters. With that being said, the water volumes can still be quite large with some plant treating 100s of millions of gallons per day, which offers some prospect for dilution to occur.

From a security standpoint, another advantage of treatment plants is that they have a relatively small footprint. Even the largest are contained in a controllable geographic area. This allows the deployment of physical security measures such as locks, gates and cameras. These measures, while not fool proof, do offer a means of protecting these sorts of facilities. While such measures would probably not thwart a determined insider from causing harm, there is a second tier of protection at the treatment plant. Most modern treatment plants are the most closely monitored and instrumented portions of the entire water supply system. On-line, laboratory and field spot testing of the various processes at the plant lead to a good picture of the overall water quality leaving the plant. Severe anomalies are liable to be detected and addressed.

Finished Water Storage and Distribution:

Initially following the terror attacks of 9/11 many governments declared water supplies to be secure due to the concept of dilution. The concept of dilution providing security for the system was short lived. It wasn't long before government officials and

industry experts realized that the crucial vulnerability to contamination was in the distribution system. By October 2003 a Government Accounting Office report to the United States Senate stated that the distribution system was the area most vulnerable to attack.⁴⁸ Conceding that an intentional contamination event would most likely take place somewhere in the distribution system, several misconceptions about this type of attack still persist. Historic (and incorrect) dogma holds that such attacks require the assistance of several technicians, are expensive to carry out, and require complicated and expensive pumping equipment to inject contaminants into a pressurized system. More recent studies by the United States Army Corps of Engineers, among others, show that CBR attacks could in fact be carried out for 50 cents or less per lethal dose, that a single individual can obtain or produce effective contaminants in quantity, and that contaminants can be introduced into the distribution system with the aid of inexpensive and easy to obtain pumping equipment via a method called *backflow attack*.^{49,50,51,52}

What is a Backflow Attack?

A backflow attack occurs when a pump is used to overcome the pressure gradient that is present in the distribution system's pipes. This is usually around 80 lbs/in² and can be easily achieved by using pumps available for rent or purchase at most home improvement stores. After the pressure has been overcome and a contaminant introduced, Bernoulli effects pull the contaminant into the flowing system and the normal movement of water in the system acts to disseminate the contaminant throughout the network effecting areas surrounding the introduction point. The introduction point can be anywhere in the system such as a fire hydrant, commercial building or residence. See figure 2. Studies conducted by the US Air Force and Colorado State University have shown this to be a very effective means of contaminating a system.⁵³ A few gallons of highly toxic material was enough, if injected at a strategic location via continuous feed, to contaminate an entire system supplying a population of 150,000 people in a matter of a few hours. A terrorist could launch such an attack and be on a plane out of the country before the first casualties begin to show up.



Figure 2. All distribution systems are vulnerable to backflow attacks.

Due to the fact that the distribution system is by its very nature widespread and accessible, there are no physical security measures that can effectively safeguard the system. This leaves the concept of on-line monitoring and early warning as the only alternatives to ameliorate the effects of such an attack. One monitoring concept that is rapidly becoming widely deployed is the concept of bulk parameter monitoring coupled with interpretive algorithms

Bulk Parameter Monitoring

Bulk parameter monitoring is the method of monitoring common water quality parameters and then looking for anomalies that may be indicative of a water contamination event. Immediately after 9/11 the concept of deploying common sensors to act in just such a manner was investigated for water security monitoring. A number of government⁵⁴, academic⁵⁵, and private industry studies⁵⁶ evaluated various sensors to see if they would respond to the contaminants most likely to be used by a terrorist in an attack.

Various instrument manufacturers have developed multiple parameter water quality monitors for both source water and distribution system water. These systems encompass a diverse selection of different sensors and can be tailored to meet monitoring needs. The current state of bulk parameter online monitoring with existing instrumentation is that significant actual events should be detectable. The problem is what to do with all of this data. Enormous amounts of streaming data need to be processed. Another problem is the minute-to-minute variability that is present in a system. How are we to determine if alterations in water quality parameters are significant against a background of dynamic changes? In the words of an anonymous sixth grader, “I have heard that you can tell what time it is by looking at the sun. I myself have never been able to make out the numbers.” Unless a full-time team of statisticians is to be employed to make sense of this information, there is a need for intelligent algorithms to streamline the process.

An assortment of sophisticated algorithms for interpreting online data and recognizing threats is being developed by a number of private and public entities including Sandia National Labs and the EPA in their Threat Ensemble Vulnerability Assessment (TEVA) program. One such commercially available system, makes use of five common bulk parameters that are monitored simultaneously in real time. The parameters that are monitored are pH, conductivity, total organic carbon, turbidity, and residual chlorine. When measured in real time, these parameters can show a lot of variability in a given system.

That is why a baseline estimator that is sensitive to small perturbations and yet is resilient enough to not be constantly alarming due to normal fluctuations is required when developing such a system. Many classical methods of baseline determination result in poor sensitivity or high false alarm rates. The proprietary baseline estimator used in this system seems to address these problems. In the system as it is designed, the signals from all of the instruments are processed from a five-parameter measure into a single-scalar trigger signal in an event monitor computer system that contains the algorithm. The signal then goes through the crucial proprietary baseline estimator. A deviation of the signal from the estimated baseline is then derived. Then a gain matrix is applied that

weights the various parameters based on experimental data for a wide variety of probable threat agents. The magnitude of the deviation signal is then compared to a preset threshold level. If the signal exceeds the threshold, the trigger is activated.

Even with noisy data, the system does not trigger at a threshold level set at 1. Therefore; during normal operation, with no agent present, the process deviation should not be large enough to produce a trigger signal. However, when the data for a cyanide incursion at 1% of the LD-50 or approximately 2.8 mg/L is superimposed on the system, the trigger level of 1 is easily exceeded. Other contaminants exhibit similar results.

The unknown alarm rate, when the system is tracking real world data, is also quite low. The system is equipped with a learning algorithm, so that as unknown alarm events occur over time, the system has the ability to store the signature that is generated during the event. The operator can then go into the program and identify that function and associate it with a known cause such as the turning on of a pump or the switching of water sources, etc. Then, the next time that event occurs, it will be recognized and identified appropriately. Over time as the system learns, the probability of an unknown alarm that has not been previously encountered and identified will continue to decrease and will eventually approach zero.

The probability of an unknown alarm due to a given event depends on the frequency of the occurrence of such an event and the time that the algorithm has had to learn that event. Events that occur frequently will be quickly learned whereas rare or singular events will take longer to be learned and stored. This results in a fairly rapid drop off in the number of unknown alarms as common events are quickly learned.

The deviation vector that is derived from the trigger algorithm contains significantly more data than what is needed to simply trigger the system. The deviation vector's magnitude relates to concentration and trigger signal, whereas the deviation vector direction relates to the agent characteristics. Seeing that this is the case, laboratory agent data can be used to build a threat agent library of deviation vectors. A deviation vector from the water monitor can be compared to agent vectors in the threat agent library to see if there is a match within a tolerance. This system can be used to classify what agent is present. Each vector results in a vector angle in n -space. The fact that the direction of the vector is unique for a given agent allows the use of an algorithm to classify the cause of a trigger being set off. When the event trigger is set off, the library search begins. The agent library is given priority and is searched first. If a match is made, the agent is identified. If no match is found, the library of learned responses called *the plant library* is then searched, and the event is identified if it matches one of the vectors in the plant library. If no match is found, the data are saved and the operator can enter an ID when one is determined. The agent library is provided with the system, and the plant library is learned on-site.

This type of system has unique advantages that should be noted. First, as soon as the system is turned on, it will be actively working and will have the ability to trigger and classify immediately if the signature of a known threat agent is encountered. Second, if a completely unknown agent is introduced at levels that exceed the threshold signal level, the system will trigger and classify it as an unknown agent that warrants further investigation. This attribute of the system is unique and the only available method that will trigger an alarm on contaminants not previously known to the system or its developers.

A number of similar multi-parameter measurement platforms without the addition of intelligent algorithms have been evaluated for such applications.⁵⁴ These systems appear to be a good choice for detecting water quality excursions that could be linked to water security events. There are a number of advantages in using such systems. The chief advantage is that these instruments are not new. They are common everyday parameters that the average industry worker is quite familiar, thus adding a degree of comfort in operations not afforded by other new technology.

As existing technologies, these instruments have been proven to be robust and dependable in prior field deployments. They represent measurements that would be of interest and use to water utility personnel above and beyond their role as water security devices. This in turn could allow improvements in system operation that may result in cost savings and definitely will result in a higher quality product being delivered to the consumer.

One of the largest advantages to this type is the multi-parameter array's ability to detect such a wide variety of potential threat agents from metals to organics to bioagents. The ability to trigger on unique unknown events is also a major advantage. Some of the disadvantages are that there are some events that occur during normal operation that may trigger an unknown alarm. This, however, can be an advantage if the information is used to streamline operational procedures and lower costs while improving quality. Nonetheless, this learning phase does generate "unknown" alarms associated with normal system maintenance and requires an input of time and effort to investigate and classify these alarms, so that they can be placed in the plant library.

With the current state of technology, there is no need for us to operate our water systems in the unsecured mode of the past. Admittedly, the instrumentation available today is not perfect, but it will show us a clear enough picture to avoid many of the hazards that we would surely encounter if we left the old paradigm in place.

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