Cyberterrorism & the Security of the National Drinking Water Infrastructure

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Introduction

- **IT Pro**, 5 years; have a few certs….
- **Water Commissioner**, 13 years, 1997-2010
- **Mass.** DEP 6 years**,** Legislative Liaison
- **Clean Water Action**, 10 years

Speaker: The Next HOPE, "Electronic Take Back"

Speaker:

- NEWWA Conferences, 2007 - 2009
- AWWA, National Water Security Congress, 2009

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Objective of this talk: *To make a realistic assessment of the potential of a terrorist attack, cyber or kinetic, against US public water systems.*

NOTE: Nothing will be presented here to assist anyone seeking to attack drinking water systems. Only information from open sources will be presented. The objective of this presentation is to improve the protection of public water systems from attack.

DISCLAIMER*: the views expressed are my own, not of any organization of which I am a member*

Outline

- Definitions
- Threats to Drinking Water
- National Water Infrastructure Issues
- Components of a Single Water System
- SCADA Security Issues
- Public water vulnera-bilities & programs
- Conclusions

Definitions

- **Public Water System**
- **SCADA**: *Supervisory Control And Data Acquisition;*
  - *Process Control Systems,*
  - *Distributed Control Systems*
- **Critical Infrastructure** [drinking water is a critical infrastructure]
- **Cyberterrorism**

Cyber [insert word]

- Cyber [space]
- Cyber [attack]
- Cyber [crime]
- Cyber [war]
- Cyber [espionage]
- Cyber [attack]
- Cyber [terrorism]

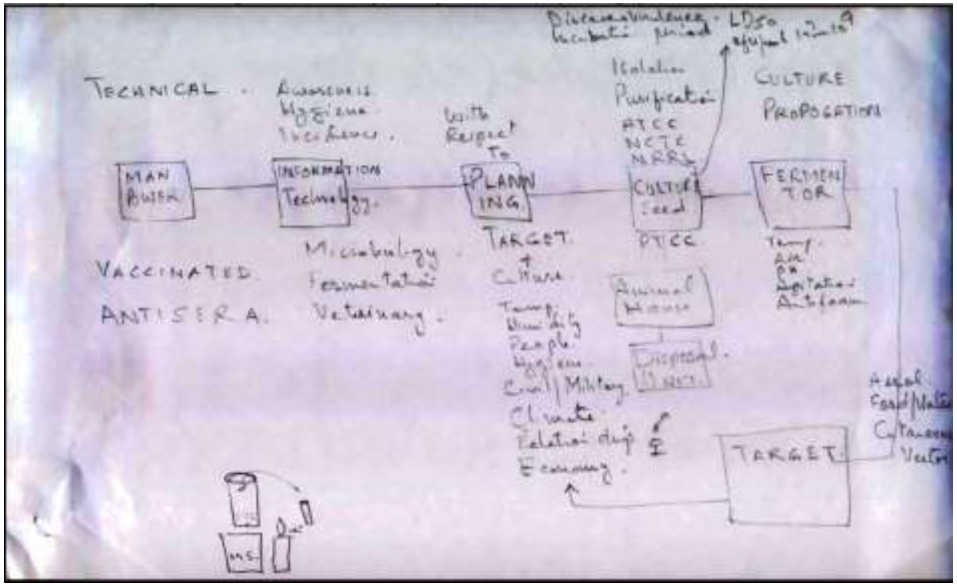
Drinking water has been the target of attacks for thousands of years

- 500 BC, Assyrians poisoned the wells of their enemies with rye argot.
- 1462, Vlad the Impaler burned villages and poisoned his own wells to deny them to the invading Turks.
- In 1844, a mob destroyed a reservoir in Mercer County, Ohio, they considered it a health hazard.
- 1907-1913, Los Angeles aqueduct was bombed to prevent diversion of water Owens Valley to LA.
- 1939-1942, Japan's Unit 73 poisoned wells and reservoirs with typhoid and other pathogens.
- 1977, North Carolina reservoir was poisoned with an unknown substance
- 1992, Turkey, potassium cyanide found in Turkish Air Force water ; Turkish Workers Party takes credit.
- 1998-1999, Kosovo, Serbs dispose of bodies in wells to poison them
- 2003, Michigan, four incendiary devises found in water bottling plant; ELF claims responsibility
- 2006, Sri Lanka, Tamil Tiger rebels cut the water supply for government held villages; government then attacks the reservoirs

Canada
United States
Mexico
North Atlantic Ocean
Iceland
Sverige
Sweden
Norge
Norway
United Kingdom
France
España
Spain
Italy
Algeria
Libya
Mauritania
Chad
Nigeria
Venezuela
Colombia
Perú
Brasil
Brazil
Bolivia
Chile
South Pacific
South Atlantic
Namibia

There have been terrorists threats to poison US public water supplies

- 1972 – Order of the Rising Sun, Chicago, typhoid cultures
- 1985 - Covenant Arm & Sword of the Lord, Arkansas, potassium cyanide
- 2001 - FBI warning of a “North African terror group” threat to 28 US water supplies
- 2002 – FBI arrests two Al Qaeda suspects with papers on poisoning US water supply
- 2003 – Al-Qaeda in Saudi magazine does not rule out “poisoning of drinking water” in US
- 2003 - Handwritten notes sized from the Al Qaeda Tarnak Farms, Afghanistan showed plans to poison drinking water with pathogens
- 2003 – Greenville, North Carolina, ricin found at Post Office with threat to water supply
- 2008 – Al Qaeda website calls on members to attack US water supplies



Terrorists do have adequate cyber capability

- Al Qaeda has computer training centers
- Al Qaeda has people with IT skills
- Al Qaeda uses the internet to connect their loosely interconnected separate cells across the world
- They perpetrate cybercrime to raise funds
- There is no evidence that Al Qaeda has perpetrated a cyber attack on a water facility, or any facility, or plans to do so.
- Evidence seems to suggest that Al Qaeda uses the internet extensively for:
  - organizing,
  - propaganda, disinformation ,
  - management of their organization,
  - raising funds, and
  - stealing money, but
  - not for cyber terrorism itself, yet
- That, of course, could change….

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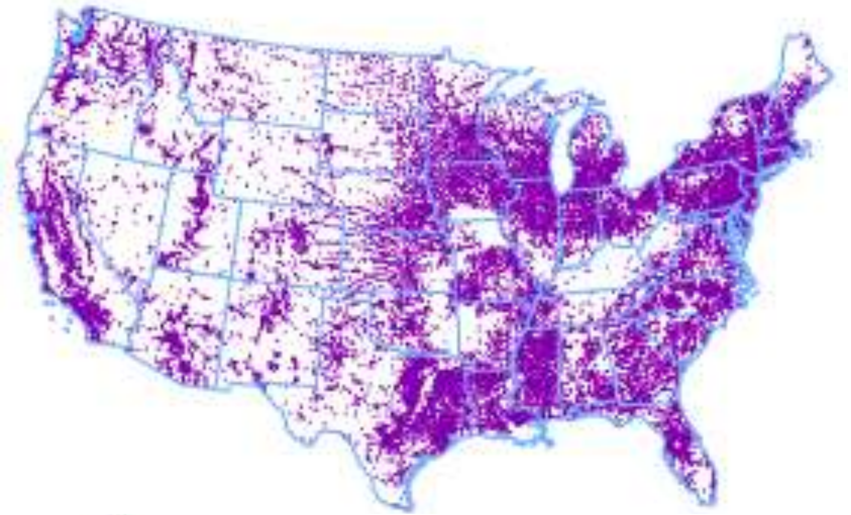
There have been some cyber attacks on water systems

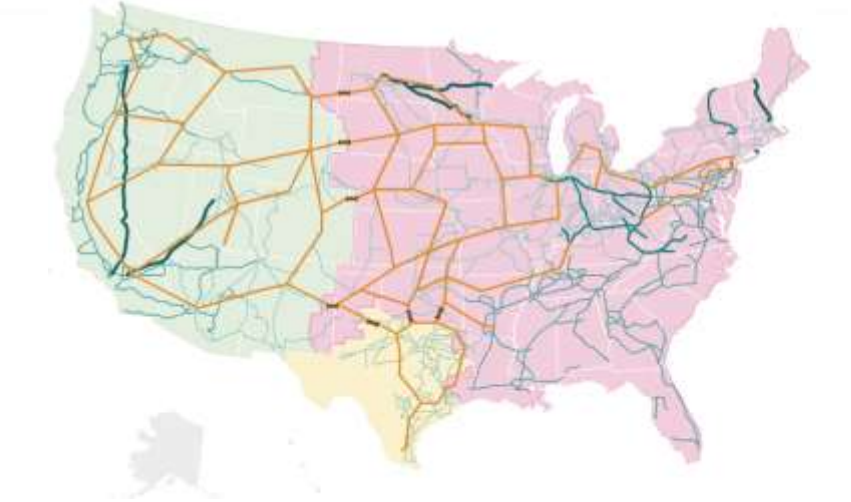
- 1994 – Salt River Project water dept., Arizona
- 2000 – Maroochy Water System, Australia
- 2006 – Harrisburg, PA water treatment plant
- 2007 – Tehema Colusa Canal Authority, California
- 2009 – Cyber incidents in water systems have increased by 30% (RISI)

Queensland's Maroochy Shire Council Water Treatment Facility
Australia

Public water system strategic advantage: *fragmented infrastructure*

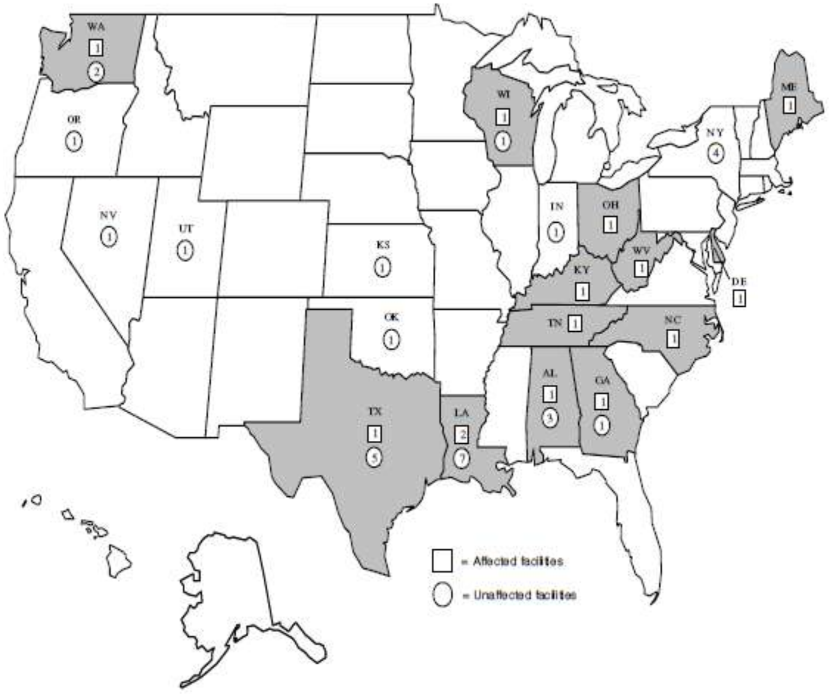
- There are 155,693 public water systems, serving 286 million Americans.
- The systems are varied, heterogeneous, run by variety of small-large local governments
- This ‘fragmentation’ is seen as a disadvantage for efficient management national water usage
- 8% of U.S. water systems (12,445) provide water to 82% of the U.S. population
- 0.2% of US water systems (404) are large systems that serve 46% of the population
- Some water ‘conglomerates’
- No one ‘infrastructure’; there are just many independent, individual systems
- *Contrast that with the national electric infrastructure which is interconnected*
- An attack on any one node of an electric grid could take that entire grid down
- Any attack on a single water system is limited to that system.



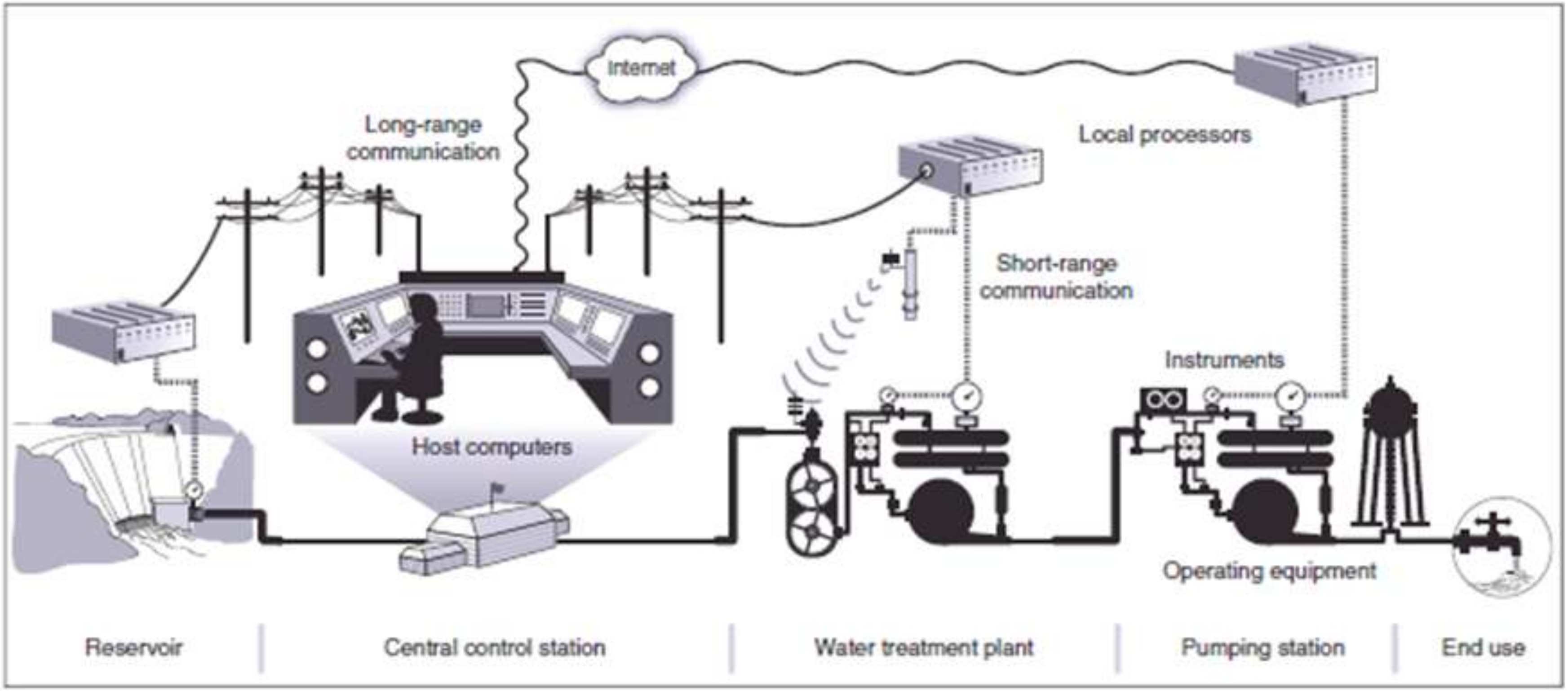


Public water systems vulnerability: Concentration of chlorine production

- Geographic concentration of critical infrastructures is a strategic vulnerability.
- Treatment chemicals could be contaminated ,as a potential vector of attack
- Treatment chemicals include potassium permanganate, lime, ferric chloride, & chlorine
- 84% of large water systems use chlorine
- Chlorine production is **concentrated**:
- 38% of all US chlorine production is in coastal Louisiana.
- A few well placed bombs at plants & railways could stop the shipments of chlorine and shut down a large percentage of drinking water supplies.
- Al Qaeda has considered directly attacking US rail lines
- A n attack on chlorine production plants could potentially shut them down or damage them.
- Or… the chlorine could be intentionally contaminated in the production plant or in transit; there are a few potential substances that could be effective for this.



Public water system components

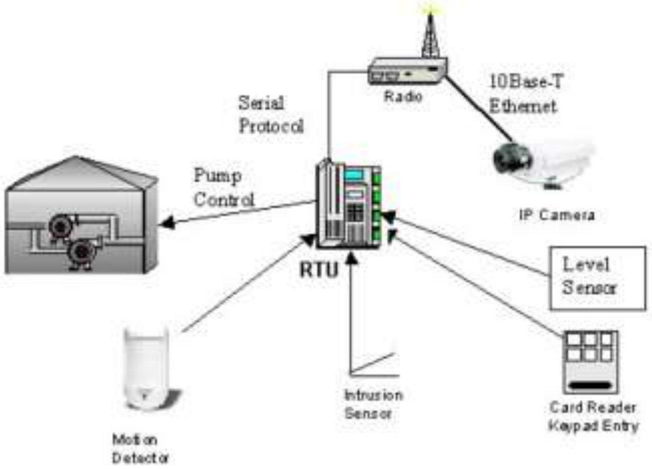


Goal of PWS is to produce water:

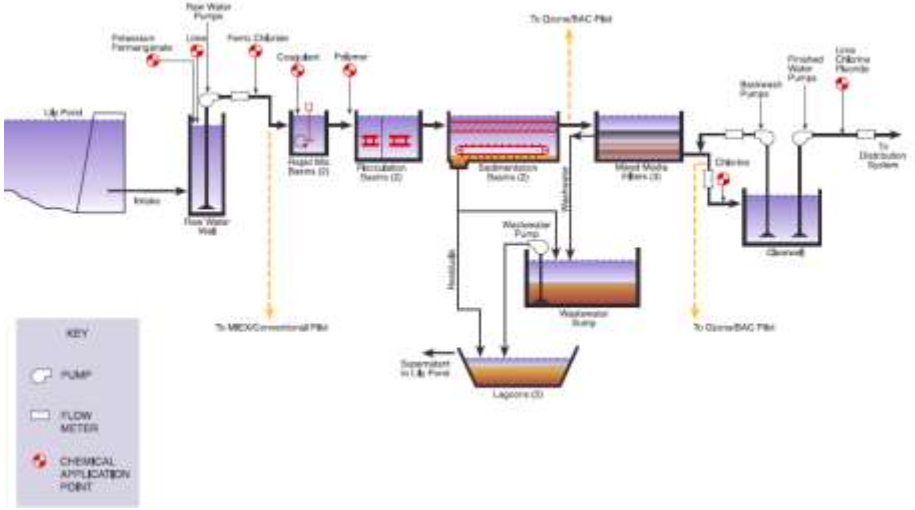
(1) With sufficient pressure;
(2) Safe to drink; and
(3) Available on demand

Source of Water Supply

- Two main sources:
  - reservoirs (surface water; watershed)
  - wells (ground water, aquifer)
- Reservoirs range in size from a few acres to the largest, Lake Mead – 247 million square miles, 9.28 trillion gallons
- Wells draw water from aquifers, underground lakes. They range in size from just a few acres to hundreds of square miles. Ogalla Aquifer in US, covers 174 million square miles over 5 states
- Large sizes are both impossible to secure but also regarded as impractical to effectively poison
- For example, Dillon Reservoir in Denver has 83 billion gallons of water; contaminating to just 10 parts per million would require 830,000 gallons of contaminant - a fleet of over 55 tanker trucks with 15,000 gallons
- Many instances of accidental contamination, such as Milwaukee 1993 , & the Walkerton Ontario 2000 ecoli contamination
- Wellheads potential targets. Usually secured in a building, even if security breached would still require large amounts of toxin
- Also, since the water is later treated, limits the effectiveness, if any, of toxins added to supply
- <u>Instrumentation</u>: some systems remotely monitor water quality in source area, also water flow, streamflow monitored



Water Treatment Plant



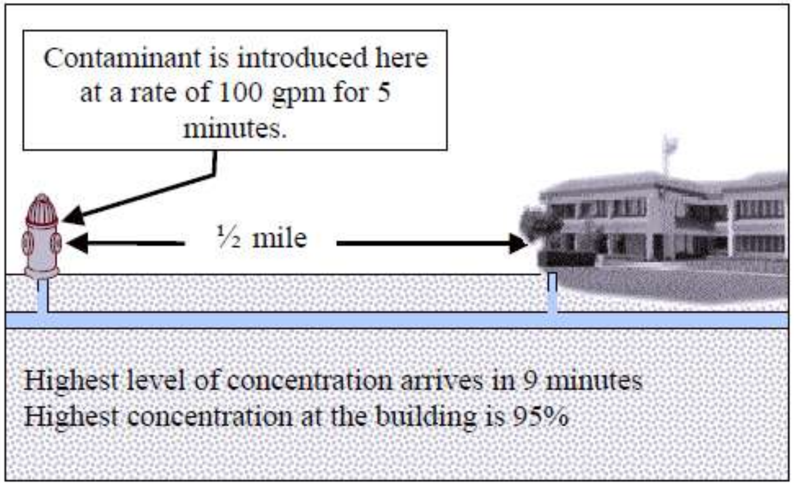
- Typical water treatment process:
  - From source water
  - Intake, raw water pumps
  - Raw water well
  - Coagulation
  - Flocculation
  - Chemical addition
  - Filtration
  - Chlorination
  - Clearwell, finished water pumps
  - To distribution system
- Monitored and controlled by SCADA
- Instrumentation includes flow meters, chemical addition pumps, variable frequency pumps, chemical sensors
- Usually in buildings, alarmed, with fencing - except for this plant in Florida, no building!
- Each plant is unique
- Clearwell is most vulnerable spot; water goes directly into the distribution system, so this is the most vulnerable point in treatment.
- However, dilution would occur as the slug of contaminated water passed through the distribution system

Finished Water Storage

- Types of water storage:
  - tanks (steel, concrete)
  - reservoirs (covered, uncovered)
- Remote facilities
- Since 9/11, most have fences, locks, video cameras, alarms
- Since its after treatment, one of most vulnerable points
- Dilution factor still would require massive amounts of toxin, dropped in from top of tank, difficult
- Instrumentation- telemetry to monitor height of water in tank, connected to SCADA by phone, radio, or internet

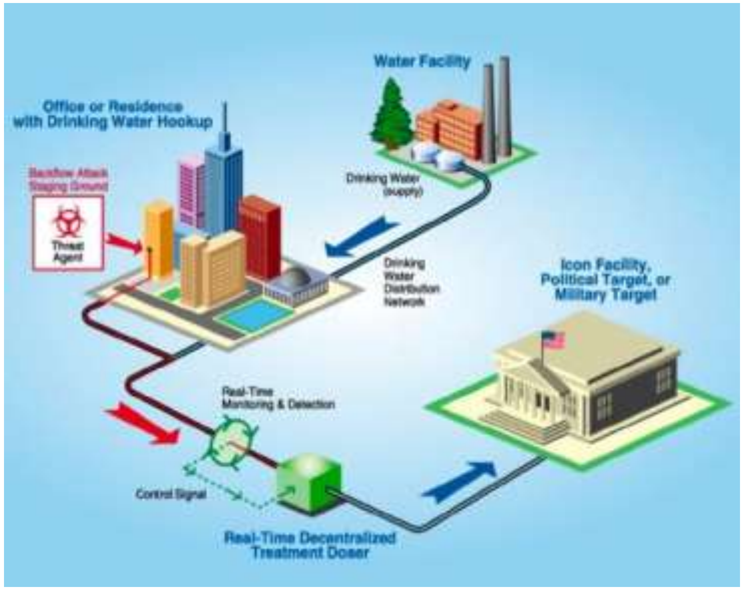
Water Distribution System

- Distribution system includes:
  - distribution mains (4” – 24” diameter, iron, ductile iron, plastic, prestressed concrete, asbestos cement)
  - transmission mains (12” – 30” diameter)
  - fire hydrants
  - valves & gates
  - blow offs
- 1.8 million miles of water pipes in the US
- 6 - 12 million Fire Hydrants in US (best estimate)
- Contaminants could be pumped into hydrants, or from end user homes or hydrants, via pressure tanks for lawn chemicals; cost only 80 cents per lethal dose; best for targeted attack
- Various ways to lock hydrants, could impede fire protection response, give false sense of security.
- Install check valve to block input into the hydrant
- Backflow prevention devices (BFPD) in building can protect them, unless the BFPD is bypassed
- Instrumentation: some have remote monitoring of water quality, especially chlorine residual
- Most vulnerable component of water system



Contaminant is introduced here at a rate of 100 gpm for 5 minutes.

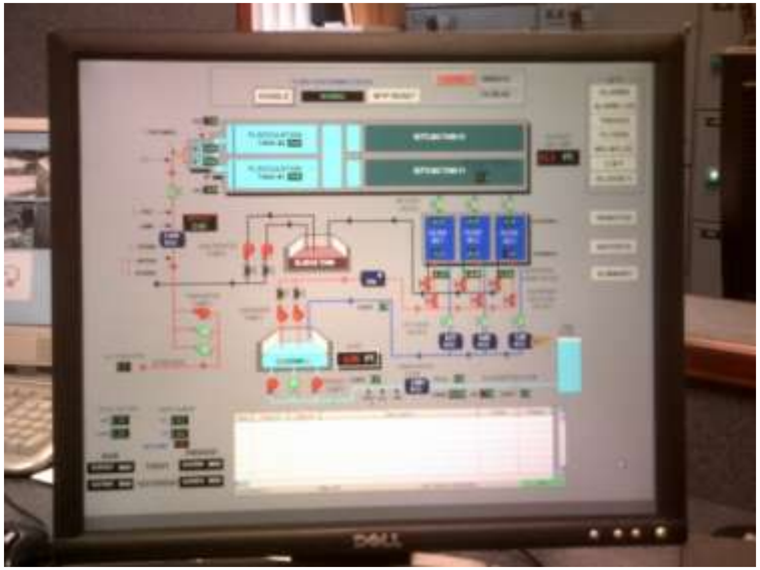
Highest level of concentration arrives in 9 minutes
Highest concentration at the building is 95%



Water Facility
Office or Residence with Drinking Water Hookup
Backflow Attack Staging Ground
Threat Agent
Drinking Water (supply)
Drinking Water Distribution Network
Icon Facility, Political Target, or Military Target
Real-Time Monitoring & Detection
Control Signal
Real-Time Decentralized Treatment Doser

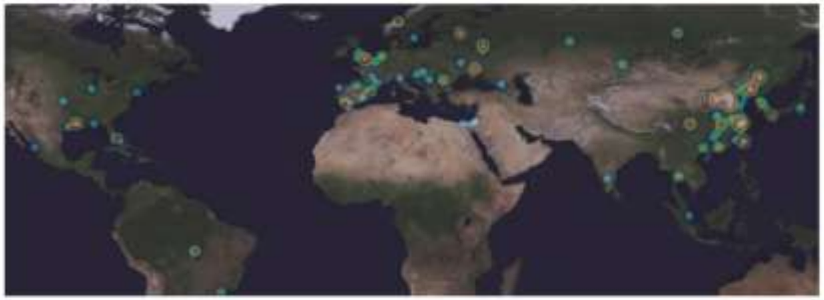
SCADA - System Operation

- **S**upervisory **C**ontrol **A**nd **D**ata **A**cquisition
- Central control is usually from a Windows XP or Server 2003 box
- Takes input from PLCs in plants & remote facilities
- Usually connected through off the shelf Ethernet wire, routers, switches, etc.
- Usually has some internet connectivity for the SCADA network.



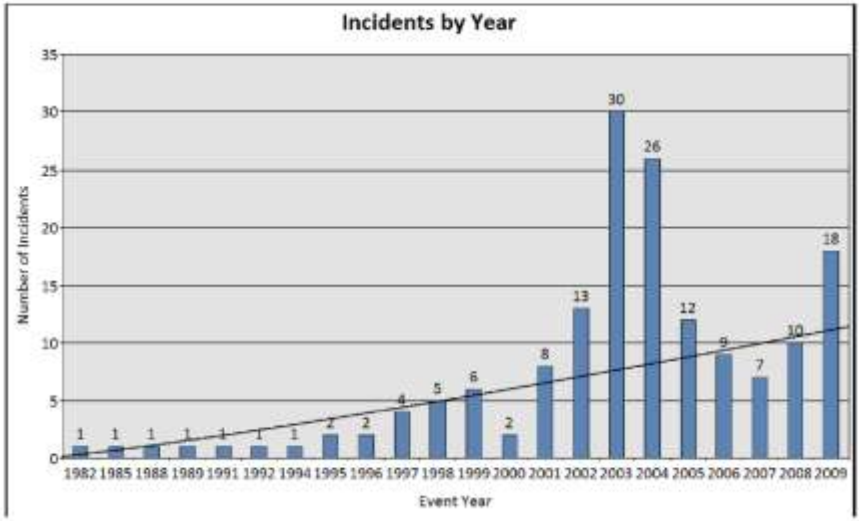
SCADA: Vulnerabilities

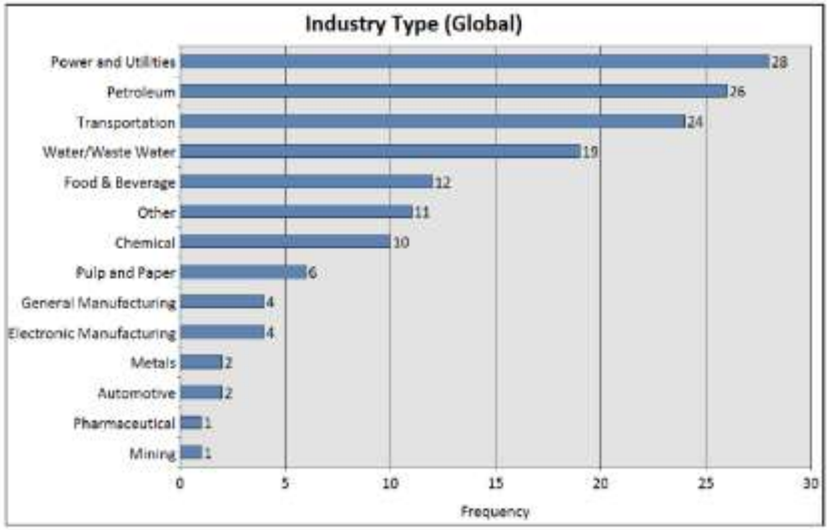
- 76% of respondents with SCADA/ICS responsibilities said their networks were “connected to an IP network or the Internet.”
- 47% admitted that the connection created an “unresolved security issue.”
- SCADA ports are being scanned from all over the world – why?
- Test bed studies show that external attackers can penetrate systems, brick the box, etc.
- Chinese researcher has detailed how attack on US power grid could cause cascading failure to shut entire grid down!



SCADA cybersecurity incidents

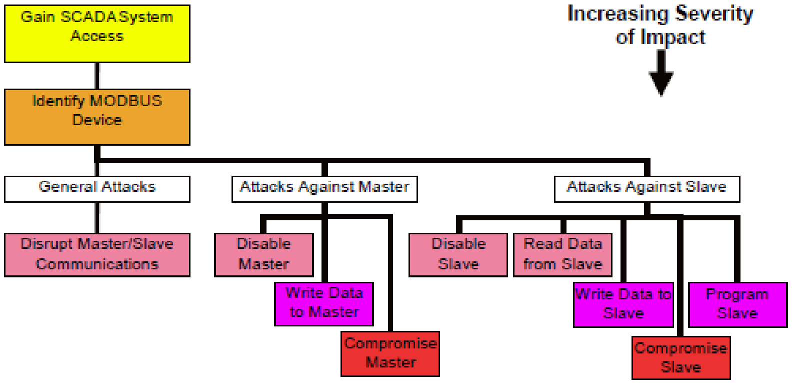
- Cybersecurity SCADA incidents are increasing
- Majority of cybersecurity incidents occur in critical infrastructure
- Water/wastewater incidents increased 367%
- 22% are targeted attacks, rest are mostly malware
- Cyber attacks sometimes severe – caused multi-city power outages outside US
- US electric grid known to be repeatedly penetrated





Potential impacts of a cyber attack on a public water system SCADA

- Interfere with operations
- Make unauthorized changes to programmed instructions
- Block data
- Send false information
- Change alarm thresholds
- Prevent access to account information



Gain SCADA System Access

Identify MODBUS Device

General Attacks

Disrupt Master/Slave Communications

Attacks Against Master

Disable Master

Write Data to Master

Compromise Master

Attacks Against Slave

Disable Slave

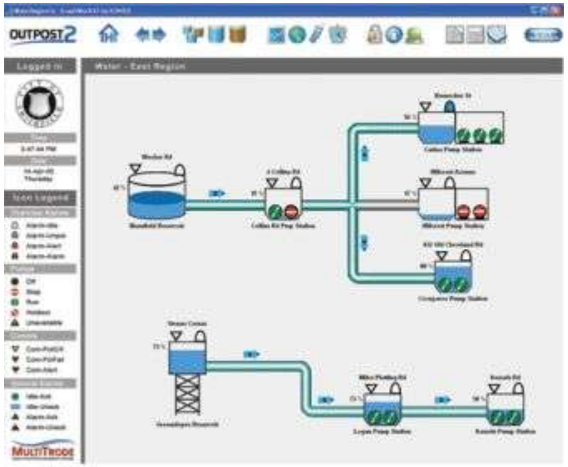
Read Data from Slave

Write Data to Slave

Program Slave

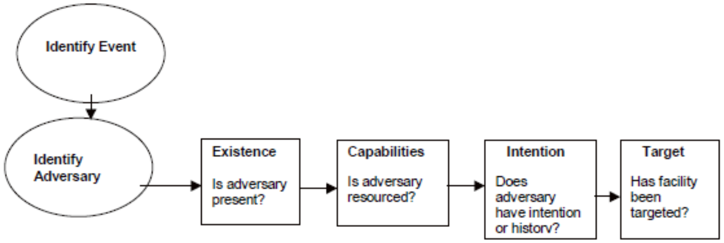
Compromise Slave

Increasing Severity of Impact



What is the extent of the cyber & kinetic risk to public water systems?

- Bottom line: it is too big and too exposed to protect 100%
- Fragmentation limits effects of any attack to a single system; no cascade as in electric grid
- Has many redundancies, but there are some 'single points of failure', such as the distribution system.
- Major $350B national shortfall in funds for improvements for the crumbling infrastructure
- There are frequent unintentional contamination of water systems, but few intentional, because of the difficulty
- I'd be more worried about bombs than cyber attacks, but can't rule cyber attacks out
- While vulnerabilities exist, most incidents are from vandalism, not terrorism



Identify Event

Identify Adversary

Existence

Is adversary present?

Capabilities

Is adversary resourced?

Intention

Does adversary have intention or historv?

Target

Has facility been targeted?

What is being done to protect public drinking water systems?

- Bioterrorism Act of 2002
- Vulnerability Assessments
- Homeland Security grant programs
- Water Infrastructure Security Enhancements (WISE) Program
- Water Information Sharing and Analysis Center (ISAC)
- Infragard
- Open SCADA Security Project
- SCADA Honeypot
- SCADA Testbeds
- SANS
- Cyber Shockwave

WaterISAC Pro

Open SCADA Security Project

What still needs to be done?

- At least $1 - $1.6 Billion is needed for public water systems to implement recommended security improvements.
- All water systems need funding to implement real-time monitoring of water in the distribution system.
- There must be EPA-required federal standards or agreed upon industry practices regarding readiness, response to incidents, or recovery, for public water systems.
- These standards should incorporate the "21 Steps to Improve Cyber Security of SCADA Networks"
- The Homeland Security Department branch that monitors cyber attacks needs the authority to force other agencies to protect their systems, needs more staff, and needs continuity of leadership.

Conclusions

- Public water systems are attractive targets of attack.
- Terrorist have, and can be expected to continue to, threaten to attack US public water supplies.
- Terrorists have cyber capability and use the internet.
- There have been cyber attacks on water systems, and many cyber incidents on SCADA on critical infrastructure.
- The concentration of chlorine production in the US is a strategic vulnerability affecting all public water systems.
- SCADA systems have numerous vulnerabilities.
- A kinetic and/or cyber attack on a water system SCADA system can shut it down or alter water quality.
- Distribution system is the most vulnerable component, relatively easy to attack and difficult to defend against.
- While progress has been made in hardening public water systems, more than $1 billion is needed to fund needed security upgrades and federal authority to require cyber and physical improvements needs to be established.
- A cyber terrorist attack on public water systems does not appear imminent, but cannot be ruled out in the future.
- Contact me: johnmcnabb@comcast.net