The Untapped Military Drinking Water Surveillance Resource

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Overview

- Introduction/Today's challenge
- Tapped resources
  - COTS equipment
  - On-line equipment/SCADA
- Syndromatic surveillance
- The untapped military resource
- Conclusions
- Recommendations

Today's Challenge

Water utilities worldwide are searching for an "all-inclusive" drinking water monitor to detect any contamination of the water source and treated water.

The Ideal Water Monitor

- Alarm sounds when there is a problem
- Located at every point in the distribution system
- Provides real-time feedback
- Detects water quality changes
- Detects hydrant access
- Detects pressure changes
- Detect contaminants at 10^{-9} ng/L or 0.000000001 grams per liter
- Multi-sensor
  - Odor
  - Taste
  - Color
  - Texture

COTS Equipment

- Handheld water testing equipment
- Advantages
  - Give to operators to check water throughout the system
  - Quick data feedback (with walkie-talkie)
  - Cheaper than online devices
  - Operators can give their opinion
  - Small-portable equipment
  - Results within 5 seconds – 30 minutes

Available COTS Water Quality Analyses

Acidity
Alkalinity
Arsenic
Bromine
Calcium
Chloride
Free chlorine
Total chlorine
Combined chlorine
Hexavalent chromium
Color
Conductivity
Copper
Free cyanide
Dissolved oxygen
Fluoride
Total hardness
Hydrazine
Iodine
Total Iron
Lead
Manganese
Ammonia Nitrogen
Nitrate Nitrogen
Nitrite Nitrogen
Ozone
pH
Reactive phosphorous
Total phosphorous
Sulfate
Sulfide
Suspended solids
Turbidity
Zinc
And more……..

Parameters Utilities are Choosing to Monitor

Acidity
Alkalinity
Arsenic
Bromine
Calcium
Chloride
Free chlorine
Total chlorine
Combined chlorine
Hexavalent chromium
Color
Conductivity
Copper
Free cyanide
Dissolved oxygen
Fluoride
Total hardness
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And more……..

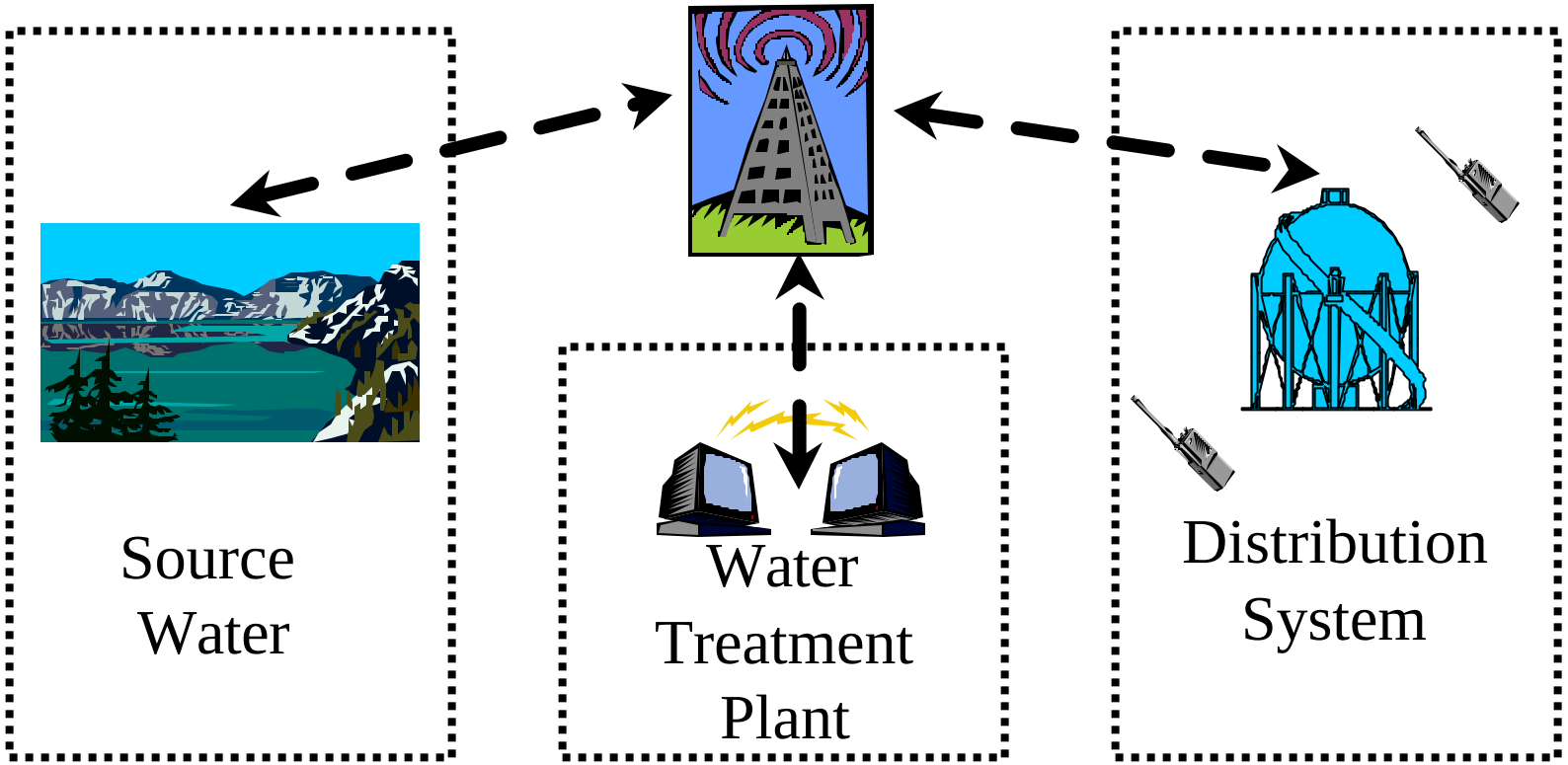
COTS Equipment Disadvantages

- Must know limitations
- Instant in time
- Maintenance
- Calibration
- Expensive
- Shelf-life
- Requires on-site use
- False-positive alarms
- Detection limits
- Contaminant interference
- Only provides a value

Online Monitoring (1/2)

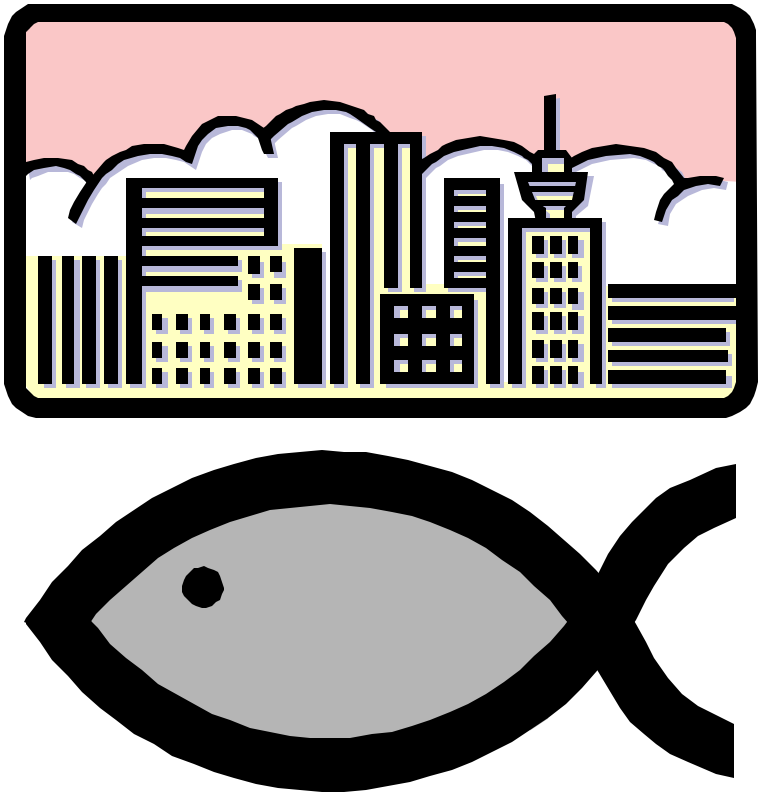
- Online sensors and support structure (a.k.a. SCADA)
  - Advantages
    - Information sent and displayed at a central location
    - Real-time data
    - Measure multiple parameters simultaneously: pH, chlorine residual, temperature, turbidity, TDS, pressure
  - Disadvantages
    - Installation and upkeep extremely expensive $$$
    - Maintenance and calibration required $$
    - False positive readings
    - Operator is only provided digital numbers
    - Can be disabled by cyber attack or manually
    - Information limited by sensor placement

Online Monitoring (2/2)



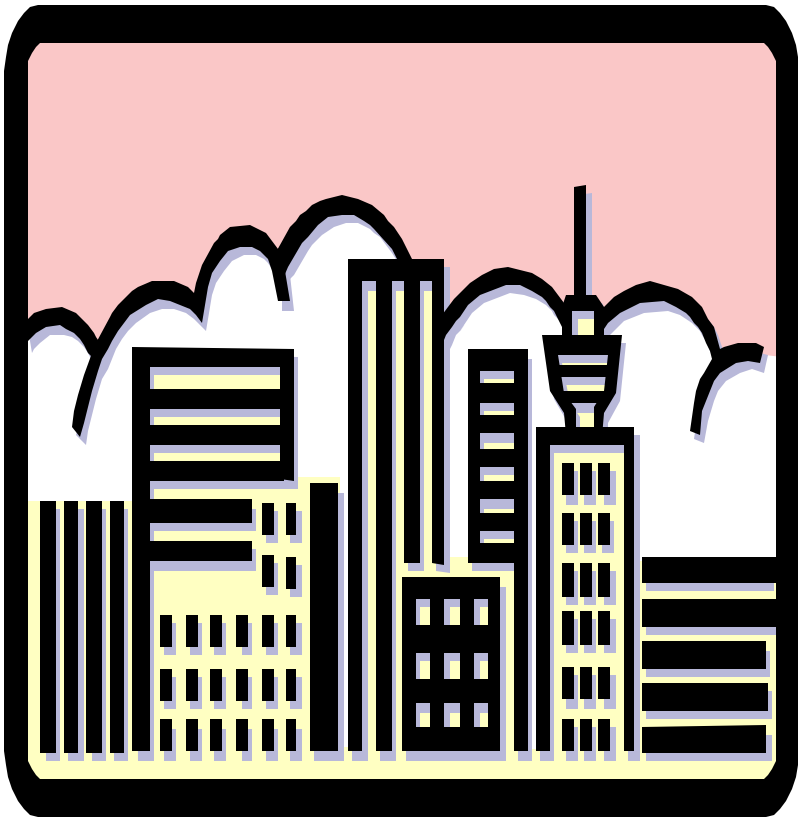
Fish Monitors

- Use a continuous acute toxicity monitor to identify developing toxic conditions in surface water
- Continuous monitoring of the breathing and movement patterns of fish
- Developed by USACEHR
- System is being tested at Fort Dietrick and New York City
- Vision to use this in distribution system



Monitoring Population Health

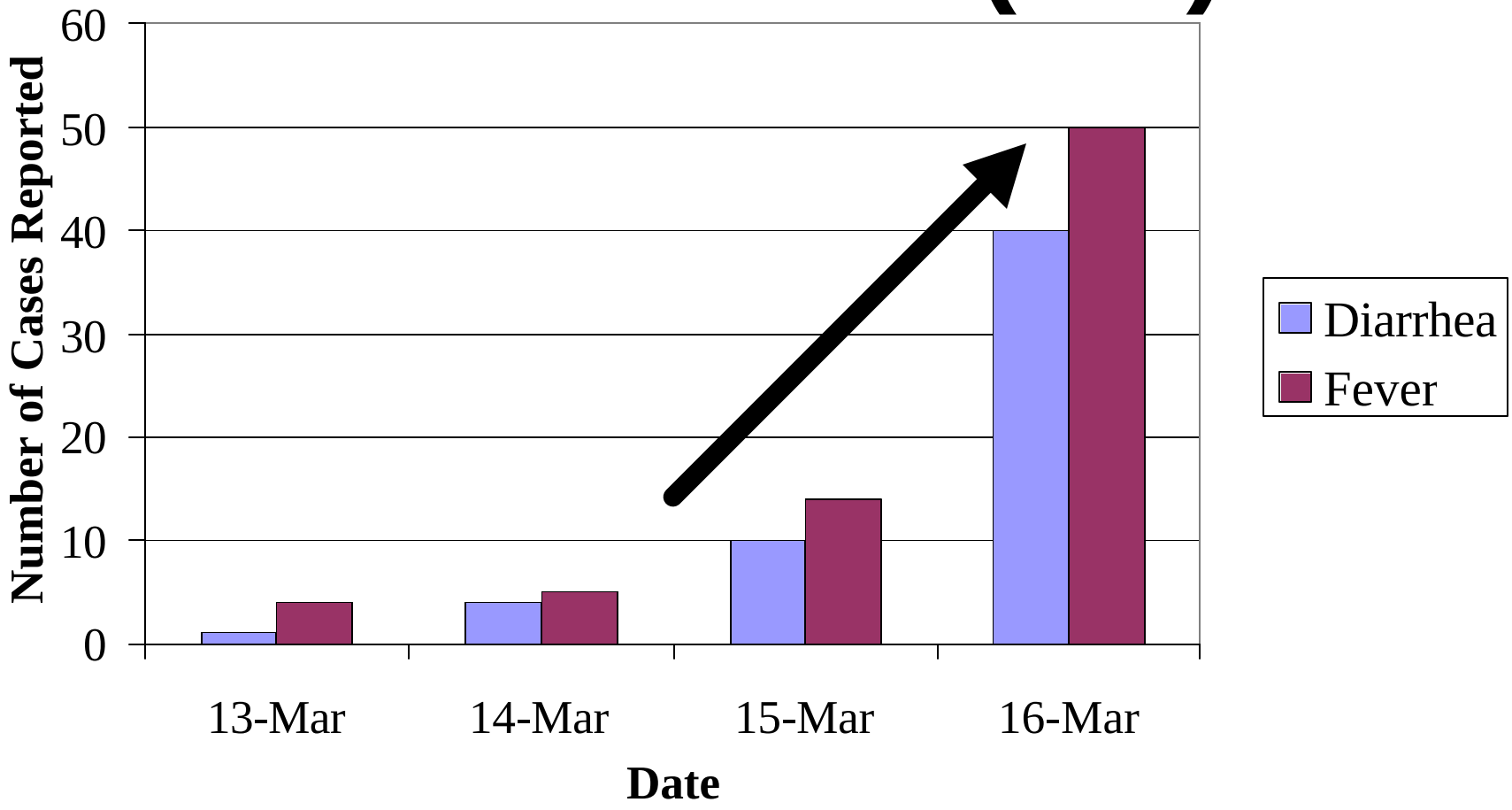
- Public health officials speculated first warning
  - Increased number of people admitted to the emergency room,
  - Increased purchases of flu medicine,
  - Increased absences from school or work



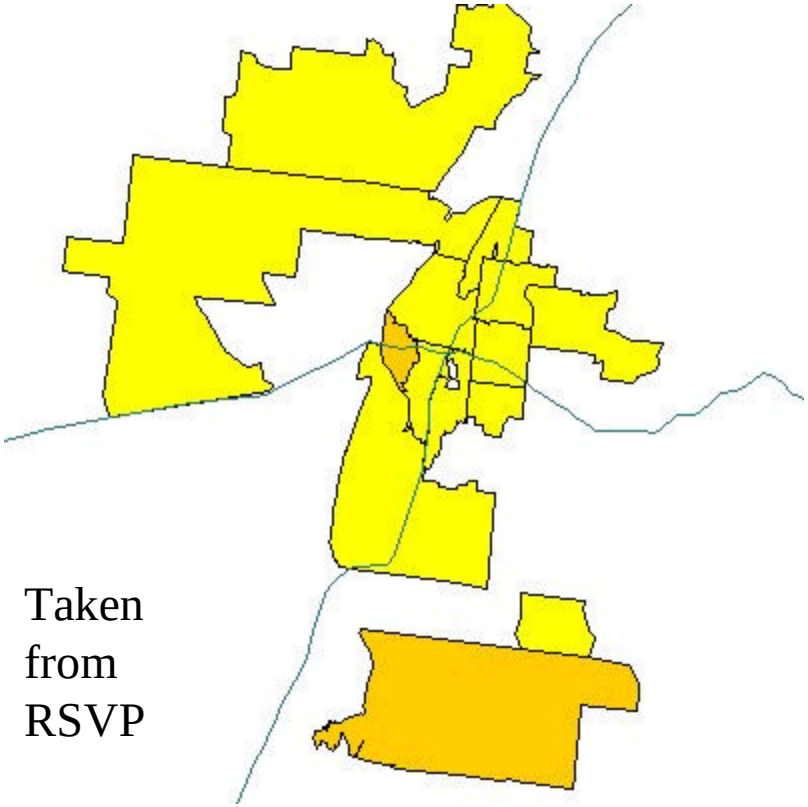
Syndromatic Surveillance (1/3)

- "Pentagon to Track Disease Outbreaks" *Washington Times*, Aug 02
- "DoD To Develop Biological Agent Early Warning System," *American Forces Press Service*, Aug 02
- "Software simulates terror hit, Sandia develops program as tool for public officials," *San Francisco Chronicle*, Aug 02
- "Rapid Syndrome Validation Program (RSVP)," developed by Sandia National Laboratories, Aug 02

Syndromatic Surveillance (2/3)



Syndromatic Surveillance (3/3)



Taken from RSVP

- Map key
  - Blue lines: Major roads
  - Dark area: Many illness reports
  - Lighter area: Fewer reports
  - White area: No reports
- Depiction on a map can show:
  - Location of people who are affected
  - Density of people affected

What good is syndrome surveillance to military water systems?

- Challenge
  - Military is looking to sure up their drinking water security and surveillance practices
- Leading Evidence
  - Population feedback is being monitored to gauge terrorist attacks
  - Programs such as RSVP can be used to generate bar charts and graphs to give public health officials a visual representation of reported cases
    - ID who is affected
    - ID where people are who are affected
    - ID number of people affected
- Conclusion
  - Use of this methodology could improve drinking water surveillance

Untapped Resource Drinking Water Consumers

- Indicate problems with water quality
- Detect contaminants at 0.000000001 grams / liter levels
- Sense FAC changes
- Notice pressure problems
- Report hydrant access
- Provide multiple descriptors
  - Taste
  - Odor
  - Color
  - Texture
  - Feelings (i.e., illness)

Chemical Warfare Agent Aesthetic Attributes in Water

Compound Name	Taste Descriptor	Odor Descriptor	Color Descriptor	Turbidity Present
Hydrogen cyanide*	Bitter, metallic	Almonds, peach kernels	Colorless	No
Cyanogen chloride	Sharp, metallic	Pepperish	Colorless	No
Soman	Not reported	Fruity, camphor	Colorless	No
Sulfur mustard	Not reported	Garlic, mustard	Pale yellow	Yes

**Includes KCN and NaCN in water.*

Biological Agent Ingestion Symptoms

- *Cryptosporidium parvum* (protozoan)
  - Nausea, diarrhea, and stomach cramps
- *Giardia lamblia* (protozoan)
  - Nausea, diarrhea, bloating, headache, stomach cramps, weight loss
- Smallpox (virus)
  - Nausea, vomiting, fever, headache
- Botulinum toxin (toxin)
  - Paralysis but mentally alert

Effective Example 1

- 1988 Connecticut water utility fluoridation system malfunctions
- Concentrated fluoride pours into the distribution system (40x normal concentration; ~160 mg/L)
- Consumers contacted water utility and reported complaints
  - Illness included nausea, vomiting, diarrhea, cramps, skin irritation
  - Abnormal tastes
  - Turned blue with contact with soap

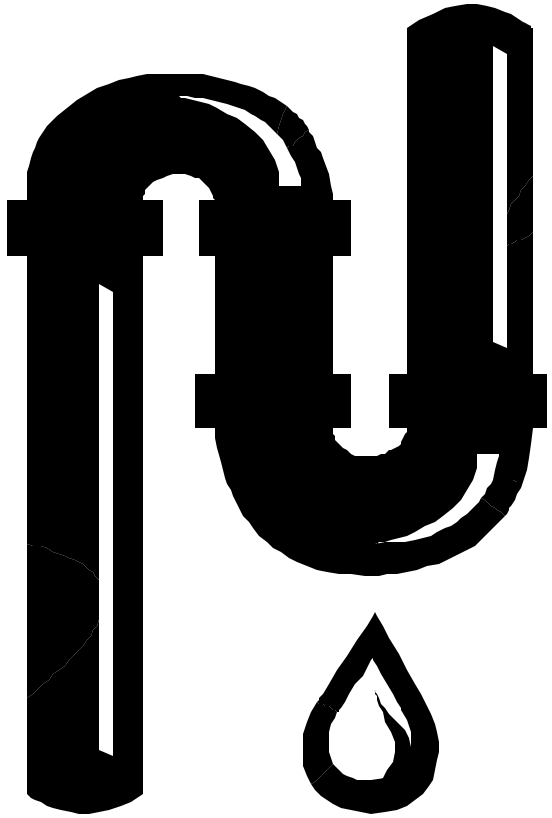
Petersen et al (1988)

Effective Example 2

- 1993 Milwaukee, WI *Cryptosporidium* outbreak
- 400,000 people sick; 100^{+} died
- Illness complaints were reported to the water plant

Effective Example 3

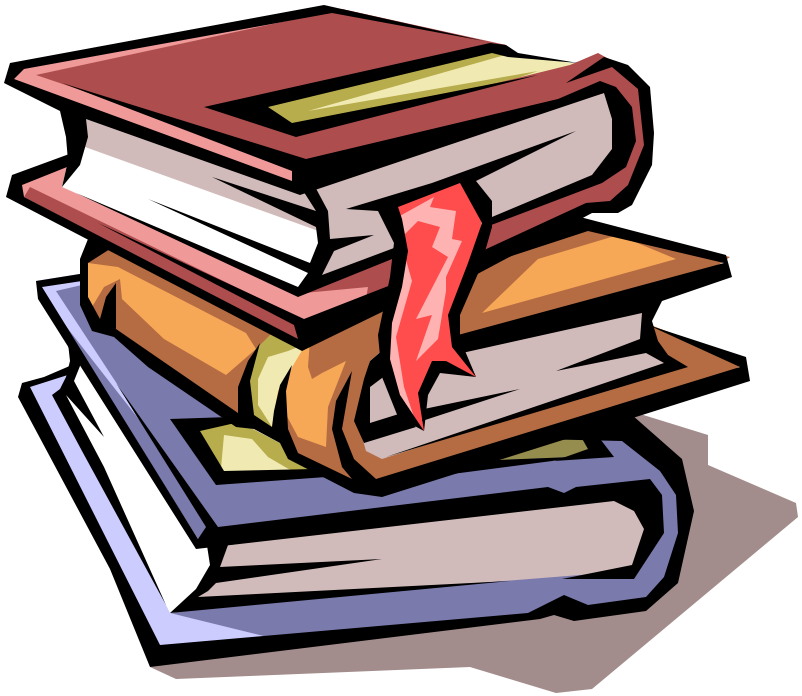
- 1990s at one Army plant
- Contractor super chlorinates an offline storage tank after repairs are completed, 100 ppm FAC
  - Valves are not completely shut
  - Super chlorinated water enters the distribution system
- Consumers filed complaints
  - 4.0 mg/L FAC found at taps
  - 1.0-2.0 mg/L FAC normal



Consumer Complaint System Components

- Standard operating procedures (SOPs)
- Single point-of-contact (POC)
- Electronic database/records
  - Charts and graphs
  - Distribution system map with markings
- Consumer education

Standard Operating Procedures (SOPs)

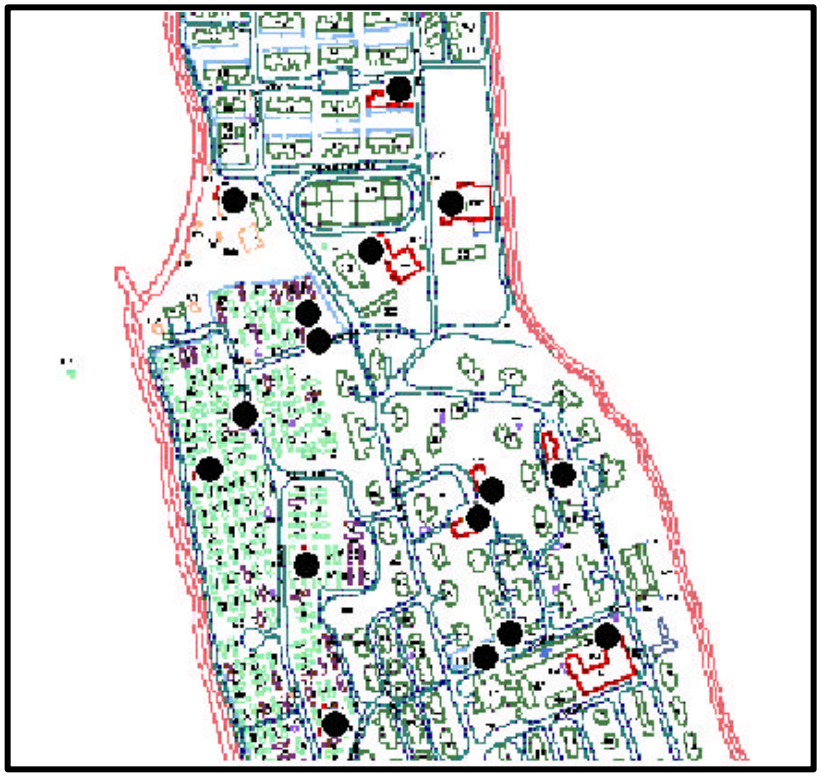


- Receiving a complaint
- Field investigation
- Pertinent lab analyses
- Internal & external research investigation
- Management & consumer notification
- Follow-up actions

Single POC (Point-of-Contact)

- Coordinates all resolution and investigation actions
- Chooses appropriate lab tests
- Reviews all data
- Ensures all complaints are addressed & rectified

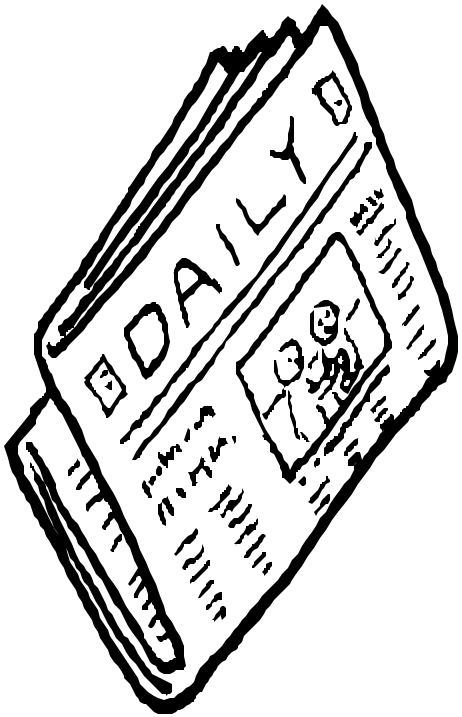
Marked Distribution System Map



- Map of a fictitious distribution system
- Map key
  - 1 circle = 1 complaint
- Conclusions
  - ID the location of each complaint
  - ID number of people affected

Educated Consumers

- Awareness and knowledge of common problems
  - Earthy & musty odors, “red” water
  - Less likely to complain
- When an unusual problem arises…
  - Complaint triggered~!
- Educational tools
  - Consumer confidence reports (CCRs)
  - Articles or advertisements in
    - Installation newspapers
    - In-processing information packages



In Focus: Fort Knox, KY

- Serves more than 20,000
- TRACKING/MAPPING
  - Records consumer complaint and ongoing status
  - Use a map to track main breaks, and will for complaints
- FIELD INVESTIGATION
  - Developed water quality field kits
- CONSUMER EDUCATION
  - Use door hangers, email, newspapers, and TV to notify about flushing activities

Conclusions (1/2)

- Find ingenious low cost methods to monitor water quality with our current resources
- COTS and online monitoring equipment are useful
  - Must acknowledge their limitations
  - Must continue to search for ways to better monitor drinking water quality

Conclusions (2/2)

- Terrorist attacks could be first noticed by people
- Complaints not fully and in some cases not at all integrated into military water system surveillance
  - Some are addressed but not filed or mapped
  - Many are seen as nuisance caused (iron in water) vs. water quality problem cause by a terrorist attack (new concept)
- Comprehensive guidance not provided anywhere
  - Department of Defense/Public/Private sectors included

Recommendations

- Talk about how complaints are handled
- Establish a systematic approach
  - POC for all complaints
  - Standard operating procedures
  - Simple database/file to include graphs and maps
  - Consumer education/outreach effort
- Follow the USACHPPM
  - NDIA proceedings paper (on conference CD)
  - Fact Sheet (on USACHPPM web site)
    - Drinking Water Consumer Complaints
  - Technical Guide 284 (final expected April 2003)
- Contact the USACHPPM for additional guidance

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