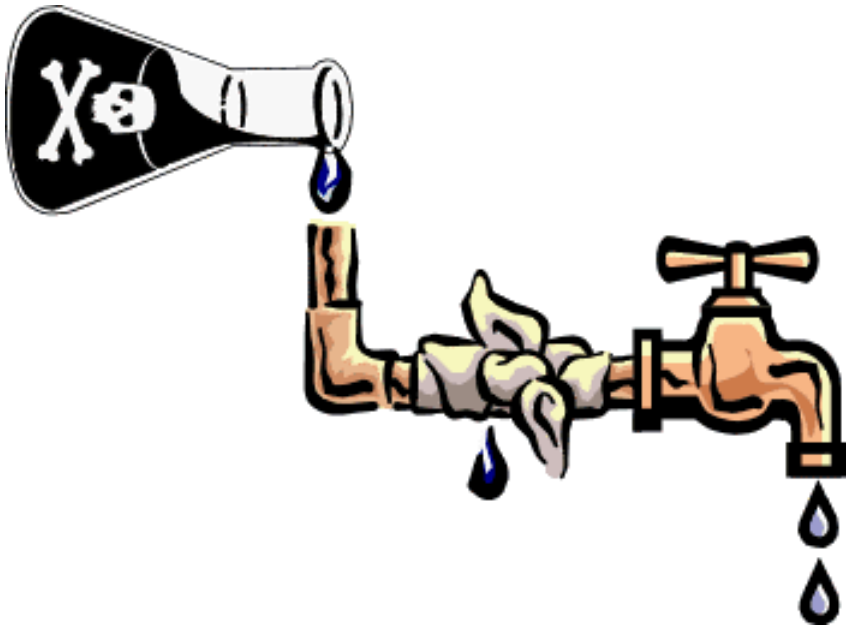
Real World Experiences With Real-Time On-Line Monitoring For Security and Quality. Detecting and Responding to Events.



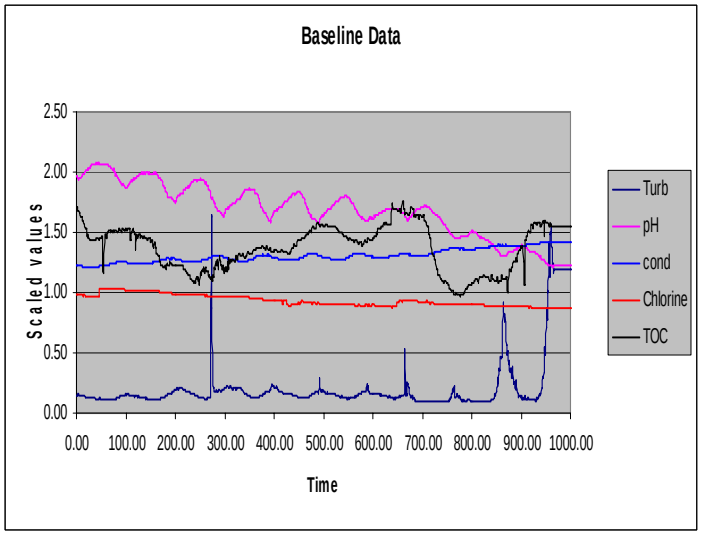
By Dan Kroll, Karl King and Greg Klein

Hach Homeland Security Technologies

International Workshop on Water and Wastewater Security Incidents
May 28th-29th, 2009
Calgary, Canada

What is our vision?

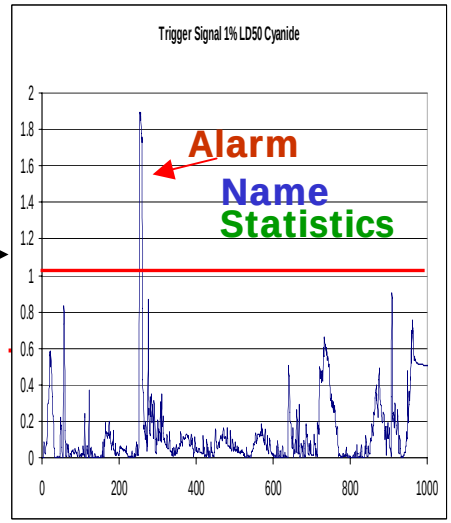
Input Five Parameter Signals



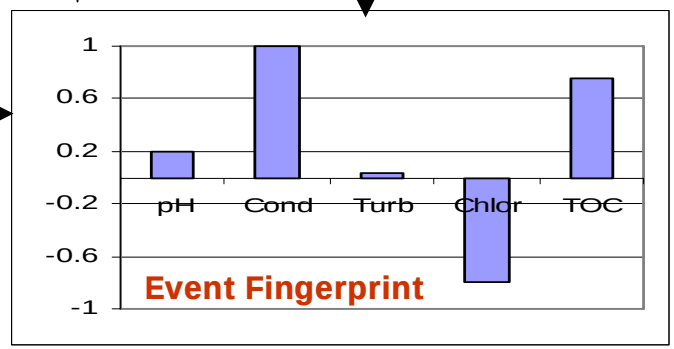
Analyze

Software

Output Single Signal



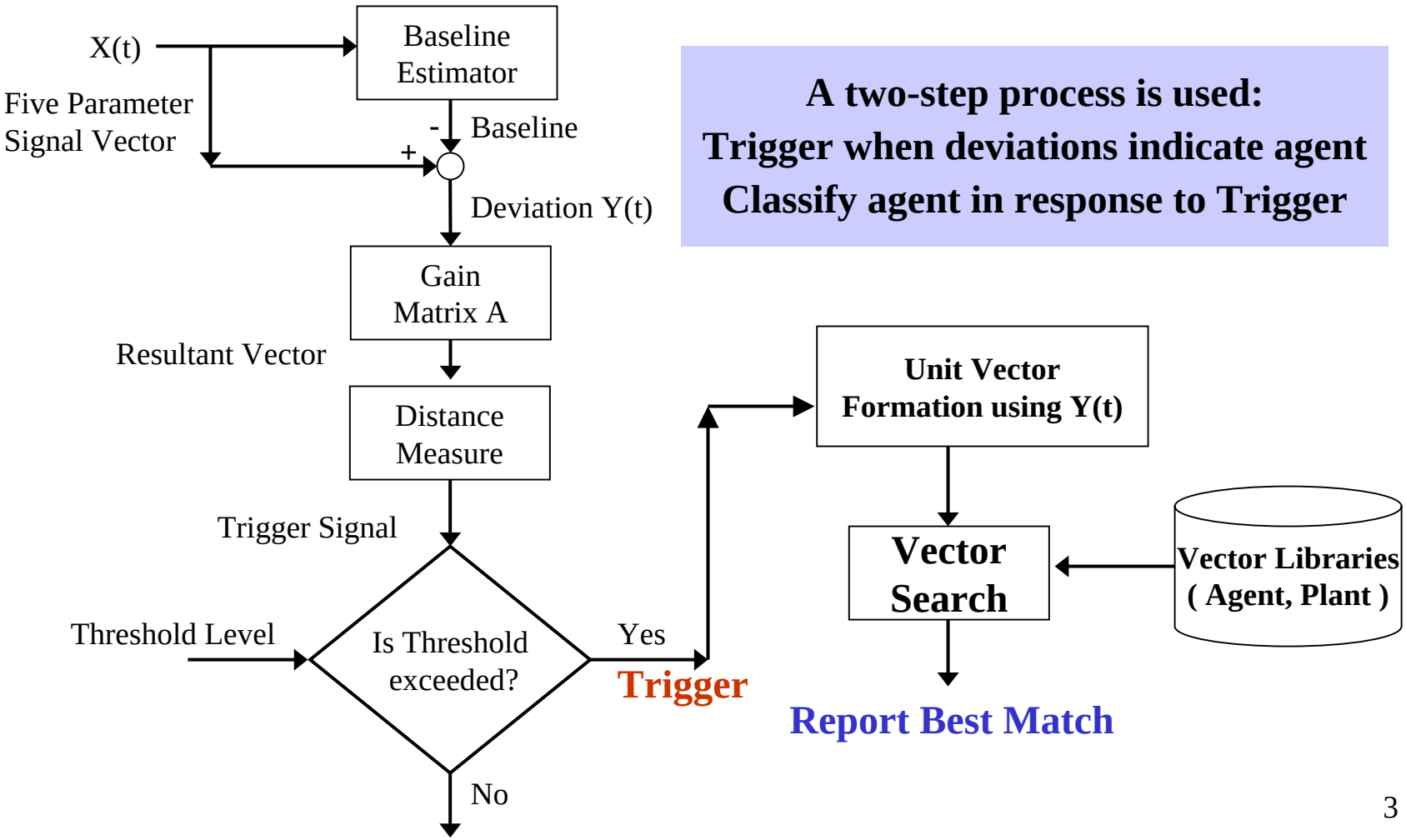
Learning



Plant Event Library

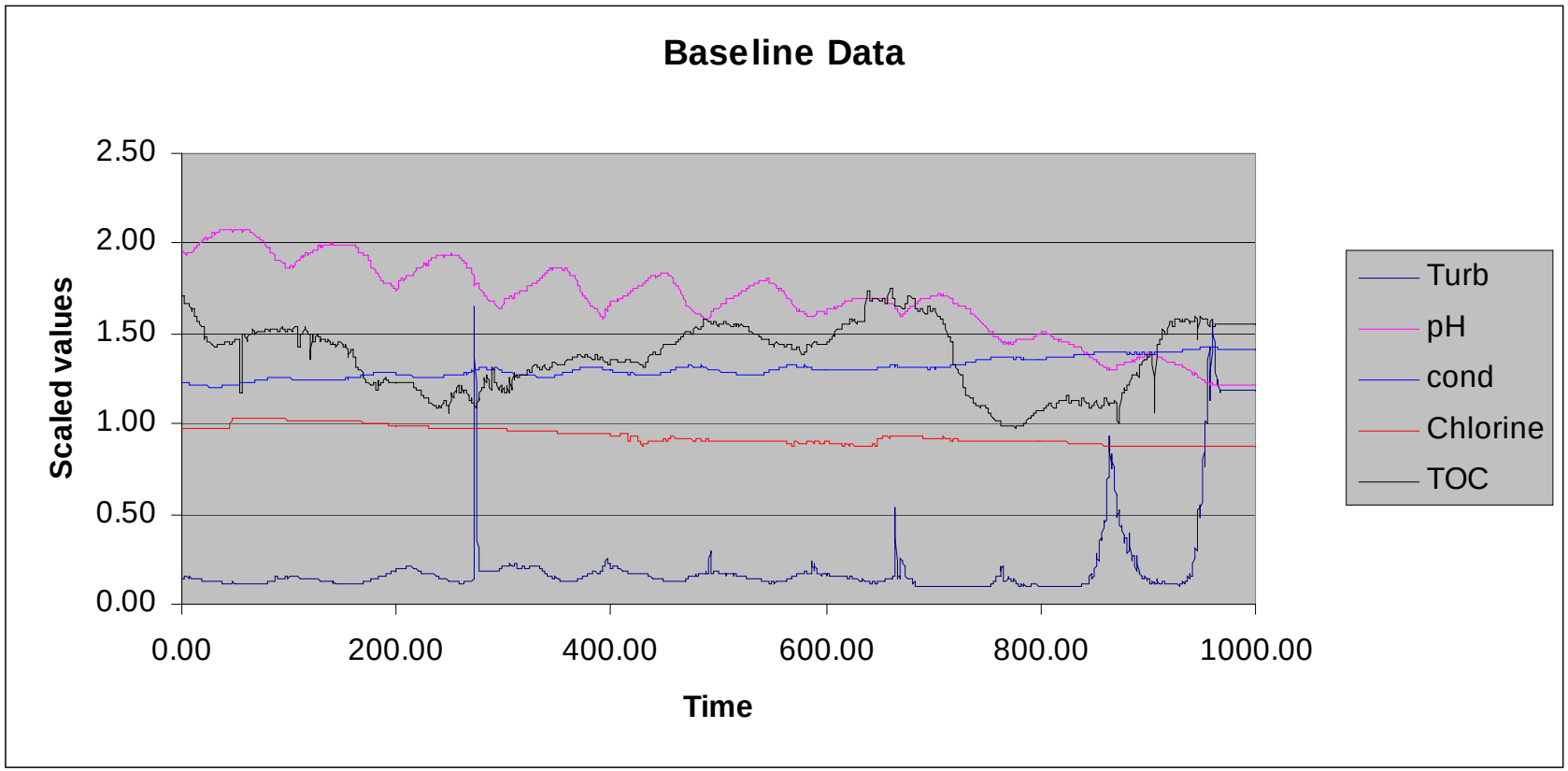
The Event Monitor analyzes plant data, alarms on significant deviations from baseline, reports the Event Name if found, and learns the event fingerprint if not already in the Plant Event Library.

How the Algorithm Works



A two-step process is used:
Trigger when deviations indicate agent
Classify agent in response to Trigger

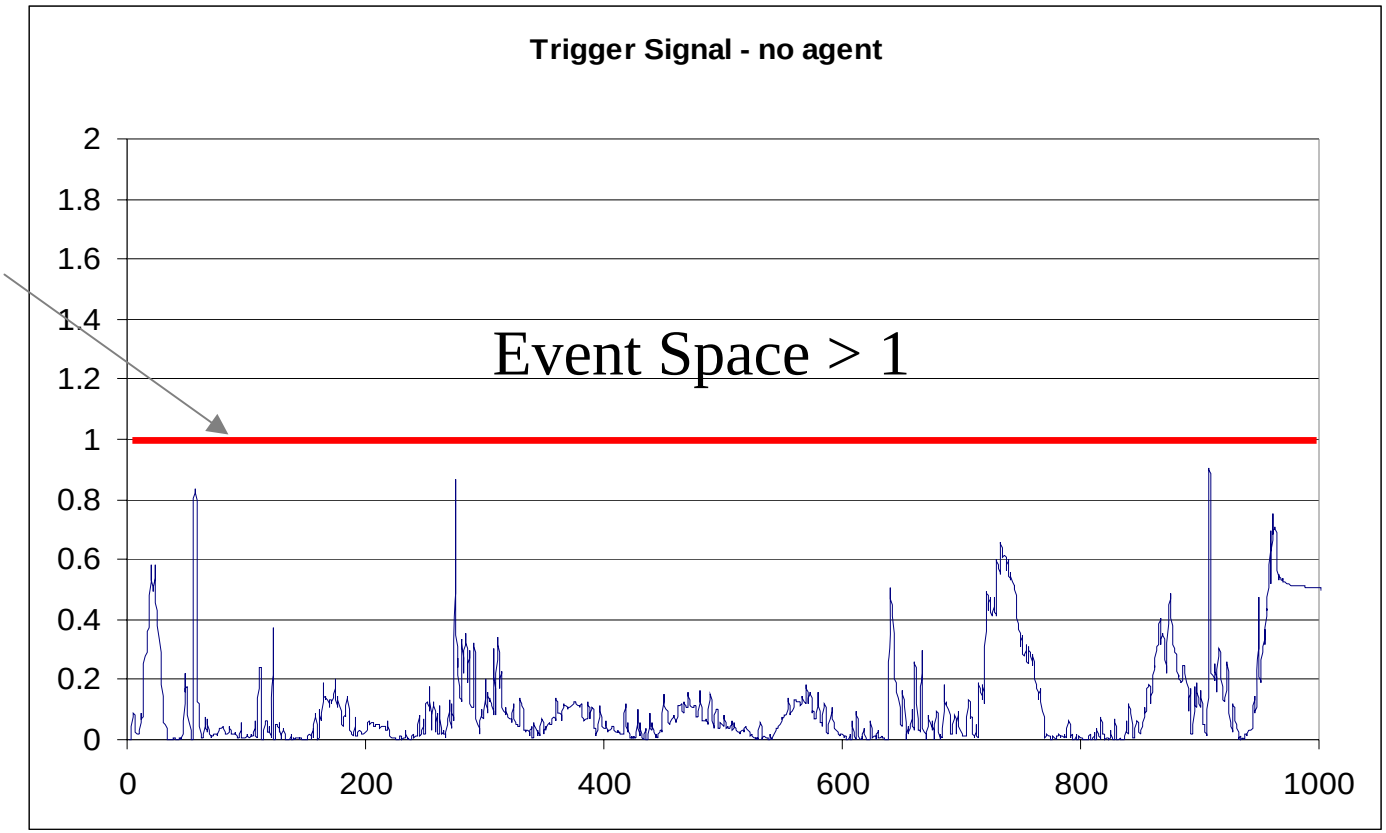
Raw Parameter Data for Trigger Analysis – Surface Water Facility



Raw data obtained in the distribution system is not static … where is the real baseline?

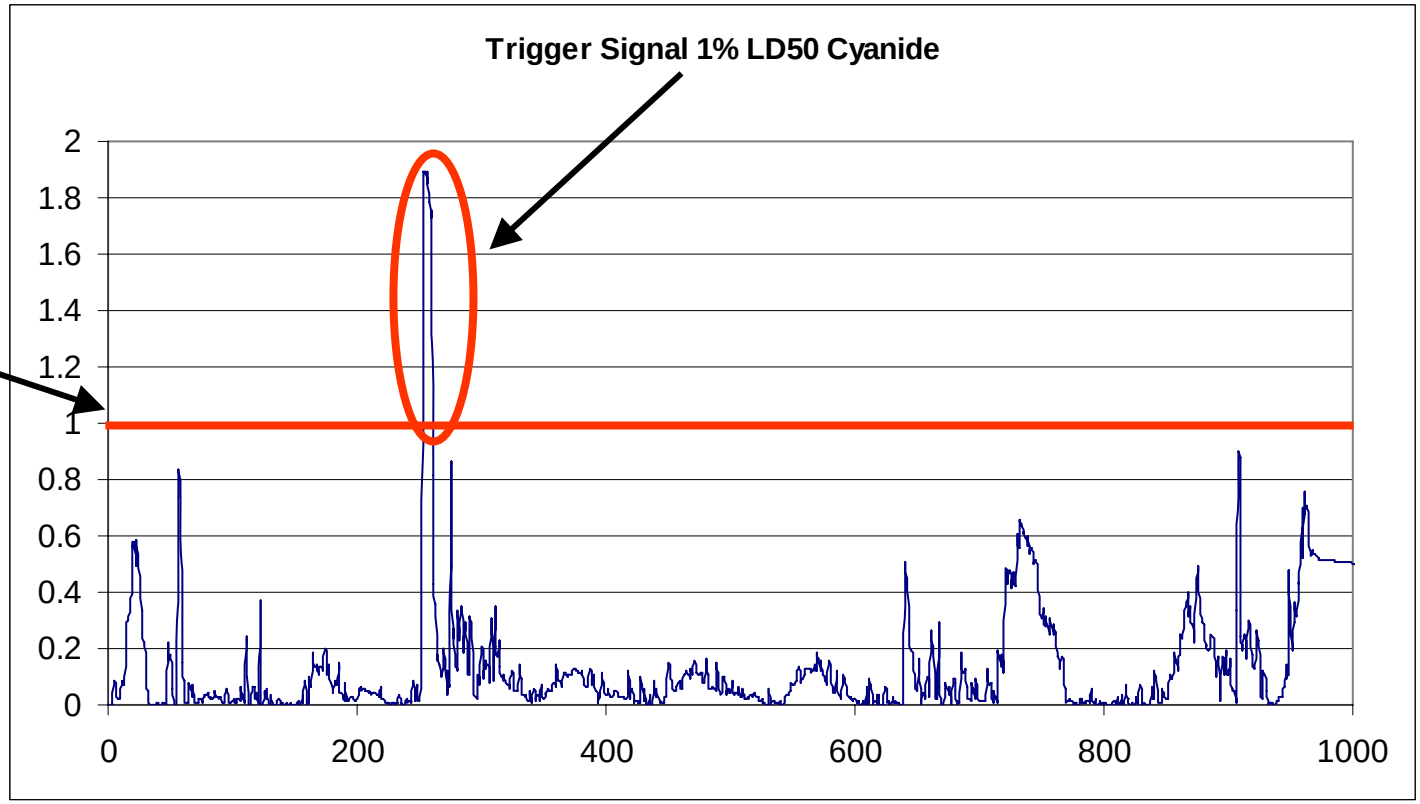
Trigger Signal w/ No Agent

Trigger Level = 1



During normal operation, process deviations are not larger than 1 on the trigger vector derived from grouped variations from baseline operation. The 5 parameters condensed into a single signal become easy to interpret.

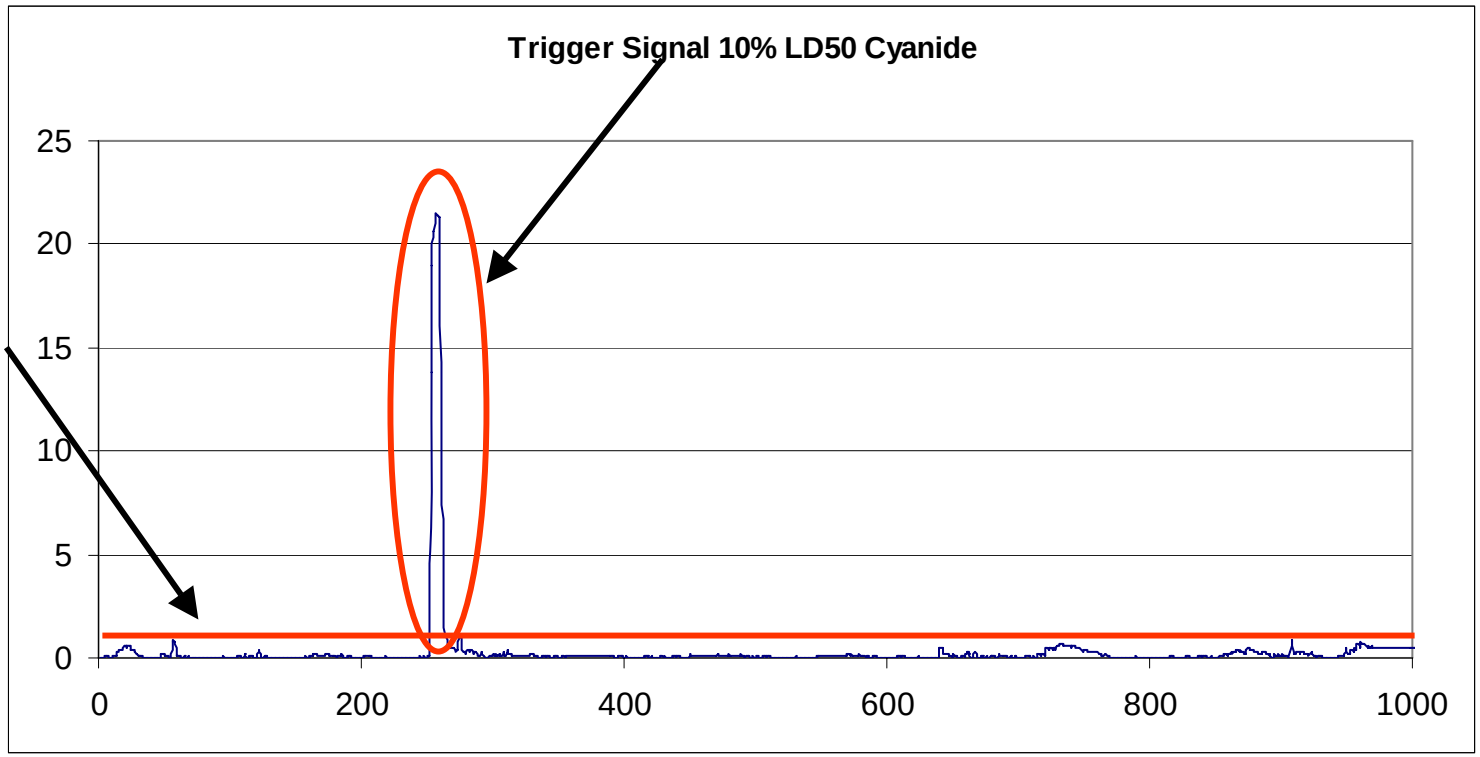
Event Level with low dose of cyanide



Process variations grow quickly when a significant amount of contaminant is present.

Event Level with higher, but still sub-lethal dose of cyanide

Trigger Level = 1



A huge signal is obtained form this still non-lethal dose of cyanide.

Extensive Testing and Verification Has Been Conducted

- Hach Laboratory testing and verification.
- EPA/Battelle Environmental Testing Verification (ETV) program testing and certification.
- Army Edgewood Chemical and Biological Command (ECBC) and Army Corps of Engineers Engineer Research and Development Center-Construction Engineering Research Laboratory(ERDC-CERL) Testing.
- Real world deployment testing.

All of this Led to DHS Safety Act Approval

- The SAFETY act is part of the 2002 Homeland Security Act. **Support Anti-terrorism by Fostering Effective Technologies Act**
- Provides litigation protection for manufacturers and end users of designated anti-terror technologies.
- All testing data was submitted to DHS for review and approval.

This is currently the **ONLY** DHS Designated and Certified on-line water anti-terror technology protecting you from system disruption and potential litigation

Certificate of Conformance

This will certify that, on this date,

the United States Department of Homeland Security issued to

HACH COMPANY

a Delaware corporation

a **Certification** *for its*

Hach GuardianBlue™ Early Warning System

as an **'Approved Product for Homeland Security'** *under the*

Support Anti-terrorism by Fostering Effective Technologies Act of 2002 (the SAFETY Act).

Jay M. Cohen

Jay M. Cohen

Under Secretary for Science and Technology

10/31/2006

Date

Dual Use Capabilities

- The security aspects of the system derive form the event detection software and the agent library compiled by Hach.

- The everyday utility derives from the event detection software and the plant library that is learned on site.

What does all of this have to do with every day operations

- The distribution system is the last analytical frontier in the water industry.
- Water in the distribution system is in a dynamic state of flux.
- Treatment changes required to comply with new regulations may have unforeseen effects on distribution.

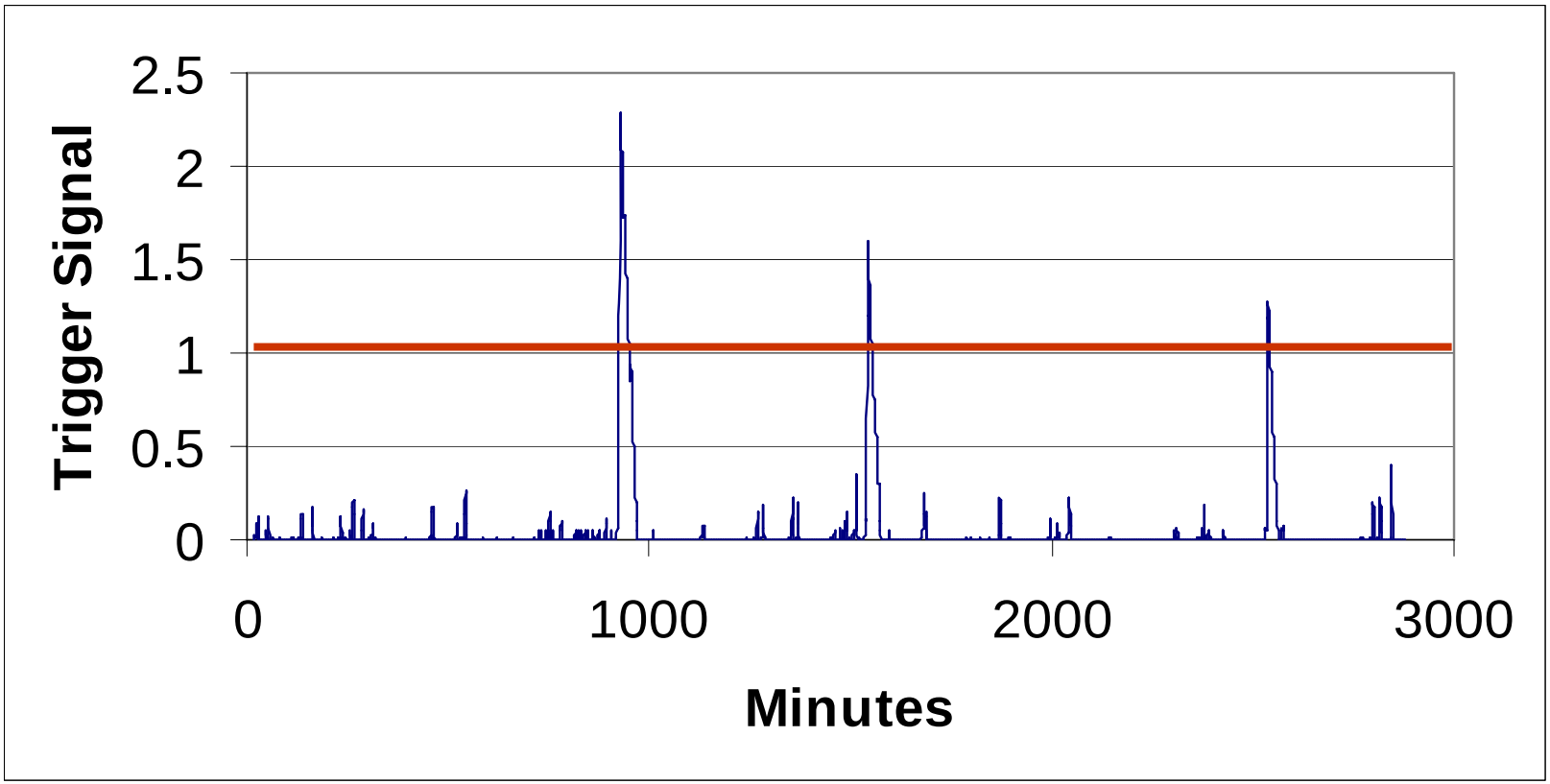
- The distribution system in many cities is aging and falling into disrepair thus presenting a possible route of contamination.

- While a deliberate attack on a given facility is unlikely water quality changes occur on a daily basis and there are process control advantages to be achieved by monitoring incoming water supplies.

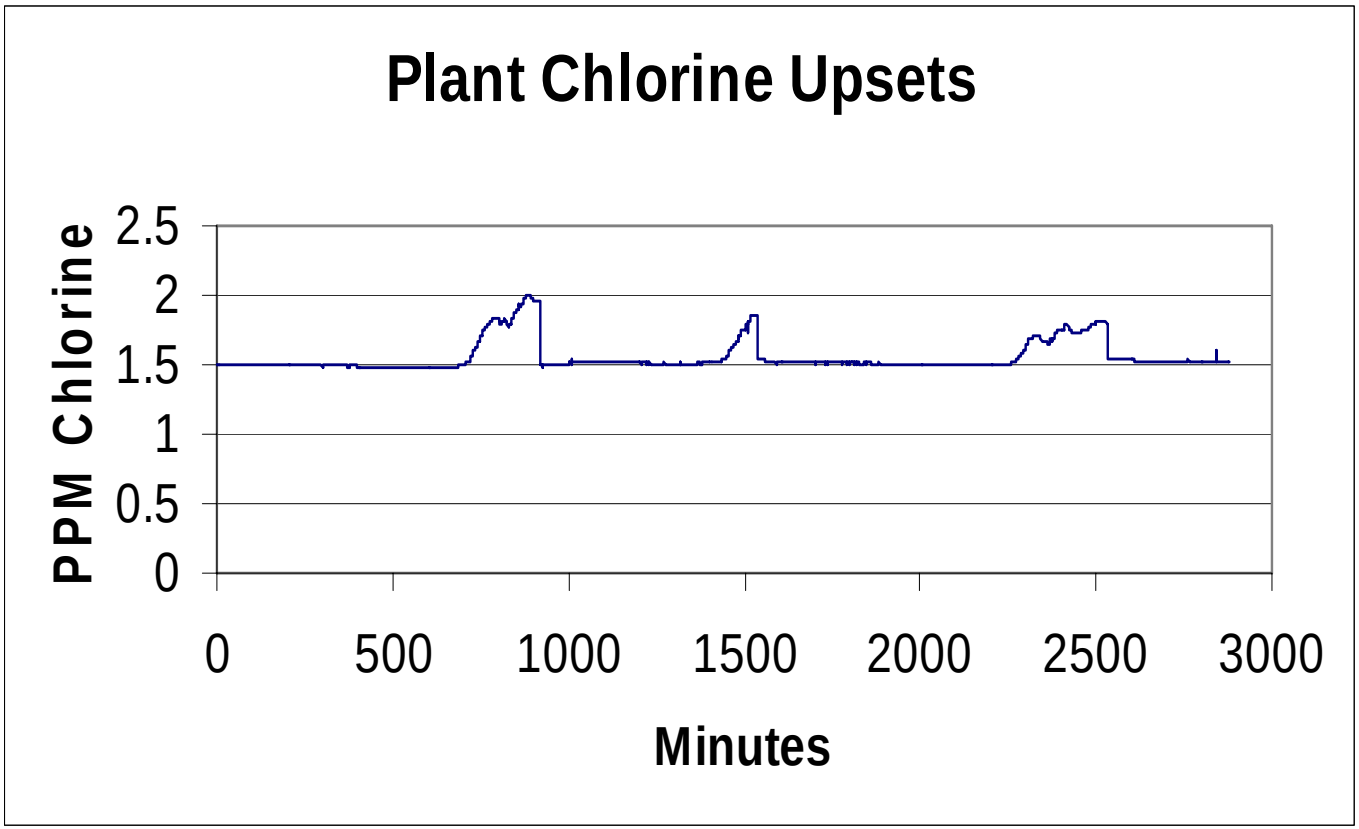
Computerized Institutional Intuition

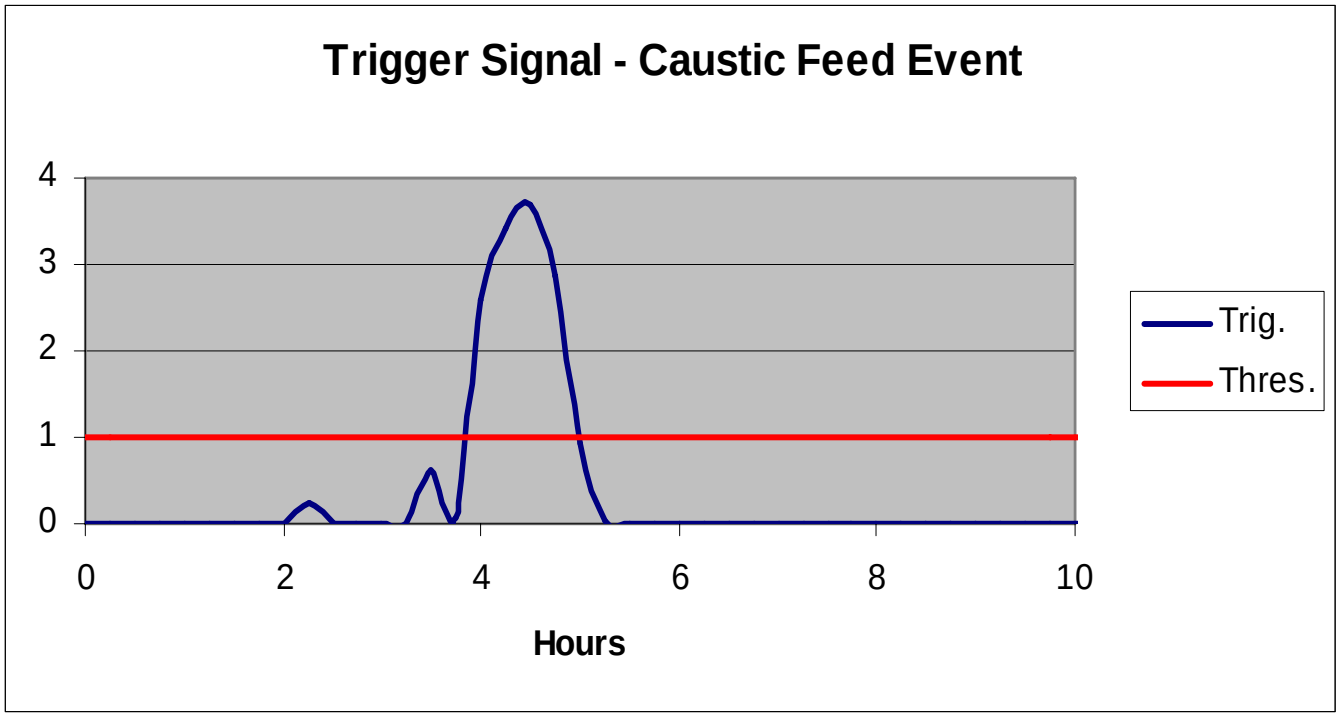
- Best old hands know when something is amiss. Aging work force results in loss of this knowledge.
- The learning ability and plant library can be used to correlate quality problems to changes in water quality.
- System can be programmed to alert operators when such changes recur so that corrective action can be taken and the water supply is not compromised.

East Coast Location Near Water Storage Tank– alarm triggered .



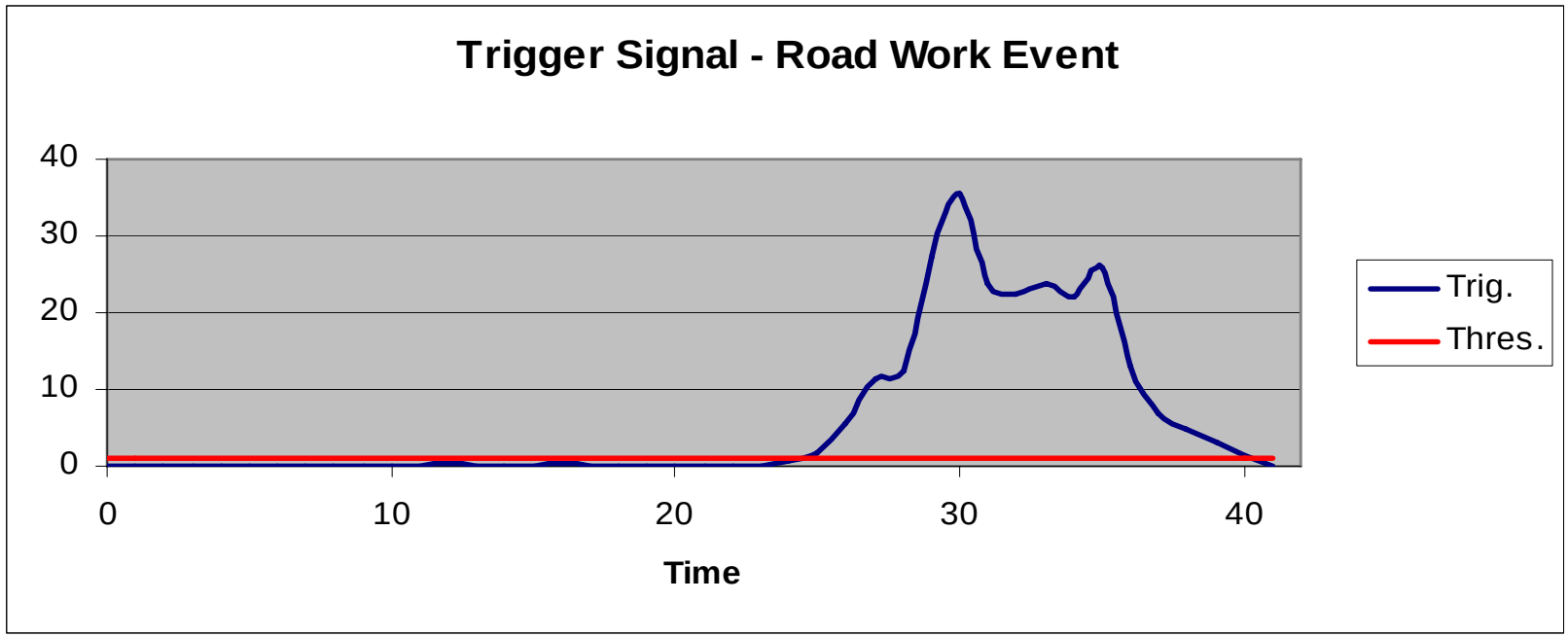
Plant Event Defined
Name: Pump Shut Off, Type: NORMAL



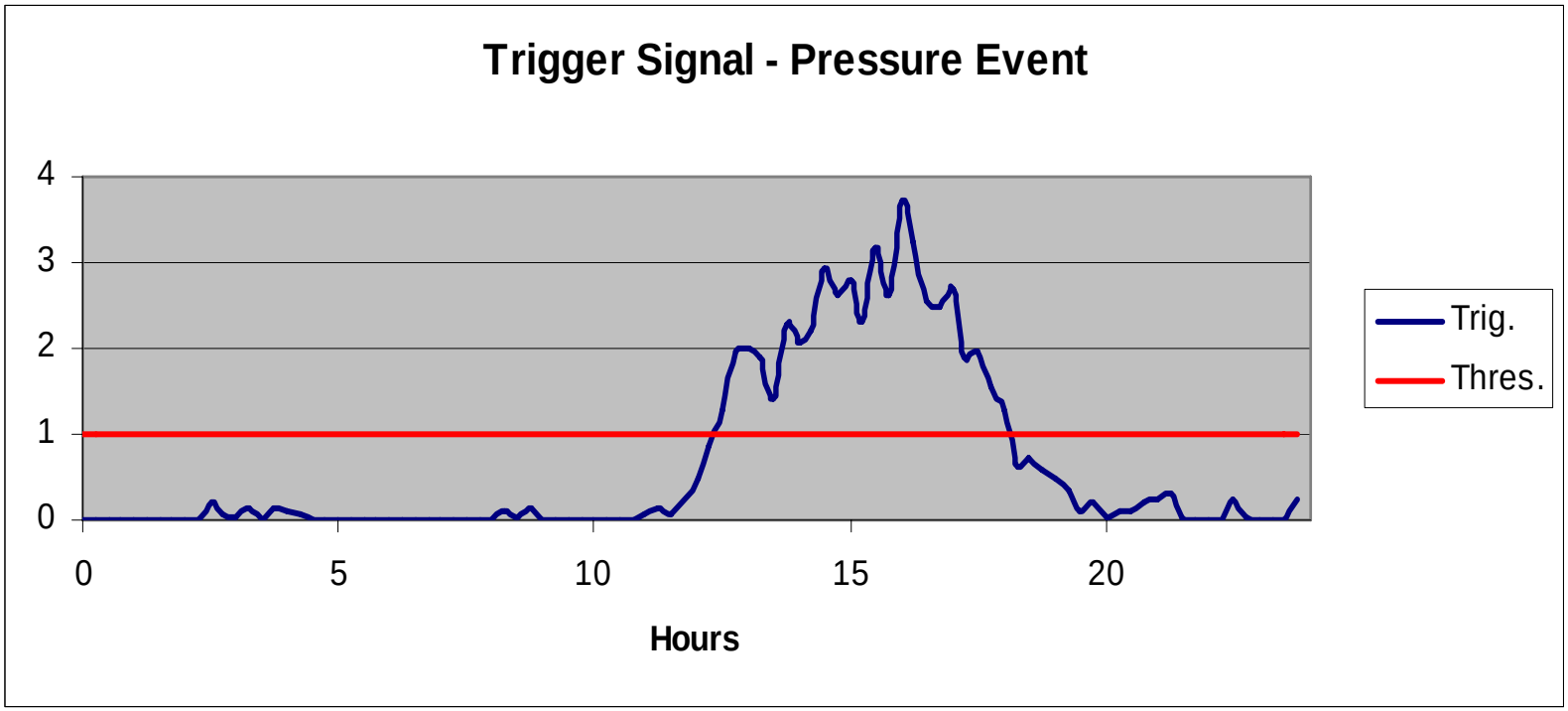


The plant uses caustic feed to control water pH and experienced an operational problem that resulted in the feed of excess caustic. That affected the pH and the conductivity of the water, causing the Event Monitor to alarm.

The Event Monitor learned this Plant Event and can identify a recurrence of the event.



Road work near a distribution line dislodged biomass and other particulate matter from the lining of the pipe. There was a massive increase in turbidity, which not only showed up on the turbidimeter, but also showed up as an interference in the chlorine measurement (optical). As expected, the conductivity and pH also showed minor changes. The increase in biomass in the water was indicated by the TOC analyzer. This event illustrates the ability of the Event Monitor to detect and alarm on unanticipated events. This event also provides a signature for the materials adhering to the walls of the pipes in this location.

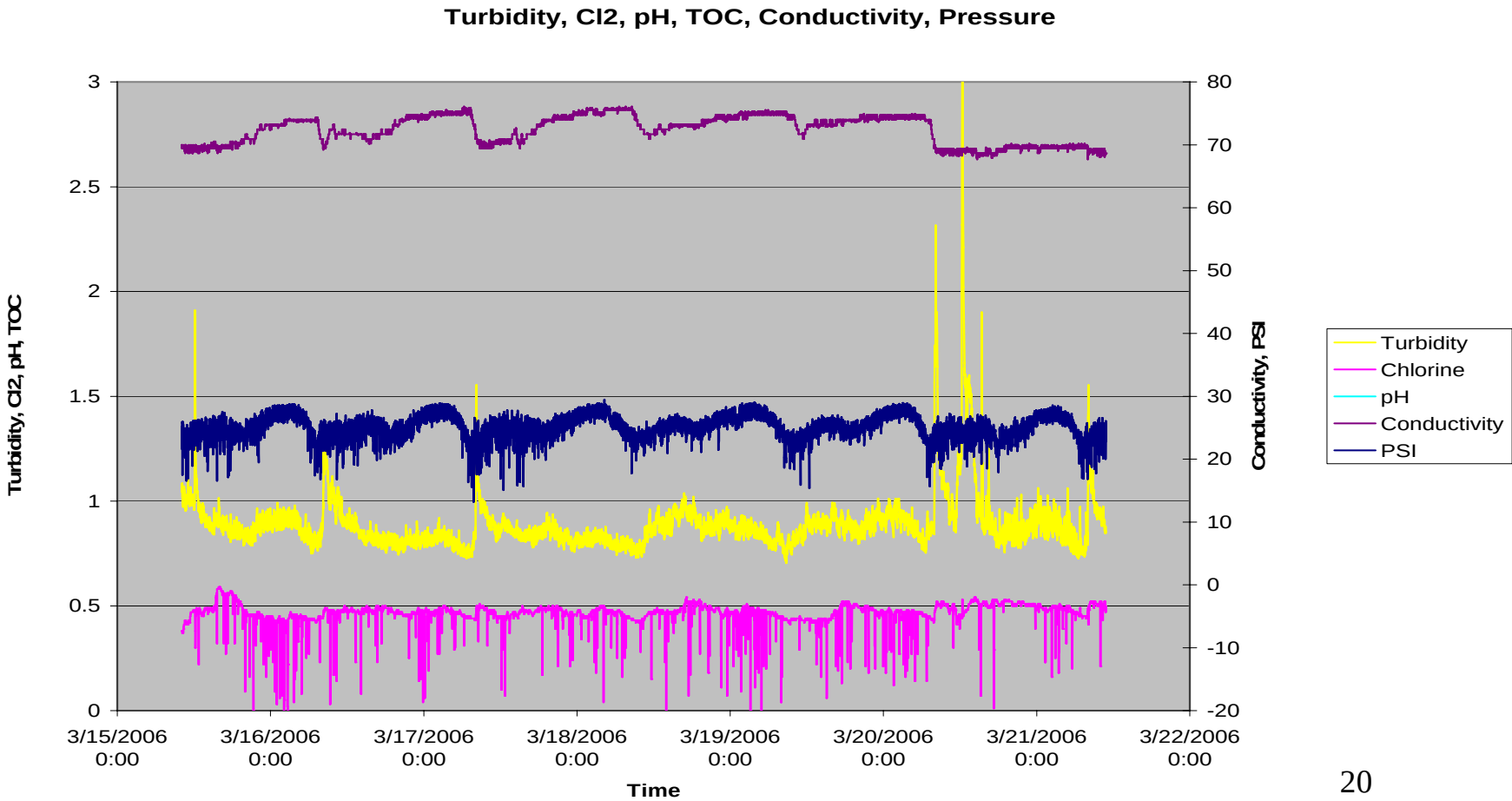


The Event Monitor is located in a building which experiences a daily variation in water pressure. The sample variation is associated with a turbidity increase that causes a Trigger. There is also a small pH decrease at that time, possible because of increased solubility of CO2 in the water, dropping the pH slightly. This pattern is recognized by the Event Monitor as a "Normal" event, rather than an alarm condition.

Effects of Variable Demand

Daily events influencing turbidity, chlorine, pH and possibly conductivity are not completely understood but suspected to be caused by water demand fluctuations in the area.

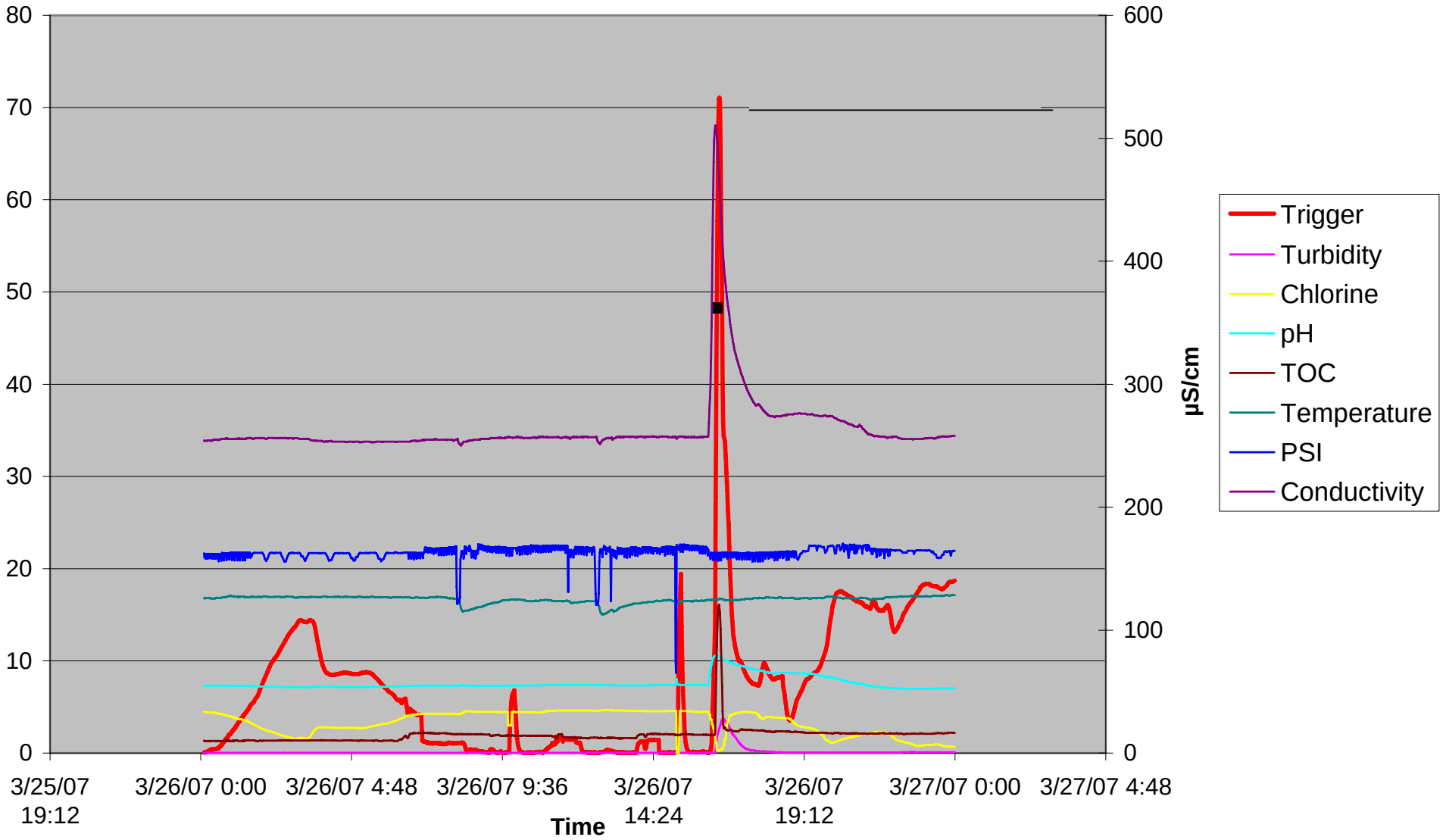
May indicate need for flushing and chlorine booster.



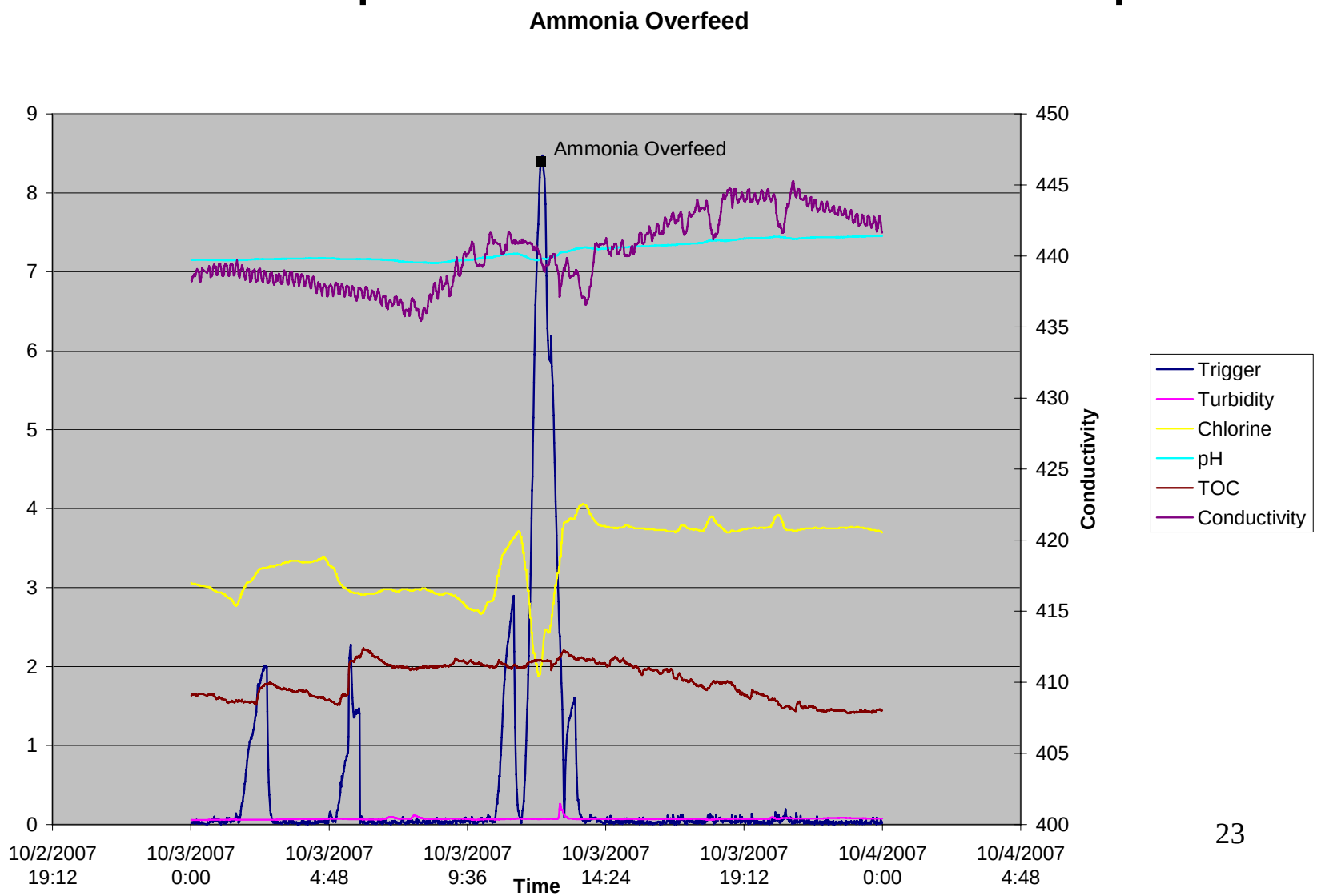
Ammonia Overfeed Events

- On March 26th, 2007, maintenance was performed at the Plant. After maintenance was completed, the plant was restarted and the system that feeds the ammonia overfed the chemical. The operator noticed an increase in pH and contacted operations at 16:25. Operations reported a problem with the ammonia feed pumps. The problem was temporarily fixed but a slug of ammonia was sent into the distribution system. Several customers called, complaining about an ammonia smell and taste coming from the tap. The exact amount of ammonia released was unknown, but was believed to be less than 10 ppm. The facility continued operation but temporarily utilizing free chlorine as a disinfectant until July 2nd.

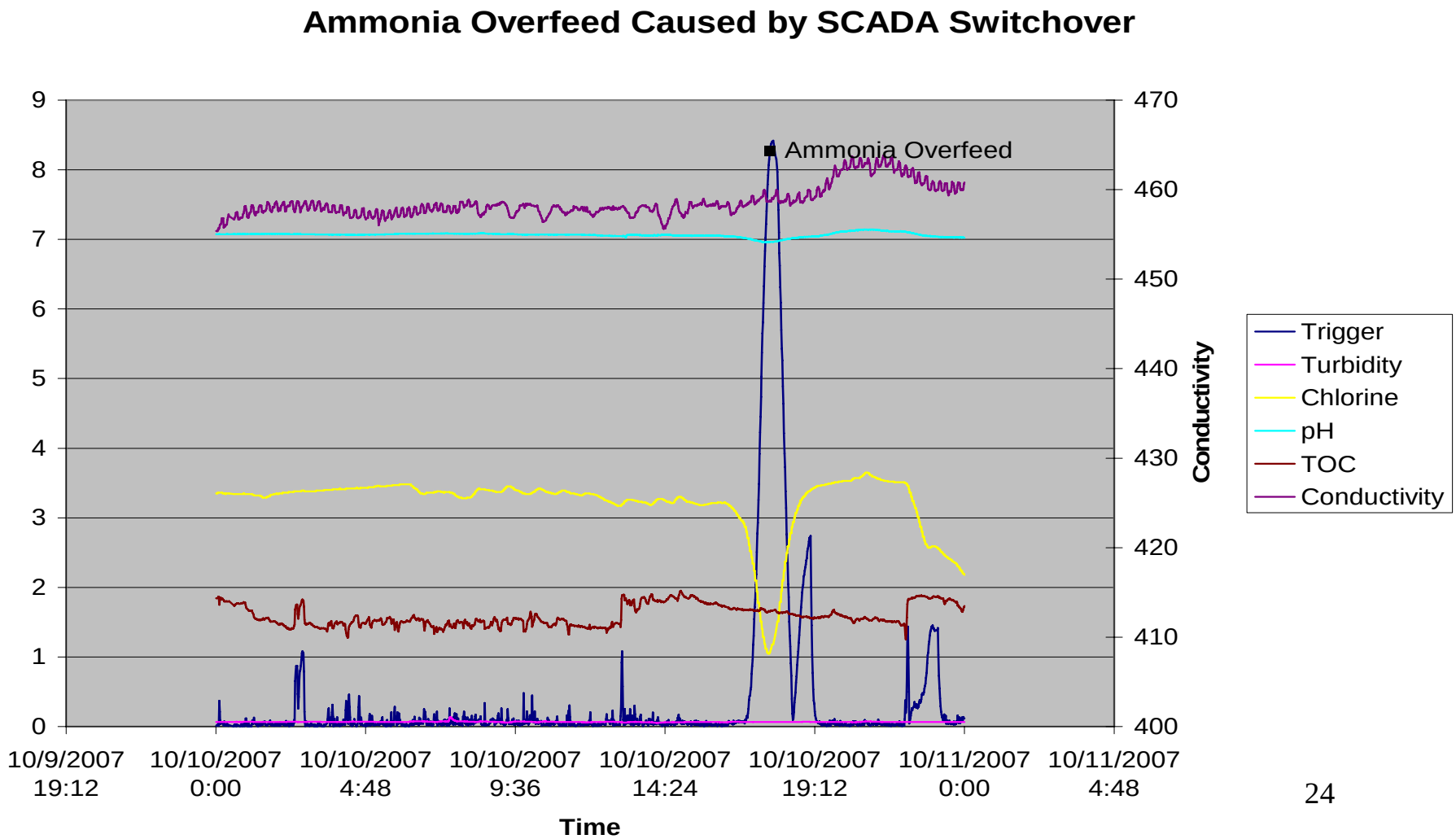
Ammonia Event



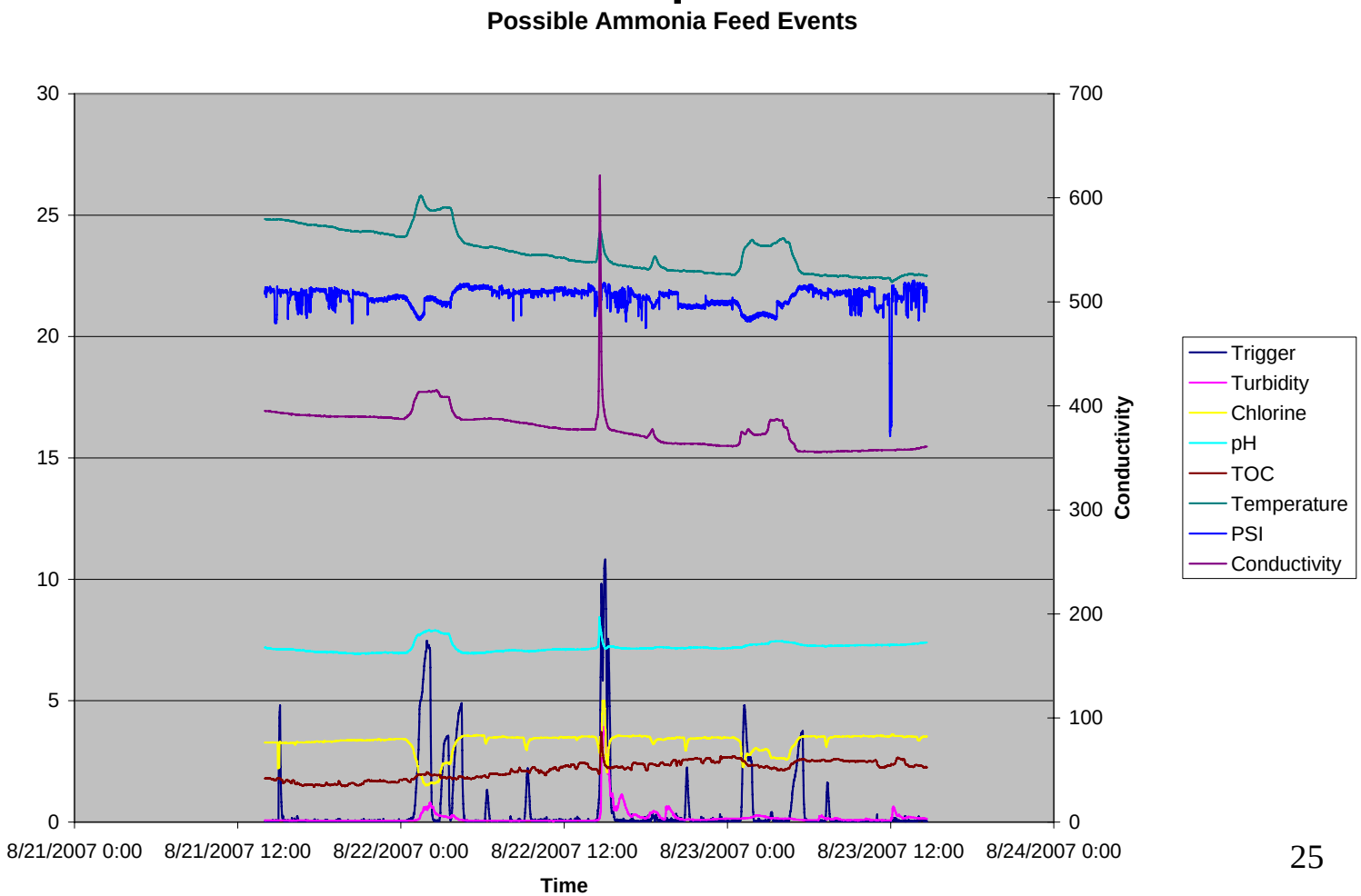
On October 3rd, the plant experienced a brief ammonia overfeed. A pump was turned on and not switched off in time. There was a drop in chlorine and a small decrease in pH.



On October 10th, 2007 there was another ammonia overfeed caused during the switchover from the old SCADA system to the new. This created a similar drop in chlorine and pH as the October 3rd overfeed.

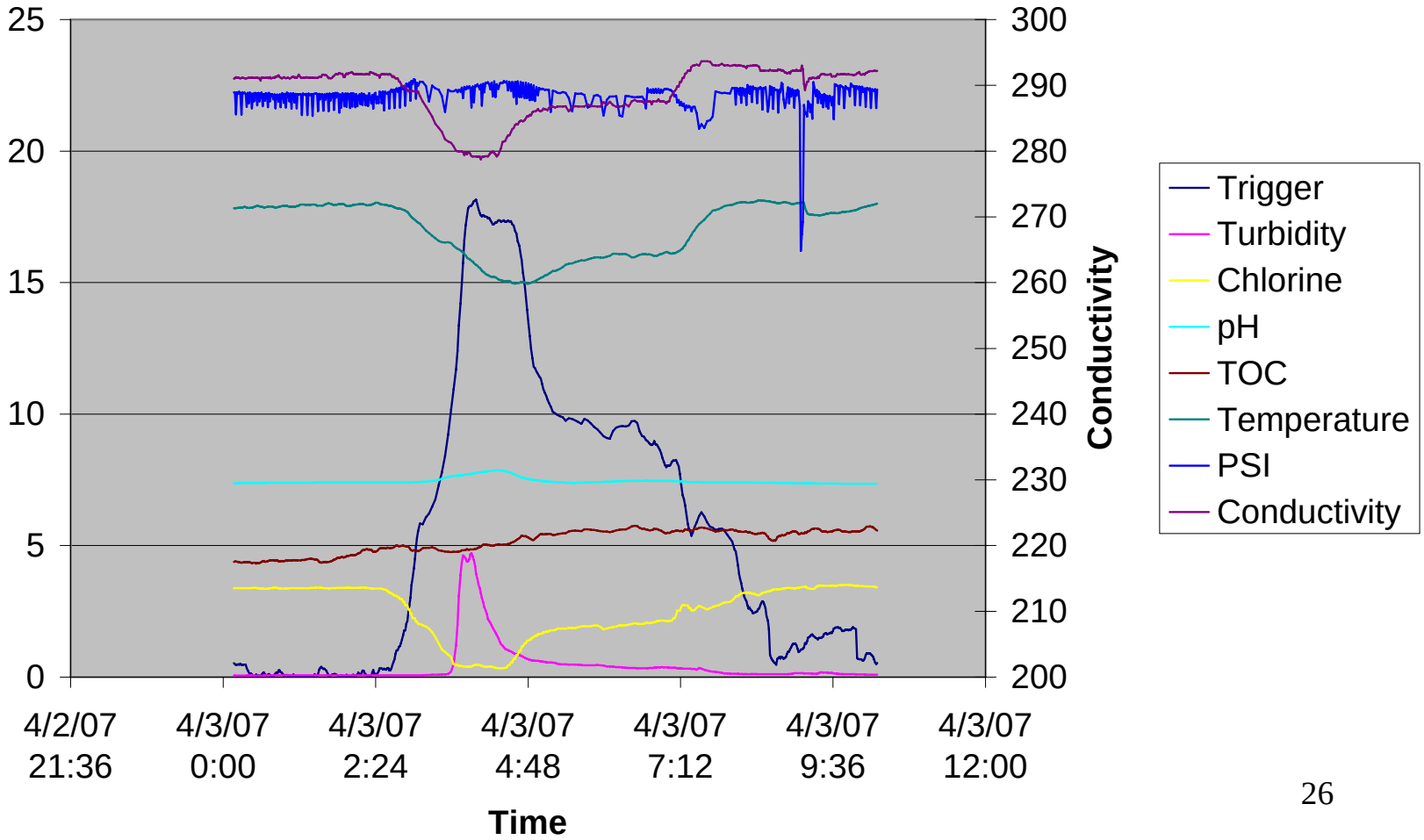


Between August 22 and August 23, 2007, three similar events occurred. Increases in turbidity, pH, and possibly TOC with drops in chlorine caused triggers. These changes resemble the large ammonia event that occurred in March. Operator believes these could be be ammonia feed events but cannot confirm it with operations.



Possible Chlorine Feed Event

On April 3, 2007 there was a turbidity and pH increase and a decrease in chlorine and conductivity. Operator believes that there might have been a problem with the chlorine feed at the plant. However, this cannot be confirmed. The plant was using free chlorine instead of chloramines at the time which rules out the ammonia feed problem.



Air Bubble Event

- In one Northern Midwest system, every Friday, the sensors would behave extremely erratically resulting in multiple alarm signals being generated. Investigations led to the discovery of extreme amounts of entrained air bubbles being present in the systems water on Friday afternoons and evenings.
- Further investigation revealed that school buildings that were to be vacant over the weekend had a policy of using air to blow out their water lines to prevent freezing so that the heat could be turned off over the weekend. A faulty check valve at one of the schools allowed the air to bleed into the distribution system. The valve was replaced, thus closing a possible backflow route into the system. After this the erratic readings ceased.

Distribution Flushing Case Study

- Customer experiences poor water quality in certain areas of the distribution system and did not know why
- Installed series of Distribution Monitoring devices
- Found ‘dead ends’ and low flow areas based on monitoring results; revised flushing schedule
- Results: Improved Water Quality

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Grab Sample vs On Line Case Study

- Customer performed extensive grab sampling and believed water quality to be good
- Installed WDMPs, found turbidity spiked to 20 NTU at night and high variability of Cl_2 levels
- Changed processes to minimize spike to about 1.5 NTU at night
- Result: Improved Water Quality and Consistency

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Water Mapping Case Study

- Customer has many WDMPs out in system and 3 water plants serving the area
- Discovered conductivity is a valuable parameter to trace where water is going and aid in hydraulic mapping
- Other benefit: uses CL17 for regulatory reporting
- Value: Predict where problem water is going
- Result: Improved Water Quality

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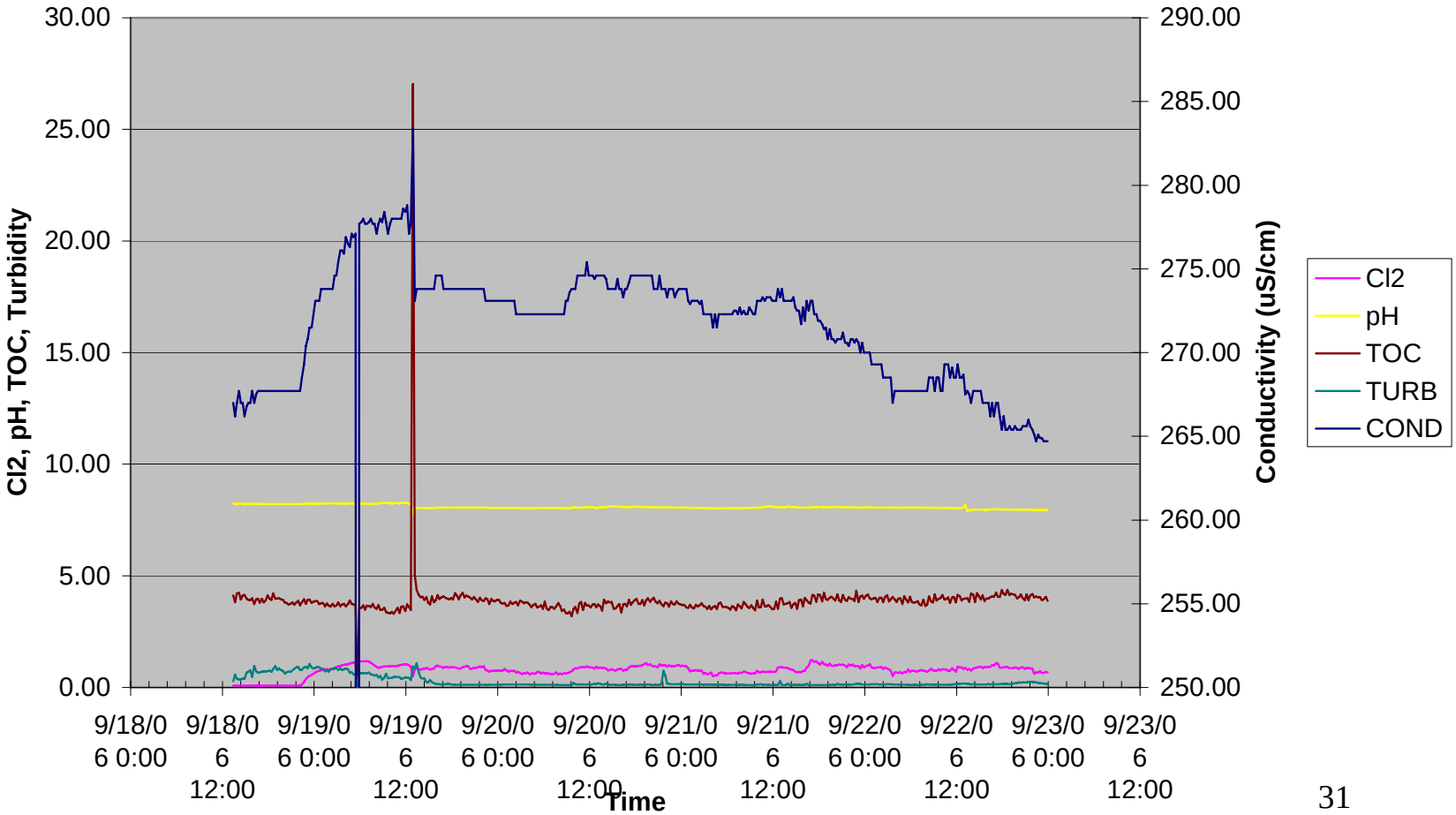
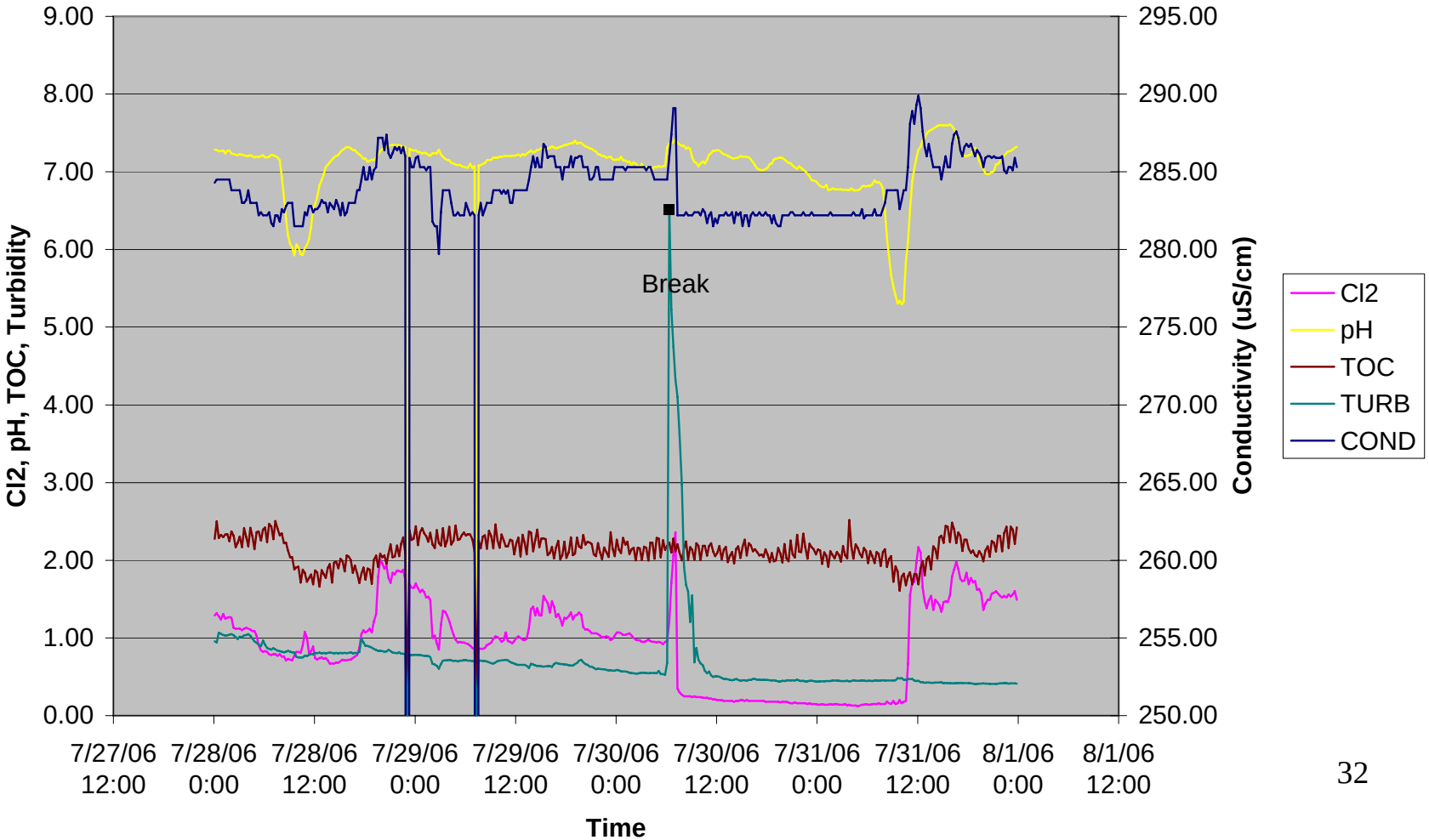
Main Break #1

The break occurred on June 29, 2006. The pipe was an 8” line and located 1.8 miles away from the WDMP. There was an increase in turbidity and chlorine. Turbidity appears to have increased the day before the break.



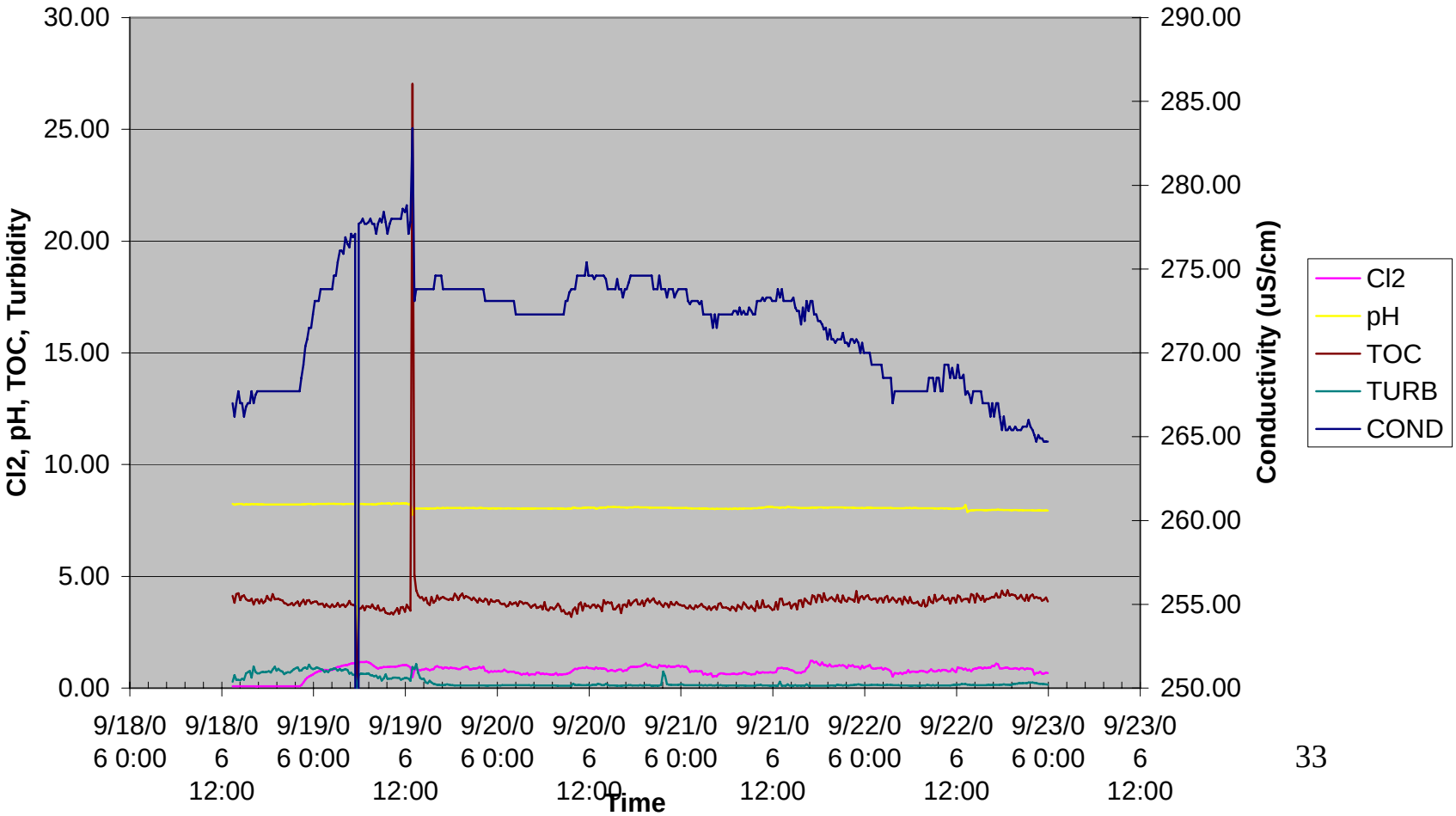
Main Break #2

The break occurred on July 30th, 2006. The line was a 36" water main located 1.0 miles from the WDMP. Conductivity, turbidity, and chlorine spiked. There appears to be two water flow interruptions to the WDMP the night before but it's unclear if they are related to the break on the 30th.

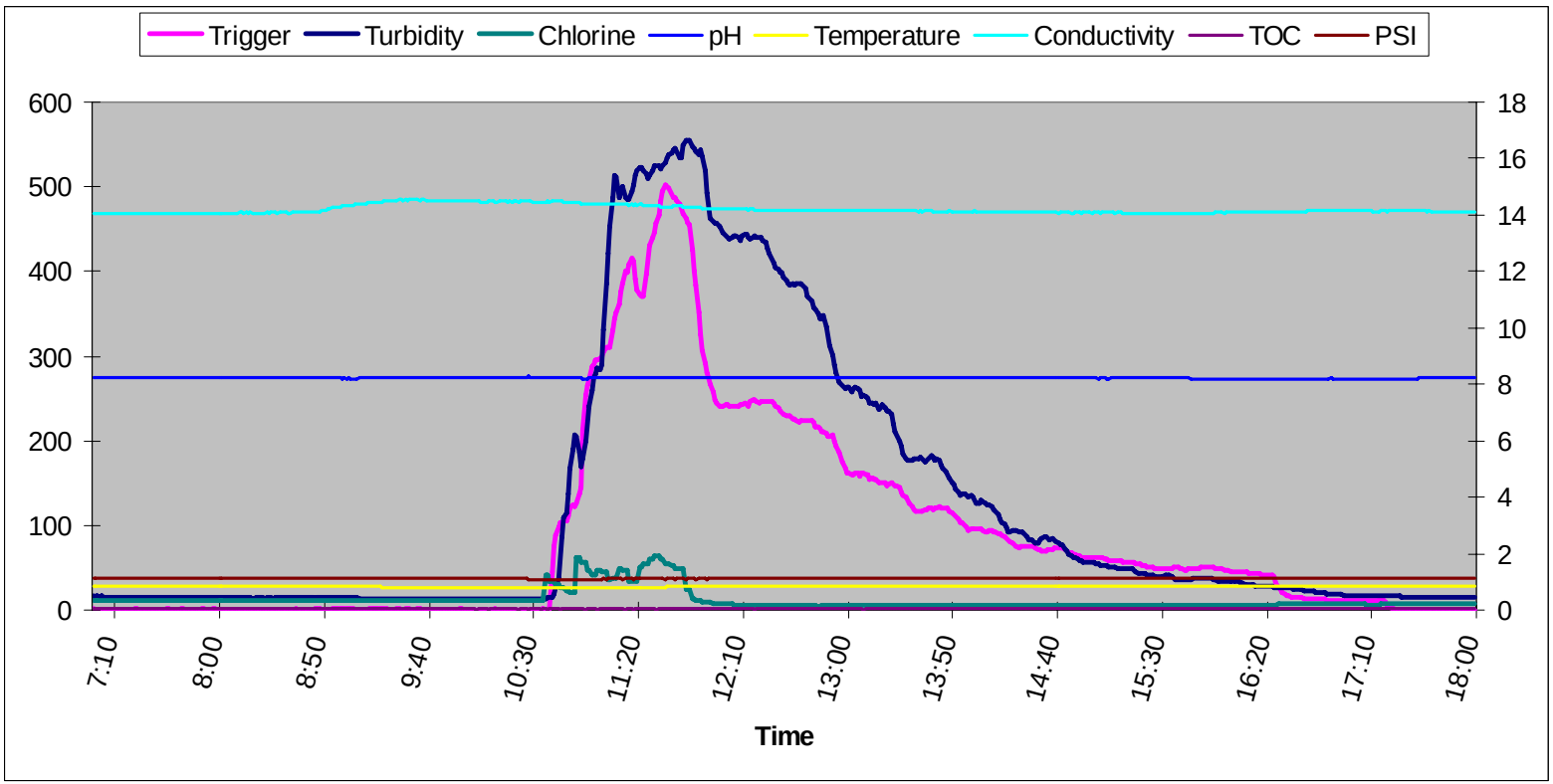


Main Break #3

The break occurred at night on September 20th, 2006. The exact time of the break is currently unknown, although there appears to be a flow interruption to the WDMP the previous morning. The line involved was a 12" water main which is 0.4 miles from the WDMP.



Main Break Event #4

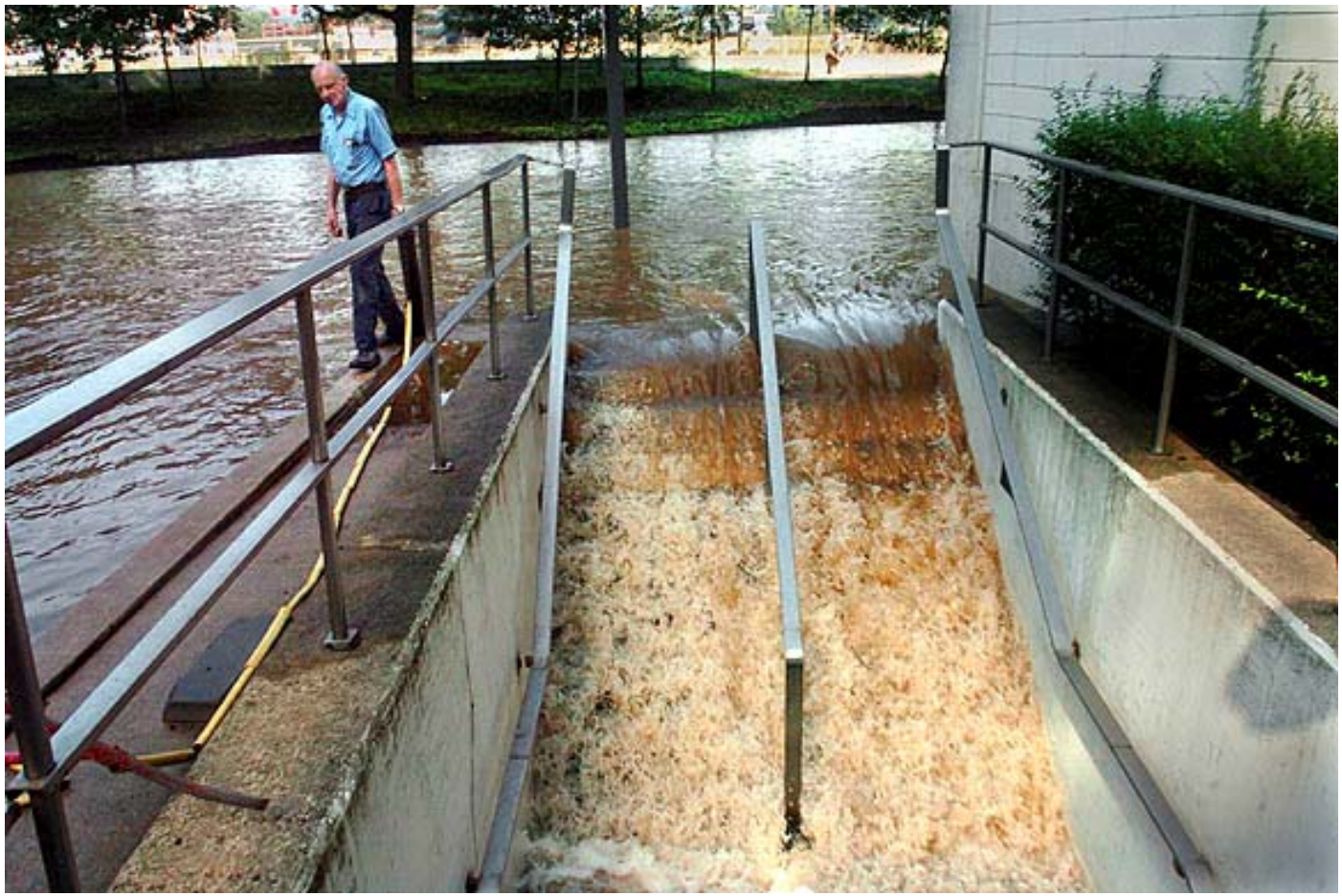


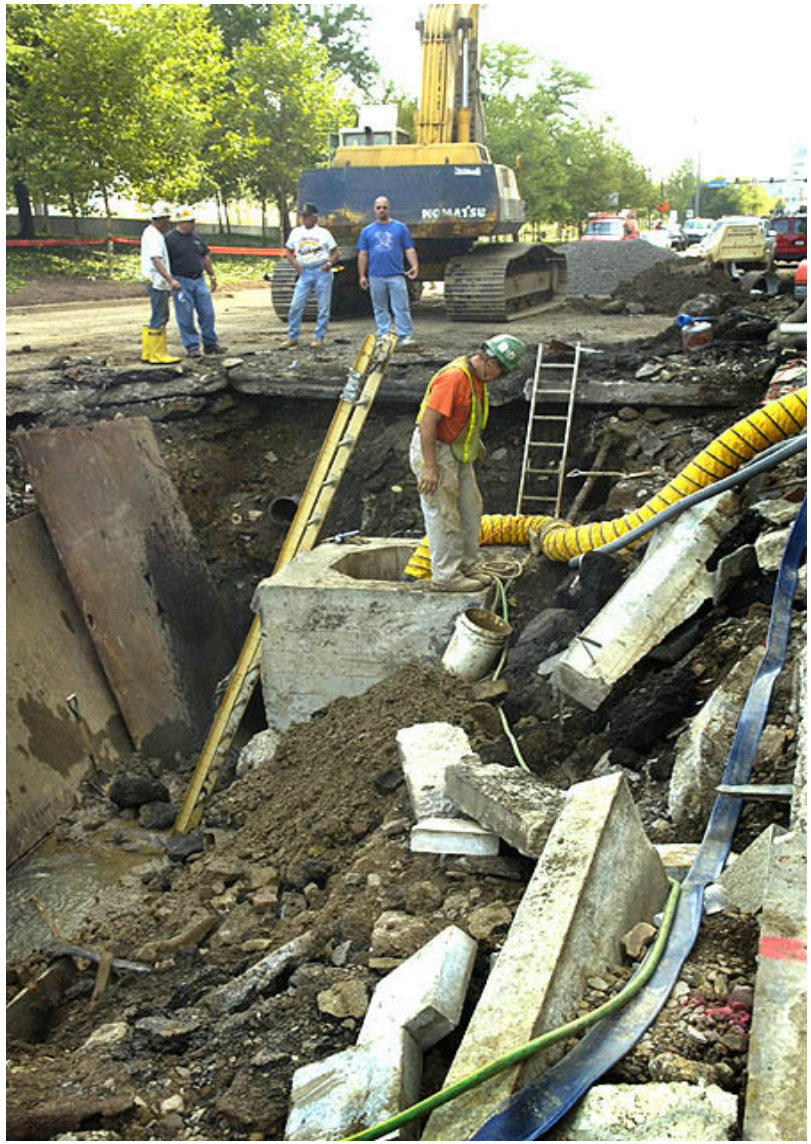
36 Inch Main Break

A geyser caused by a severed 36-inch water line erupts 10:30 a.m., August 17th. One of the largest water main breaks in the city's modern history.

A driver who was able to rescue a vehicle follows a man on foot out of a flooded parking garage, following a water main break

More than 20 million gallons of water poured out and into nearby parking garages and other low-lying areas Downtown.





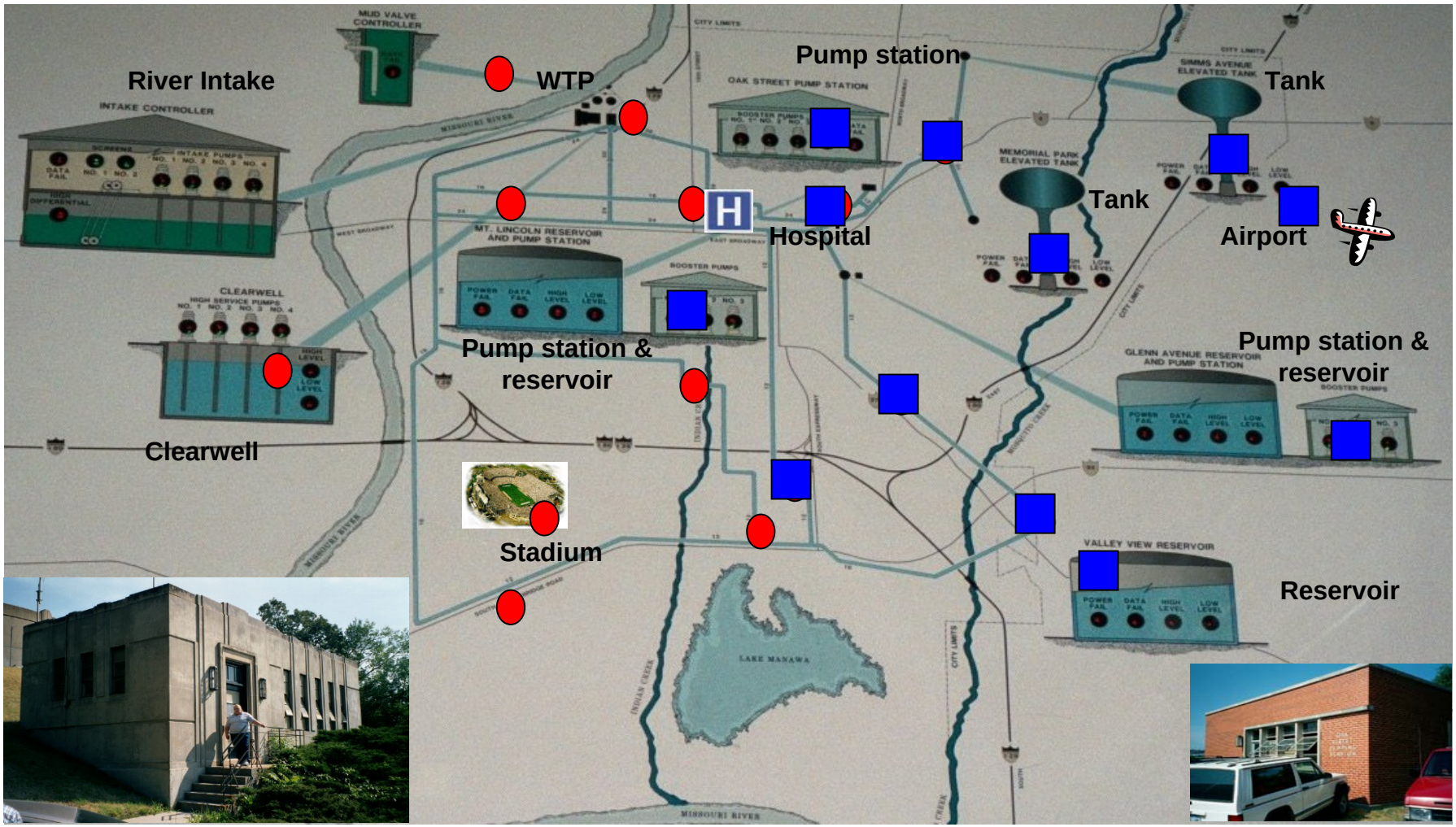
- Workmen do preliminary work before the 36 inch main could be

Workers move a section of new pipe into position as the broken 36-inch water main can be seen in the background.

The System is all you need to detect and preliminarily classify anomalous events in the drinking water distribution system increasing security and streamlining operations

Best Approach is a Network Approach

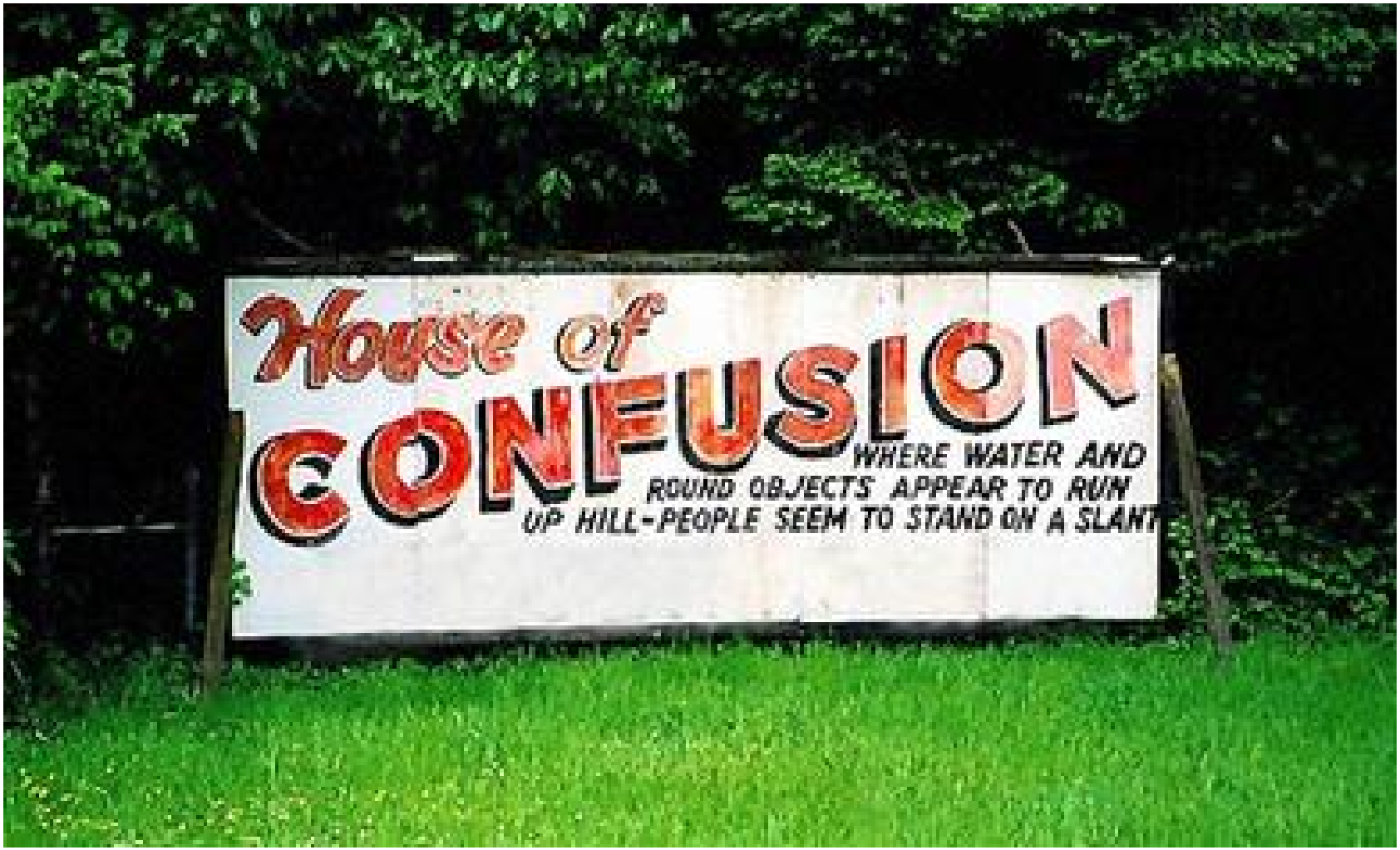
Not a choice of just one, or two instruments



A Network Monitors the "Health" of the Distribution System

- Creating a multi-dimensional network:
  - Provides a more robust system able to generate timely and accurate indications of a wide-variety of events and changing conditions.
  - Allows system managers to be "on-top" of issues before customers experience them.

Questions?


House of
CONFUSION
WHERE WATER AND
ROUND OBJECTS APPEAR TO RUN
UP HILL-PEOPLE SEEM TO STAND ON A SLANT