



Homeland Security
Technologies

Treating Water as an Ingredient Not a Utility: Monitoring to Safeguard the Integrity of Water from Accidental or Intentional Contamination

By Dan Kroll

Hach Homeland Security Technologies Division

Rocky Mountain Conference on Analytical Chemistry

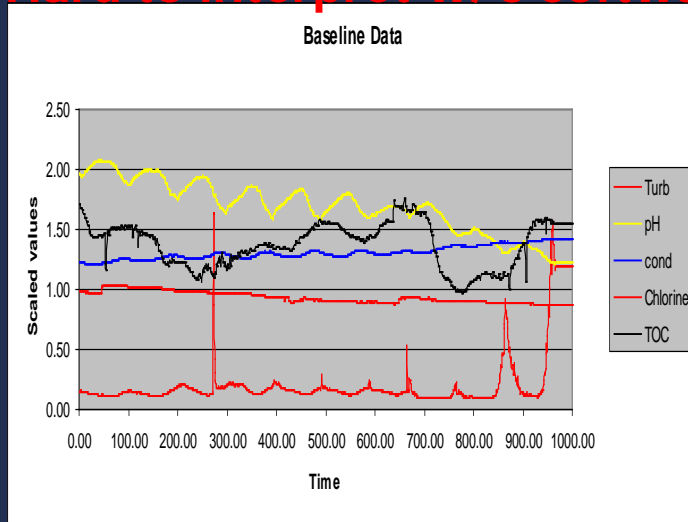
July 24th, 2007

Breckenridge, Colorado

What does the system do?

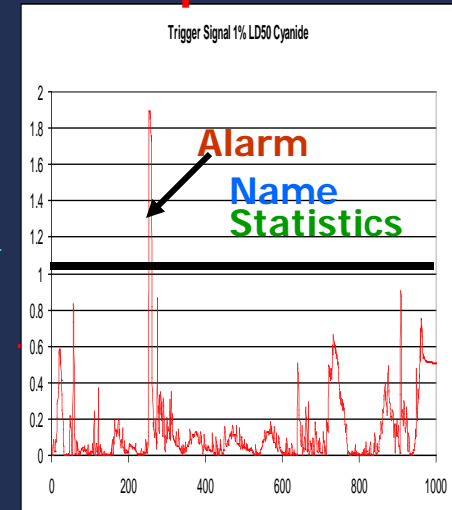
Input Five Parameter Signals
Hard to interpret w/o software

Output is a single signal.
Easy to interpret

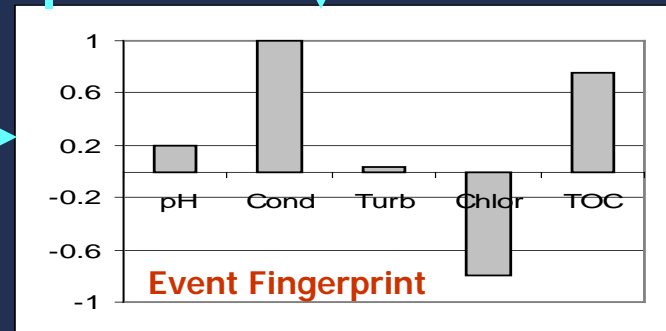


Analyze

Software



Learning



Plant/Agent Event
Library

The GuardianBlue™ 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.



Homeland Security
Technologies

So, why worry about water in the distribution?

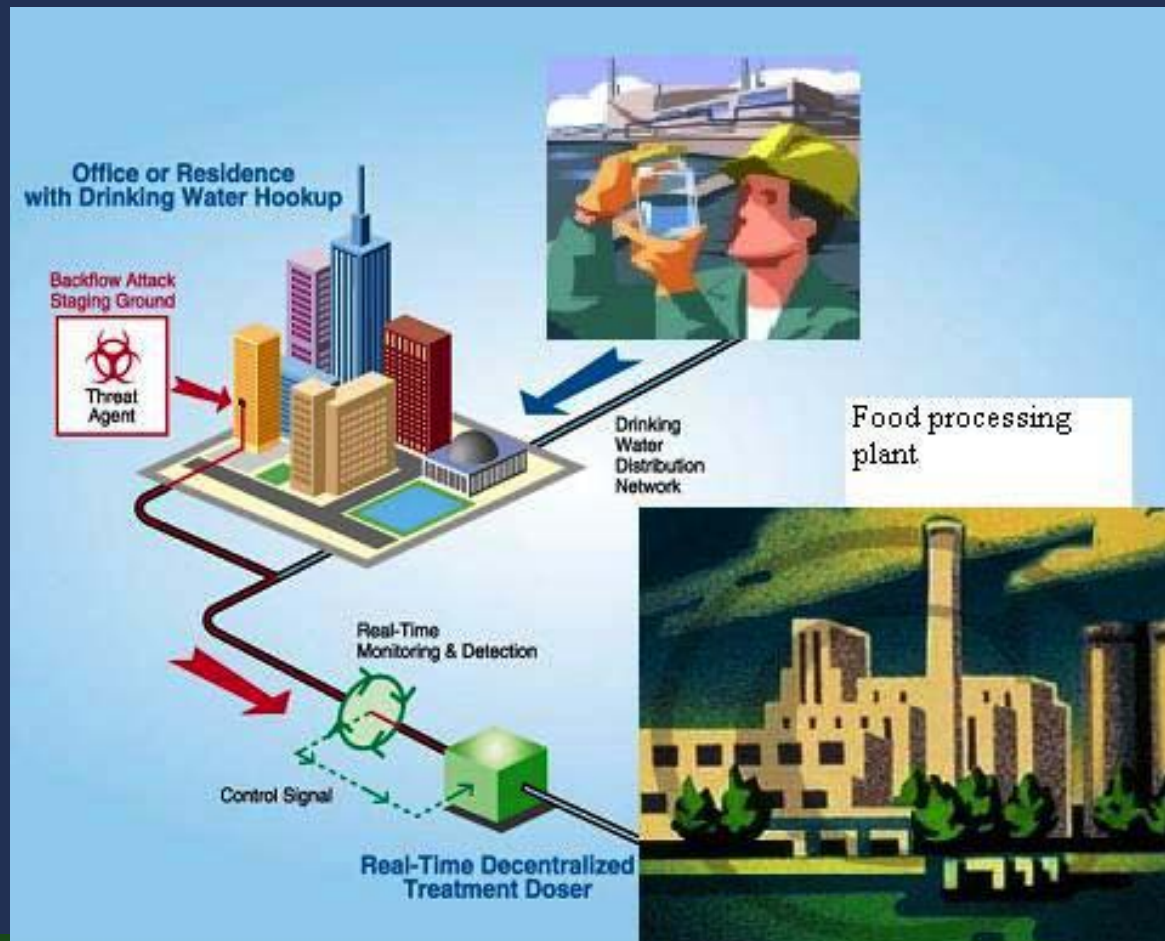
Traditional water facilities, operated correctly, are capable of handling most transitional events that occur in source waters.

However,

once the water leaves the facility, a number of different events (backflow, cross-contamination ...) can / have compromised the health and safety of the distribution system making the water in the pipelines either un-safe for consumption, or making it no longer palatable to the customer.

How do you monitor for the events in the distribution system?

All Distribution Systems are Vulnerable to Backflow Attacks and Accidental Contamination



Backflow attack is widely recognized as the most serious vulnerability to water supplies.

If kids can get through the gates with paint, terrorists can get through with toxins!!!!



*Physical barriers, like locks and gates are no solution.
The only choice is monitoring!*



Homeland Security
Technologies

Why Attack Distribution?

- Smaller volume to contaminate → smaller amount of toxic material required
- Shorter travel time from point of intrusion to target(s)
- Few if any ‘barriers’
- Studies have shown that an attack on the distribution system is easy and inexpensive to mount. Such an attack could result in 10’s of thousands of casualties and devastate a city.

GuardianBlue™ Has Gone Through Extensive Testing and Verification

- 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.



Homeland Security
Technologies

What Can We See?

Testing at the Hach Loveland, Colorado facility on a variety of agents: Over 80 Agents Characterized so far.

Pesticides and Herbicides Including Organophosphates and Carbamates, Biotoxins, Bacterial Cultures, Heavy Metals, Cyanides, Street Drugs, Treatment Chemicals Such as Fluoride, Exotic Agents, Toxic Industrial Chemicals, Common Accidental Agents Such as Diesel Fuel and Antifreeze.

Testing at Edgewood Biological and Chemical Command

Warfare Agent, Biological Agents, Toxins

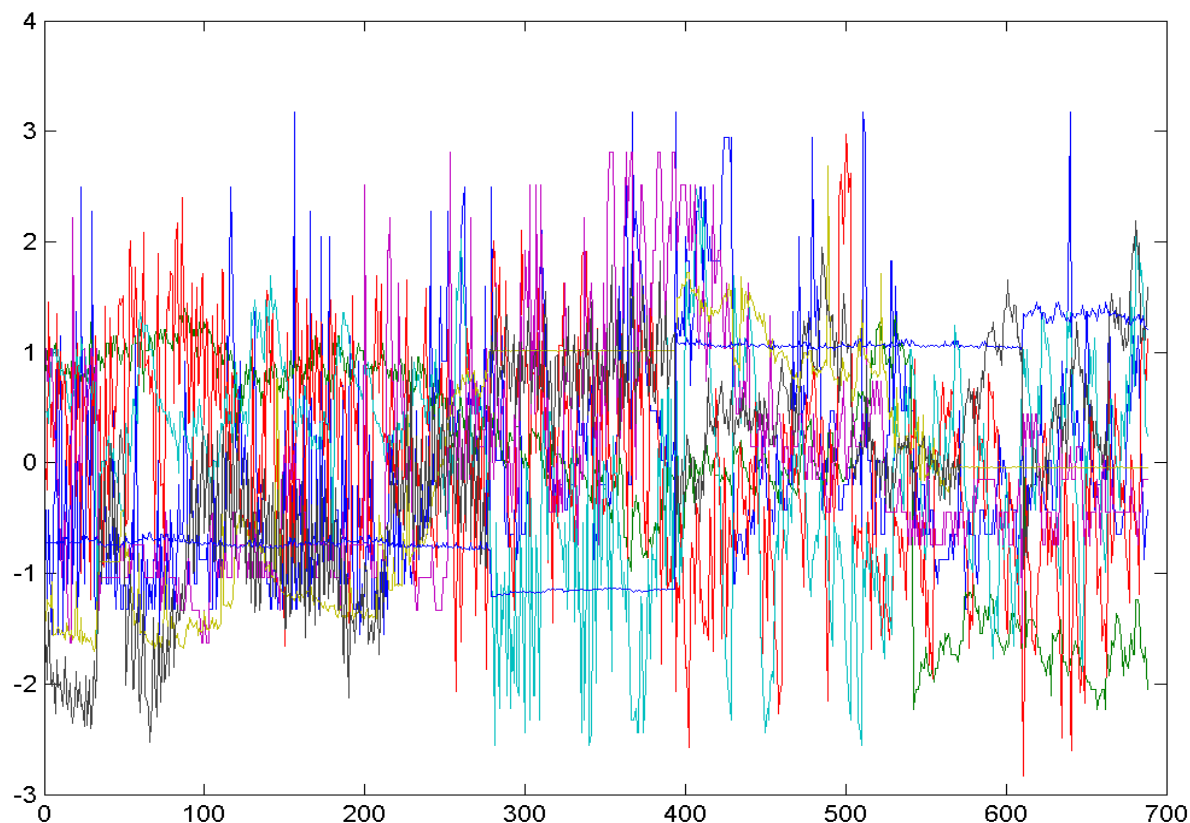
Real World Evaluations at Numerous Sites

Pipe main breaks, Pipe disruptions (road work), Source water changes, Chemical overfeeds, etc.

More details are available upon signing of a specific non-disclosure agreement to cover this topic.

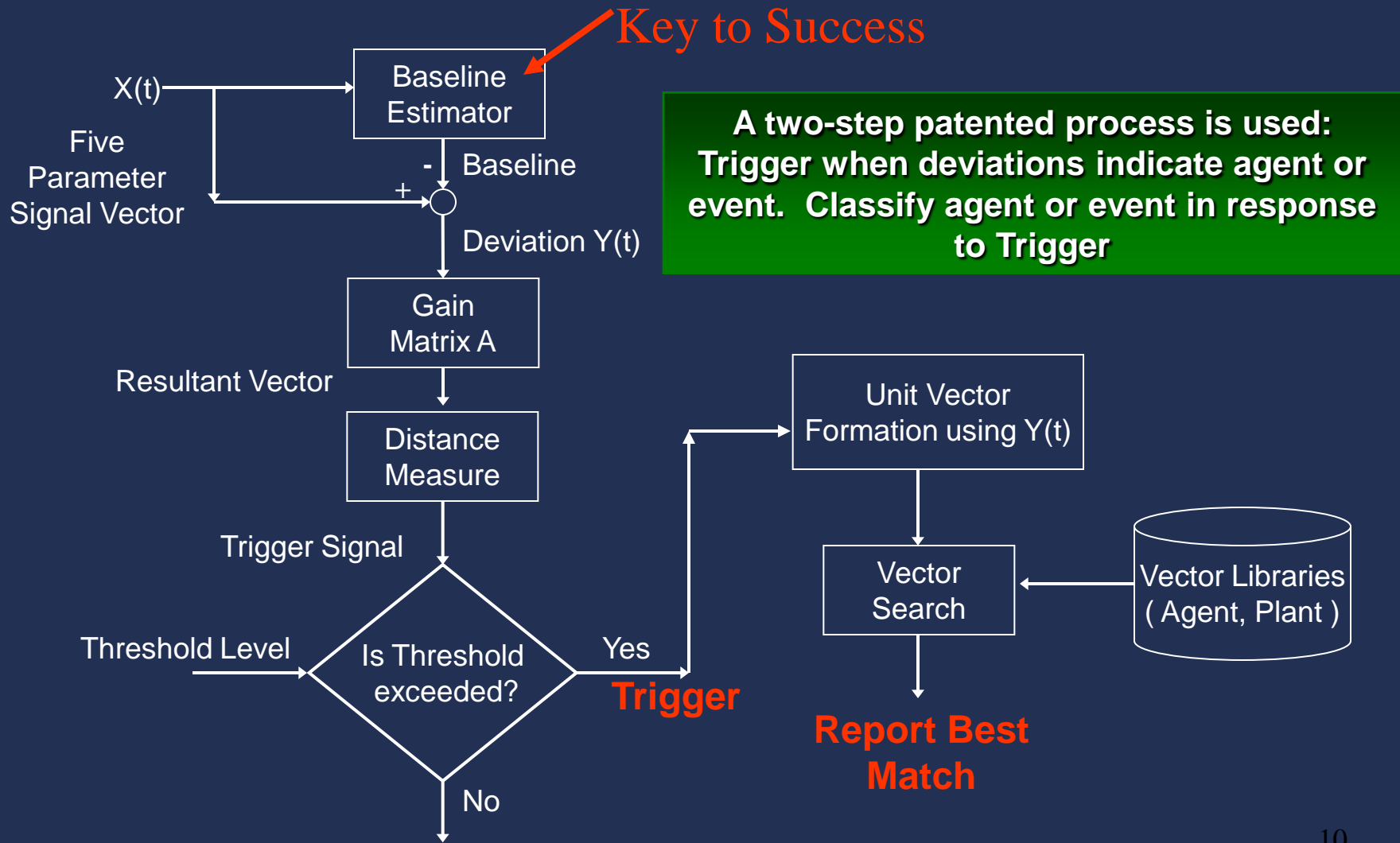
Technical Challenges

What is Background Here?

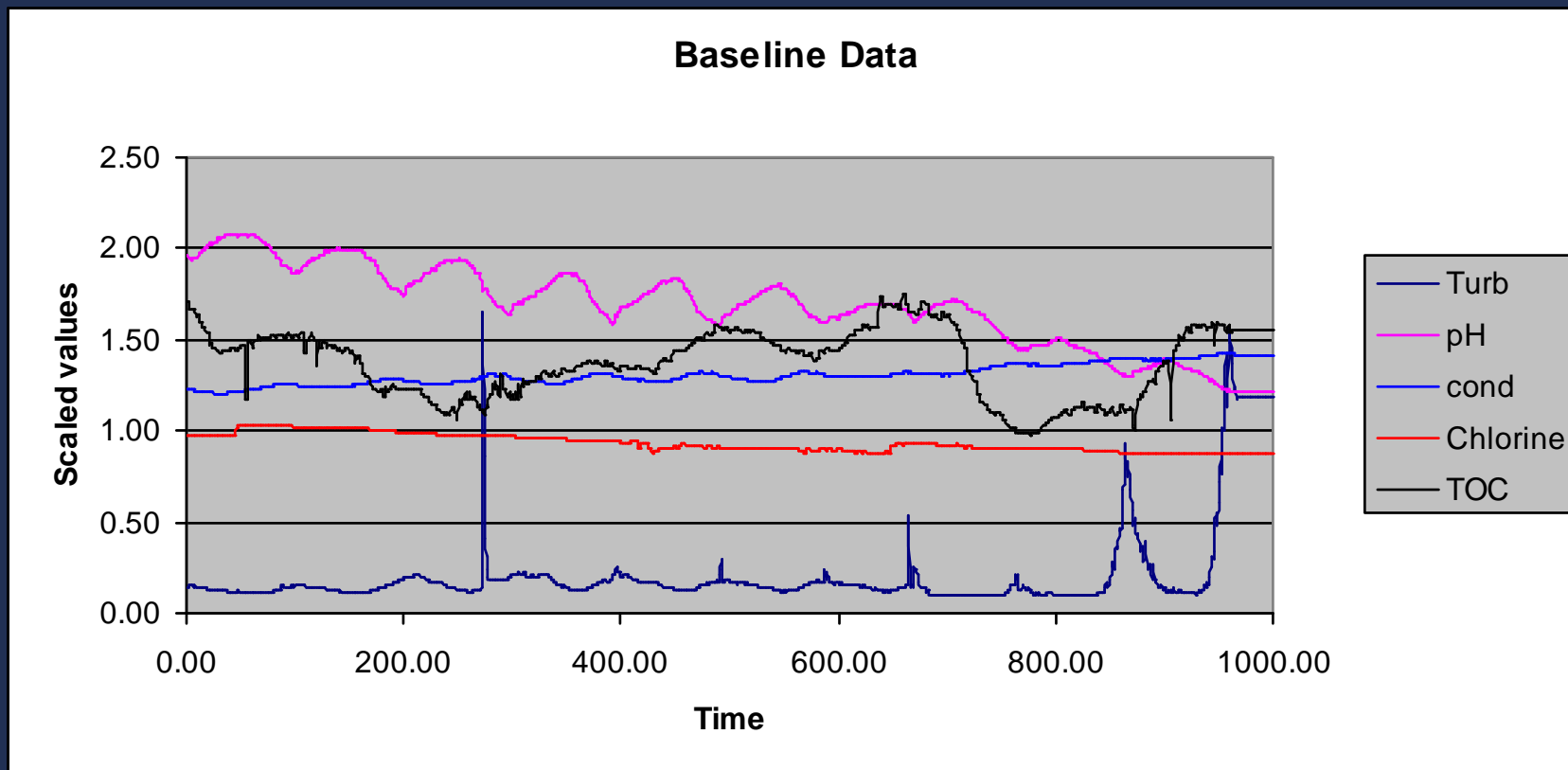


Contrary to common belief – the background of each water system is a non-stationary process and the evolution of the background is dependant upon multiple influences (weather, surface water, ground water, water purchasers)

Intelligent Trigger Software Flow Chart



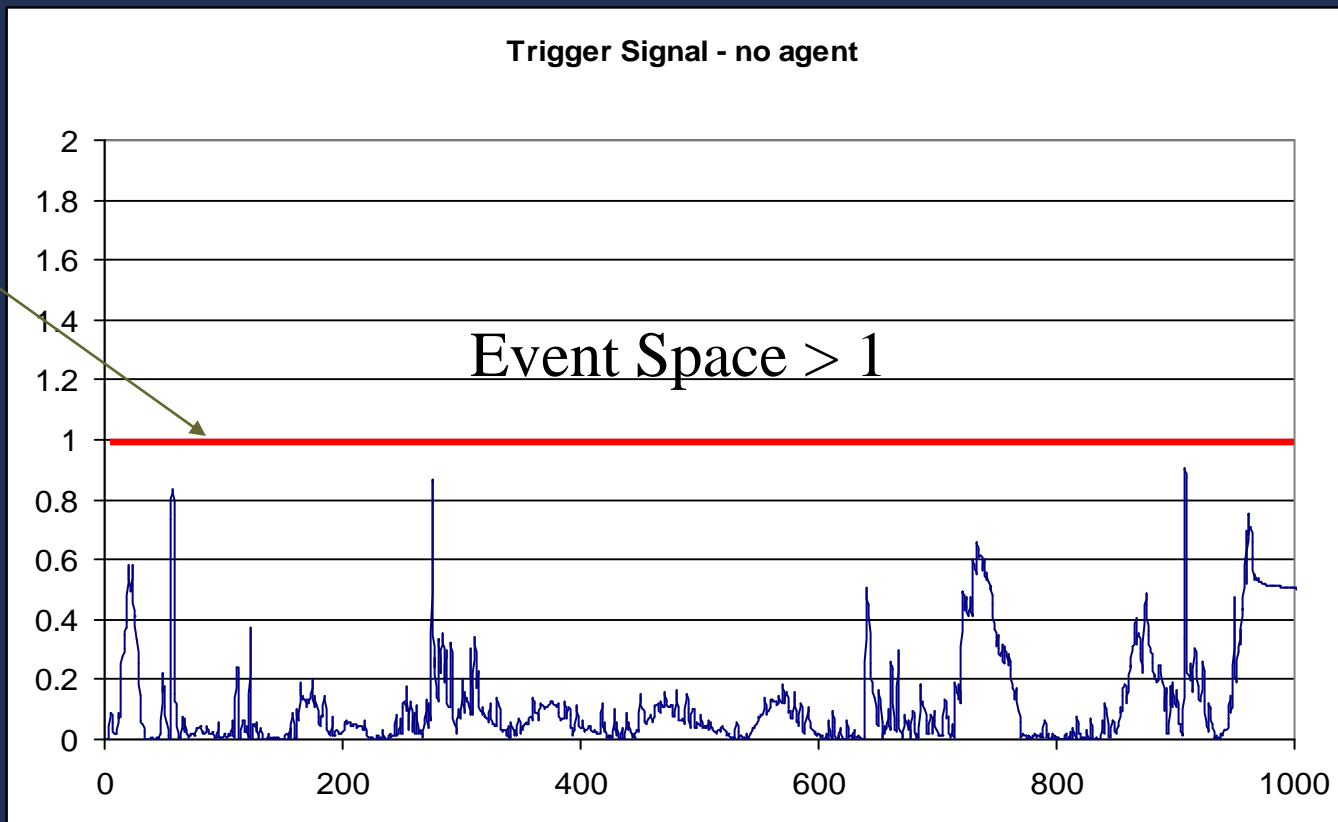
Raw Parameter Data for Trigger Analysis – Surface Water Facility



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

Trigger Signal w/ No Agent

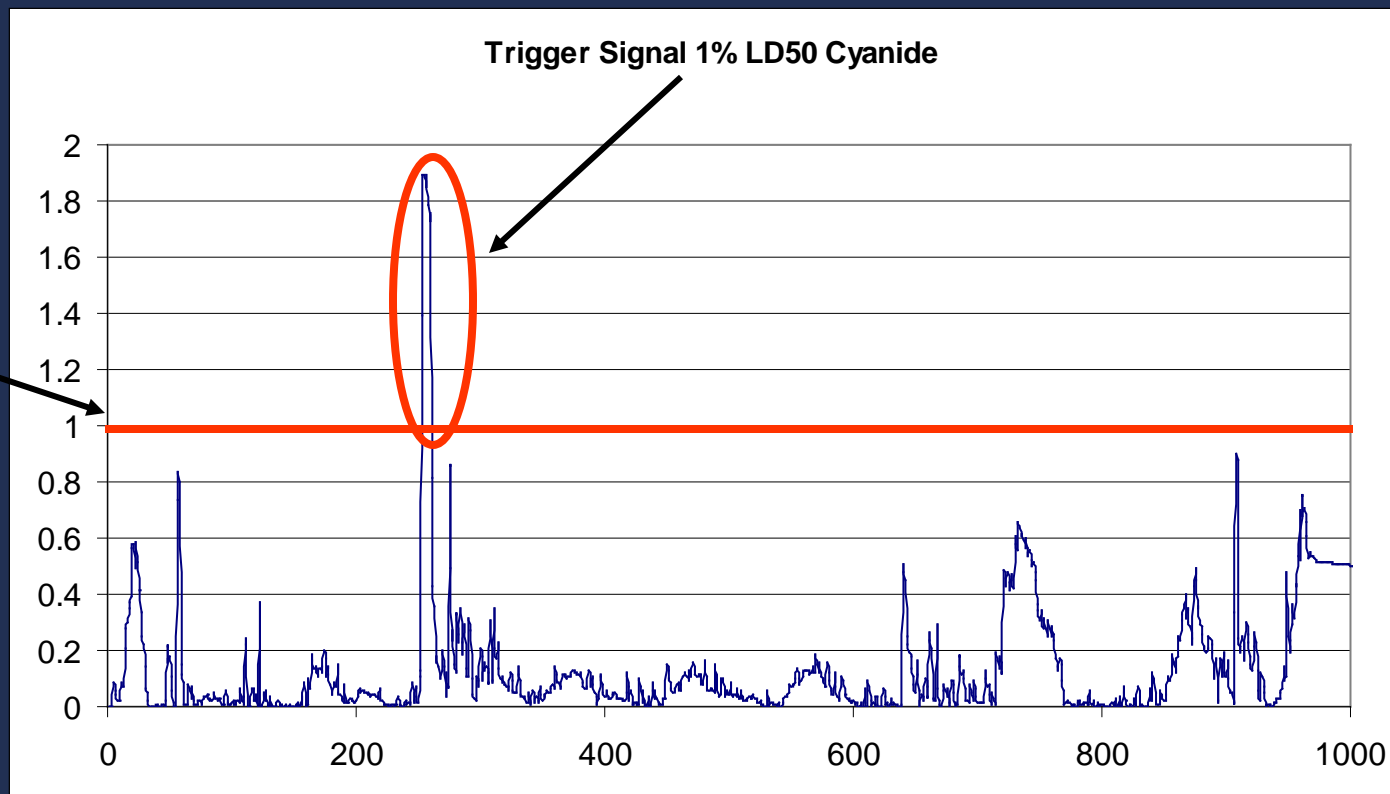
Trigger
Level = 1



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.

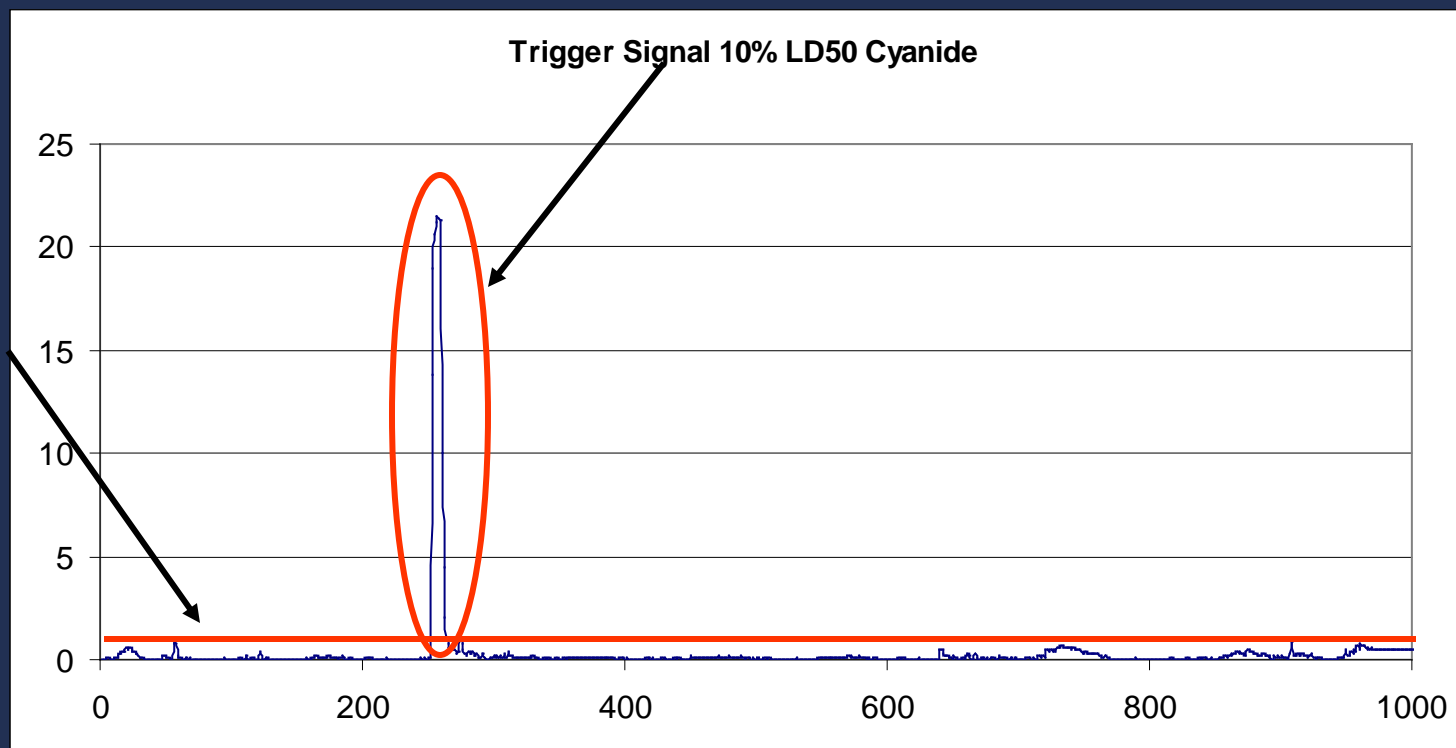
Event Level with low dose of cyanide

Trigger
Level = 1



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

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



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

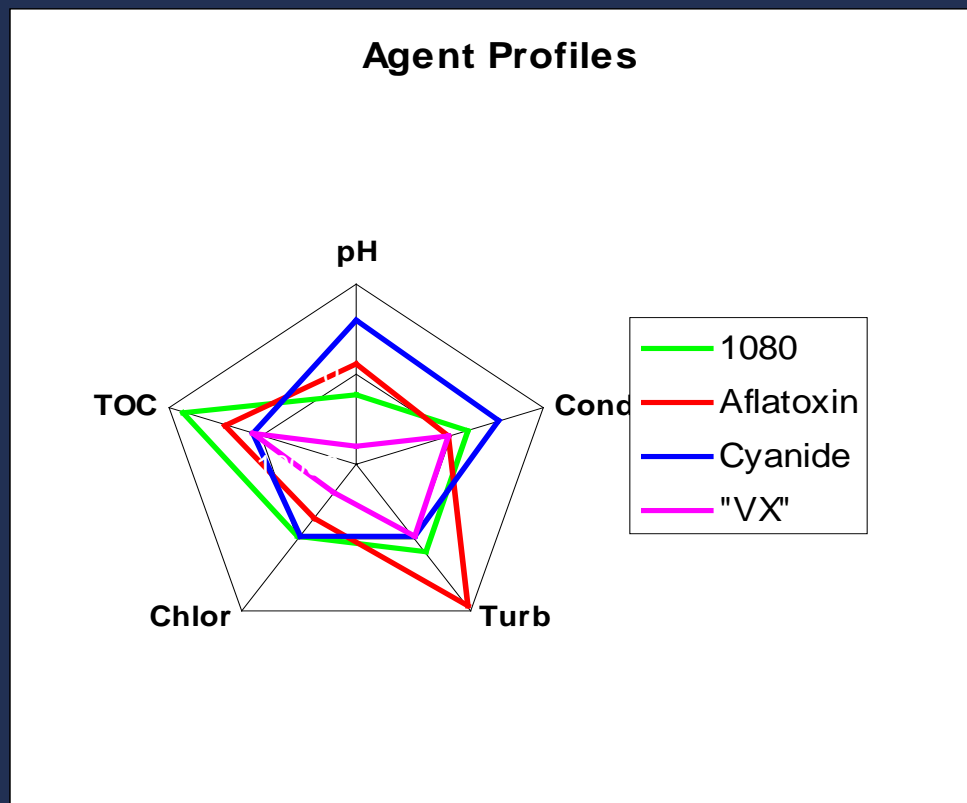


Homeland Security
Technologies

After the Trigger: Detection/Classification Algorithm

- **Deviation Vector Magnitude** relates to concentration and Trigger Signal
- **Deviation Vector Direction** relates to the agent characteristics.
- 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.

"RADAR" PLOT OF AGENT DEVIATIONS

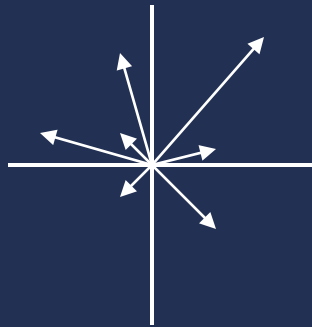


Agents have unique patterns in N space. These patterns can be generated in the laboratory and programmed into the event monitor as a library to which triggers can be compared.

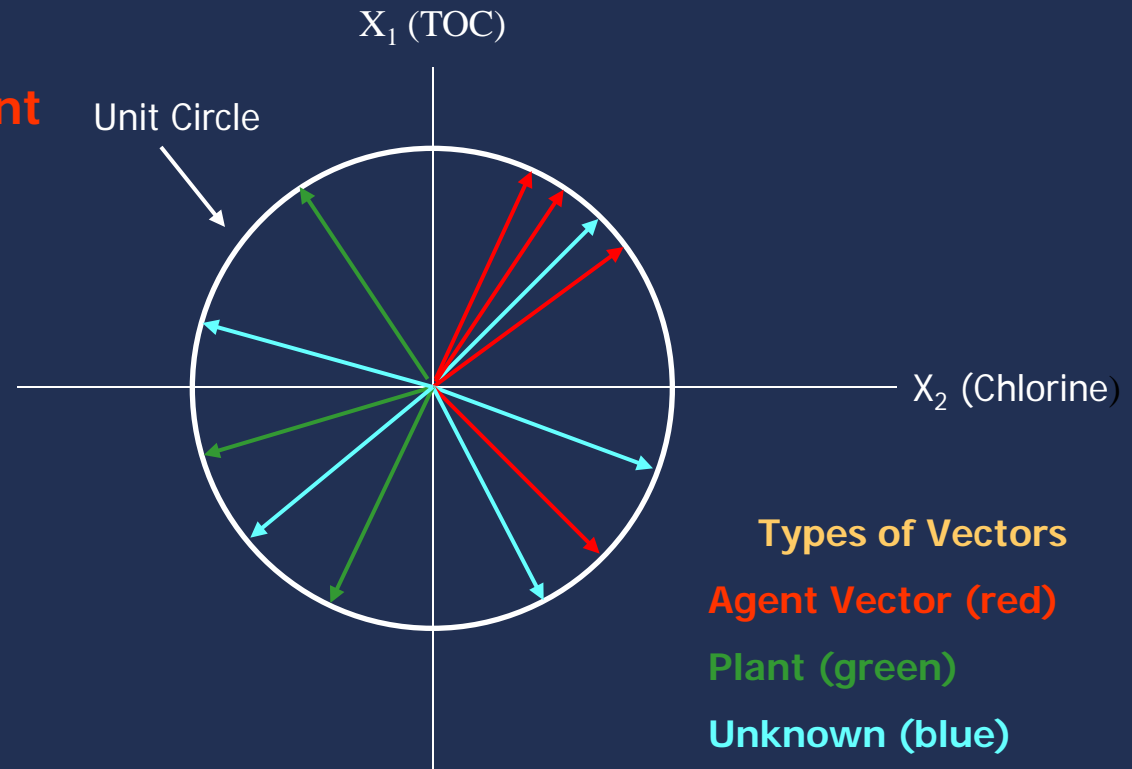
Unit Vector Approach to Classification

2D example of Unit Vectors

Vectors are dose-dependent



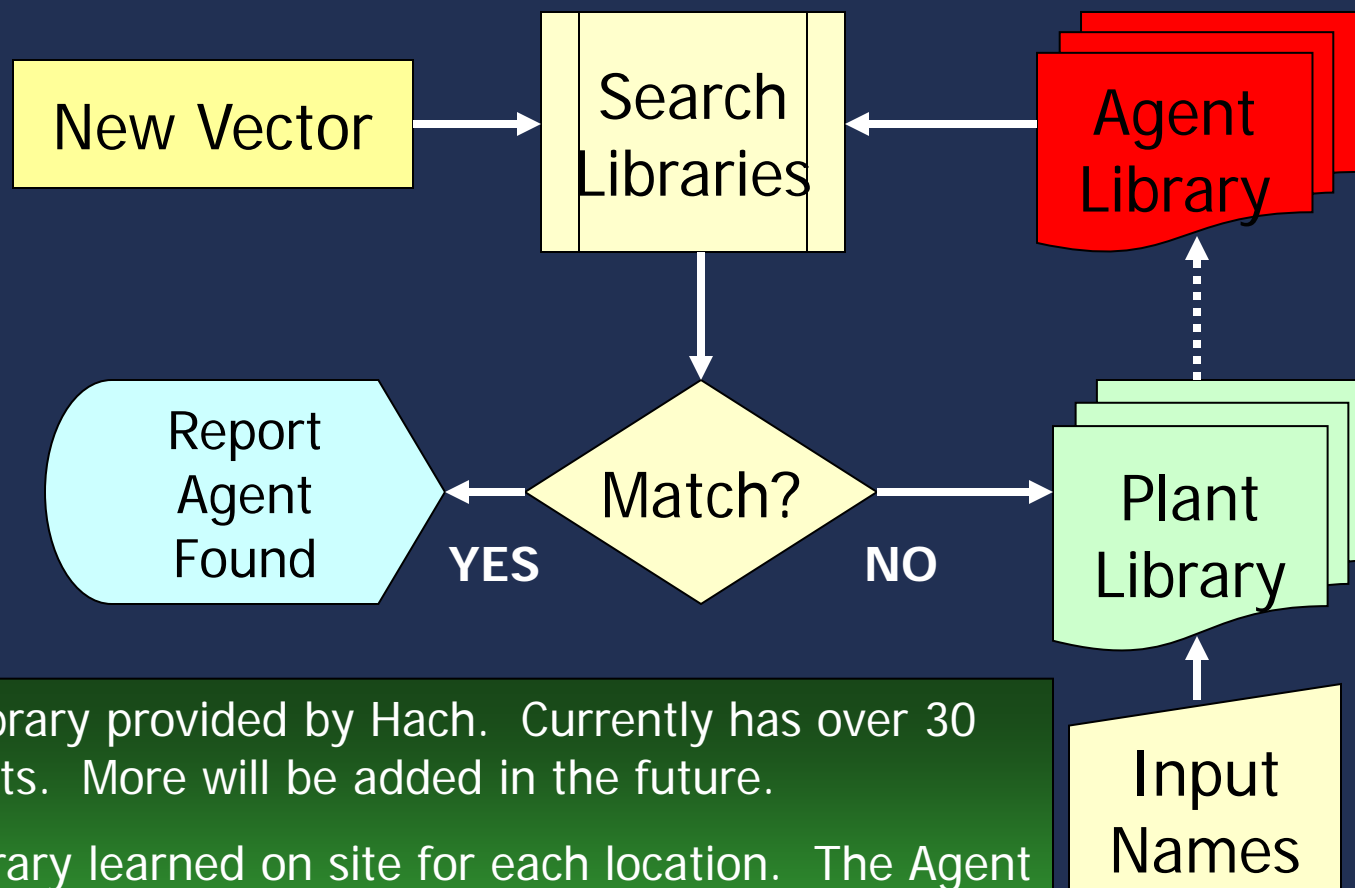
When Determining a Trigger, Original Vectors Before Forming Unit Vectors Have Magnitude



After triggering, Unit Vectors are Formed for Classification

Unit Vectors are Dose-Independent.

Trigger Event Analysis



Agent Library provided by Hach. Currently has over 30 key agents. More will be added in the future.

Plant Library learned on site for each location. The Agent Library is searched first then the Plant Library. If no matches are found an unknown alarm is reported.



Homeland Security
Technologies

Learning Plant Events

Operational events in the water distribution system will also cause deviations with a magnitude capable of causing a Trigger.

The system needs to recognize these, and store their Deviation Vectors (which in most cases will be quite different from Threat Agent Vectors).

When one of these events occur that hasn't been seen before, it will result in an unknown alarm. After it has been identified, the name can be entered into the Plant Library.



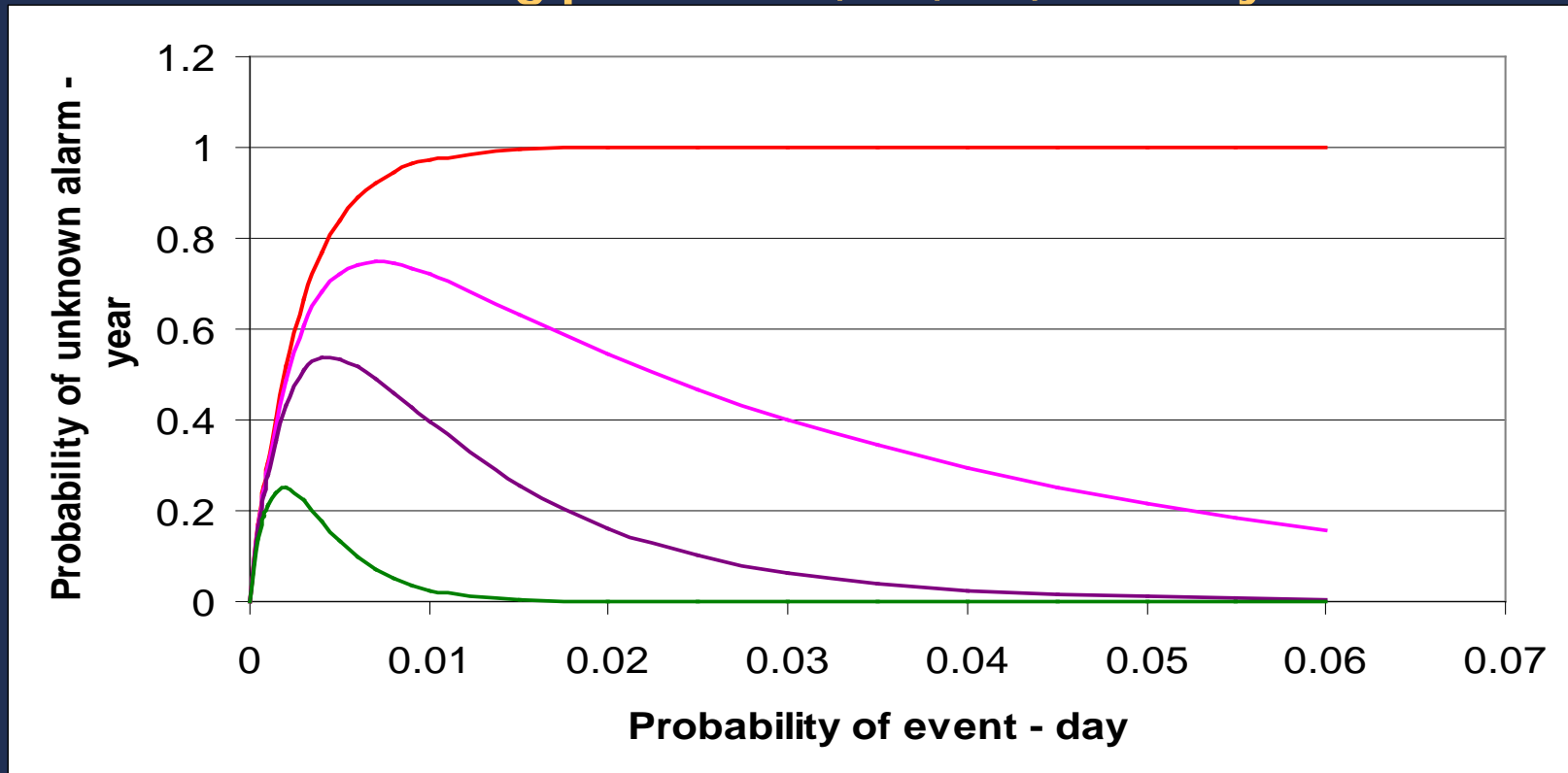
Homeland Security
Technologies

What about unknowns?

- When an unknown is detected it requires investigation to determine the cause.
- The ability to trigger on unknowns is of value in improving water quality and also allows the system to detect and trigger on unanticipated contaminants.
- While investigation requires some expenditure of time, it can be of great benefit. Learning the causes of unusual water quality readings can help improve processes and the quality and consistency of water reaching the end customer.
- Most common events are learned rapidly.

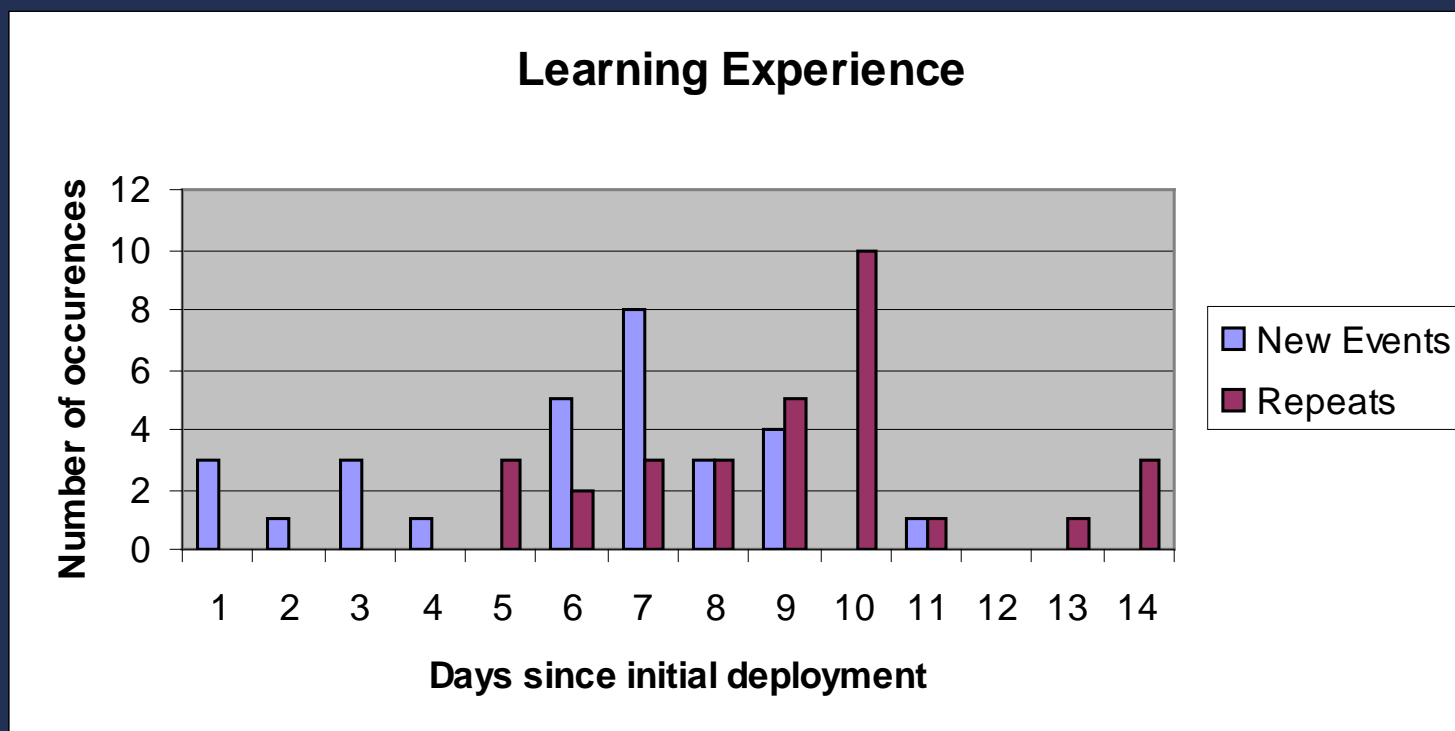
Reduction of Unknown Alarms via Hach Learning Algorithm

Learning period = 0, 30, 90, 365 days



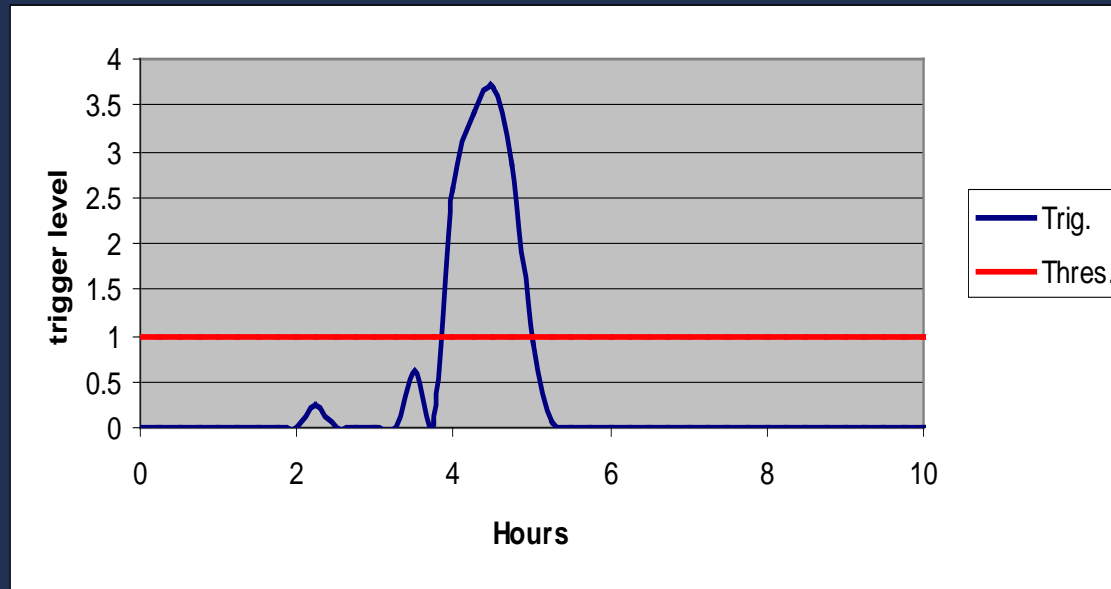
The probability of an event being learned depends upon how common the event is. It can't be learned until it occurs. Common events will be learned quickly. Rare events will take longer.

An Example of Learning at a Very Noisy Location



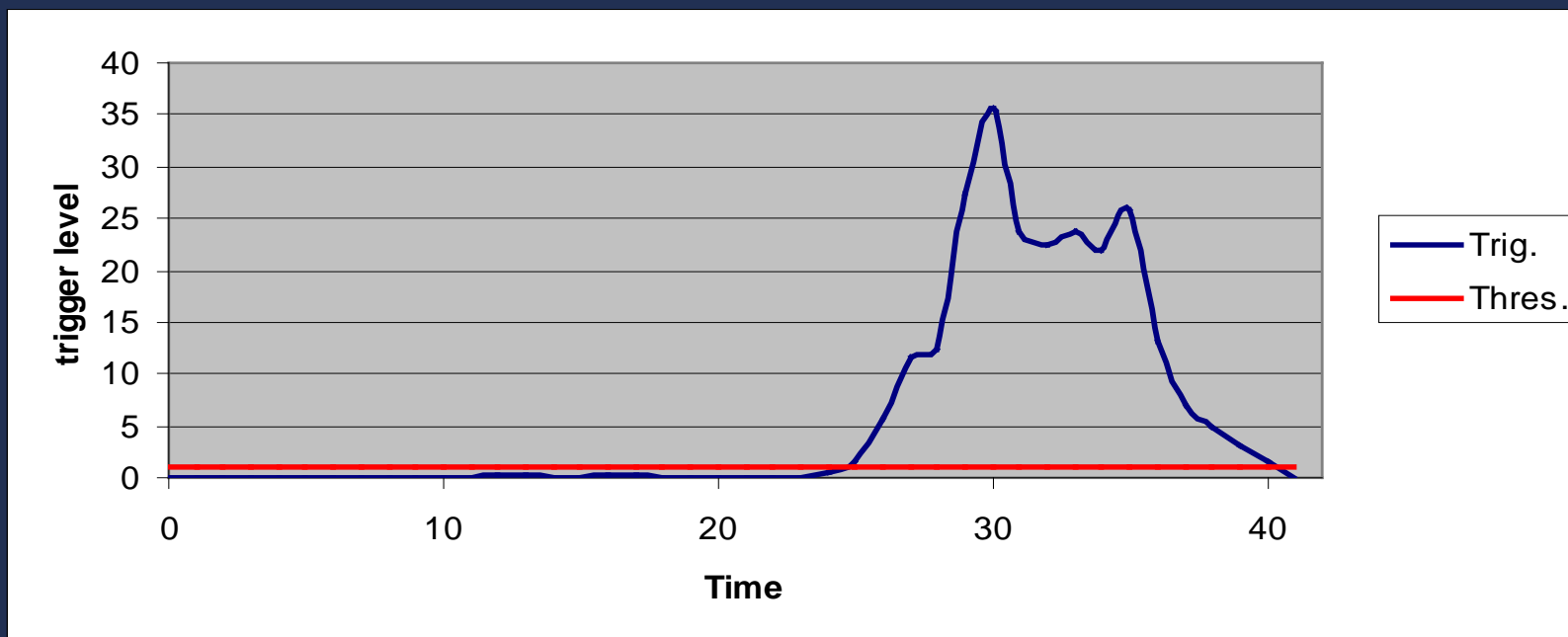
There were 26 unique events over the first 11 days of operation. All were learned, 16 of them were repeated. After the 11th day all of the common events had been learned.

Caustic Feed Event



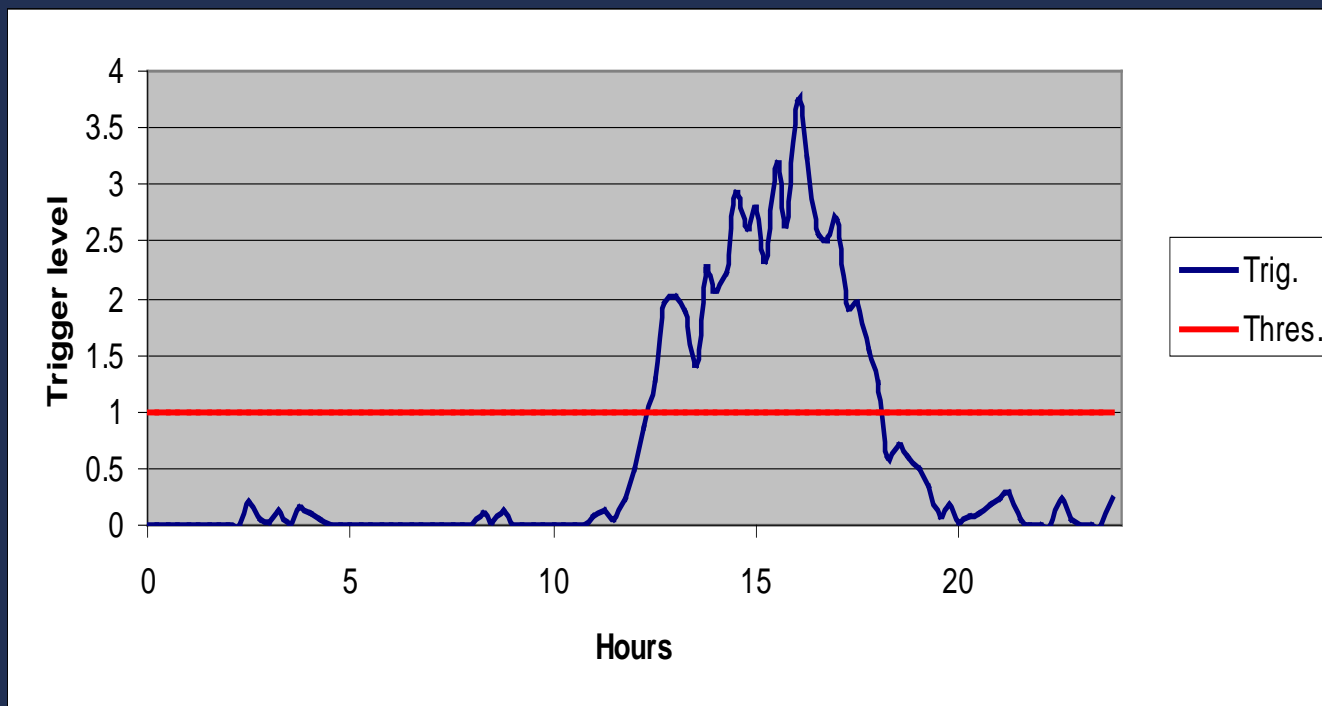
The plant uses caustic feed to control water pH and experienced an operational problem that resulted in the feed of excess caustic. That affected the pH and the conductivity of the water, causing the Event Monitor to alarm. The Event Monitor learned this Plant Event and can identify a recurrence of the event.

Roadwork Event



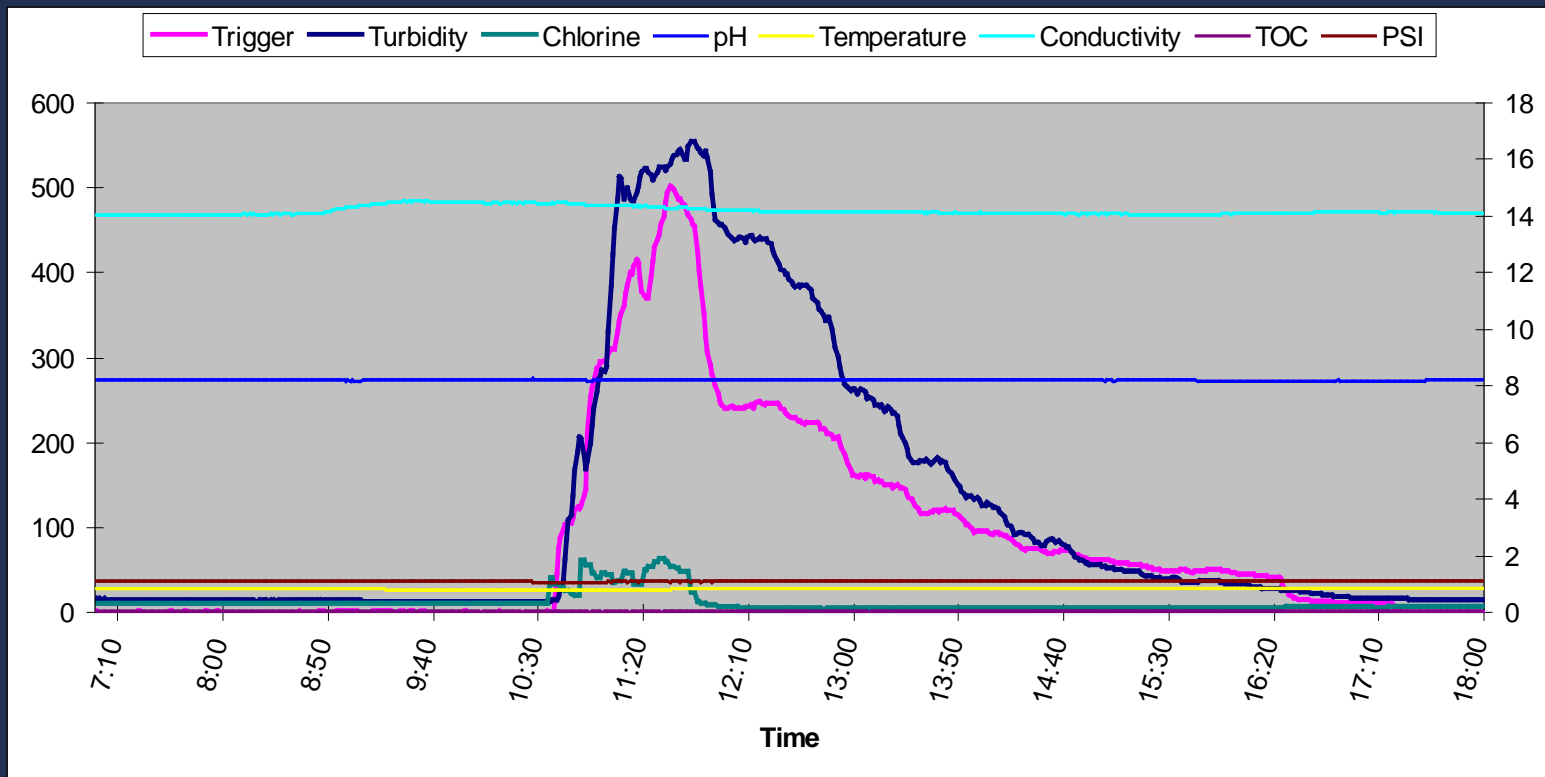
Road work near a distribution line dislodged biomass and other particulate matter.. This event illustrates the ability of the Event Monitor to detect and alarm on unanticipated events. This event also provides a signature for the materials adhering to the walls of the pipes in this location.

Pressure Event



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 and slight pH decrease that causes a Trigger. This pattern is recognized by the Event Monitor as a "Normal" event, rather than an alarm condition.

Pennsylvania Event



Pittsburgh 36 Inch Main Break

- A geyser caused by a severed 36-inch water line erupts from Fort Duquesne Boulevard on August 17th. One of the largest water main breaks in the city's modern history.



The Event Monitor triggered **Several Hours** before this catastrophic main break!!!

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.

The Hach Guardian Blue System 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

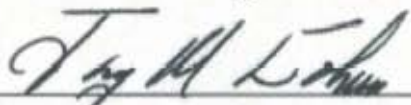
a Delaware corporation

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



Date

Under Secretary for Science and Technology

What does all of this have to do with food processing?

- Water is a key component in the growing and processing of foods and beverages.
- Water is also an ingredient of many food stuffs.
- Many processors rely on city supplied water that is carried through the distribution system to reach the plant, thus presenting a possible route of contamination.
- While such 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 batches are not compromised.



Homeland Security
Technologies

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





Homeland Security
Technologies



Thank
You –
Questions
?