New Sensor Technologies for Real-Time Water Quality Monitoring

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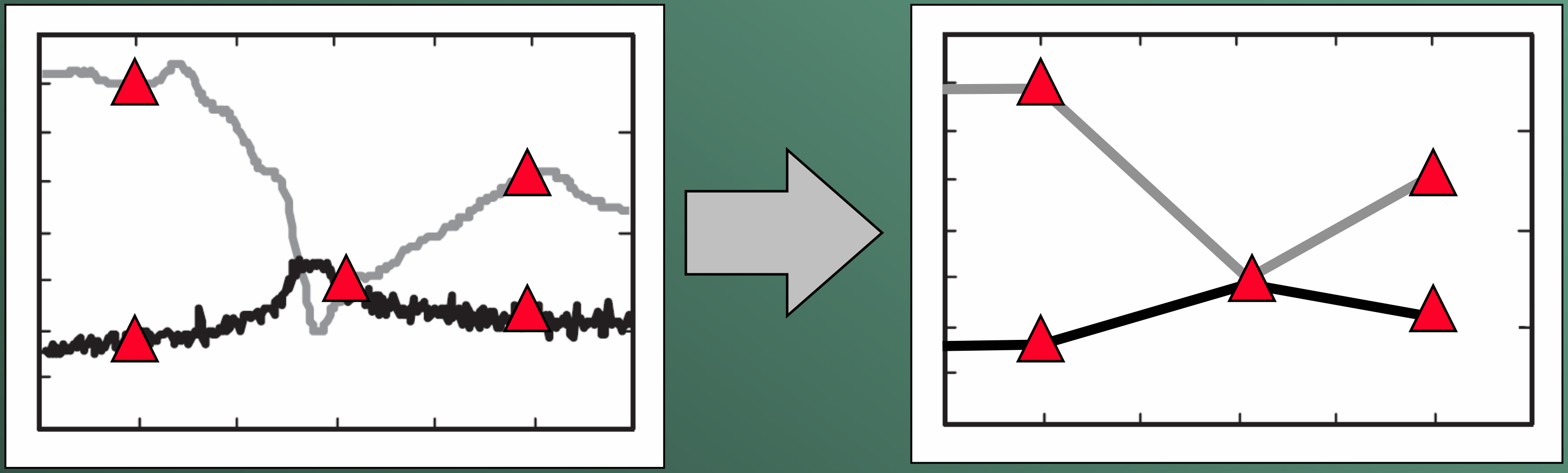
Outline

- Definition of Real-Time Water Quality
- New Real-Time Sensors for Natural Waters *(Luminescent DO, UVAS, TOC, Biomonitor)*
- Preventing Data Overload
- Example Application in Maryland
- Use at Remediation Sites

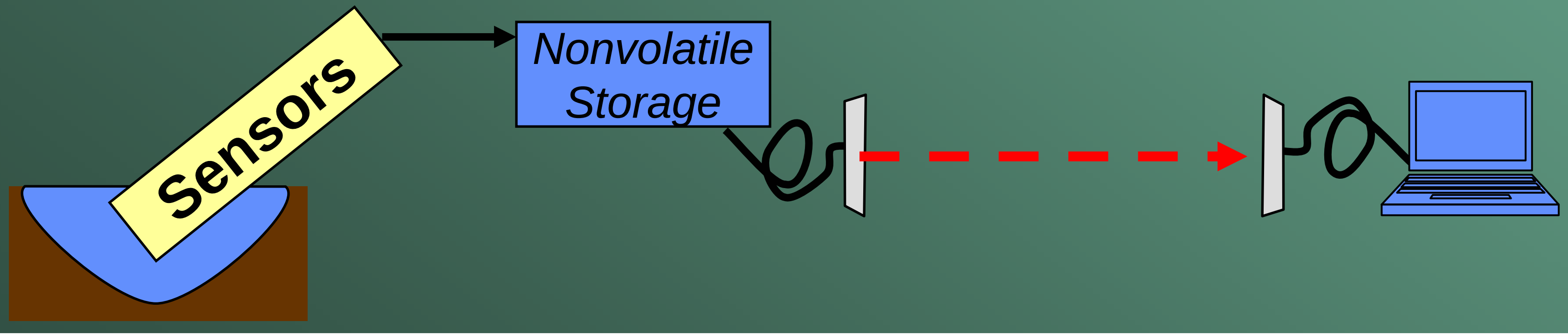
Defined: Real-Time Water Quality

- Traditional Laboratory Analysis
  - Collect one sample in time, send to lab.
  - Delay of hours to weeks for analytical results.
  - Might lose high-frequency information content.



Defined: Real-Time Water Quality

- Continuous Water-Quality
  - Sampling frequency typically 15 minutes.
  - While not truly “continuous”, captures most natural variability.
  - Store readings onsite, manually download periodically.



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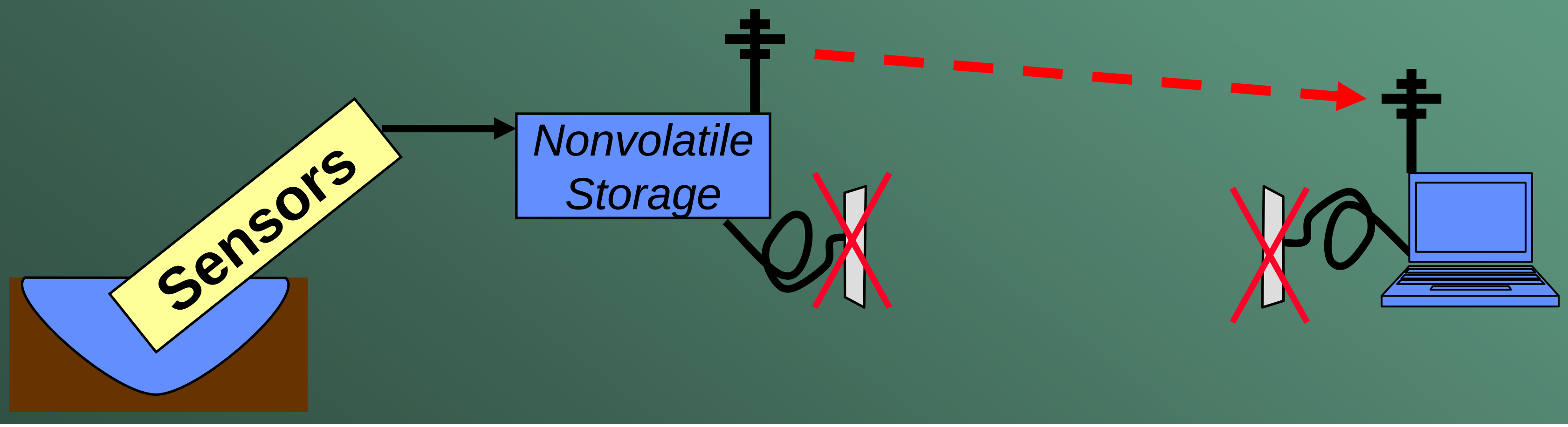
Defined: Real-Time Water Quality

- Real-Time Water Quality
  - Add telemetry to a continuous monitoring system.
  - Download data hourly, automatically.
  - Improves response time, hours instead of weeks.



New Types of Sensors

- The usual sensors →
  - Water temperature
  - pH
  - Specific conductance
  - Dissolved oxygen
  - Turbidity

- Many new and improved sensors are being used in natural waters for continuous monitoring.

New Types of Sensors

- Improved: Dissolved Oxygen
  - Clark Cell, the old way
    - Often, hardest sensor to maintain good data quality with.
    - Often the limiting factor for site servicing interval.
  - Luminescent D.O., the new way →
    - O_2 concentration inversely proportional to red-light emission from luminescent material.
    - Less calibration drift, and doesn't consume O_2.

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New Types of Sensors

- **Ultraviolet Absorption (UVAS)**
  - **Emits 254 nm UV light, measures amount absorbed**
  - **Particularly, compounds with benzene rings.**
  - **Compensates for suspended solids using a 500 nm light measurement.**
  - **SAC254 is an indirect measurement of dissolved organic matter.**

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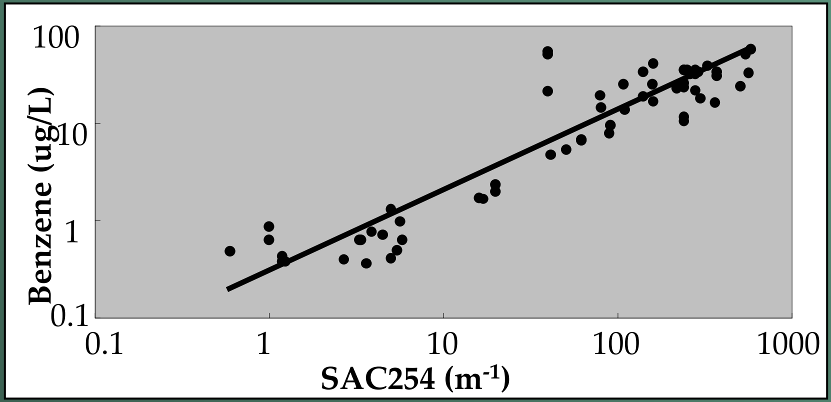
New Types of Sensors

- Ultraviolet Absorption (UVAS)
  - With traditional lab analyses, a site-specific regression model relating SAC254 to a particular compound might be possible.
  - For example:



$$\log_{10}(\mathbf{BENZENE}) = m \log_{10}(\mathbf{SAC254}) + b + \mathit{Error}$$

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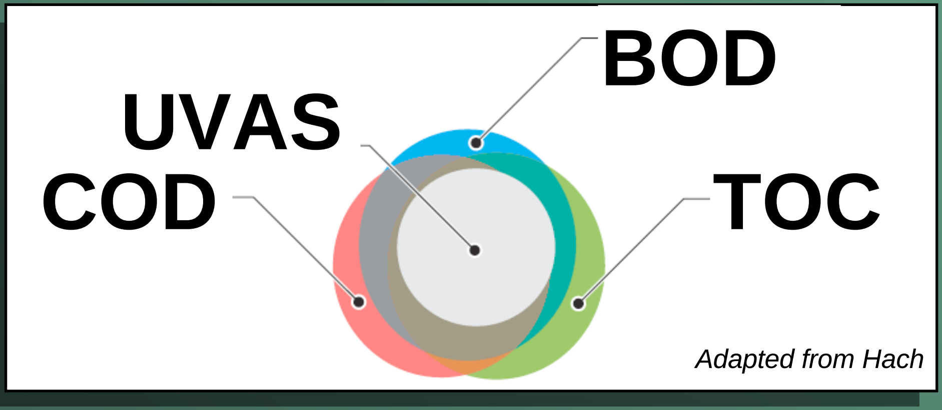
New Types of Sensors

- Total Organic Carbon

  - Been monitored in industrial processes for years.
  - Measures using wet chemistry method.
  - Reagents mean high maintenance.
  - Must interpret with care—may not be full digestion.

New Types of Sensors

- No one organics measurement gets it all.



- What if your true goal is measuring toxicity… directly?

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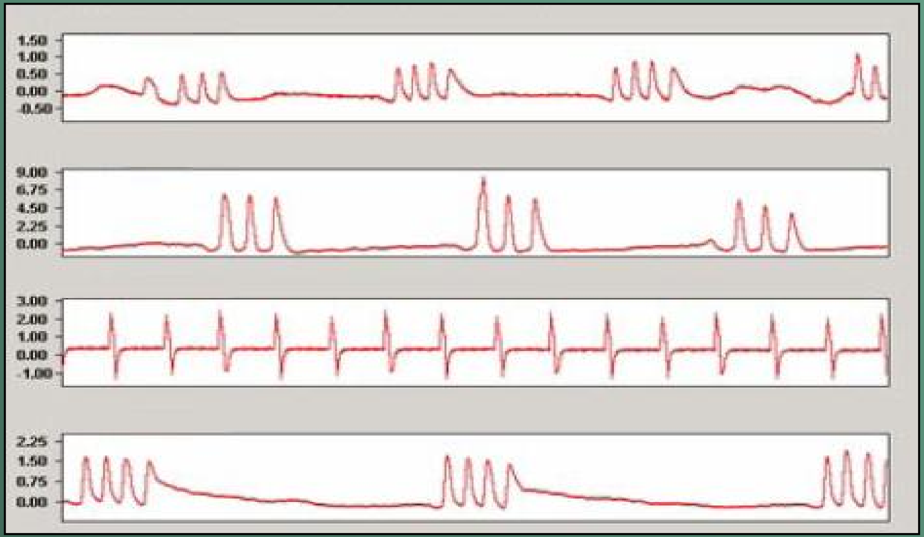
New Types of Sensors

- Canary in a coal mine for the 21st century.
- Quantitatively measure life processes of an organism in real-time.

- Measurements →
  - *Moving*
  - *Breathing*
  - *Sinking / floating*
  - *"Coughs"*



Intelligent Automation Corp.

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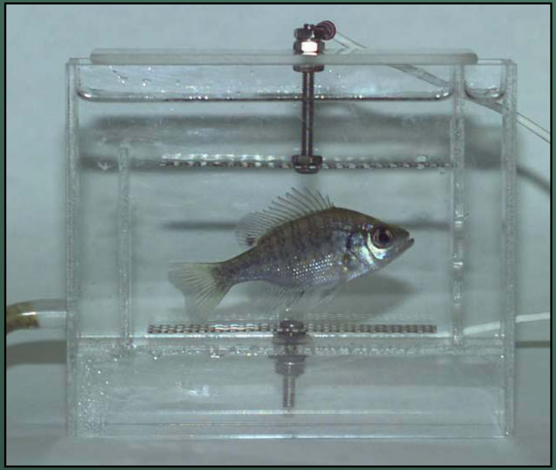
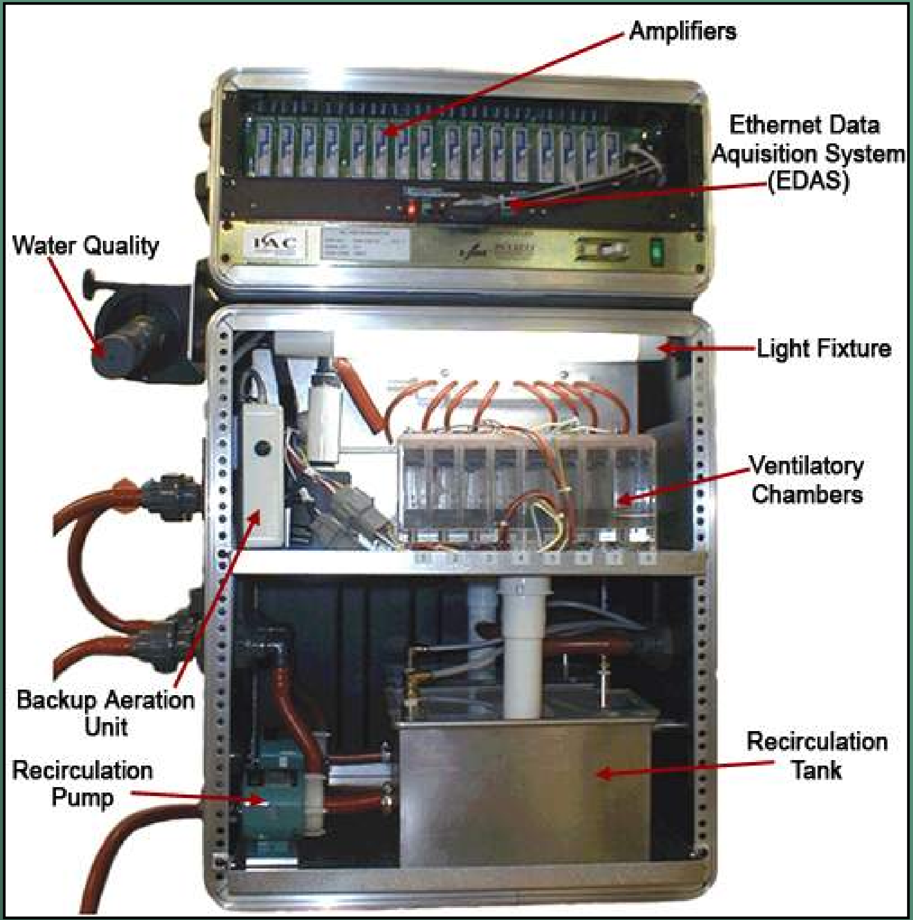
New Types of Sensors

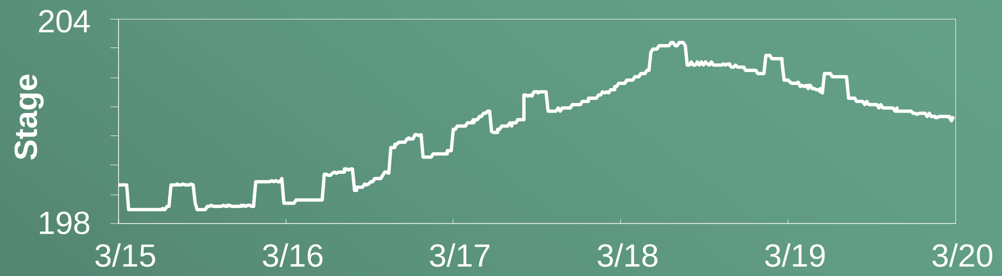
- Eight bluegill fish in parallel, with 2 parallel systems →
- Replace fish every 2-4 weeks.



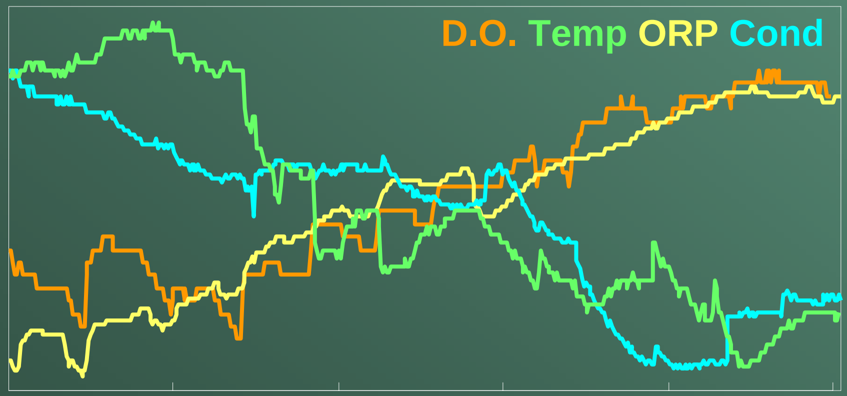


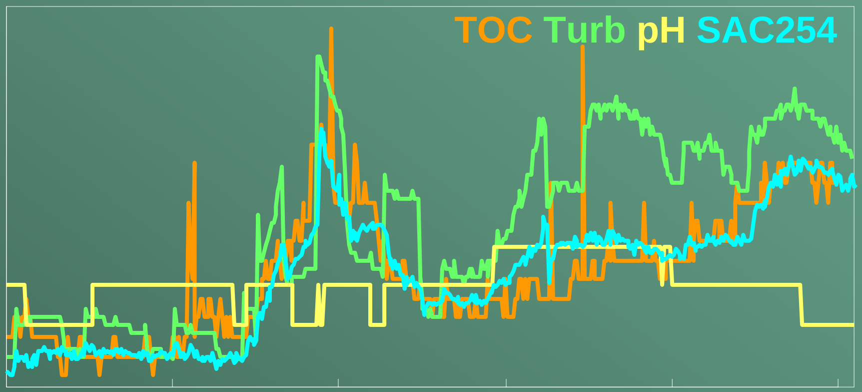
Preventing Data Overload

- Consider a surface-water rainfall event in MD, March 15-20, 2007 →



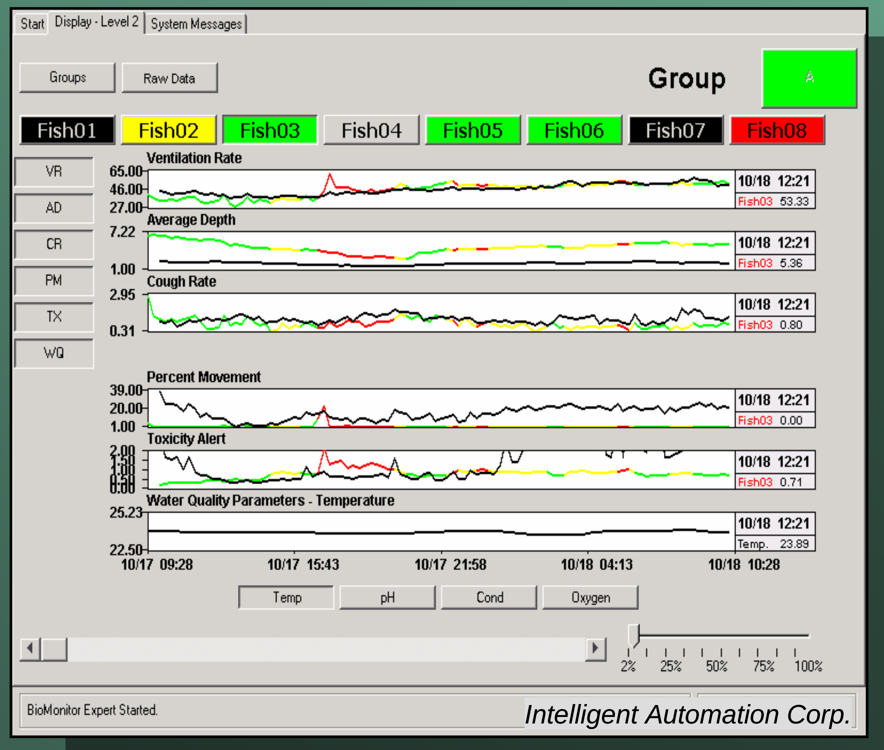
- Variations in 8 other measurements at the same time:





- Can you figure out what's going on? Objectively? On a continuous basis?

Preventing Data Overload



- Can you figure out what’s going on? Objectively? On a continuous basis?

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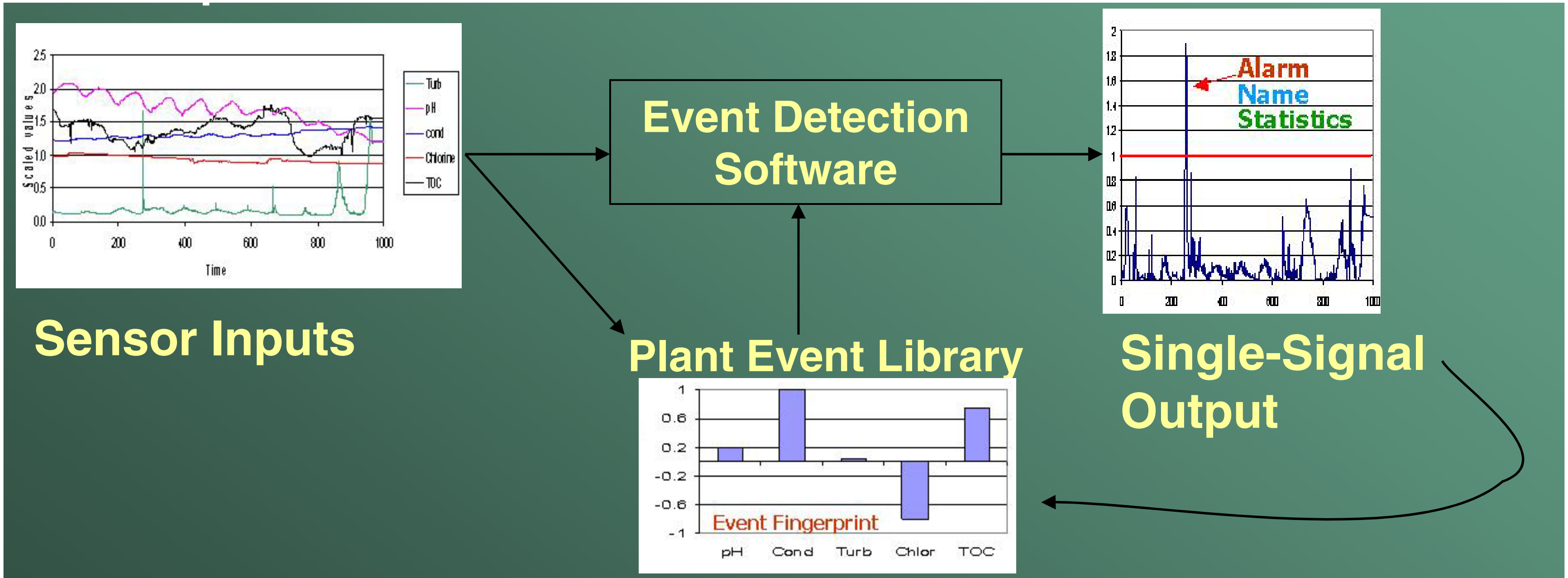
Preventing Data Overload

- Goal: Reduce many signals down to one.
- This one signal is a “novelty” measurement, or a quantification of departure from normal baseline conditions.



Adapted from materials courtesy of Hach, Inc.

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Preventing Data Overload

- **An example implementation of Event Detection Software:**
  - **Hach Event Monitor Trigger System**
  - **Converts all signals to *<u>one</u>*, by measuring *departure from baseline***
  - **Developed for drinking water systems, viability for natural water still not fully known.**

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Example in Maryland

- Chemical and biological monitoring with new sensors on large Maryland river system.
- Discharge range about 300 mgd to 300,000 mgd

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Example in Maryland

- **Incorporates all sensors described today, and more →**

- **Equipment needs:**
  - **Water pumped through a flow-through cell.**
  - **Dry, powered, secure, climate-controlled environment.**
  - **More maintenance than traditional real-time sensors.**

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Example in Maryland

- A challenging environment to install expensive equipment in!
- But it’s what the USGS has done for over 125 years.

Possible Uses at Remediation Sites

- Could monitor effluent water from site, or effluent from a treatment process.
- Event detection software could detect potential remediation failure events.
- Software could start an automatic sampler to capture water for further laboratory study.

- Longer-term, could monitor temporal trends in water quality to assess effectiveness of remediation.

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Conclusion

- Real-Time monitoring is high resolution with a fast response time.
- Real-time sensors are more limited than laboratory analyses, but are continually improving.

- Event Detection Software tries to prevent data overload, while keeping response time low.
- Remediation sites can benefit from real-time monitoring with proven and new sensors.