Innovative Data Collection and Management Strategies for Improved Water Treatment Efficiency

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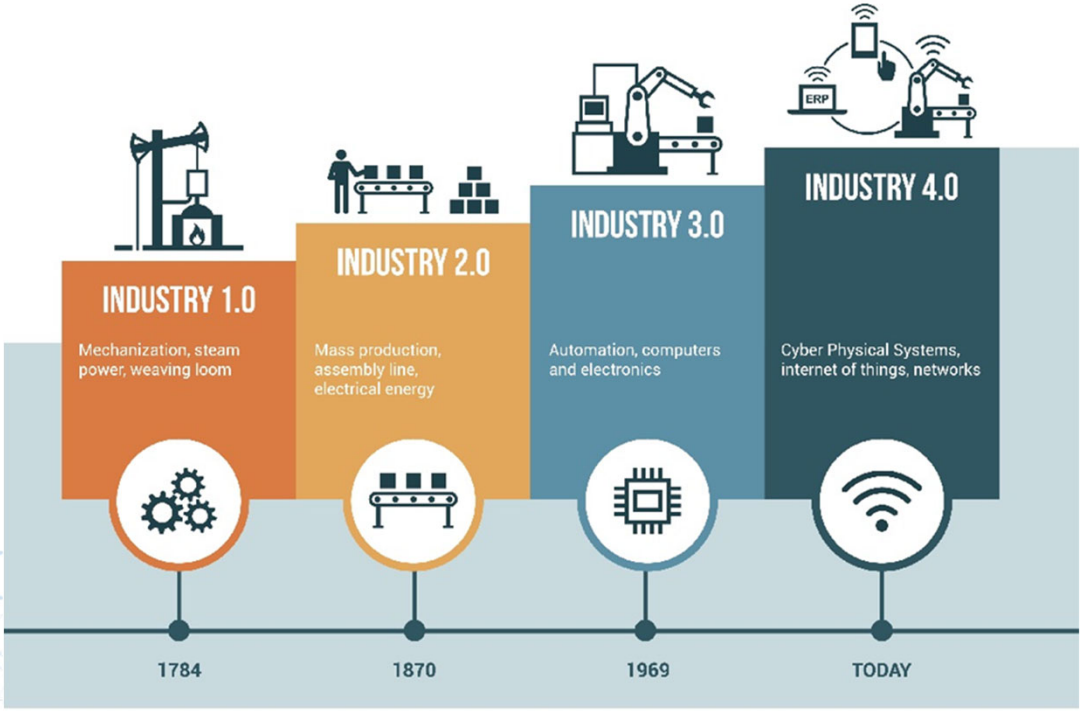
Presentation Outline

1. Introduction to Automated Water Treatment Systems
2. Challenges with Traditional Water Treatment
3. The Automated Workflow
4. Technological Components of Automation
5. Case Study: Implementation and Impact
6. The Future: Digital Twin and Beyond



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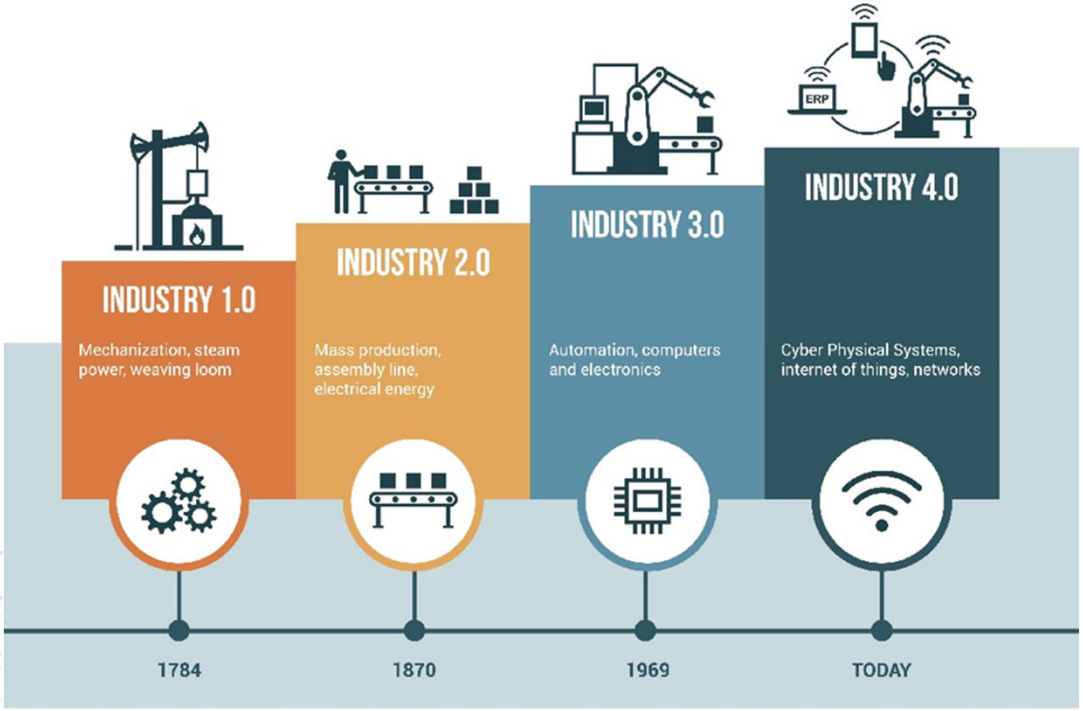

Evolution of Water Treatment Systems

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Traditional Methods

- Manual sampling
- Visual inspections
- Periodic laboratory analysis (long analysis times)

Technological Advancements

- Sensor technologies
- Microcontrollers for real-time monitoring

Shift to Automation

- Adoption of automated data collection
- Real-time alerts
- Cloud-based data management

Enhanced Analytics

- Advanced data processing techniques
- Machine learning for predictive insights

Towards Digital Twins

- Fully integrated systems
- Predict, optimize, manage operations remotely

Overcoming Obstacles

Manual Sampling Limitations

- High labor intensity and slow response times

Data Collection Gaps

- Inconsistent, infrequent data leading to suboptimal monitoring and management

Analysis Delays

- Long turnaround times for laboratory results impede timely decision-making

Operational Inefficiencies

- Manual adjustments and lack of real-time data lead to inefficiencies and increased costs

Staff Training Challenges

- Continuous need for highly skilled personnel to manage complex water treatment systems

Automated Water Treatment Workflow

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Data Collection

- Automated, sensor-based monitoring at key points

Alerts & Alarms

- Immediate notification of system upsets for rapid response

Cloud Management

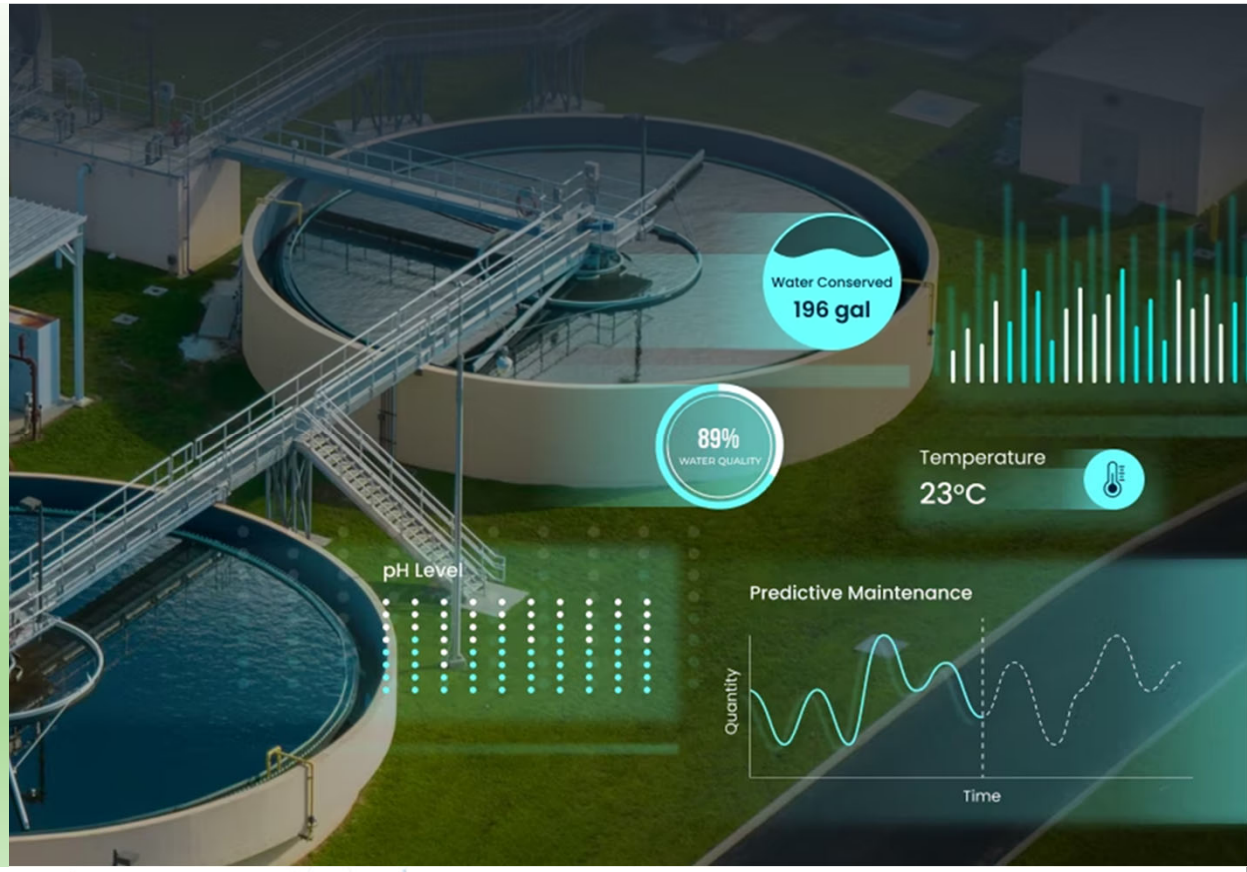
- Secure, scalable data storage, and advanced analytics

Data Analysis

- From raw data to actionable insights with AI & machine learning

Real-time Decision Making

- Intelligent guidance for optimal water treatment



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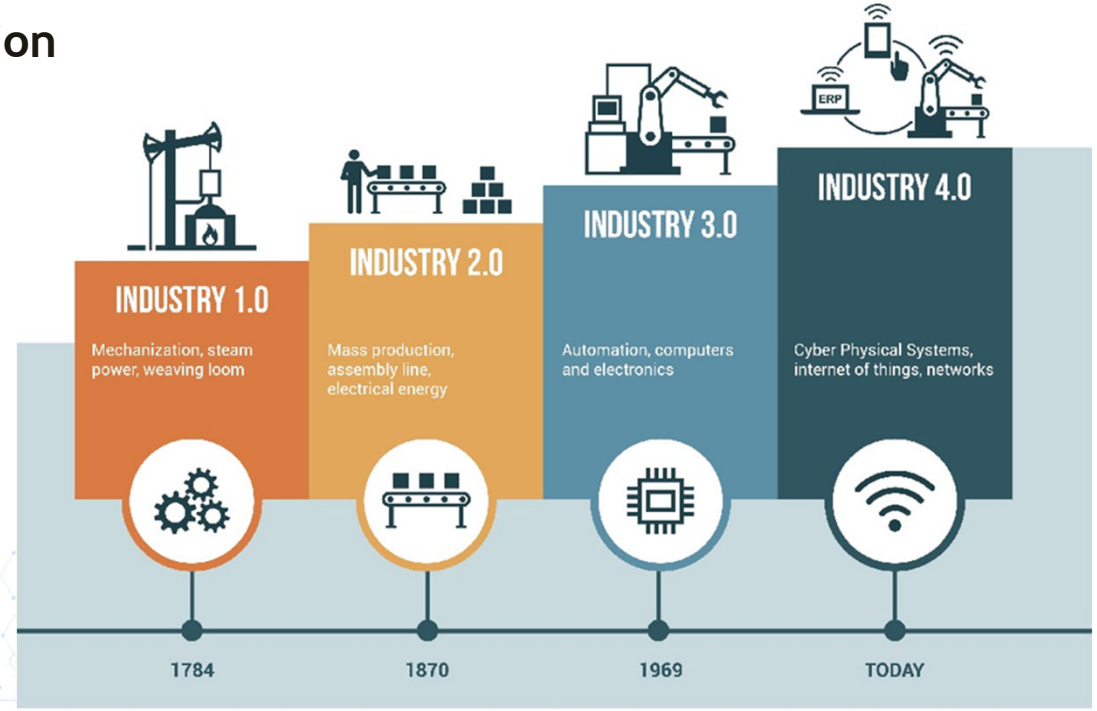


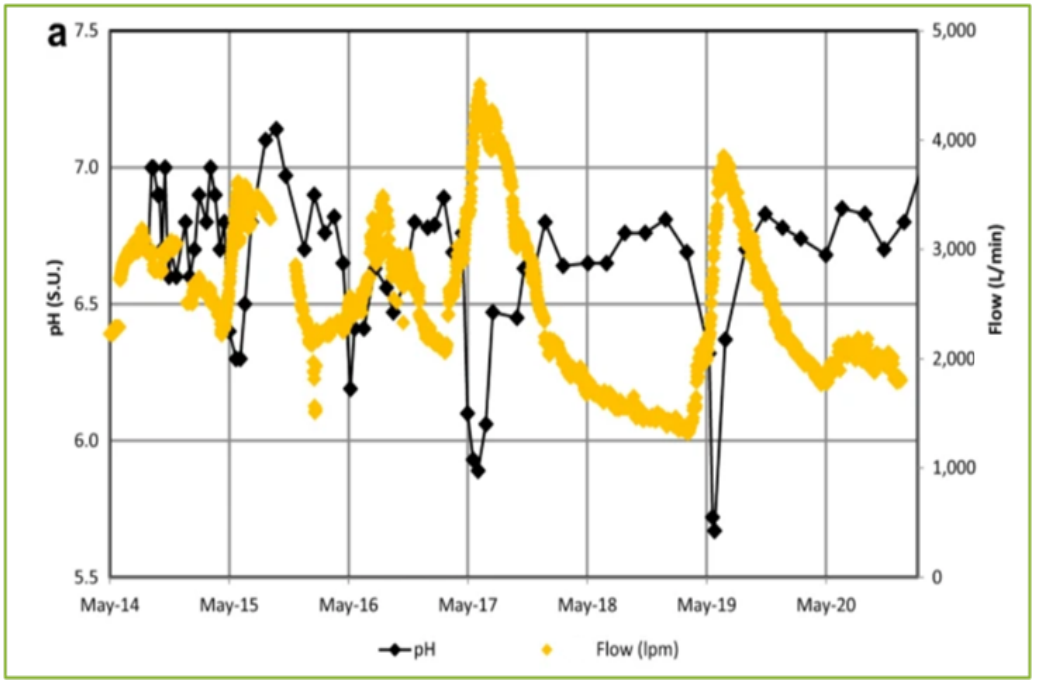
When is Higher Frequency Data Useful?

Varies from system to system

Any temporary condition that deviates from the ideal in passive to active systems

Examples

- Variable flow- diurnal freshet, multiple influent
- Variable chemistry



"Passive treatment of circumneutral mine drainage from [undisclosed]" Moore et al., 2022

Data Collection

Traditional Data Collection

- Manual, single time interval, requires laboratory analysis
- Multiple data types: spreadsheets, legacy data, images, audio and video

The Modern Solution

Auto-Samplers

- Reduced labor, multiple time intervals, requires laboratory analysis

Sondes

- Calibration/maintenance only, high frequency, no laboratory analysis, limited to bulk parameters

Multi-element Sensors

- Calibration/maintenance only, high frequency, no laboratory analysis, all major and trace elements (“entire periodic table”)

Data Management at Sampling Point

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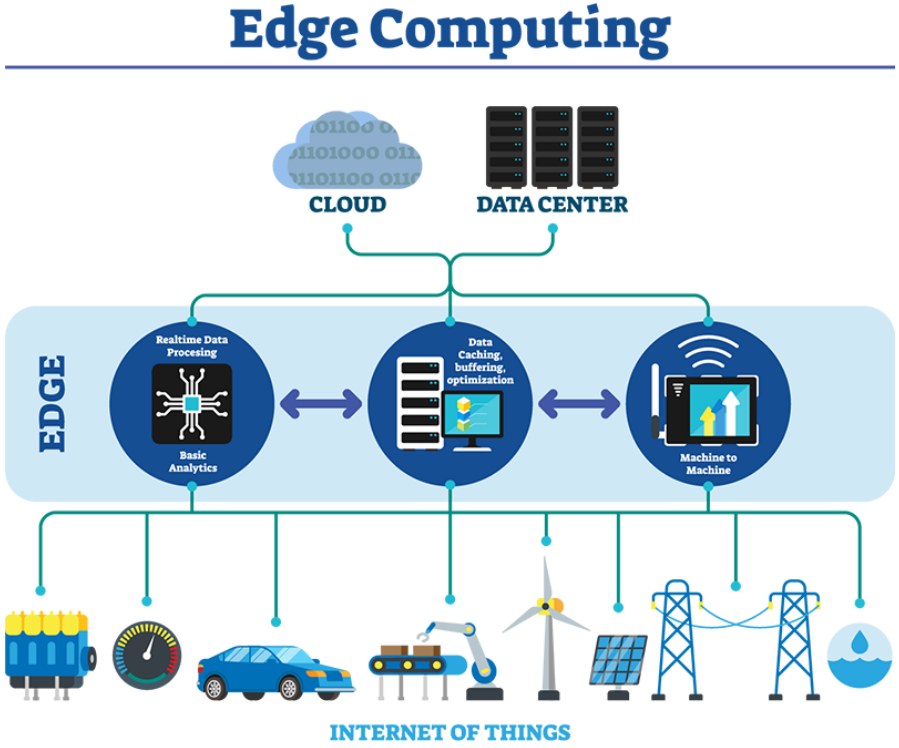
Edge Computing

- Processing at data collection point
- Bandwidth
- Latency
- Economics
- Reliability
- Privacy
- Decisions at the edge? (PLC etc.)

Telemetry - Upload to Cloud

- Hardwire
- Radio frequency (Wifi, ISM bands)
- Cellular
- Satellite



Data Management in the Cloud

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Benefits of Cloud

- All data in one place
- All data types allowed
- Real-time data ingestion, cleaning, analysis
- Platform agnostic (EQuIS, MonitorPro, SQL)
- Dashboarding
  - Standard: Power BI, Tableau
  - Custom: Python
- Intelligence and automation:
  - Recommendations
  - Decisions
  - PLC

→ **Analytics (machine learning)**

Data Analysis

Objectives

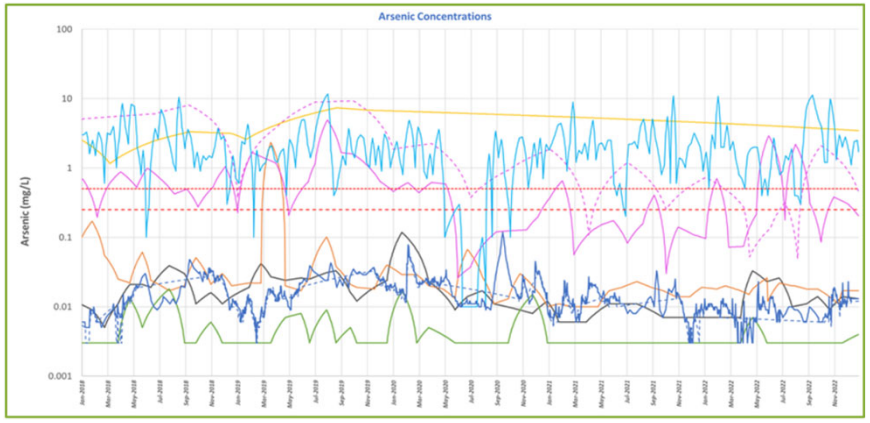
- Meet discharge standards
- Optimize plant efficiency
- Predict failures

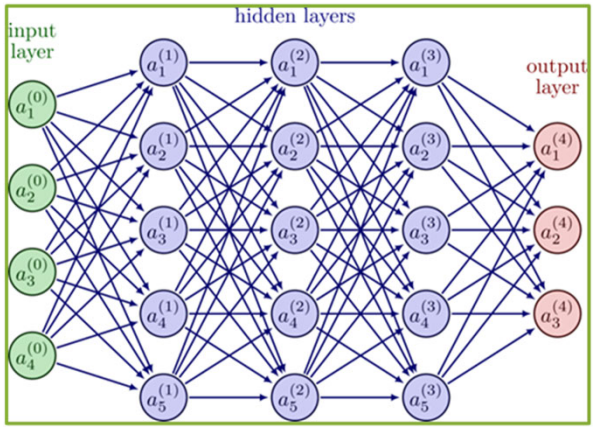
Data Cleaning Pipeline

- Rule-based data validation (detection limits/ outliers)
- Missing data imputation
- Standardization of units and format
- Data transformation

Data Analysis

- One or two parameters
  - Simple visualization: monitor trends (pH, lime etc.)
  - Forward prediction: anticipate future system conditions
- Multiple parameters - machine learning:
  - Identify root causes
  - Optimize system performance
  - Evaluate testing scenarios





Actionable Insights → Decision Making

Operator tools:

- Alarms/monitors
- Reports
- Dashboards

Data analysis outcomes:

- System failure predicted
- System not running optimally

Operator decisions:

- Change dosing/reagent
- Reconfigure/design treatment system
- Adjust feed stream
- Setup and program PLC

What if it doesn't work?

- Data collection feedback loop

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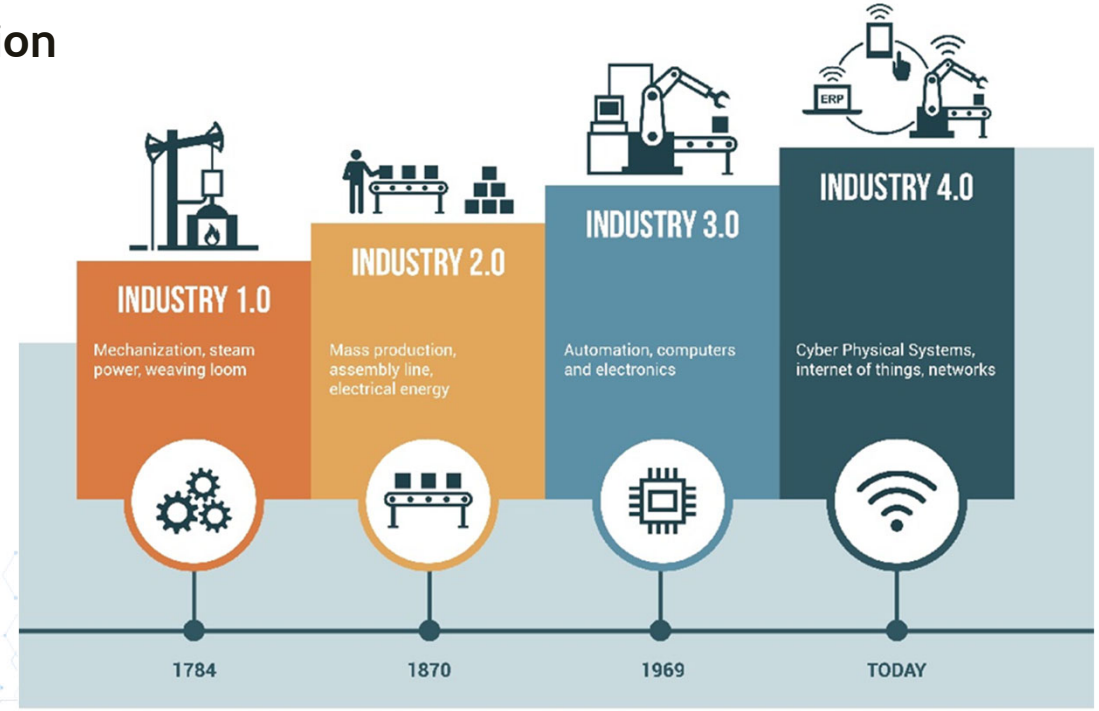


Case Study

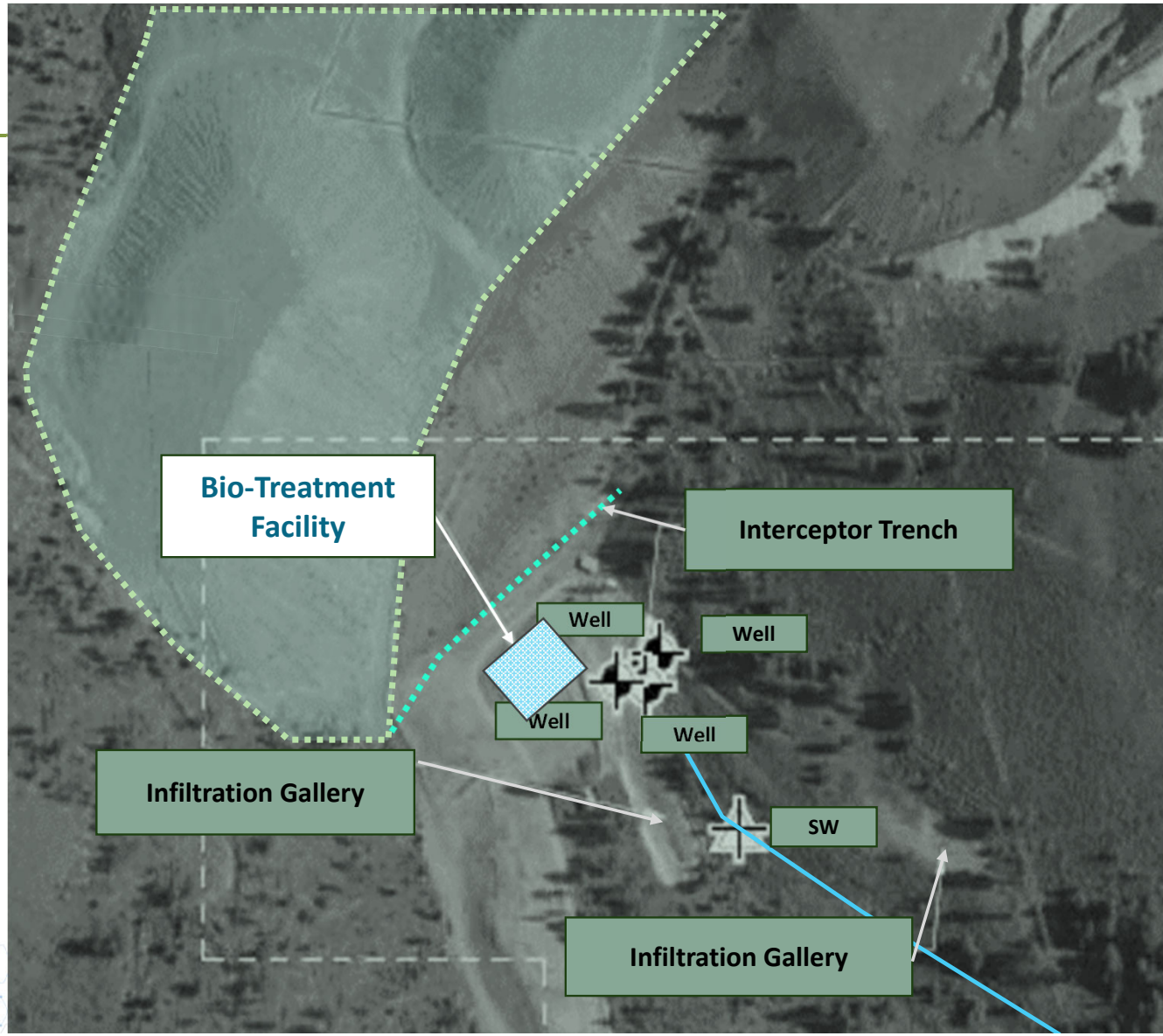
Reviving a Semi-Passive System

Challenges

- Seasonal water volume fluctuations
- Manual operation inefficiencies
- Maintaining trained professionals for remote operation

Solution - Automation

- Real-time monitoring and control
- Integrated sensors
- Cloud-based data management
- Dashboarding



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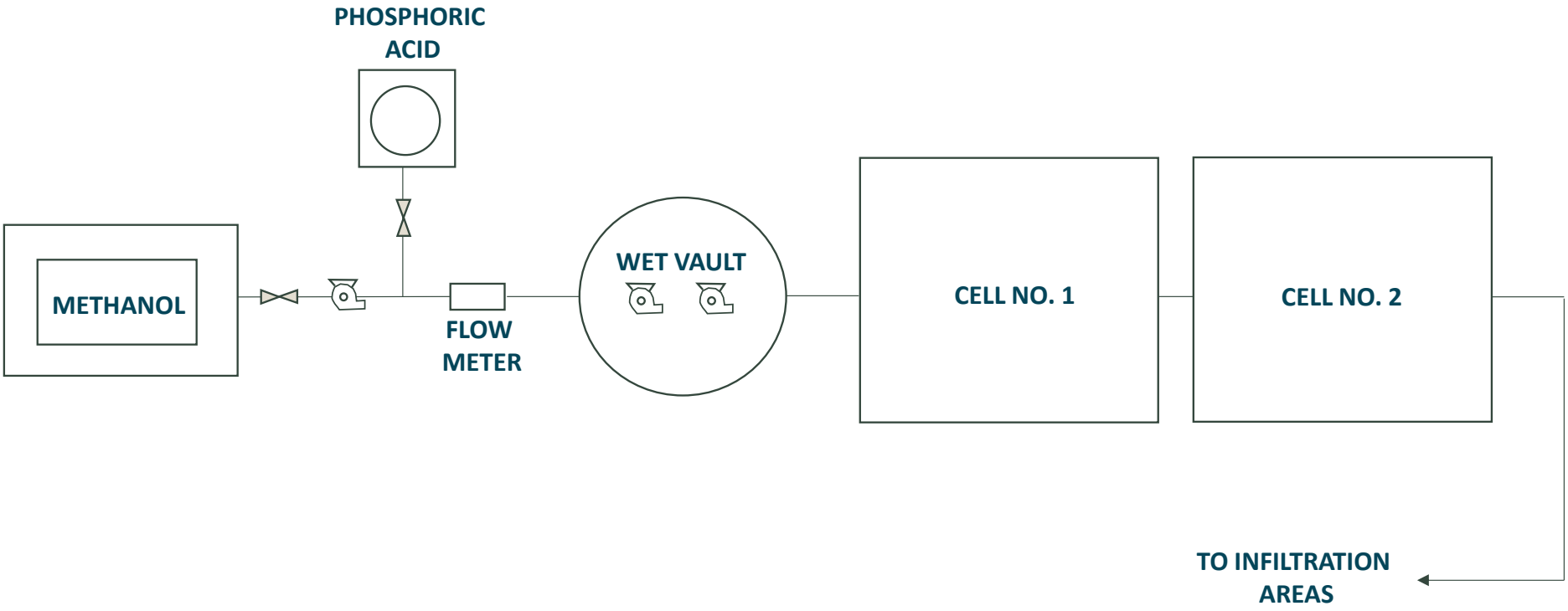

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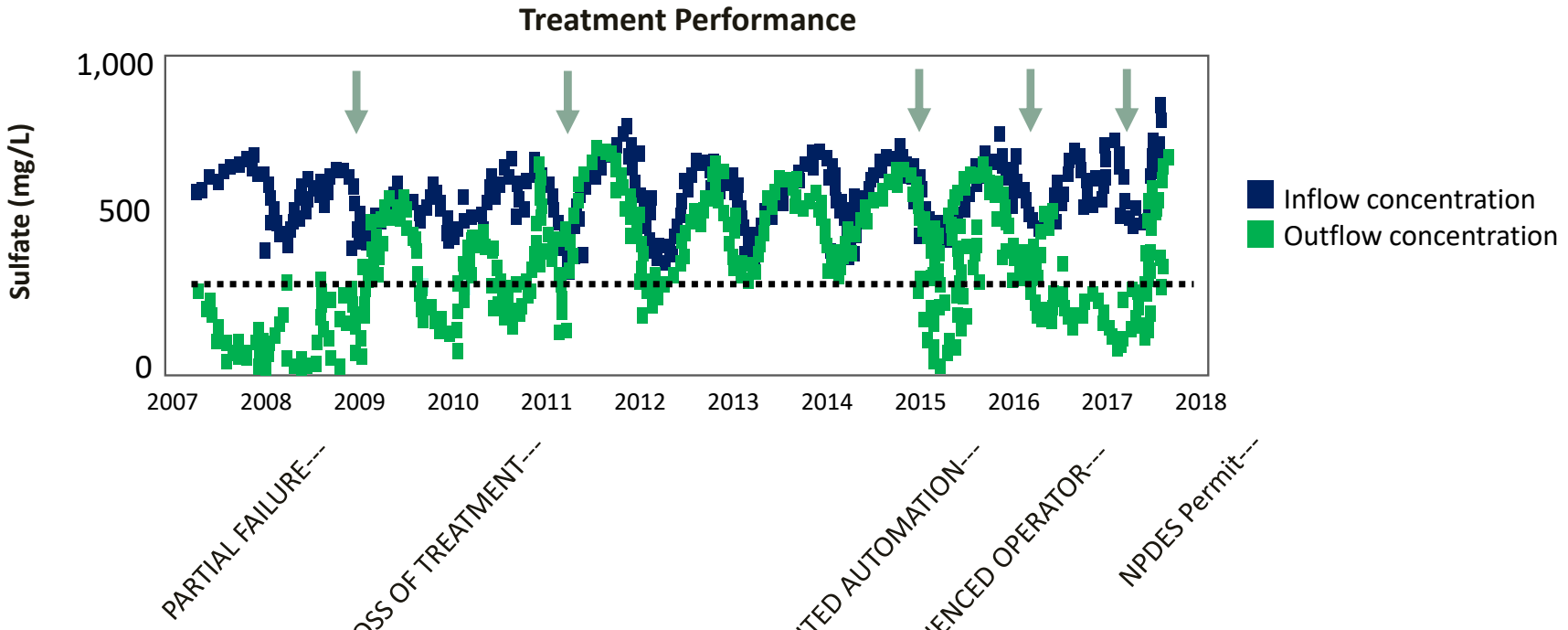

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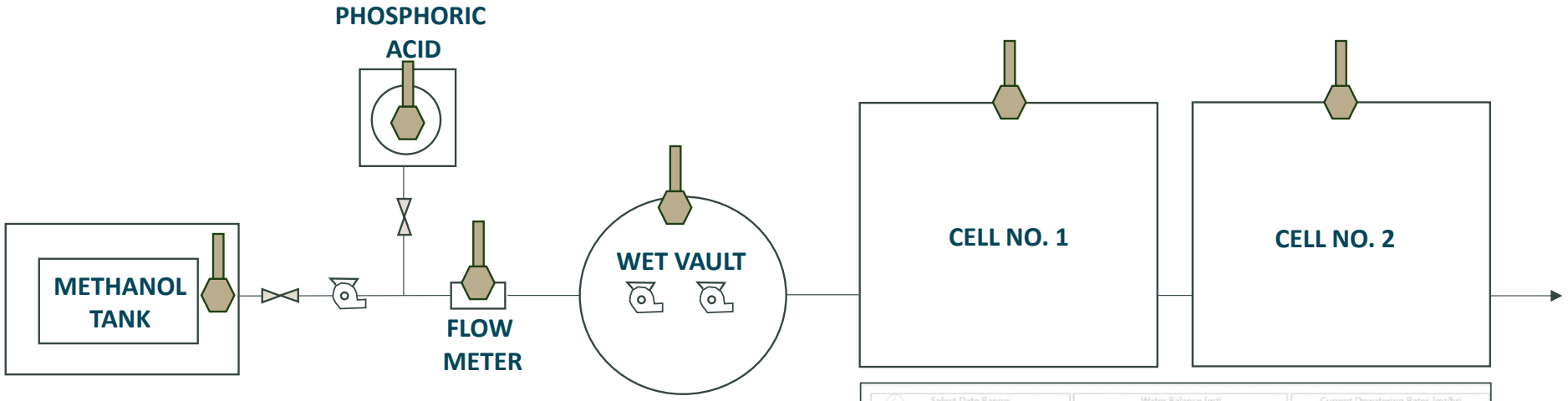

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Automation in Action: Case Study Results

System Stability

- Automation countered fluctuating impacts, stabilizing treatment performance

Compliance Achievement

- Automated controls ensured adherence to environmental standards

Operational Advantages

- Real-time adjustments reduced need for manual oversight, optimized reagent use

Not a replacement for experienced operator

Digital Twin:
The Future of Water Treatment

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Virtual Replicas

- Digital Twins mirror physical systems, enabling simulation and analysis

Predictive Oversight

- Anticipate system behavior, enhancing decision-making and compliance

Strategic Management

- Use historical and real-time data for long-term system optimization

Concluding Remarks: Path Forward

Enhanced Control

- Automation delivers precise, real-time management and optimization of water treatment systems

Cost & Efficiency

- Significant savings and performance gains from integrated technologies
- Assists experience operators with more informed decision-making tools – will not replace the experienced operator

Future Vision

- The Digital Twin: future for predictive, sustainable water management
- Aspirational yet increasingly attainable

Invest in Innovation

In the quest for sustainable water management, technology is not just a tool but a bridge to the future

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