

A New Framework for Multi-Reservoir Operations and Management

Robert Annear, Senior Engineer, Ph.D., P.E.
Marcus Quigley, Principal, P.E., CPESC, D.WRE

- The Internet of Things
- What are Decision Support Systems/Tools
- Introduction to the OptiRTC Framework
- Current Smaller Systems Applications
- Possible Framework for Multi-Reservoir Systems
- Q&A

- We are 28 year old consulting firm focusing on challenging problems in select engineering and environmental disciplines.
- We have been in Portland for 12 years and have 42 offices in the U.S.
- We have a wide variety of practices in geo-environmental sciences and engineering which include:
 - Watershed, Environmental, Stormwater and Waste Management
 - Geotechnical/Geological Engineering
 - Water and Natural Resources
 - Decision Support Systems, Real Time Control and Data Management
- **What do I do**
 - Hydrodynamic and water quality modeling of rivers, reservoirs and estuaries
 - River and reservoir multi-objective management (hydropower, flood control, FERC relicensing, TMDLs and ESA listings etc.)
 - Sediment and fate and transport modeling
 - Numerical model and data integration

- “things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts” (EPoSS 2008).

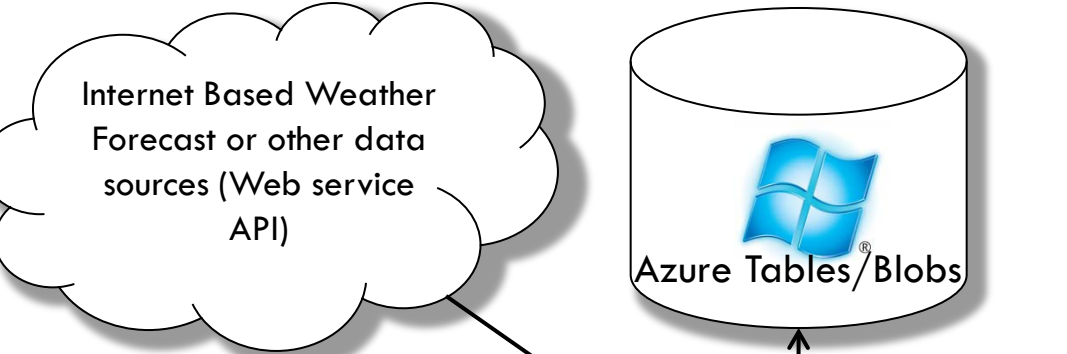
*European Technology Platform on
Smart Systems Integration*

- Geosyntec is seeing rapid and ubiquitous adoption occurring in civil environments

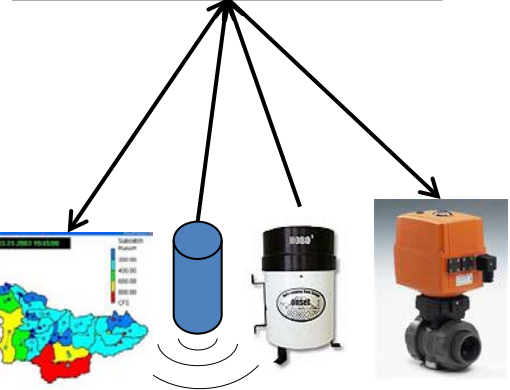
What are Decision Support Systems and Tools?

Tools that makes sense of disparate data and information in a decision space by presenting it in a compelling format

OptiRTC Solution



OptiRTC Data Aggregator and Decision Space



OptiRTC User Interface Web Services and User Dashboards

Microsoft Silverlight

Lower Alameda Creek Gauge

Lower Alameda Creek - Flow All Gauges

Flow (cfs)

Time/Date

Stage vs Flow

Data View

Call Log/Phone Time Stage (ft)

Time	Stage (ft)
4/17/2011 8:52:24 AM	1.4705989
4/17/2011 9:45:24 AM	1.4705989
4/17/2011 10:38:24 AM	1.4699942
4/17/2011 11:31:24 AM	1.4693895
4/17/2011 12:24:24 PM	1.4687848
4/17/2011 1:17:24 PM	1.4681801
4/17/2011 2:10:24 PM	1.4675754
4/17/2011 3:03:24 PM	1.4669707

Email
Tweet
SMS
Voice Autodial

OptiRTC - Executive View

https://www.optirtc.com/optirtcclient.aspx/#/dashboards

Web Slice Gallery NIC DESIGN WW-EAP and Artific... Contact Us uShopMall, Your Onlin...

Navigate To

OptiRTC System

Options

Dashboards

Sort: Dashboard Name

Search...

Dashboard Name

Sort: Quantity

- Broadway 1
- Deep Creek Road 1
- Joaquin Miller Basin Summ... 1
- Lake Merritt Basin Summary 1
- Lower Alameda Basin Summ... 1
- Lower Alameda Creek Gaug... 1
- MBS, Connectivity 1
- MBS, Renaissance Block C 1
- MBS, Renaissance Block F 1
- MBS, Renaissance Block G 1
- NC State, System Overview 1
- Nimitz Freeway 1
- Oakland Airport Basin Sum... 1
- Royal Ann Dr 1
- SAP Green Roof, Raw 1
- Valpey Park Ave 1

















User Group

Client

Task

Environmental Interface

Feature

The screenshot displays the Geosyntec OptIRTC System dashboard in a web browser. The interface includes a navigation bar with options like 'Executive View', 'Map View', 'Pod View', and 'SysAdmin'. The main content area is divided into several sections:

- Map View:** A satellite map of the Lower Alameda Creek region in Alameda County, California. A black arrow points from a text box to a specific location on the map.
- Lower Alameda Creek Gauge:** A line chart titled 'Lower Alameda Creek – Flow All Gauges' showing flow in cfs over time. The y-axis ranges from 0 to 1, and the x-axis is labeled 'Time/Date'. The chart shows a peak in flow around 4:30 PM.
- Stage vs Flow:** A scatter plot showing the relationship between flow and stage. The y-axis is labeled 'Flow' and ranges from 0 to 70. The x-axis ranges from 1.63 to 4.63.
- Data View:** A table displaying real-time data for the gauge.

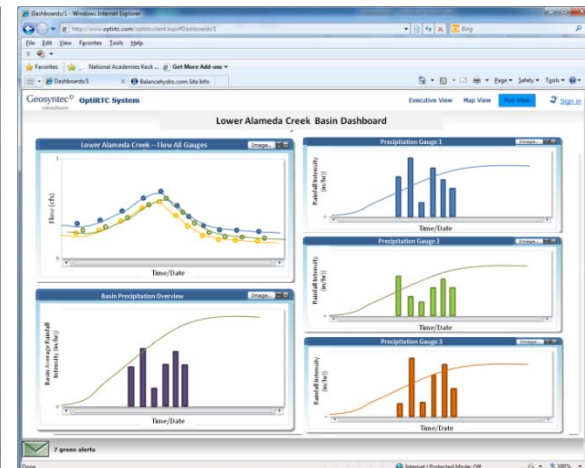
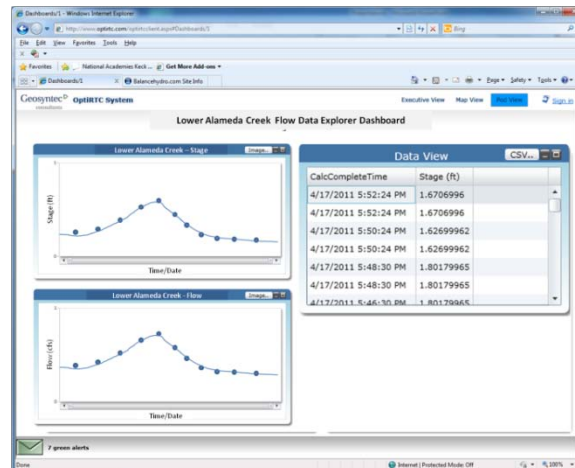
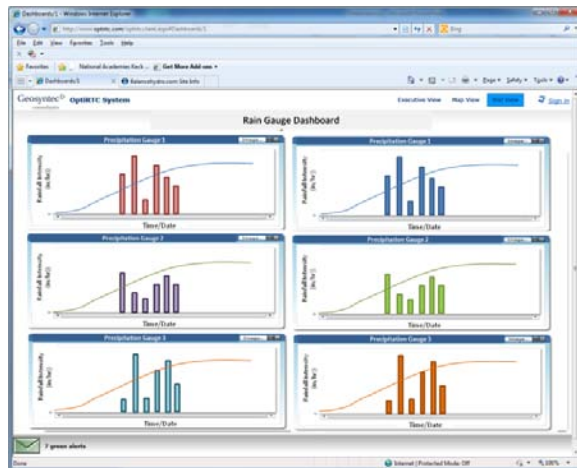
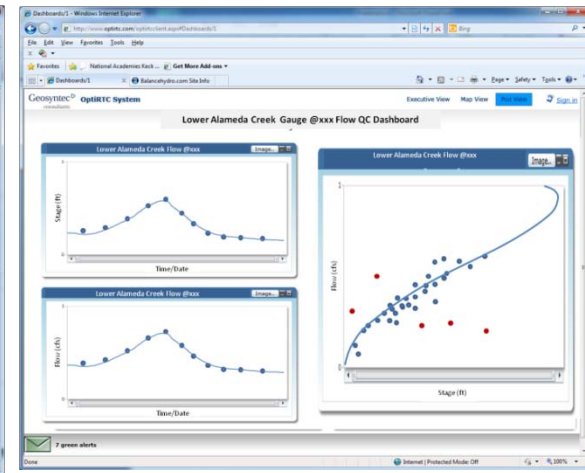
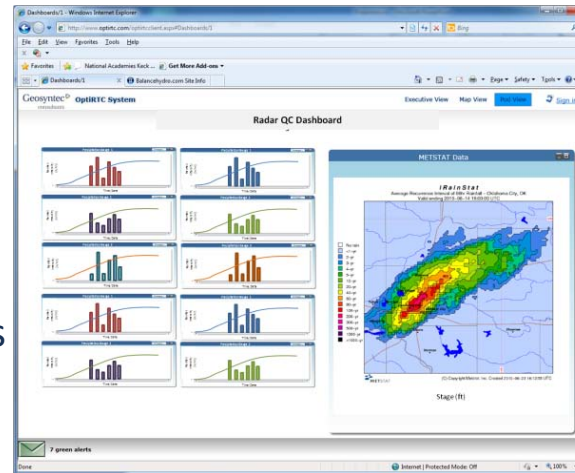
Note Live GARR Imagery Overlays on Map View Dashboard Browser

CalcCompleteTime	Stage (ft)
4/17/2011 5:52:24 PM	1.6706996
4/17/2011 5:52:24 PM	1.6706996
4/17/2011 5:50:24 PM	1.62699962
4/17/2011 5:50:24 PM	1.62699962
4/17/2011 5:48:30 PM	1.80179965
4/17/2011 5:48:30 PM	1.80179965
4/17/2011 5:46:30 PM	1.80179965

Interactive Dashboard Browser (Map/Pod View) Interface and Alerts

Example Real Time Dashboards with "Pod" Components

- Time Series - Stage, Flow, Precip.
- Scatter Plots
- External Data Sources (e.g., Real Time Radar, QPF)
- Data Viewers/Explorers
- QA/QC tools
- Basin and Summary Stats and Charts



- OptiRTC is different than your standard DSS.
- It's not a piece of software, it's a framework to generate many different solutions based on needs.
- Overarching considerations
 - Integration of data collection, analysis, and control
 - Fully scalable
 - Fully customizable
 - No special software requirements
 - Competent developer base

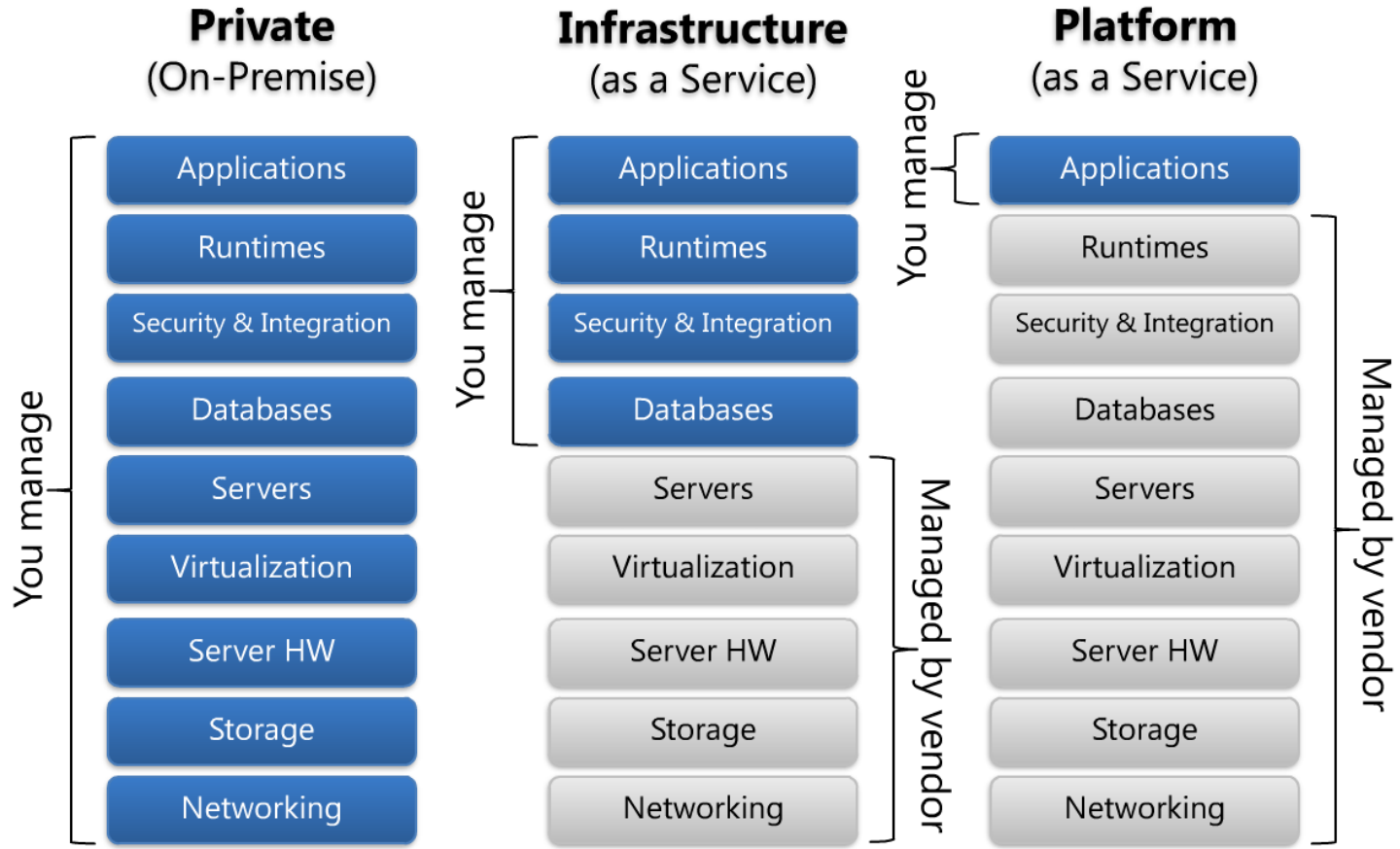
- Environmental data is like any other enterprise data stream, utilizes enterprise data management solutions
- Used by many industries so there is a large and competent developer base (i.e., Microsoft Azure, Silverlight, HTML 5, etc...) which means forward compatibility
- ANY internet-accessible structured dataset (IoT) can be integrated.
- Cloud-based (internal or external) data processing and storage allows 99.95% application uptime.
- Mobile Applications

ioBridge Pro Controller



Types of Clouds

MS AZURE (OptiRTC Environment)





Server Stack/Cloud Platform
and Storage Solution



Federated
Authentication Service



Physical-world
interface

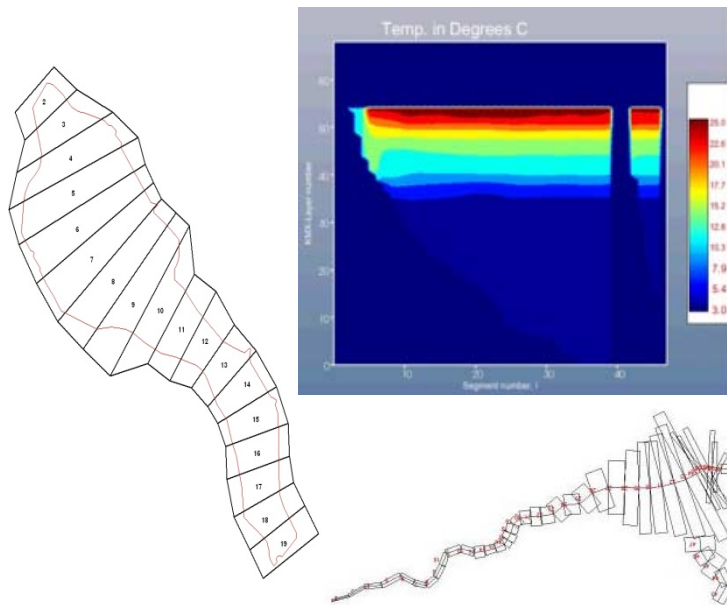


Primary User Interface
for Dashboards

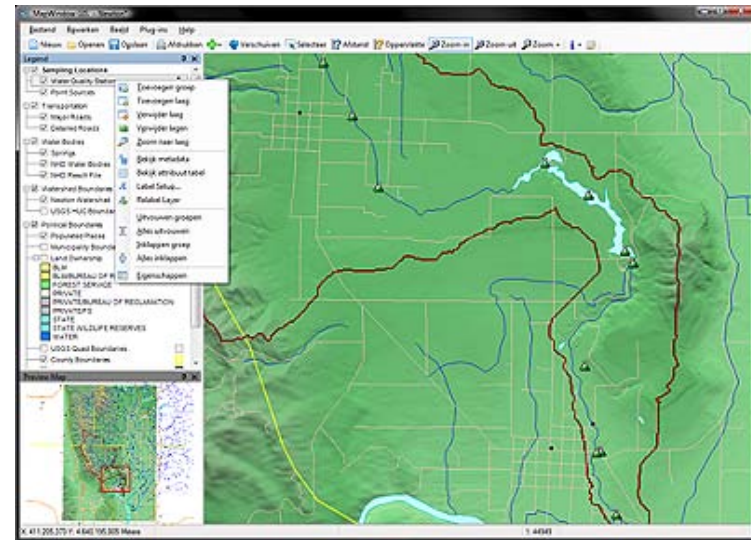


Future Mobile
Applications

- Run HEC-RAS, CE-QUAL-W2, HEC-ResSim, HYDSIM and other models as part of decision space calculation.
- Incorporate spatial processing libraries.



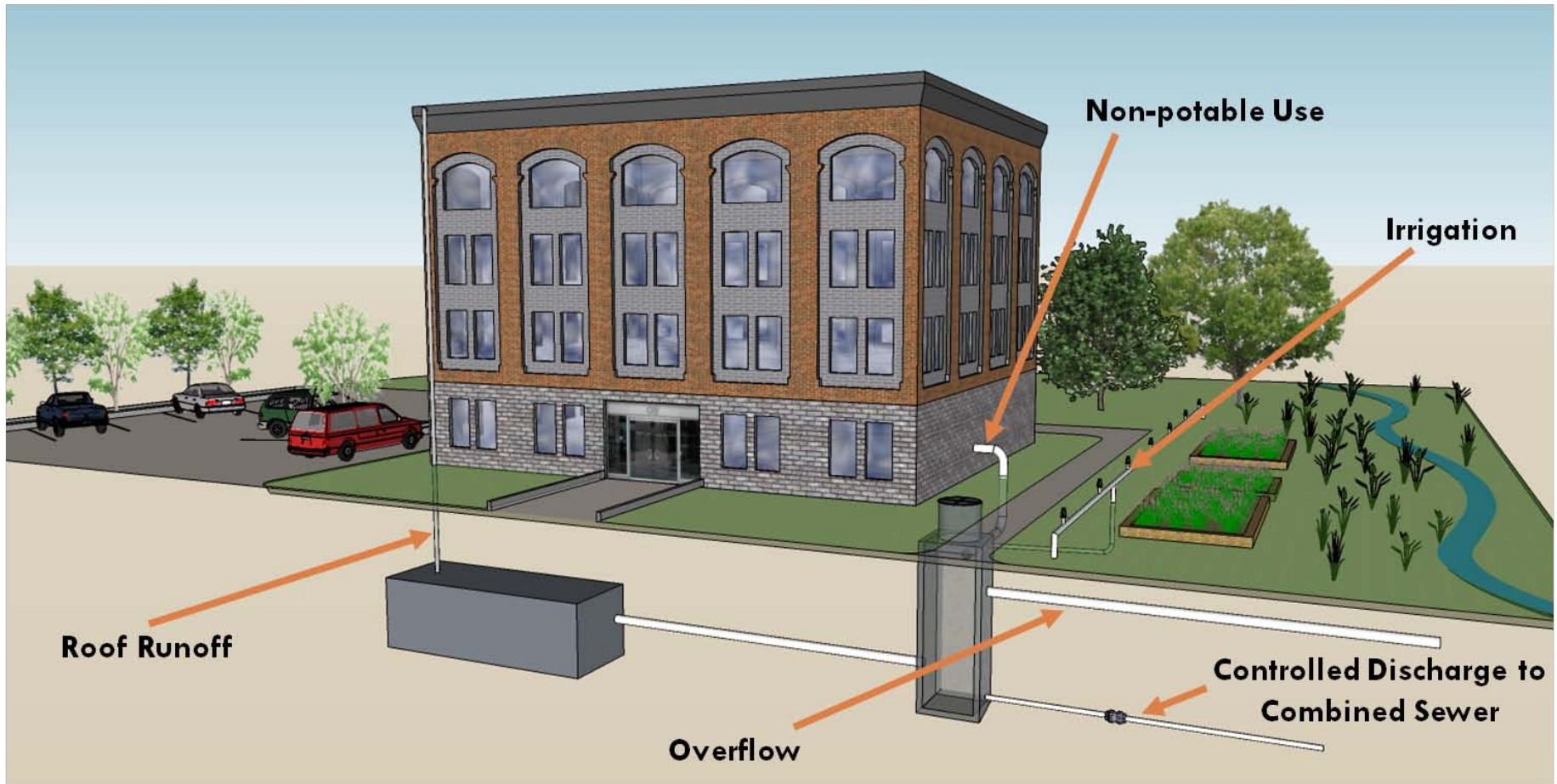
CE-QUAL-W2 Model



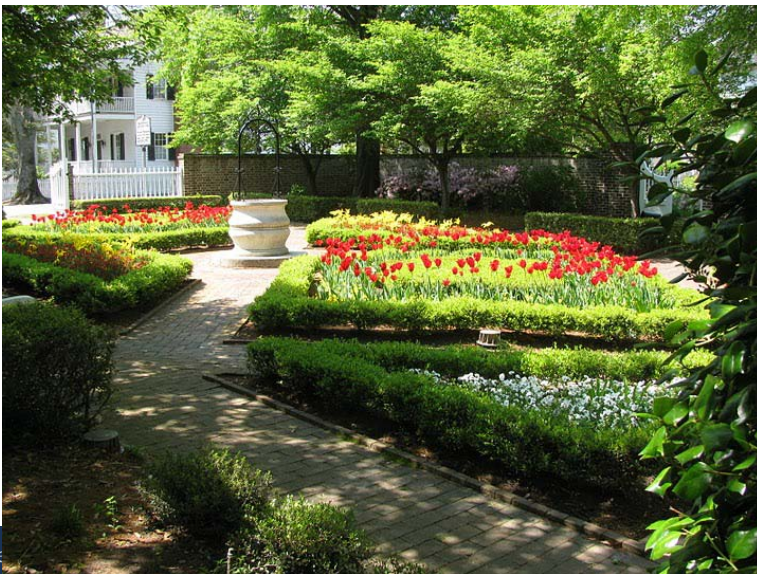
MapWindow GIS .NET spatial processing library

- Advanced Rainwater Harvesting
 - 1 System Online since July 2011, New Bern, NC
 - 7 Systems Online since September 2011 - St. Louis, MO
 - 2 Systems, Installed, Online in March - Washington, DC
- Active Green Roof
 - SAP America's Headquarters Building, Newtown Square, PA
- Controlled Underdrain Bioretention
 - Gwinnett County, GA – Online in Q1 2012

- Data Acquisition and Management (Real Time)
 - Geotechnical and instrumentation data, Herbert Hoover Dike, FL; Wolf Creek Dam, KY; and Center Hill Dam, TN
 - Grouting Instrumentation and Water Quality Data, Wolf Creek Dam, KY; and Chickamauga Lock and Dam, TN
 - GIS-Driven Web-Enabled Decision Support
Development: Instrumentation Data, Crossrail Project, London, UK
 - Instrumentation Data, TVA Kingston Facility, Kingston, TN
 - Nestle Spring Water Monitoring: Water Quality Monitoring, Various Sites, FL



Simplest Definition: Drain storage in advance of predicted rainfall or other trigger



NC State – Dashboard (1-min refresh) System Behavior Week of 9/20/2011

Navigate To ↓

OptiRTC System

Options ↓

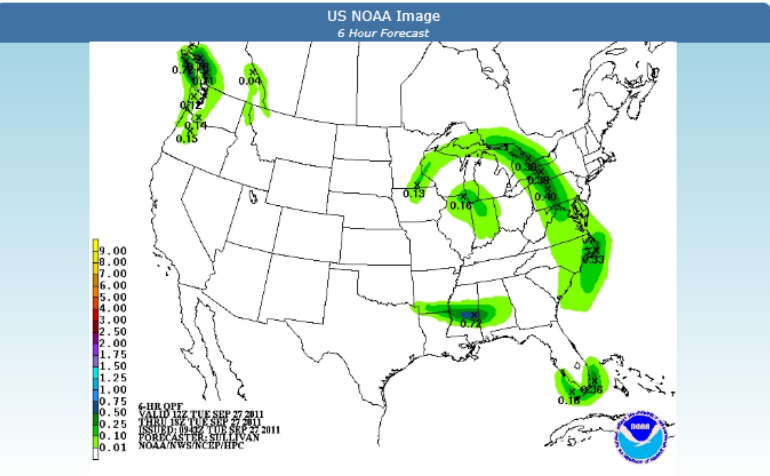
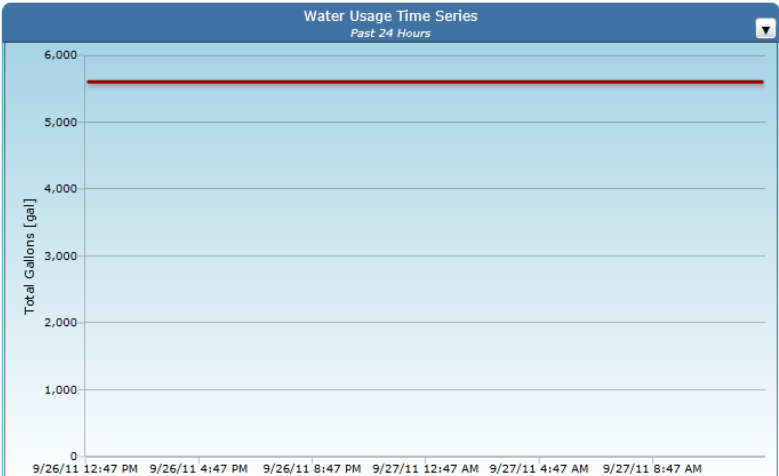
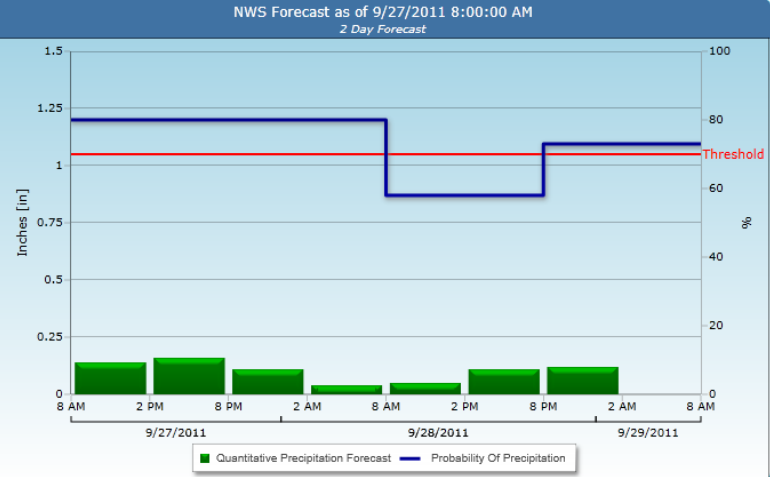
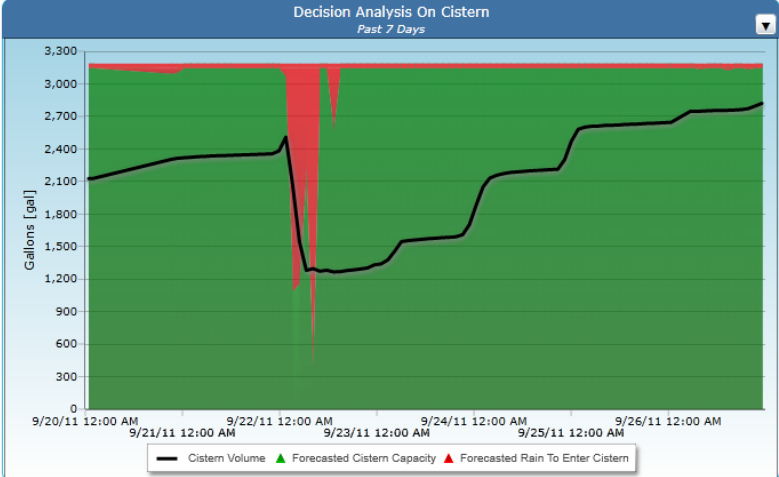
System Overview
 NC State,
 Administrators

Dashboard Tools
 Download Data Export Image

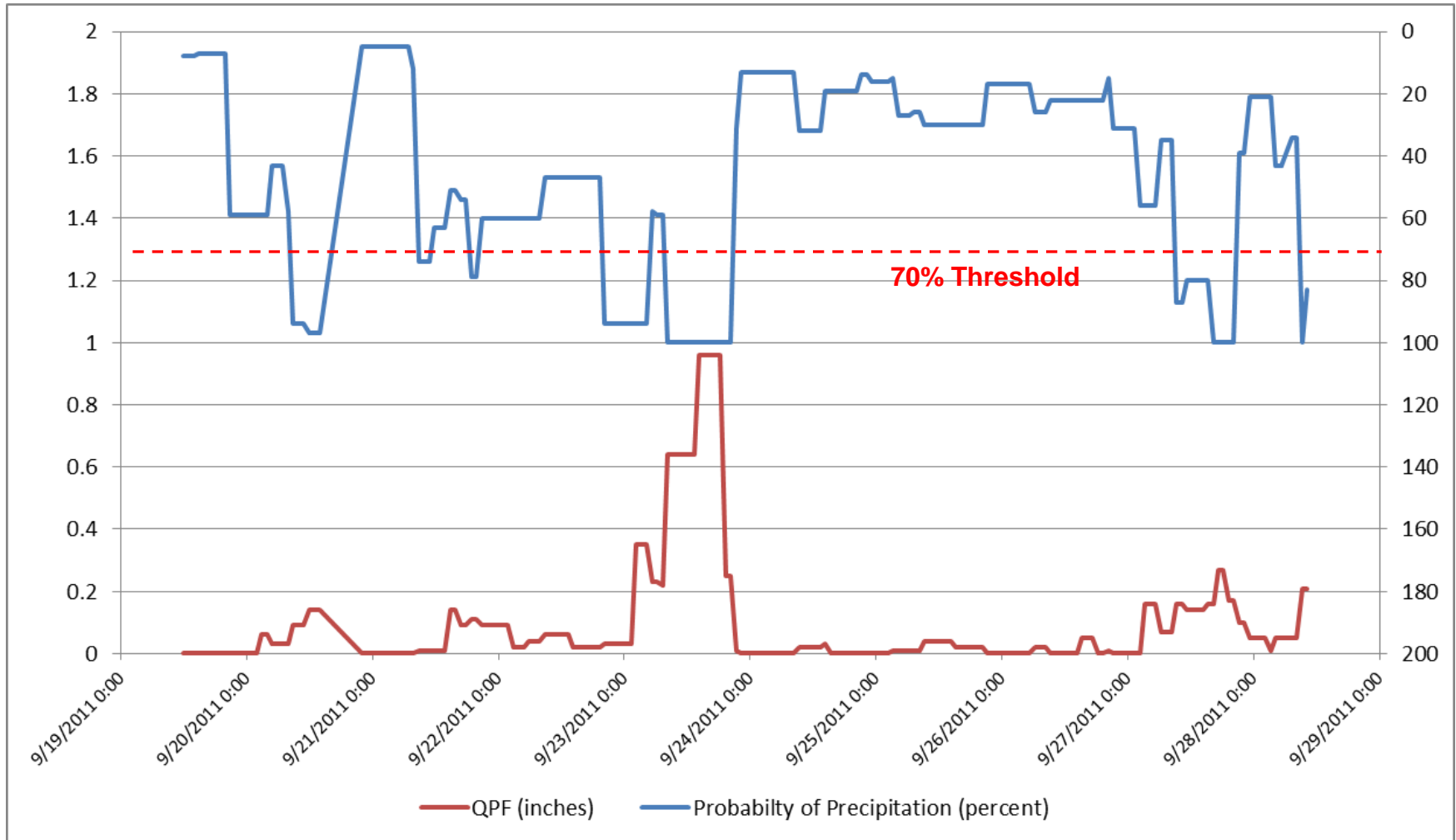
Live Cistern Readings
Active Storage: 2822 gal



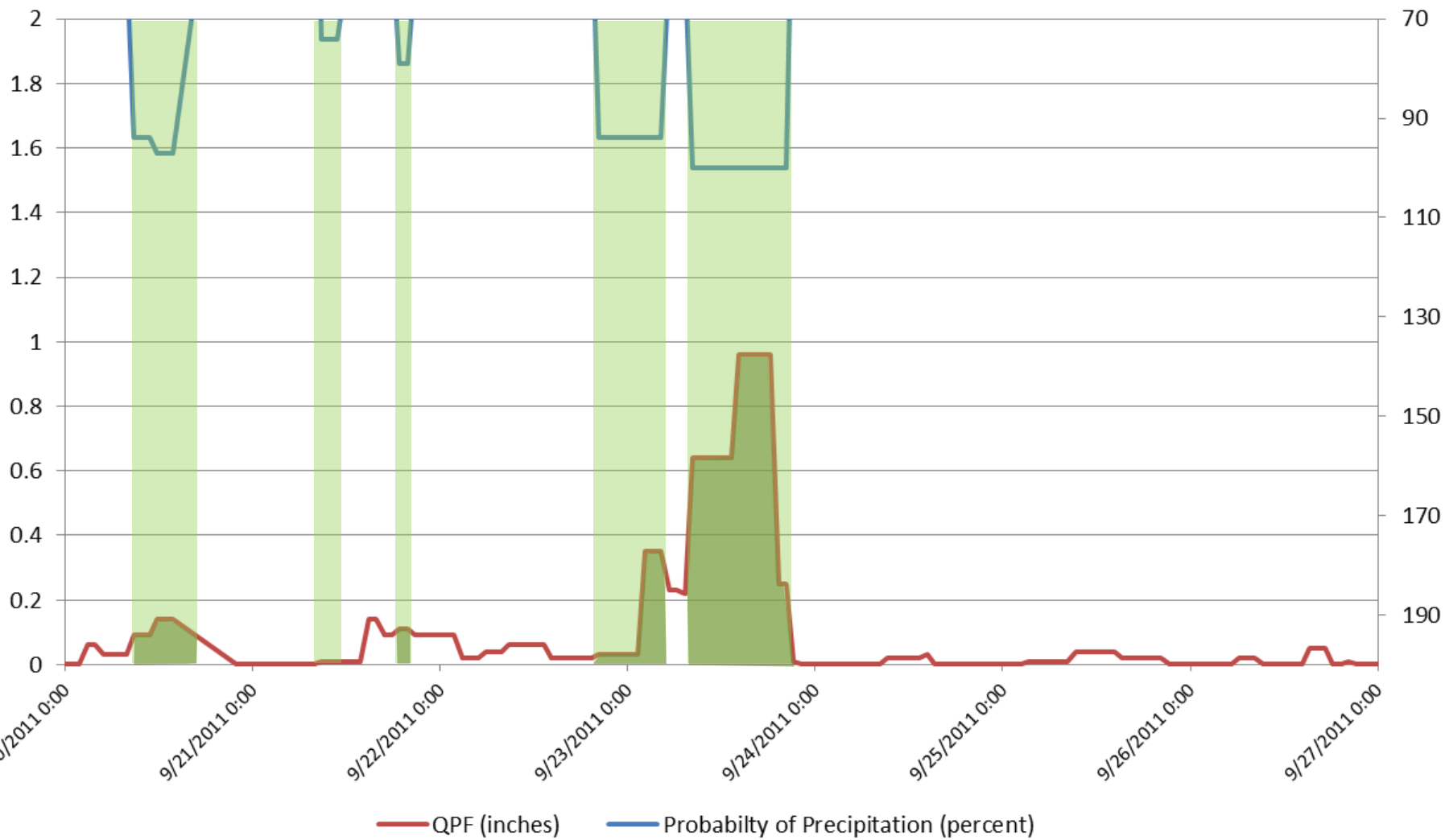
Level: 65.8 in

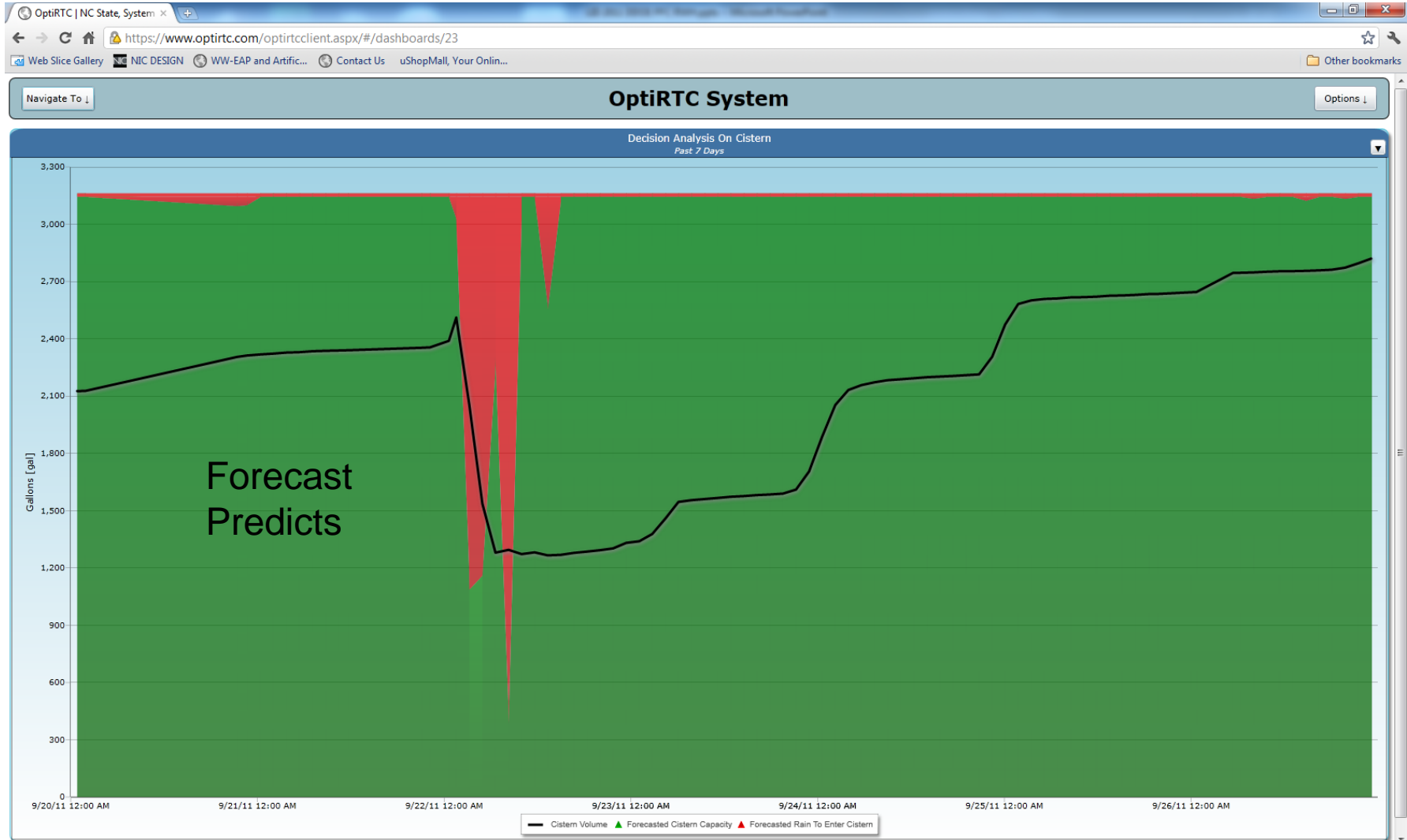


NC State, System Behavior Week of 9/20/2011, Forecast Data Stream



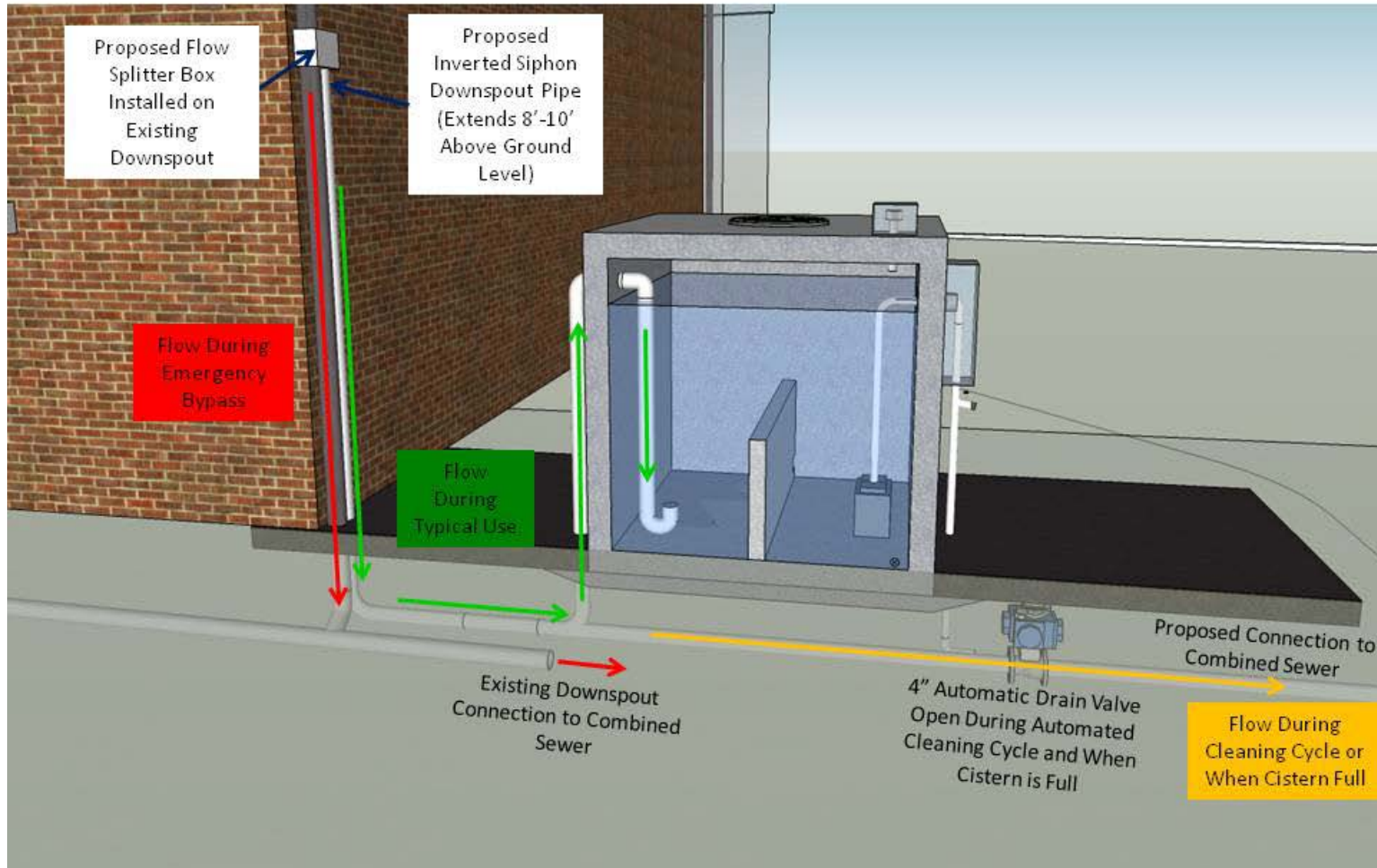
QPF and POP Forecast Data stream (Threshold of 70%)





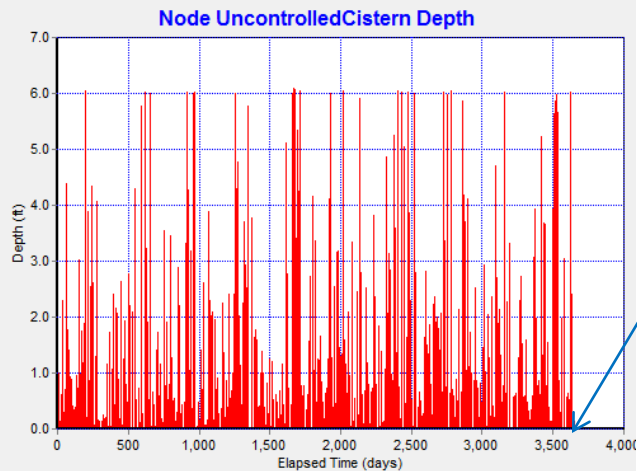
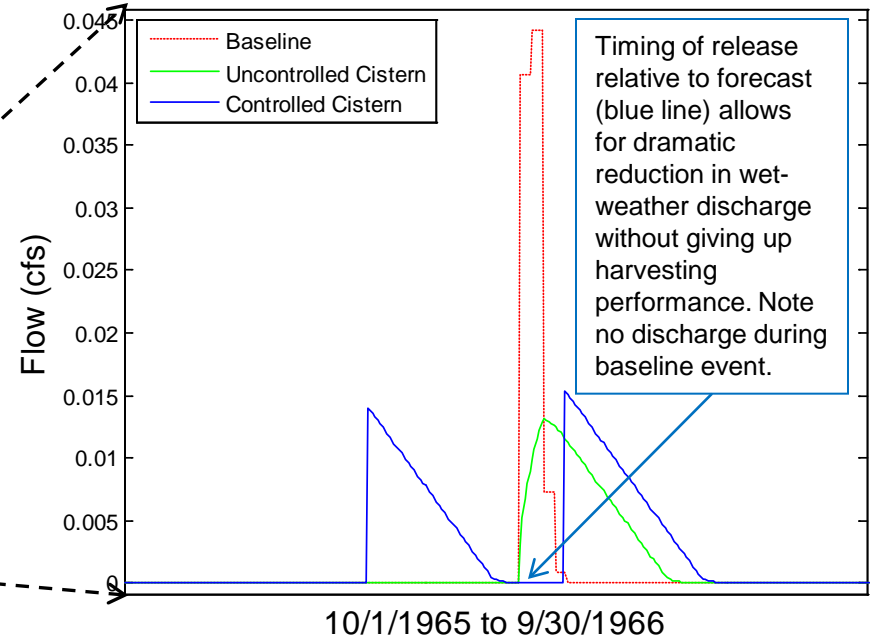
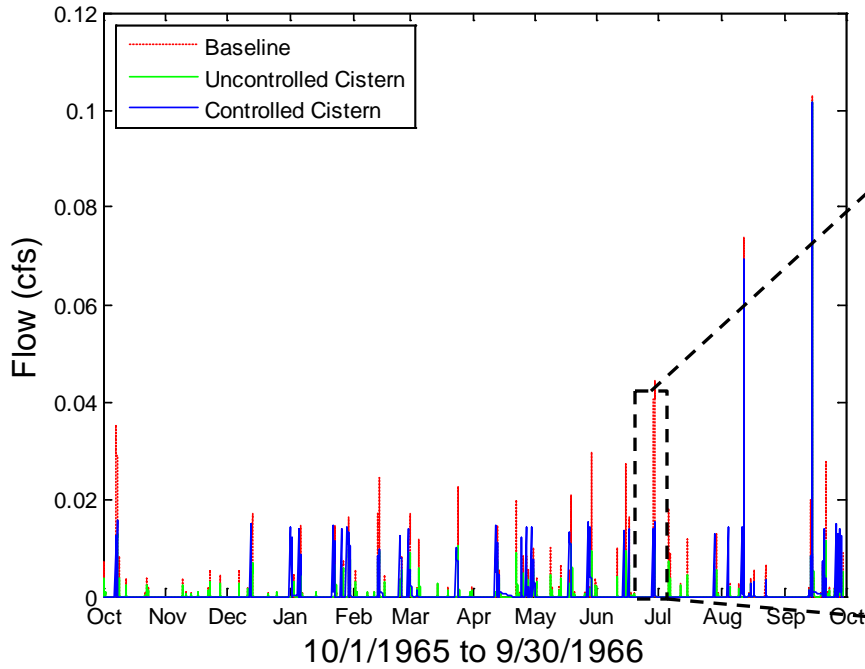
Inverted Siphon Downspout Design

(Note: location of cistern is shown close to building for illustrative purposes only)



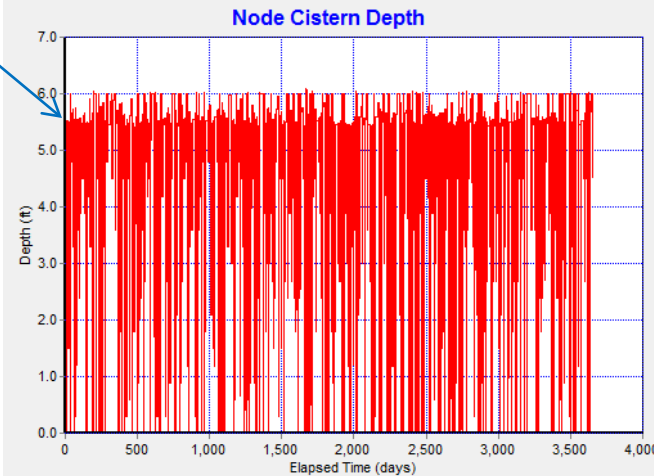
- DDOE Modeling Summary
- Baseline runoff volume:
 - 12,680 cf/yr
- Passive detention wet-weather runoff volume:
 - 11,326 cf/yr
 - 11% reduction
- Real-time controlled wet-weather runoff volume:
 - 3,899 cf/yr
 - 69% reduction in wet-weather flow volume
 - Note no harvesting factored in, assumes accurate forecasts

Flow Comparison – DDOE Modeling

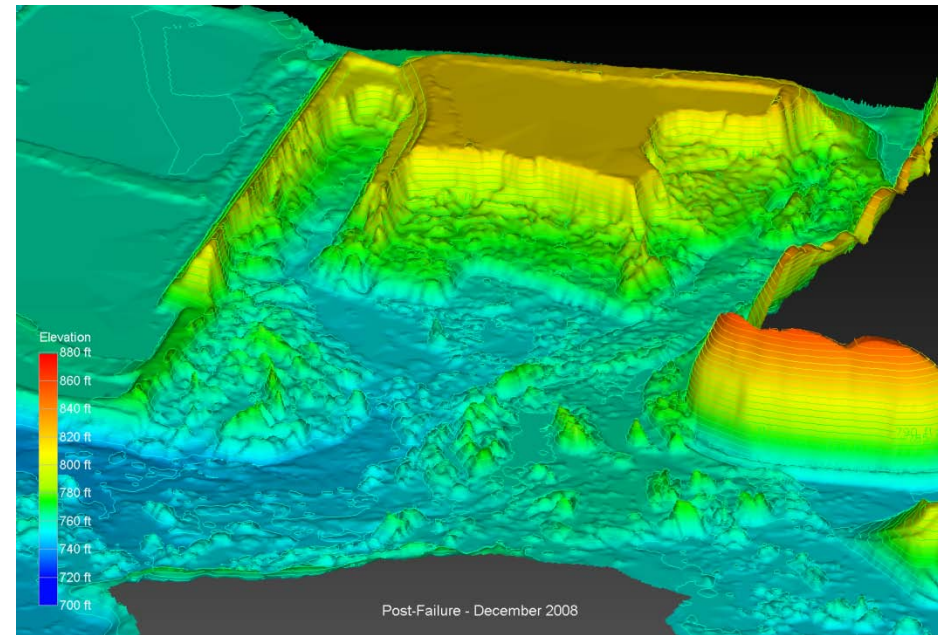
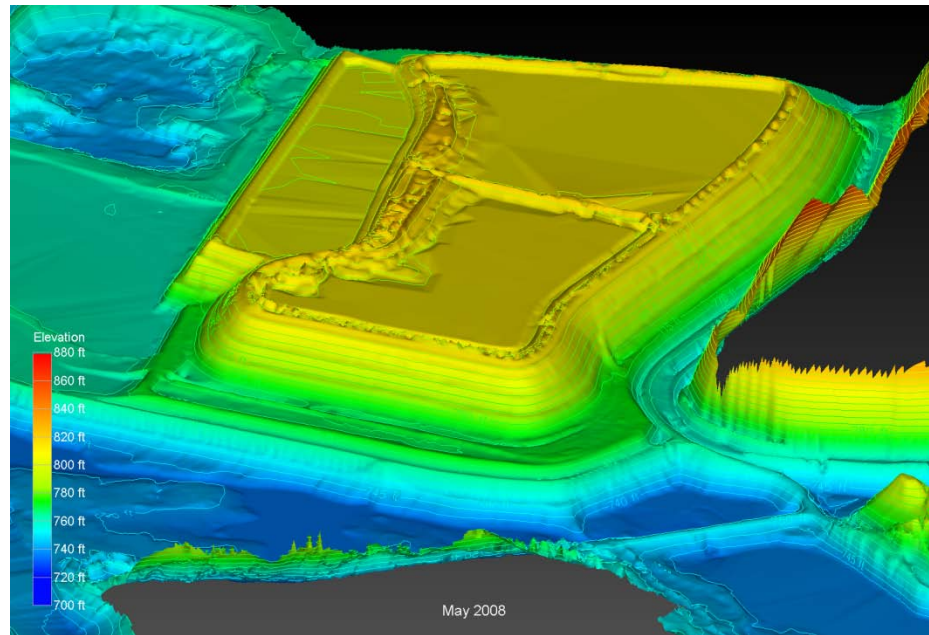


Water remains in system for potential onsite use while providing improved CSO flow control. Drains only right before events.

Detention tank empty except during rainfall.



Kingston Fossil Plant, Kingston, TN: On December 22, 2008, 5.4 million cubic yards of material released into the Emory River and other areas.



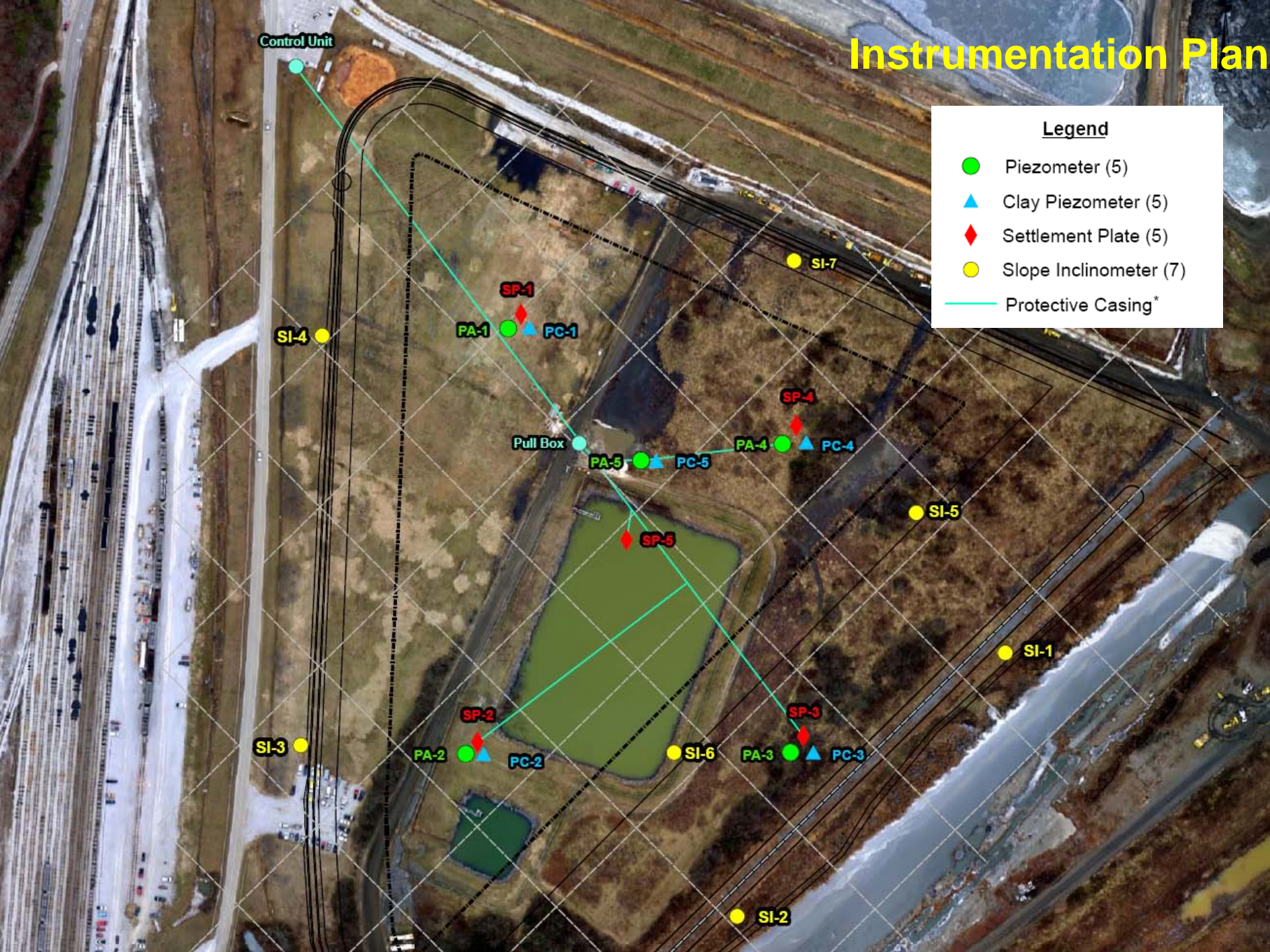
Client needed an area for temporary processing, dewatering, and storage of fly ash excavated and collected from the Emory River and other areas.

Due to presence of soft foundation materials, similar to those found underneath the Cells that failed instrumentation were needed to monitor pore pressures and settlement imposed by filling within the Site.

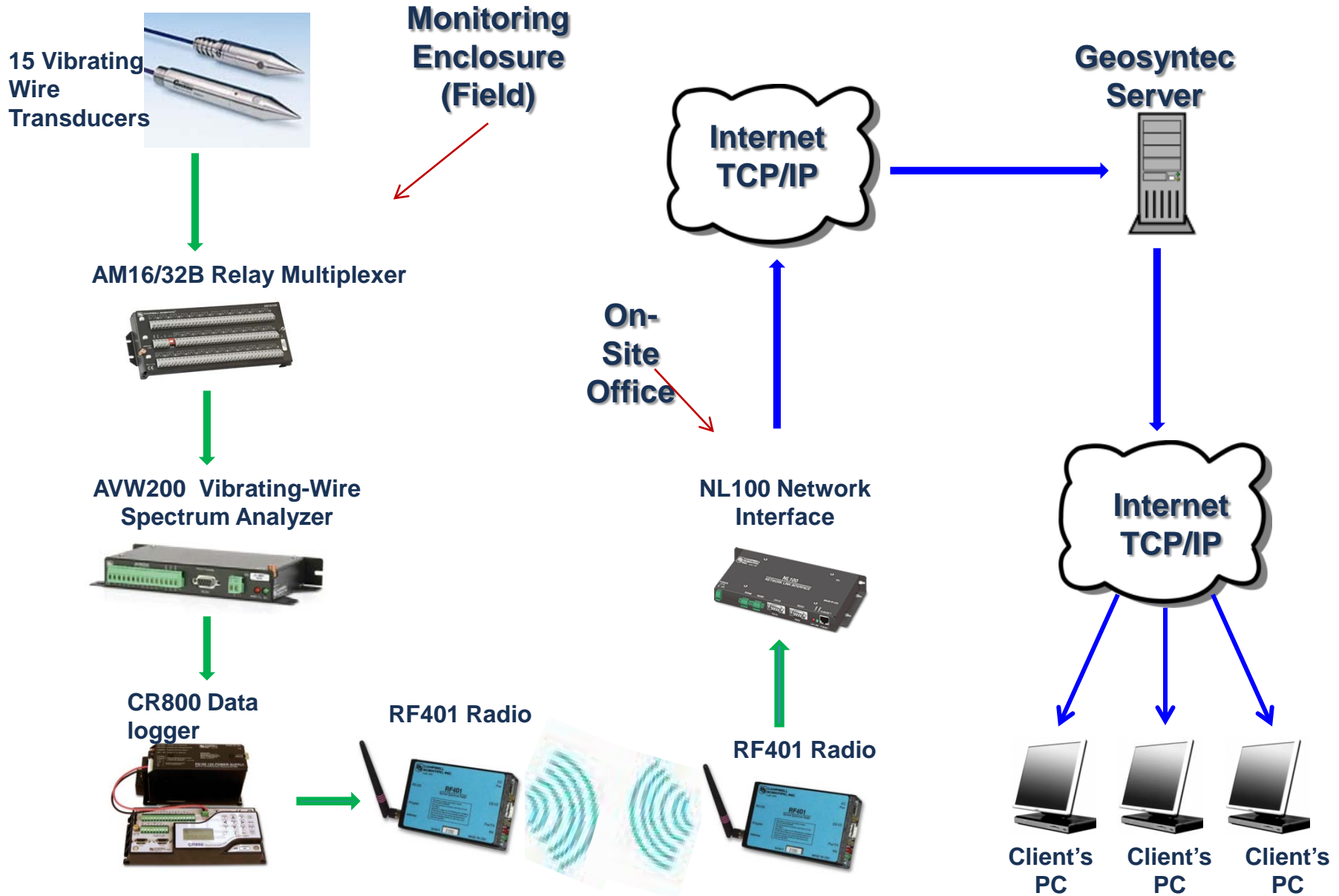
Instrumentation Plan

Legend

- Piezometer (5)
- ▲ Clay Piezometer (5)
- ◆ Settlement Plate (5)
- Slope Inclinometer (7)
- Protective Casing*



Instrumentation Network



- NOAA stream flow forecasts
- Quantitative Precipitation Forecasts (QPFs), spatial data sets
- Quantitative Precipitation Estimates (QPEs), real time gauge adjusted rainfall radar, spatial data sets
- Real time data acquisition
- Integration with hydrologic and hydraulic models
- Multi-reservoir system operations
- Warning or alert systems and notifications

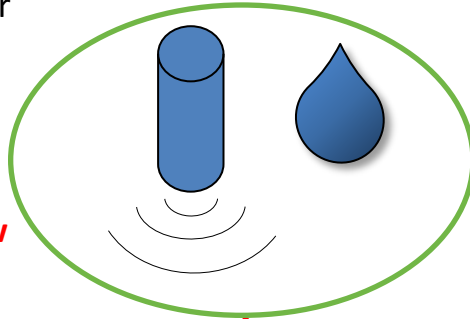
- Individual reservoir operational objectives
- Multi-reservoir system operational objectives
- ESA, BiOp, TMDLs
 - Temperature
 - Total Dissolved Gas (TDG)
 - Total Suspended Sediments (TSS)
 - Fish passage
 - Ramping rates
 - Minimum flow requirements
- Operational scenario testing
- Model scenario manager

- Individual reservoir optimization
- Multi-reservoir optimization
- Bracketing operational constraints
 - Environmental compliance
 - Flood control
 - Margin of safety for operations
- Operational scenario testing (for operators)
- Real time data acquisition and status reports
 - e.g. flow, meteorological conditions, forecasts, power usage and rates
- Integration with hydraulic and hydrologic models

- Efficient use of resources
- Hazard monitoring
- Watershed management
- Predictive control
- Adaptive management solutions
- Alert notification
- Handles any data stream, seismic, rainfall, gauge adjusted radar rainfall, QPF, meteorological, flow, discharge, temperature, water quality (any external data).
- Integration of environmental data with existing IT

Field Monitoring for Modeling and Downstream Compliance

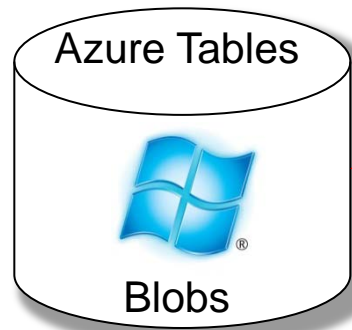
NOAA Stream flow Predictions



ResSim, HYDSIM, or Other

NN/Genetic Algorithm or Other

Model Execution and Optimization

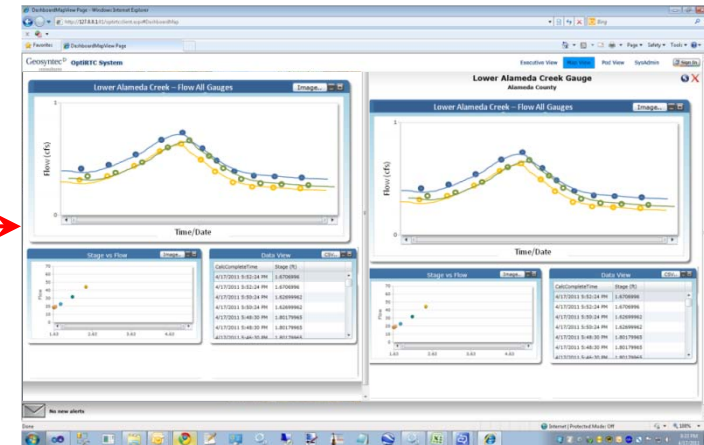


Time Series Database



OptiRTC Data Aggregator and Decision Space

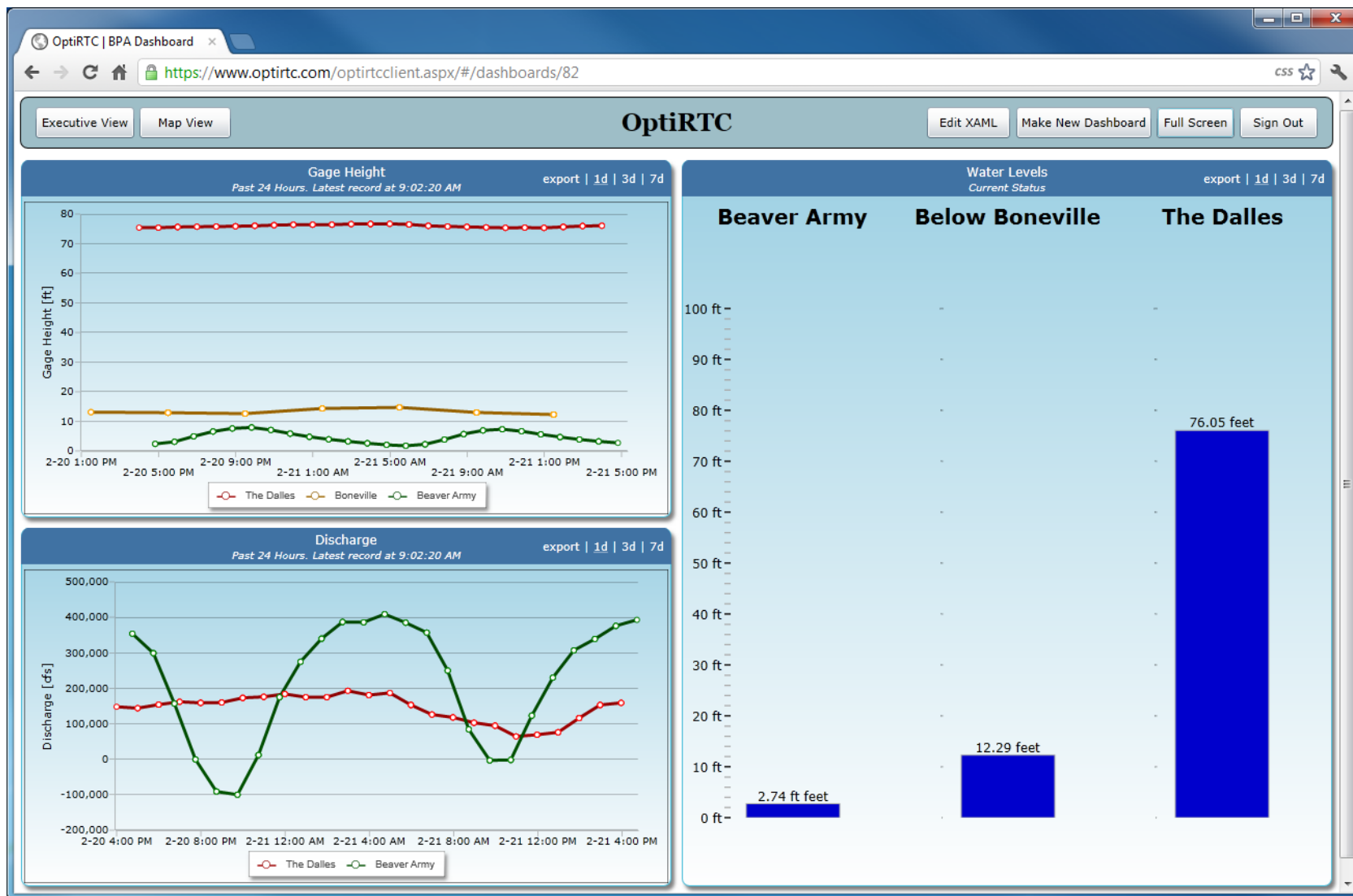
User Input data

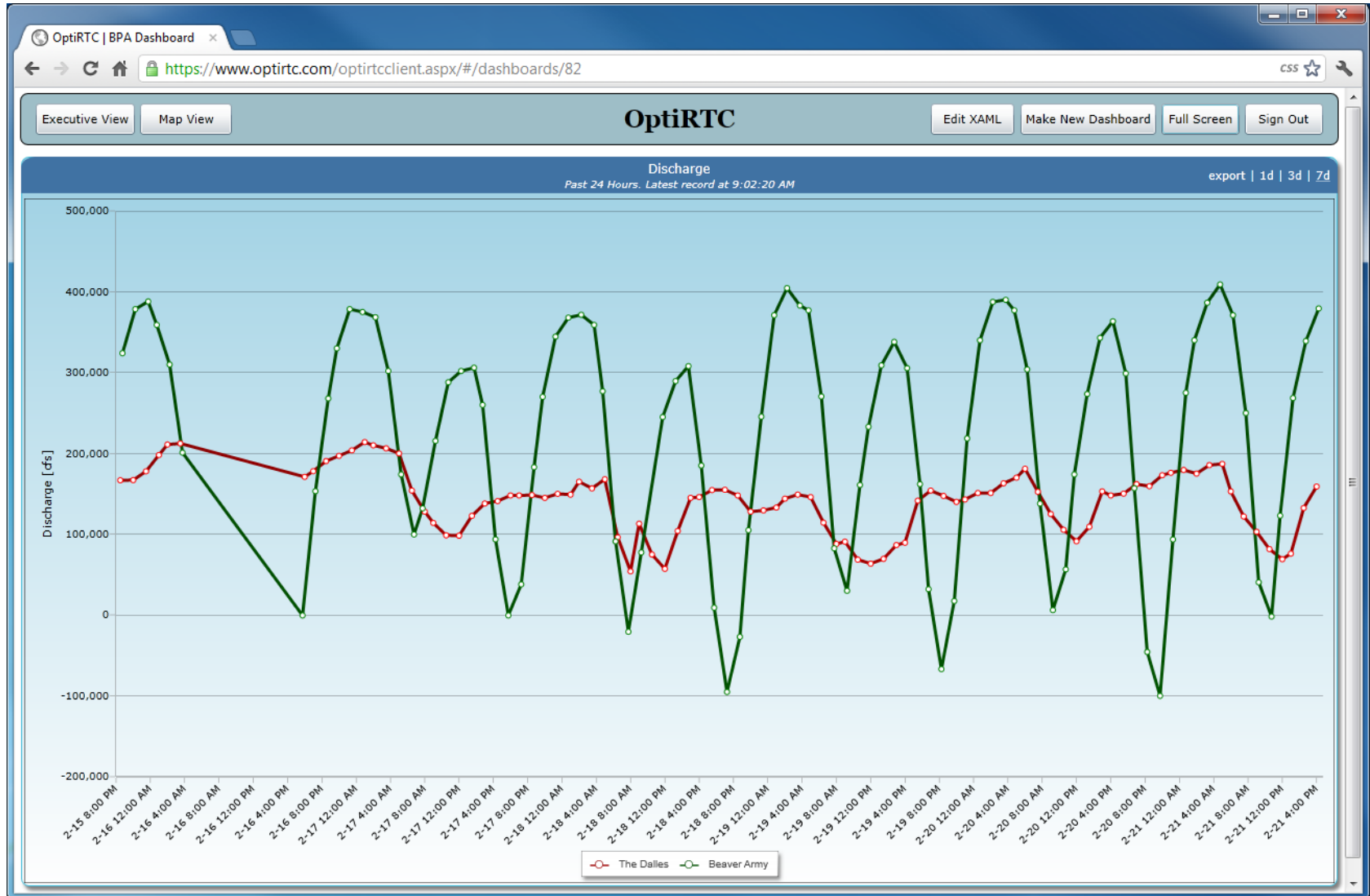


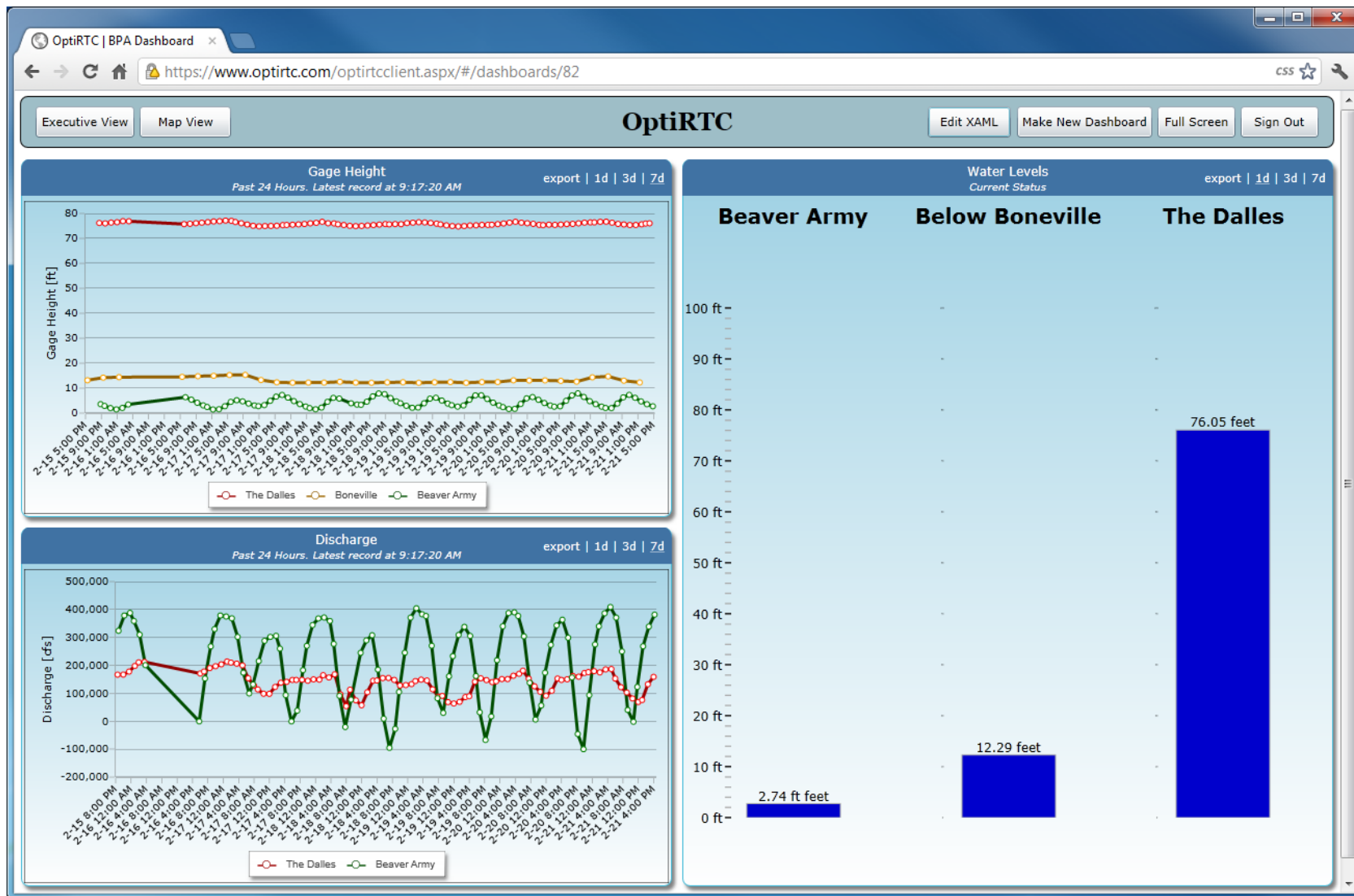
Multi-user Interface and Dashboards

Multi-Reservoir Operations

[Demo](#)







Questions?

Thank you