Team: Open-Storm Detroit Dynamics

The team comprises a utility-university partnership, with the participating utility the Great Lakes Water Authority (GLWA) and the University of Michigan.

Name	Title	Organization	Email	Skill-set/ Area of Expertise
Wendy Barrott	Program Director R&D	GLWA	Wendy.Barrott@glwater.org	Research and Development
Christopher Nastally	Manager	GLWA	Christopher.Nastally@glwater.org	CSO Controls
Branko Kerkez	Assistant Professor	University of Michigan	bkerkez@umich.edu	Intelligent water systems, Real-Time Control
Sara Troutman	Student, Ph.D. Candidate	University of Michigan	stroutm@umich.edu	Control Theory, Water Quality
Abhiram Mullapudi	Student, Ph.D. Candidate	University of Michigan	abhiramm@umich.edu	Software Development, System-Scale Control
Gregory Ewing*	Research Scientist	University of Michigan	gregjewi@umich.edu	Hydrology, Program Management

**Team Lead, point of contact*

Roles and Responsibilities

Wendy Barrott serves as the Team's primary liaison within the partnered water utility, GLWA, having many years of experience working within GLWA's Research & Innovation division to develop pilot projects and transform them into operational activities.

Christopher Nastally is an engineer at GLWA who manages GLWA's Combined Sewer Overflow (CSO) Facilities. His experience with these facilities provides the team with knowledge of current feasibility of control applications for GLWA infrastructure.

Branko Kerkez is an assistant professor and director of the Real-Time Water Systems Lab at the University of Michigan. He is an internationally-recognized researcher and instructor in the area of smart water systems. For this project, he will manage the team, mentor students, and develop control algorithms and sensing strategies.

Sara Troutman is a Ph.D. candidate, advised by Dr. Kerkez. Her research includes the development of dynamic control algorithms for theoretical stormwater systems to make control decisions in a multi-objective space. She will develop the framework for applying these control algorithms in the real system.

Abhiram Mullapudi is a Ph.D. candidate and is advised by Dr. Kerkez. Abhiram is also a developer for Pyswmm and Open Water Analytics SWMM (OWA-SWMM,) two open source tools for stormwater analyses. His research investigates system-scale control of stormwater treatment and conveyance systems. Abhiram will help the Team develop and implement the software applications for the project.

Gregory Ewing is a research scientist in the Real-Time Water Systems Lab at the University of Michigan. Gregory is the primary point of contact for the LIFT Challenge and will coordinate the synthesis of the concurrent research into the decision support tool for application within the GLWA system.

Problem Statement

The Great Lakes Water Authority (GLWA) is a regional water and sewer authority that services nearly 40 percent of the water customers in Michigan, including the City of Detroit and its surrounding suburbs (approximately 3.9 million customers). Due to many stressors, such as aging infrastructure, changing populations, and rapid development in the service area, the sewer and stormwater conveyance system is strained well beyond its design. As a result, the combined sewer system experiences frequent and unpermitted combined sewer overflows to the Detroit River. To combat these persistent untreated outflows, and with a vision to create more controlled inflows into the waste water treatment facility, GLWA launched a project in late 2017 with the University of Michigan's Real-Time Water Systems Lab to investigate the application of dynamic control to existing infrastructure in real-time. The desired outcomes of dynamic, real-time control are to:

- Maximize current storage utilization
- Reduce Combined Sewer Overflows, and
- Equalize flows to the Waste Water Treatment Plant.

Project Scope

The scope for this LIFT Challenge is to deliver a web-based decision support tool that can be used by the stormwater operators during wet weather and dewatering events. The tool will assist operation of a portion of the stormwater footprint and incorporate control algorithms developed as part of the LIFT Challenge.

Expected Benefits, Success Metrics

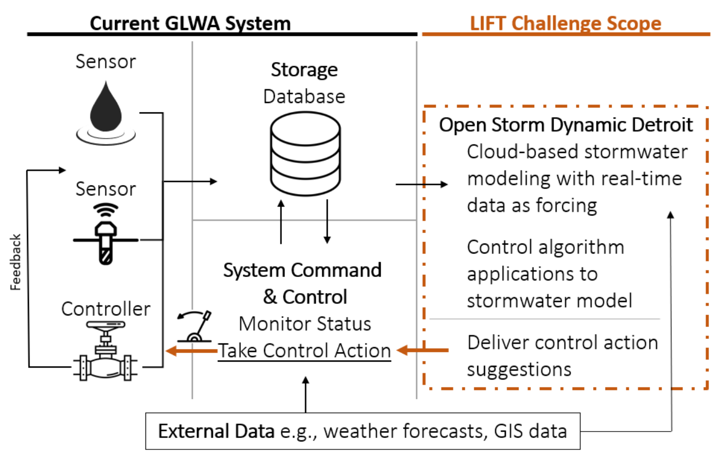
Application of the real-time control approach offers the potential to significantly improve the existing GLWA wastewater and CSO management system by reducing, and potentially eliminating, the occurrence of CSOs and by reducing peak flows going to the treatment plant. These benefits can be achieved without new construction, but rather by relying entirely on existing infrastructure, which will free up significant capital savings for future investments. This project will evaluate this potential and frame the magnitude of the performance and cost savings benefits for GLWA.

Success within the scope of the LIFT Challenge project will be defined by the support tool's ability to assist stormwater operators to mitigate unpermitted CSO frequency and volume. Because GLWA is required to report CSO events to regulators, there is a large dataset with which to compare outcomes. We will use historical records to compare the frequency and volumes for similar periods and storms before and after application of our decision tool. Success will also be measured in the percent utilization of existing infrastructure, and reduction of peak flows to the treatment plant.

Intelligent Water System

GLWA Storm and Sewer Collection System, Current System

Currently, GLWA has many of the components in their system that must be leveraged to realize dynamic control of their assets. Primarily, GLWA leadership is committed to intelligent, data-driven solutions and supports infrastructure towards this end. GLWA operates a robust measurement and transmission infrastructure, with minutely and sub-minutely data for flow, level, and precipitation measurements from across the conveyance network and is available in real-time via a web interface. Further, GLWA currently operates their gates, pumps, and valves from a centralized command and control center. By mid-summer, GLWA will complete the upgrade of their in-line storage dams to be remotely controlled, adding additional opportunities for dynamic control. Because these data are



accessible via web services in real-time, web-based analytics and decision support tools can be built out to assist in system control.

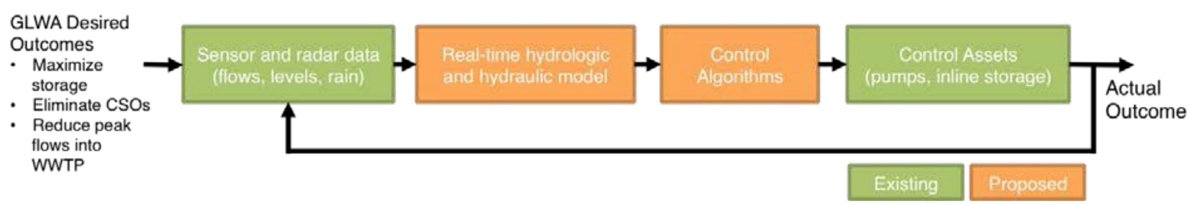
Previous Work

Prior to competition kickoff, the Team has made progress toward our goal of realizing an operational decision support tool for dynamic control. Our Team has investigated the system assets, identifying promising locations for active control. Additionally, we have carried out initial control case studies across subsets of the service area.

Plan

Due to the size and complexity of the GLWA collection and interceptor system, a single region and subset of the larger system was chosen as a pilot project. The focus area was selected for the number and size of its controllable assets, including pump stations, in-line storage dams, and a 120-million-gallon retention basin complex. This area has many outfalls that are unpermitted to release untreated CSOs.

Our solution will be iterative, using the feedback that exists in the conveyance system to inform control decisions to continually nudge results to a desired state. This idea of feedback is a critical component to the control algorithms that we will apply. First, we will develop the real-time control approaches in a model space, and then move to the application of these approaches using real-time data across the GLWA footprint. The novelty of our project is the application within a real system in real-time of these control approaches that were designed in the model space specifically for use in stormwater conveyance networks.



Visual summary of proposed approach: The *feedback* control approach continually compares the desired state of the collection system to the actual state using a suite of real-time models that ingest streaming sensor data. A series of control algorithms then makes concrete recommendations that can be used to manually or autonomously control the system to ensure that the system performs optimally.

We will begin by developing control formulations based on historical events. Using these historical events in a local model space with "full knowledge" will allow us to develop insights into the dynamics of the system and help inform how to apply our control algorithms on the utility's assets. This process will be followed systematically for all potential control locations within the study area.

Concurrently, we will develop a web application that ingests data in real-time from GLWA's system. These data will include flow and level measurements, but also states of control points like pump status and percent open for gates and valves. With these data, we will run models and analyses that incorporate the insight gained from our control studies of historical storms. The results of these models will be control recommendations for operators that can be incorporated into their operations during wet weather and dewatering events.

In accordance with Real-Time Water Systems Lab practice, all algorithms, back-end/cloud infrastructure, and control models will be shared open source and available to the public under the GNU License.

Timeline

Task & Deliverables	2018						
Month	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Analysis of storage utilization and opportunities on the east side of GLWA service area							
Development of dynamical control model using sensor data							
Implementation of real-time control algorithms 1: Reducing East Side CSOs							
Implementation of real-time control algorithms 2: Reducing variability of flows into plant							
Development of Web Application for Real-Time Data Ingest							
Launch Control Analytics Web Application							
Success Metric Calculations Using Historical Data							
Prepare and Deliver Final Solution Submission							**x**