# Project Status, July 2018: CS-175; Dynamic Collection System Control

## Summary

The two areas of focus for the project CS-175; Dynamic Collection System Control are: analysis of dynamic control for the GDRSS system, and an operator decision support dashboard. Here we provide a review of progress made for each of these tasks and discuss future work.

## Updates

### Dynamic Control for the GDRSS

In June, we added the capability to operate multiple parallel marketplaces within the same simulation and continued control parameter optimization trials. These marketplaces are independent of each other, with prices and actions in one not affecting those calculated in others. This addition allows us to look at the combinatory effects of control clusters and is a step towards being able to apply our frameworks with real measurements.

In July we added a flood elevation condition to the control decision algorithm, such that if a flood elevation is reached at an upstream storage element the respective action of the associated control element would override the market and discharge at full capacity. During simulations Freud Pump Station showed to be the most sensitive to its flood elevation limit. Flood elevations in current use were provided during the March meeting and can be found in Table 1. We request that these flood elevations be confirmed. Further, if there are other flood elevations that should be consider for assets, such as the inline storage dams, we request that these be provided as well.

**Table 1. Flood elevation limits for upstream storage assets in GDRSS**

| Control Asset Storage, SWMM Model Element | Flood Elevation, Feet Above Detroit Datum |
|---|---|
| Conner Creek Forebay, 17311 | 98.0 |
| Freud Storm Pump Station, 5220 | 84.0 |
| Conner Creek Pump Station, 5010 | 95.0 |
| Fairview Pump Station, 1700 | 96.0 |

This month we also explored multiple market setups for the Conner Creek – Freud – Fairview complex, with setups ranging from a single market to three markets. Detail on the division of assets within these markets can be found in tables 2-4 below. Multiple storm events were simulated with each setup and the performance of each was analyzed. Results indicate that a single marketplace better maintains higher storage levels in the upper assets such as the Conner Creek Pump Station and Freud Pump Station. However, the single marketplace setup is prone to reach flood elevations, especially in Freud Pump Station, and as a result triggers releases that surge overflows from the Conner Creek Retention Basin in the model. Dividing these assets into two marketplaces helped ameliorate the flooding in upstream elements, however did not lower overflow volumes from the retention basin. Upon inspection of the two-marketplace setup, we noted that the Conner Creek Sewer Pump Station had yet to be included in our markets and could form a market with the Conner Creek Retention Basin dewatering pumps with the in-line storage upstream of Fairview Pump Station as a seller, forming one of the three marketplaces in our three-marketplace setup for this complex. In simulations, we have observed that the three-marketplace setup performs better than the other two setups. This is apparent in the reduction in CSO's from the Conner Creek Retention Basin and the peak inflow to the treatment facility (see Figure 1.)



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<table>
<tr><th colspan="2">Table 2. Setup #1: Single Market</th></tr>
<tr><th colspan="2">Market 1</th></tr>
<tr><th>Upstream Buyers</th><th>Downstream Seller</th></tr>
<tr><td>Fairview Pump Station</td><td rowspan="5">DRI Downstream of Fairview</td></tr>
<tr><td>Conner Creek Storm Pump Station</td></tr>
<tr><td>Conner Creek Forebay</td></tr>
<tr><td>Conner Creek Retention Basin Dewatering</td></tr>
<tr><td>Freud Pump Station</td></tr>
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<table>
<tr><th colspan="4">Table 3. Setup #2: Two Markets</th></tr>
<tr><th colspan="2">Market 1</th><th colspan="2">Market 2</th></tr>
<tr><th>Upstream Buyers</th><th>Downstream Seller</th><th>Upstream Buyers</th><th>Downstream Seller</th></tr>
<tr><td>Conner Creek Storm Pump Station</td><td rowspan="3">Conner Creek Retention Basin</td><td>Conner Creek Retention Basin Dewatering</td><td rowspan="2">DRI Downstream of Fairview</td></tr>
<tr><td>Conner Creek Forebay</td><td>Fairview Pump Station</td></tr>
<tr><td>Freud Pump Station</td><td colspan="2"></td></tr>
</table>

<table>
<tr><th colspan="6">Table 4. Setup #3: Three Markets</th></tr>
<tr><th colspan="2">Market 1</th><th colspan="2">Market 2</th><th colspan="2">Market 3</th></tr>
<tr><th>Upstream Buyers</th><th>Downstream Seller</th><th>Upstream Buyers</th><th>Downstream Seller</th><th>Upstream Buyers</th><th>Downstream Seller</th></tr>
<tr><td>Conner Creek Storm Pump Station</td><td rowspan="3">Conner Creek Retention Basin</td><td>Conner Creek Sewer Pump Station</td><td rowspan="2">In-line Storage Before Fairview Pump Station</td><td>Fairview Pump Station</td><td>DRI downstream of Fairview</td></tr>
<tr><td>Conner Creek Forebay</td><td>Conner Creek Retention Basin Dewatering</td><td colspan="2" rowspan="2"></td></tr>
<tr><td>Freud Pump Station</td><td colspan="2"></td></tr>
</table>

Evident in these simulations is that the Conner Creek Forebay is discharging its stored volume even when there are no actions taken to open or close the forebay gates. Upon inspection, this is because the model formulation of the VR-2 regulator gates was not designed in a way to allow active control. As such the model computes discharge through the VR-2 gates into the DRI during wet weather events as if the gates were open for normal sewer operation. This is neither the current practice in real life nor helps with the desired control outcomes in our simulations. Adding in control capabilities of the VR-2 gates into our model scheme is a priority for August.

Having moved closer to a market setup that incorporates the full complexities of this system, it is apparent that manual tweaking and search of the parameter space is not tenable. Currently we are exploring the use of Genetic Algorithms and Monte Carlo optimization schemes to optimize the cost curve parameters. Fitness of parameters are determined by the minimization of both the time that any controllable element experiences depths above basement flooding and the total outflow volume from all outfall elements that are not associated with the WRRF. An update on this effort will be forthcoming in the August status update.

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We continue to investigate the overall capacity of the inline storage dams (ISDs) and their threshold to mitigate local and global downstream discharges. Preliminary results show that employing active control with ISDs are effective in lowering and delaying the local downstream flows, however the impact on the inflow signal to the WRRF is diminished with increasing volume of storms. (see Figure 2.) A general threshold for the storage dam impact will be explored further in August.

### Decision Support Dashboard

An IT Service Ticket request was opened this month to begin the process of acquiring access to a "wish list" of data points that will be used in our control algorithms. More information will be forthcoming upon the resolution of this service request.

### Future Work

**What We Need**: Confirmation and/or correction of flood elevations used for our simulations. (See Table 1. for elevations currently used.)

In August we plan to develop an optimization procedure to find sets of cost curve parameters for multiple storms, add in VR-2 control capabilities, and explore the limitations of ISD control on local and global downstream signals.

### Reporting

We look forward to providing an update of our progress on August 31, 2018.

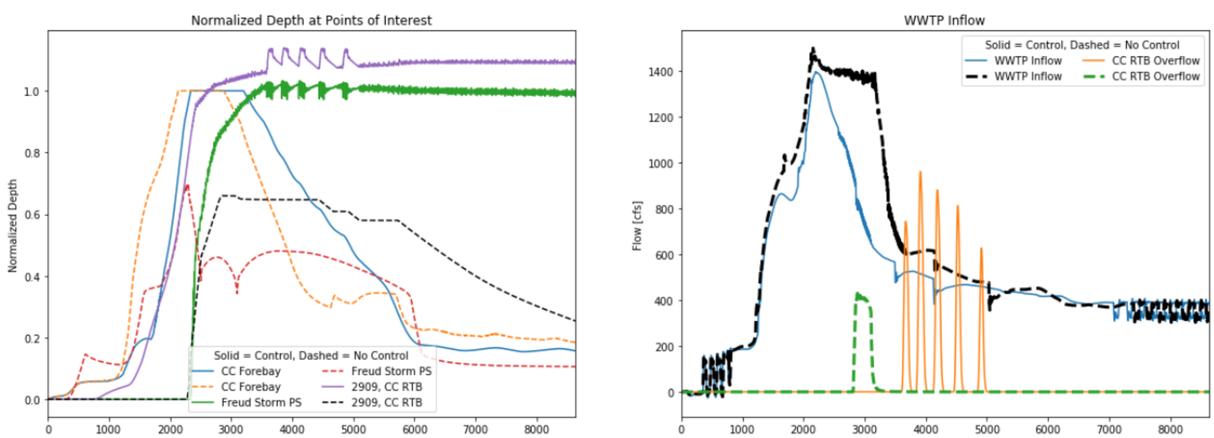


**Figure 1**. Comparison of levels and outflows associated with the Conner Creek – Fairview – Freud complex. The graph on the left compares normalized depths for controlled assets under control and no control scenarios, while the right shows the overflows from the Conner Creek Retention Basin and the WRRF inflow from the DRI. As seen in blue on the right, active control achieves a reduction in the peak inflow to the treatment facility. However, there are some brief overflows from the Conner Creek Retention Basin when the Freud Pump station cycles. Reduction towards the elimination of these surges is an ongoing effort.



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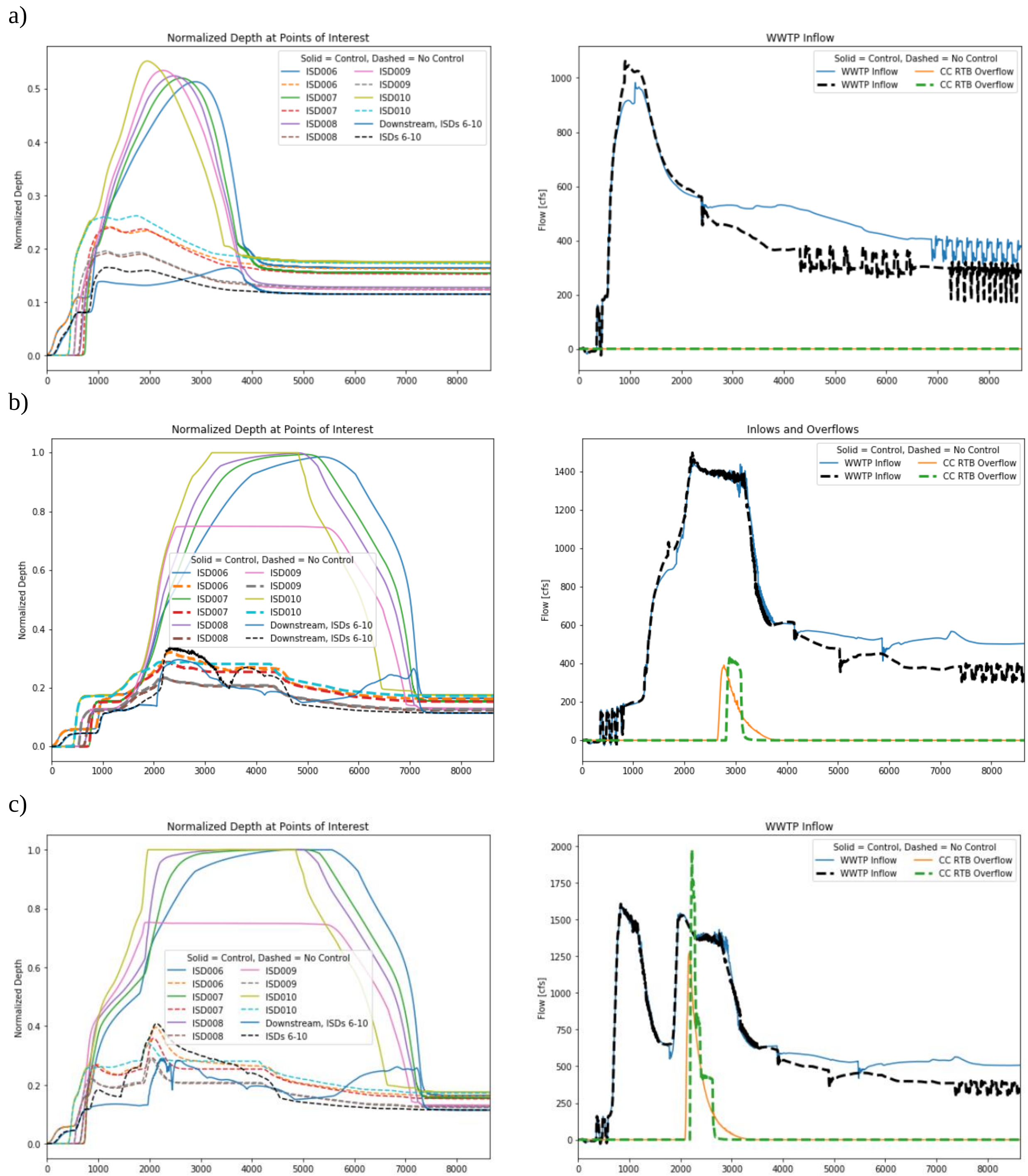


**Figure 2**. Comparison of simulation results of storms with varying rainfall depths. For each simulation, ISDs controlled within a market framework to meet a local downstream objective of maintaining a setpoint of 25% depth of pipe full. Graphs on the left compare control vs. no control depths upstream and downstream of the ISDs, while graphs on the right show the inflow to the WRRF. The precipitation depths for each storm are as follows: a) 0.5", b) 1.0", and c) 1.3". As evident in the timeseries of inflow to the treatment plant, the reduction in inflow due to the control of ISDs varies based on the magnitude of the storm. Smaller storms (a) produce a more pronounced signal, while during larger events (c) the impact of the ISDs is not clearly discernable at the global scale.

open-storm.org


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