SMITHGROUPJJR

April 26, 2017

Paul Muench, Associate Director
University Research Park
510 Charmany Dr., Suite 250
Madison, WI 53719

Re: Science Drive Drainage Study

Dear Paul,

This letter summarizes results of a drainage study completed for areas tributary to Science Drive in the University Research Park 1. The study was completed in response to flooding that occurred on July 21, 2016 when approximately 3.5 inches of rain fell in approximately a 2-hour period damaging two buildings at 525 and 535 Science Drive and flooding adjacent grounds including Science Drive. The purpose of this drainage study was to investigate the capacity of the existing system, identify probable causes of flooding, and recommend potential solutions to minimize the probability of flooding recurring.

The attached slides illustrate the drainage analysis background and findings graphically. Below is a narrative summary.

Existing Conditions

The properties at 525 and 535 Science Drive are influenced directly or indirectly by stormwater runoff from approximately 40 acres. The private drainage system serving the two buildings collects stormwater runoff from an immediate tributary area of approximately 2.2 acres, a portion of which drains easterly to a detention basin located near the east property line, and a portion of which drains westerly, connecting to the Science Drive storm sewer system. The Science Drive system collects stormwater runoff from an area of approximately 19.1 acres, discharging in a westerly direction to a large dry detention basin located west of Science Drive. Private storm sewers range in diameter from 8-inch to 15-inch diameter with the Science Drive system sizes ranging from 18-inch to 36-inch diameter.

Storm sewer sizes and inverts, low entry points such as doorway openings, and Science Drive overtopping elevations were surveyed as part of the study. Survey results indicate that the lowest opening of 525 Science Drive is approximately 993.5 and the lowest opening of 535 Science Drive is 992.6. Both of these elevations are lower than the low point on Science Drive, surveyed at 993.7. This suggests that a primary contributing factor to flooding on July 21, 2016 was the absence of a positive overland flow route. Once the stormwater runoff rate exceeded the capacity of the storm sewer system, water ponded on site, eventually exceeding the doorway elevations and allowing water to enter the buildings.

Hydrologic/Hydraulic Analysis

A computer model of the 40-acre tributary area was created to evaluate the capacity of the regional drainage system using the XP-STORM 2D computer program. XP-STORM is a computer program used for dynamic hydrologic and hydraulic modeling of urban stormwater systems. The model generated and routed hydrographs using NRCS methodology based on subbasin parameters calculated at 47 runoff nodes and using NOAA 14 rainfall depths and rainfall distributions. In addition, the model was run using recorded rainfall data for the July

21, 2016 storm event based on gage data obtained from several nearby "Weather Underground" gages along with the recorded cumulative depth from the nearby Charmany Farms rain gage. Resulting modeled flood depths, timing, and inundation extent were checked by comparison with time-stamped video from security cameras mounted on the 525 Science Drive building.

The hydraulic grade line, flow depths, and other hydraulic parameters were calculated by routing hydrographs generated in the RUNOFF module through 39 pipe sections connected by 47 separate nodes to calculate. Surface stormwater routing and ponding was calculated by the XP-STORM model based on a gridded elevation surface, created from 2016 LiDAR data provided by the City of Madison. The integrated model allowed connection of the underground storm sewer system to the ground surface so that surcharged flows were routed overland.

Modeling results suggest the following:

1. The July 21 storm approximated a 100-year flood. Recurrence is rare but not unprecedented during the life of a typical mortgage.
2. Building door elevations are lower than Science Drive making them vulnerable to flooding if storm sewers fail.
3. Flooding of the buildings occurred due to a combination of limited storm sewer capacity and the absence of a positive overland flow route.
4. Adjacent ponds do not appear to significantly impact flooding at the site.
5. Improvements to both site and regional storm sewers are necessary to provide an acceptable level of protection.

Alternatives Analysis

The following general alternatives for reducing flood risk at the site were identified based on existing conditions modeling:

1. Upsize site storm sewers.
2. Upsize "regional" (i.e., Science Drive) storm sewer sizes/capacities.
3. A hybrid approach involving upsizing of both private and regional storm sewers.
4. Modifying the west and/or east ponds to reduce backwater effects at the site.

Subsequent analyses concluded that modifying the adjacent detention basins had limited impact on site flooding so this alternative was eliminated.

Sketches and results of each of the alternatives evaluated are depicted on the attached slides. In general, the alternatives analysis concluded that:

1. Improvement of site storm sewers alone without improvements to the regional drainage system does not significantly reduce the flood risk at 525 and 535 Science Drive.
2. Improvement of the Science Drive storm sewer system significantly reduces flood depths within the Science Drive right-of-way (assuming inlet capacities are sufficient) but does not substantially reduce the flood risk at 525 and 535 Science Drive.

3. Improvement of the Science Drive drainage system along with private storm sewer improvements can reduce flood depths for the 100-year (i.e., 1% probability) storm event by as much as 1.5 feet substantially increasing the level of protection at the site.

Exhibit 1 shows storm sewer sizes, depths and routing at a schematic level for consideration in designing proposed improvements.

Recommendations

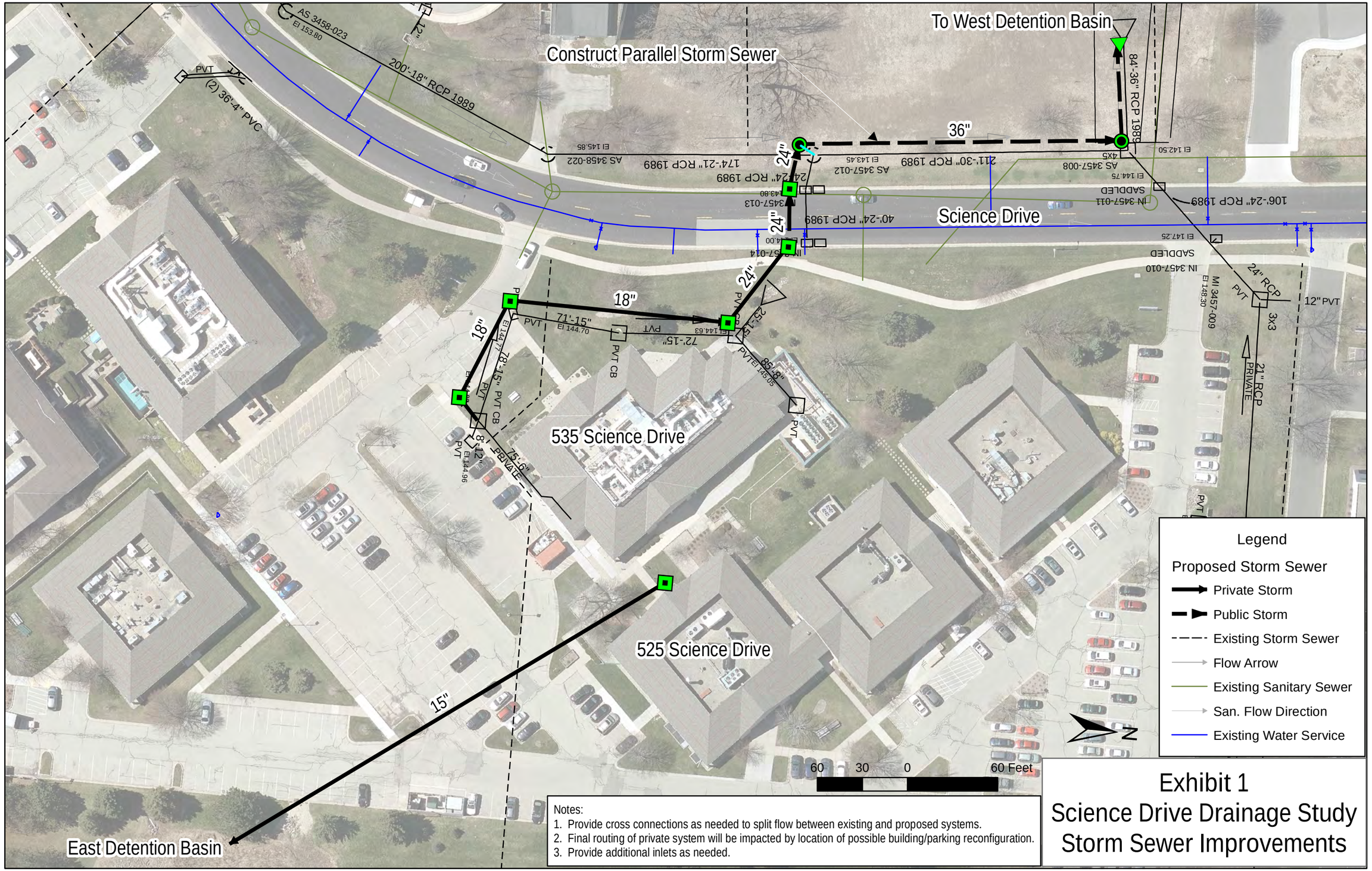
1. Explore replacement and improvement of the site storm sewer system in conjunction with future building expansion at 535 Science Drive.
2. Explore partnering with the City of Madison for construction of Science Drive system improvements using funds for flood relief arising from the July 21 storm event in the 2017 budget.

The attached slides provide additional background information, including precedence images of some constructed stormwater management features. We look forward to continuing to assist you as this process moves forward. Please call if you have any questions or comments.

Sincerely,

David Wolmutt, P.E.
Project Manager

Attachment



Notes:
1. Provide cross connections as needed to split flow between existing and proposed systems.
2. Final routing of private system will be impacted by location of possible building/parking reconfiguration.
3. Provide additional inlets as needed.

Exhibit 1
Science Drive Drainage Study
Storm Sewer Improvements

University Research Park
Drainage Study
525 & 535 Science Drive

December 12, 2016

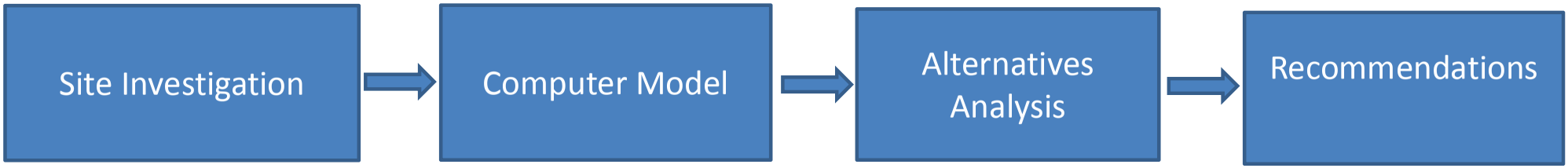
UNIVERSITY RESEARCH PARK
UNIVERSITY OF WISCONSIN-MADISON

SMITHGROUPJJR

Issues Explored

- Likelihood of the July 21, 2016 storm event recurrence.
- Adequacy of the regional drainage system.
- Adequacy of the site drainage system.
- Does the “West Pond” impact flows from the site and Science Drive?
- What is necessary to fix the system to an acceptable level of protection?

Process



- Site Visit
- Acquisition of City Records
- Acquisition/Review of Rainfall Data
- Review of Construction Drawings
- Field Survey

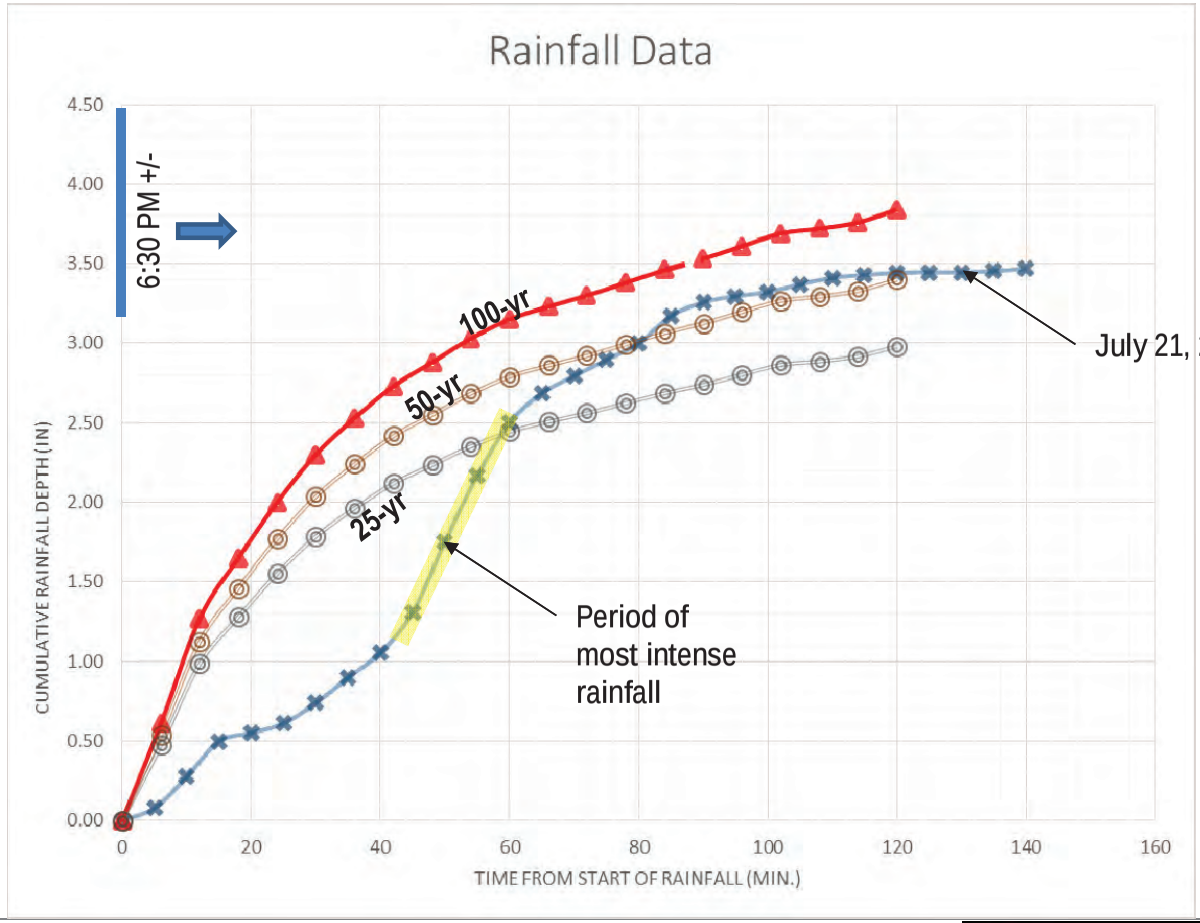
- Delineate Drainage Basins/Calculate Parameters
- Create "XP-SWMM" Computer Model to estimate flows/depths
- Compare to July 21, 2016 Storm Videos and adjust parameters

- Impact of "Regional" Improvements only
- Impact of "Site" Improvements only
- Impact of detention basin/channel improvements.
- "Hybrid" Solutions

- Level of Protection
- Cost-Effectiveness
- Impact on future development/redevelopment
- Acceptability to tenants/City of Madison

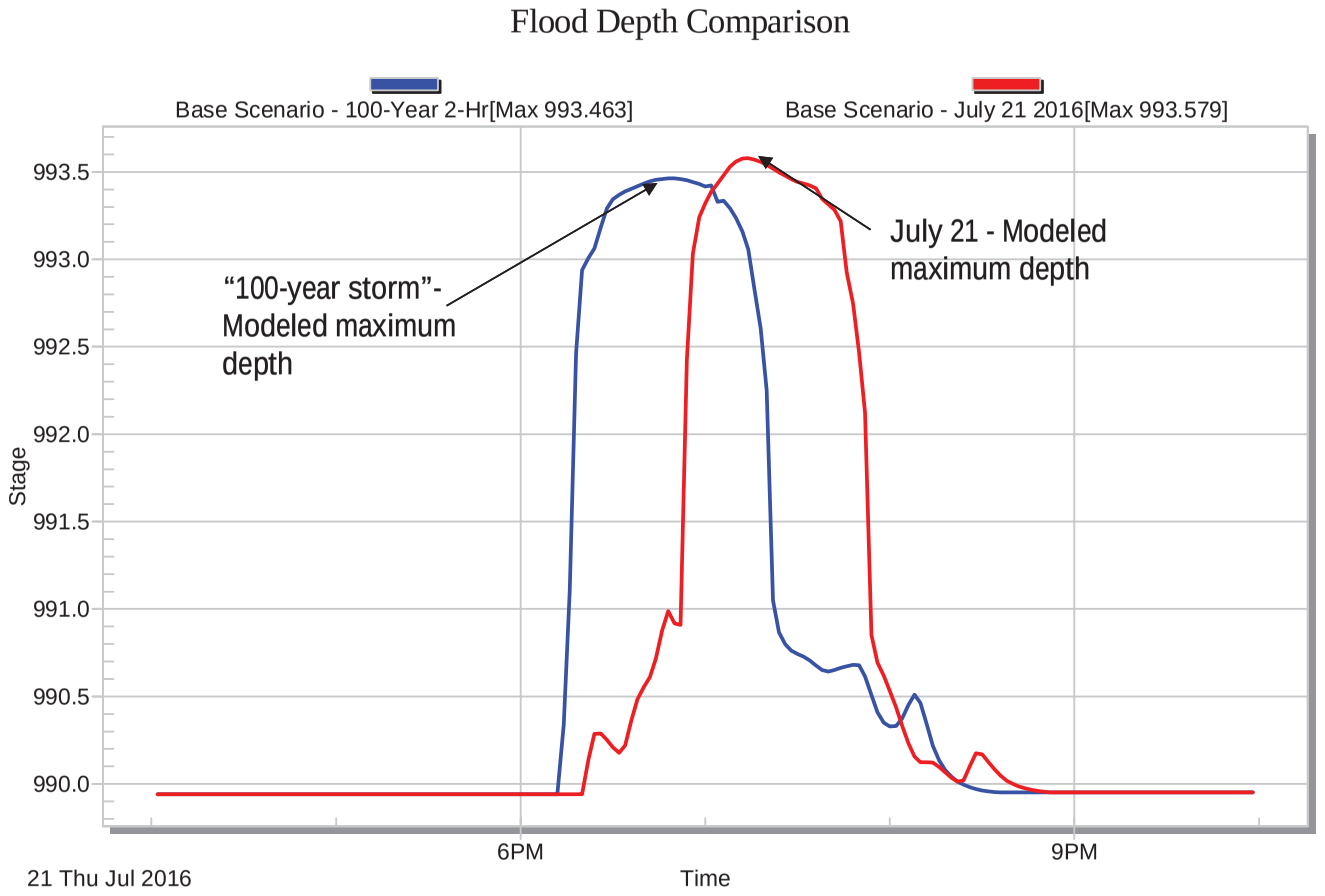
July 21, 2016 Rainfall Analysis

- Approximately 3.5 inches in 140 minutes.
- July 21 storm depth was less than the 100-year storm
- There were periods in which of "100-year" rainfall intensity was exceeded.
- Rainfall intensity exceeding standard storm sewer design capacity was one cause of flooding.



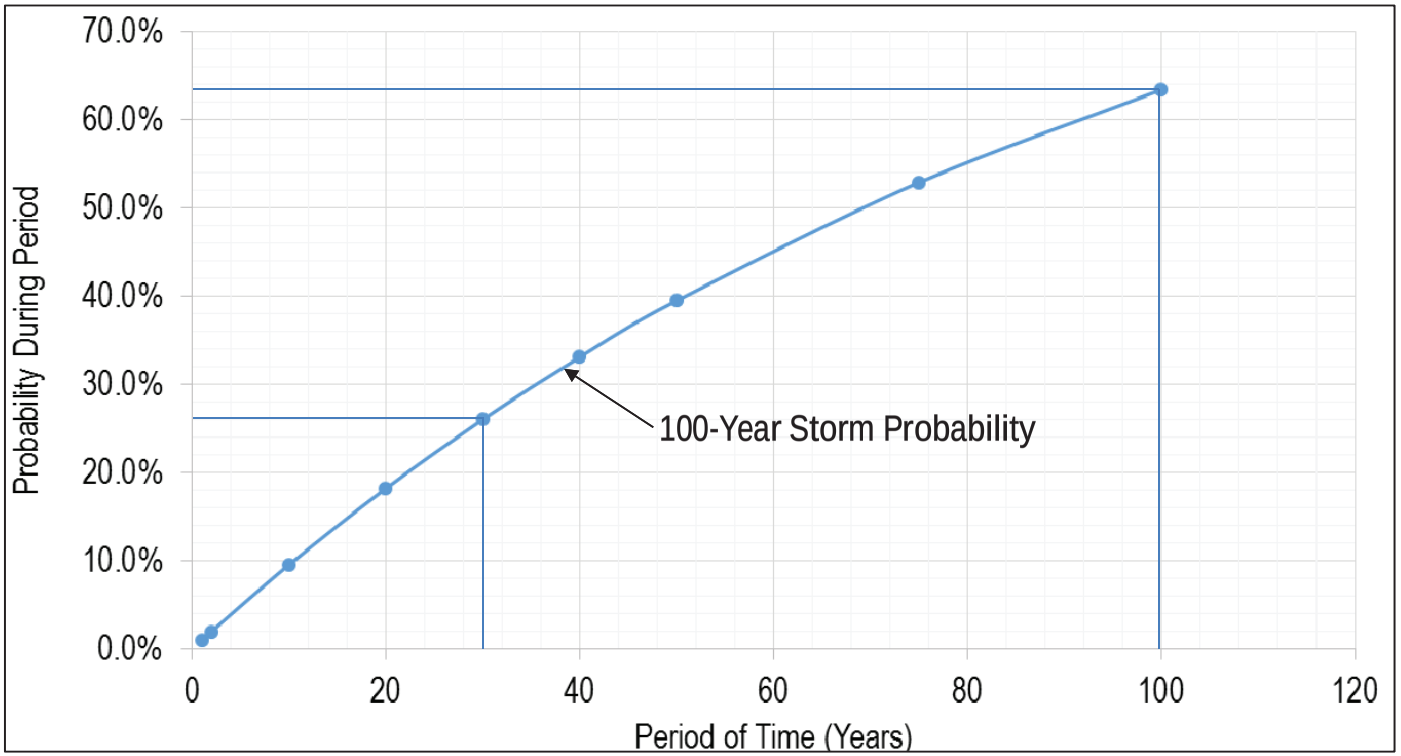
UNIVERSITY RESEARCH PARK
UNIVERSITY OF WISCONSIN–MADISON

July 21, 2016 Flood Versus 100-Year Flood



- The July 21 flood depth was slightly greater than predicted 100-year storm depth.

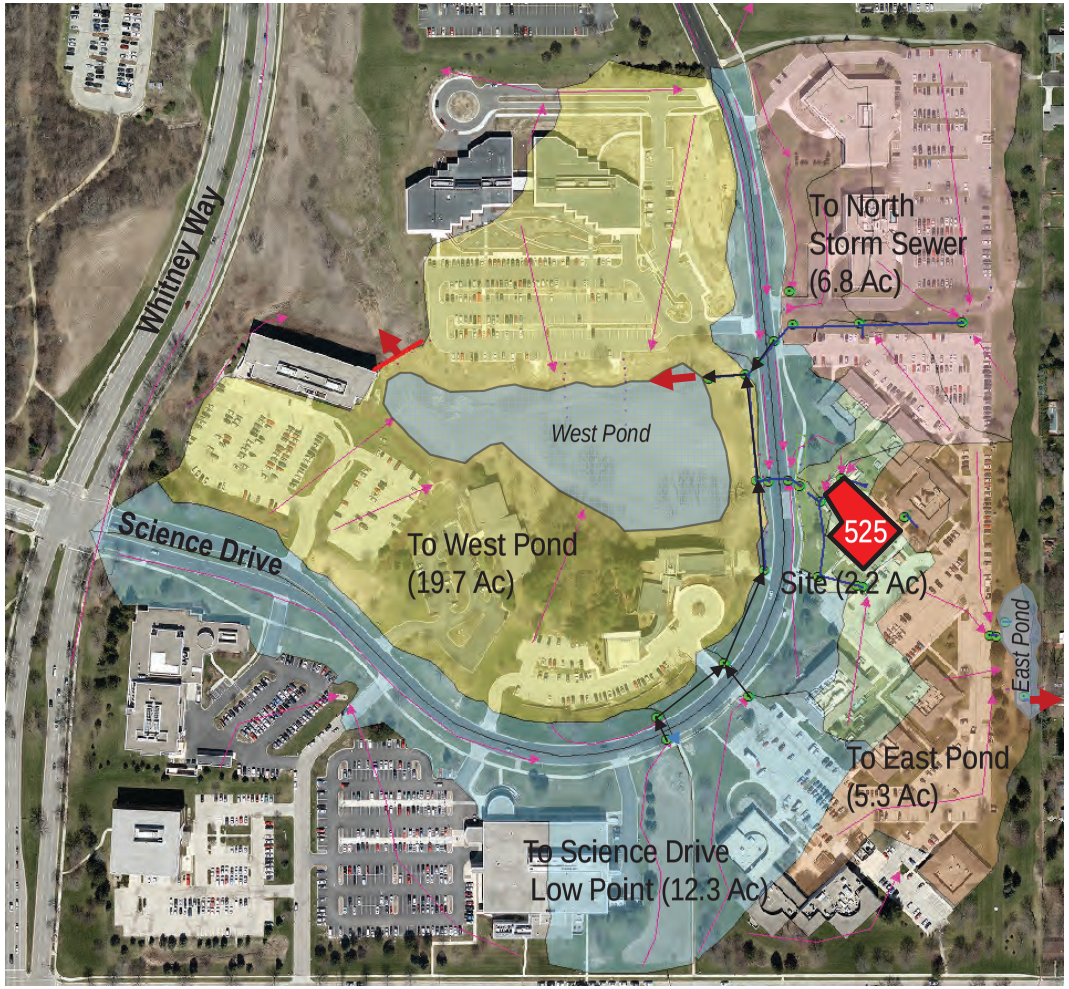
Will it Happen Again?



100-Year Storm Probability Over Various Periods

Regional Drainage

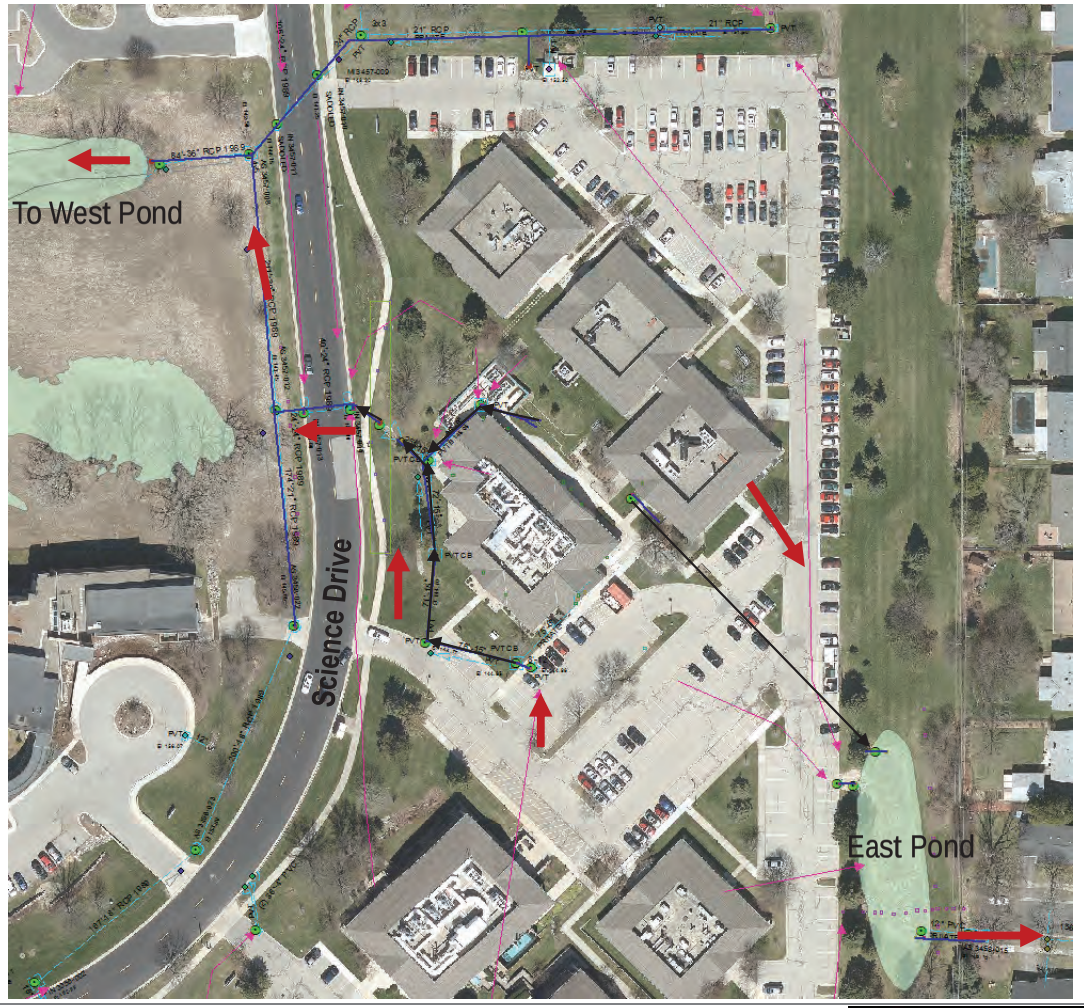
- Site influenced by Science Drive Drainage System (Owned by City, and 2 Detention Basins)
- Site system drains 2.2 acres
- Indirect impacts from over 40 additional acres.



UNIVERSITY RESEARCH PARK
UNIVERSITY OF WISCONSIN–MADISON

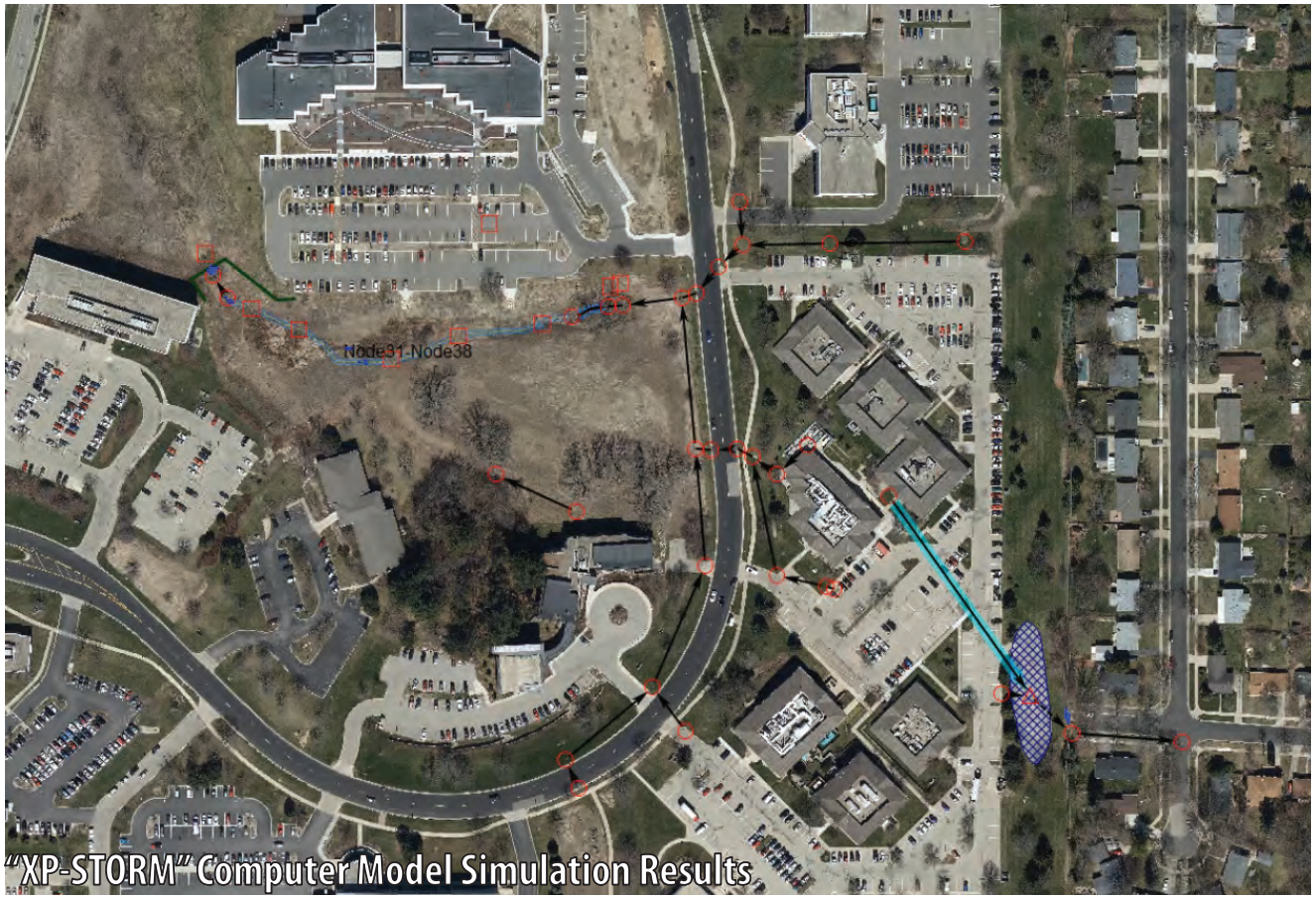
Site Drainage System

- Site system drains 2.2 acres
- Flow split – partially to West Pond via Science Drive system, partially to Manor Cross via East Pond.
- Drainage completely reliant on capacity of inlets and storm sewers (no surface overflow).
- Critical Elevations –
  - Science Drive low point = 993.7
  - 1st Floor Stratatech = 993.5
  - 1st Floor CDI = 992.6
- **No surface overflow for excess storm flows!**



UNIVERSITY RESEARCH PARK
UNIVERSITY OF WISCONSIN–MADISON

Analysis of July 21, 2016 Storm

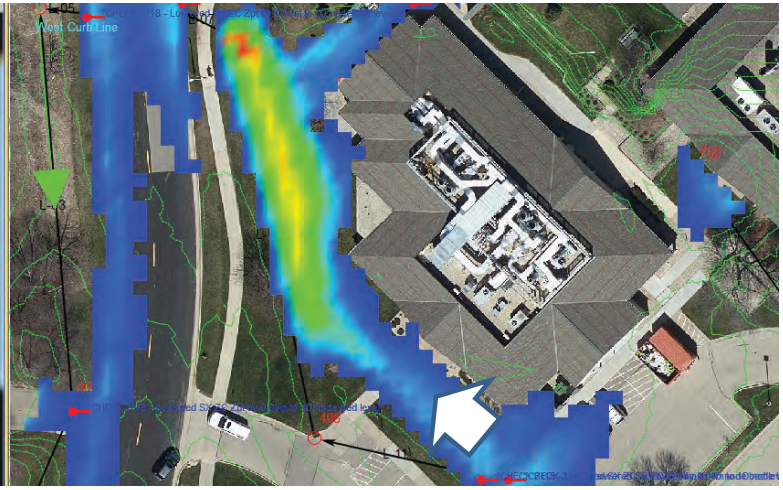


"XP-STORM" Computer Model Simulation Results

UNIVERSITY RESEARCH PARK
UNIVERSITY OF WISCONSIN–MADISON

Model Validation - July 21, 2016 Storm

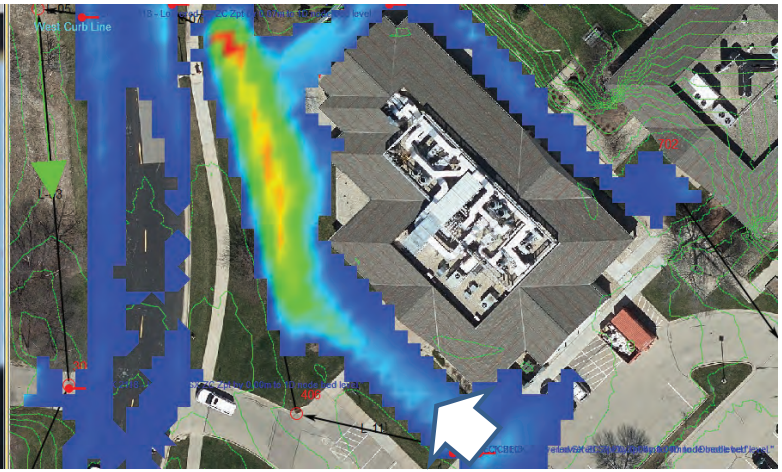
Looking northwest toward Science Drive along southwest side of building



Computer simulation – 7:05 PM

Model Validation - July 21, 2016 Storm

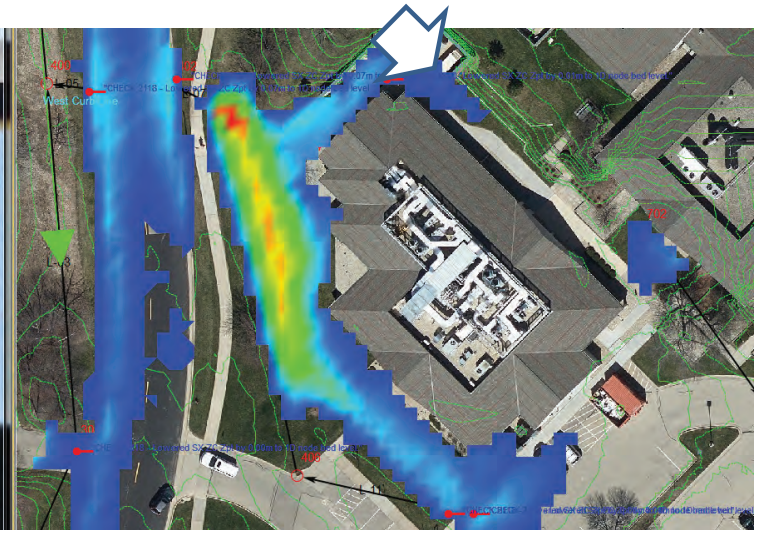
Looking northwest toward Science Drive along southwest side of building



Computer simulation – 7:24 PM

Model Validation - July 21, 2016 Storm

Looking southeast along northeast side of building

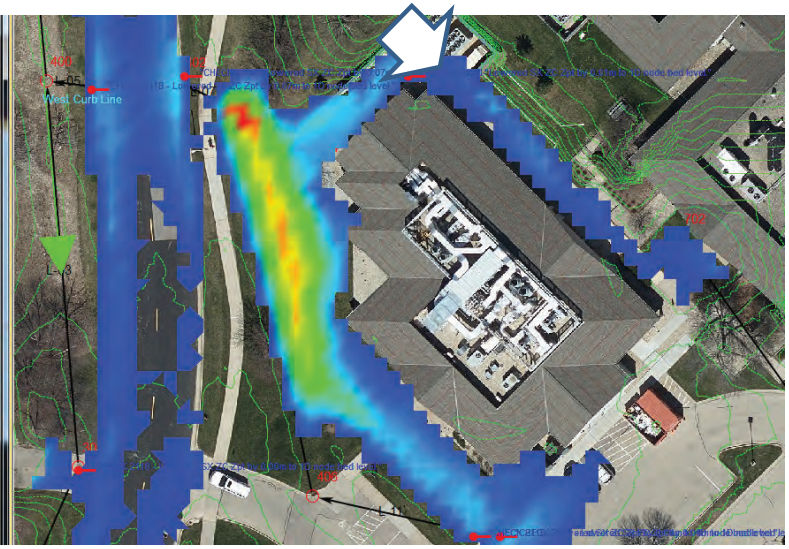


Computer simulation – 7:10 PM

UNIVERSITY RESEARCH PARK
UNIVERSITY OF WISCONSIN–MADISON

Model Validation - July 21, 2016 Storm

Looking southeast along northeast side of building



Computer simulation – 7:22 PM

Alternatives Analysis

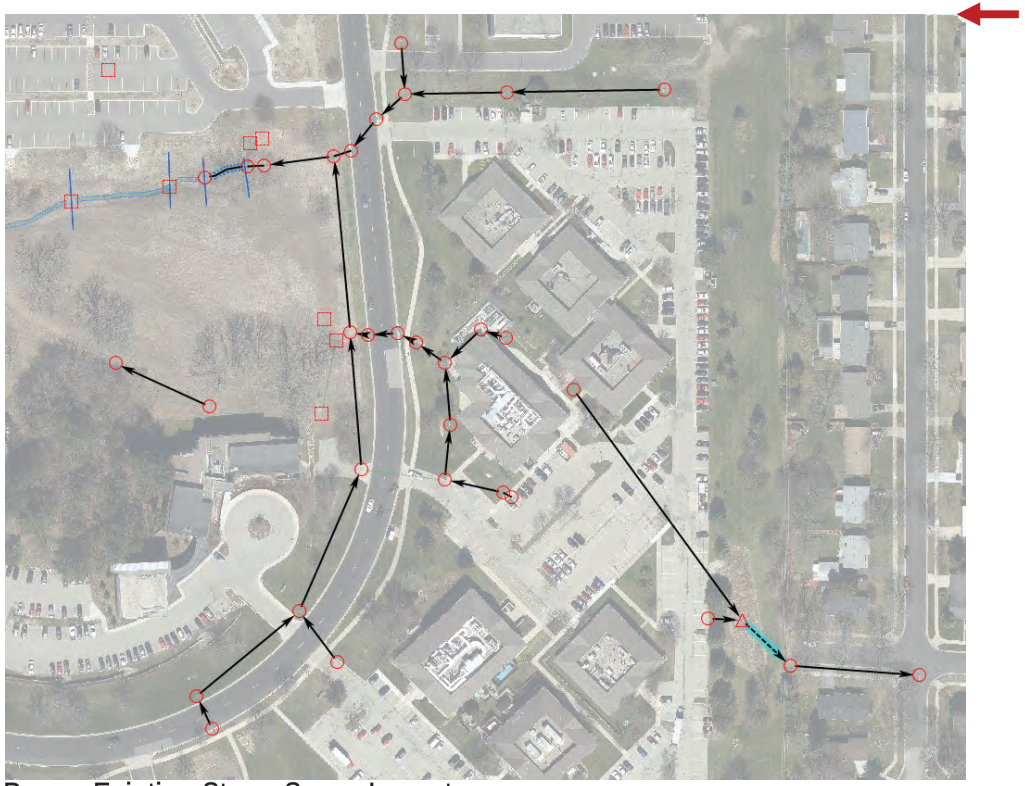
1. Upsize Site Storm Sewers

2. Upsize “Regional” Storm Sewer Sizes/Capacities

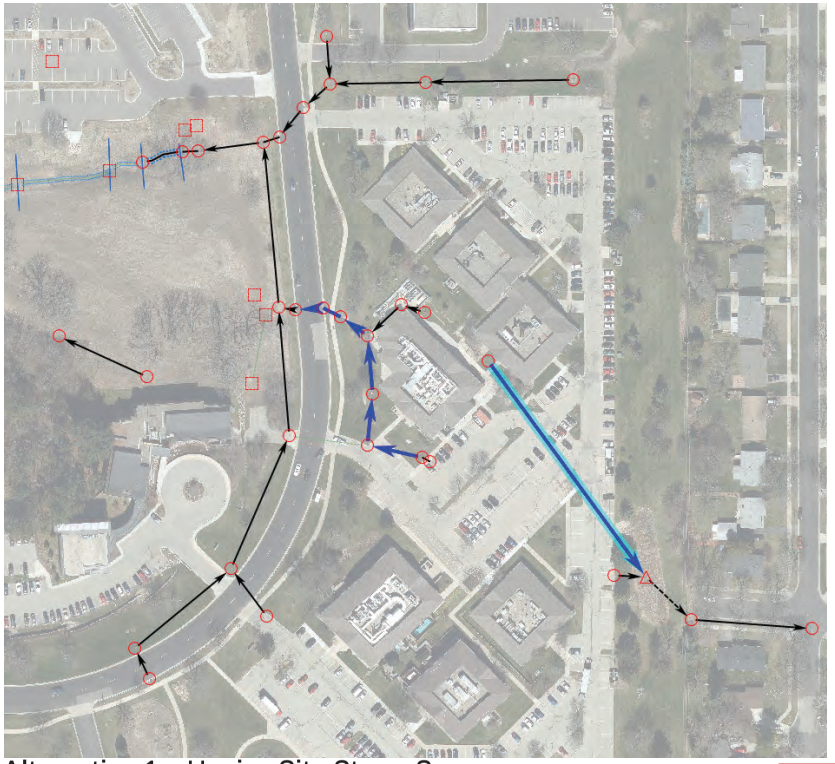
3. “Hybrid” Approach

4. Other analyses
   - West Pond improvements
   - East Pond improvements

Alternative 1 – Site Drainage Improvements Only

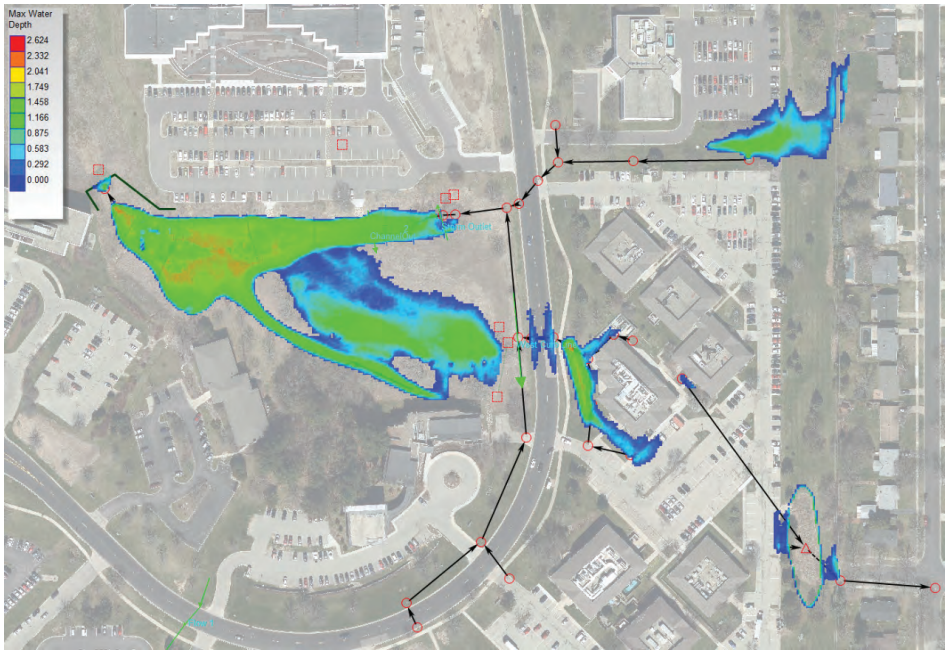


Base – Existing Storm Sewer Layout

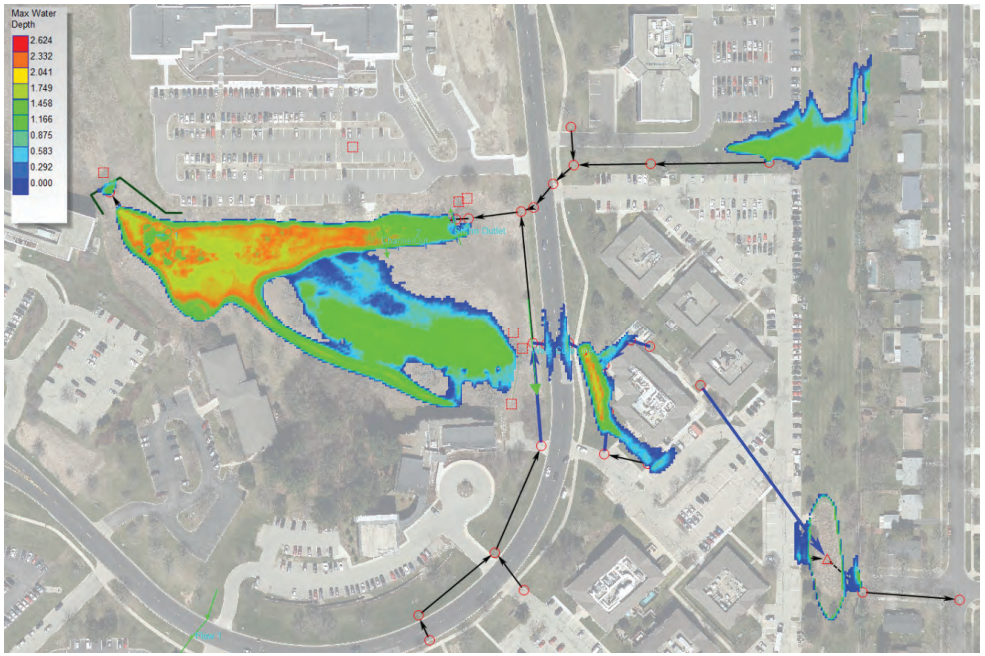


Alternative 1 – Upsize Site Storm Sewers

Alternative 1 Results (100-Year, 2-hour Duration Storm Event)



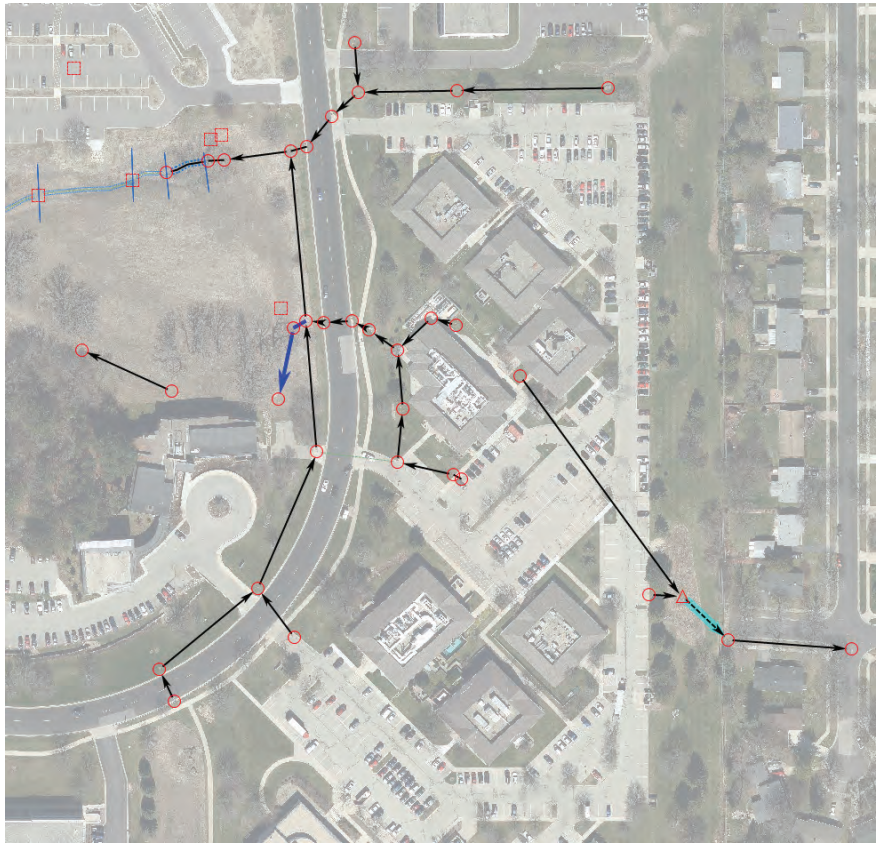
Base – Existing Storm Sewer Layout



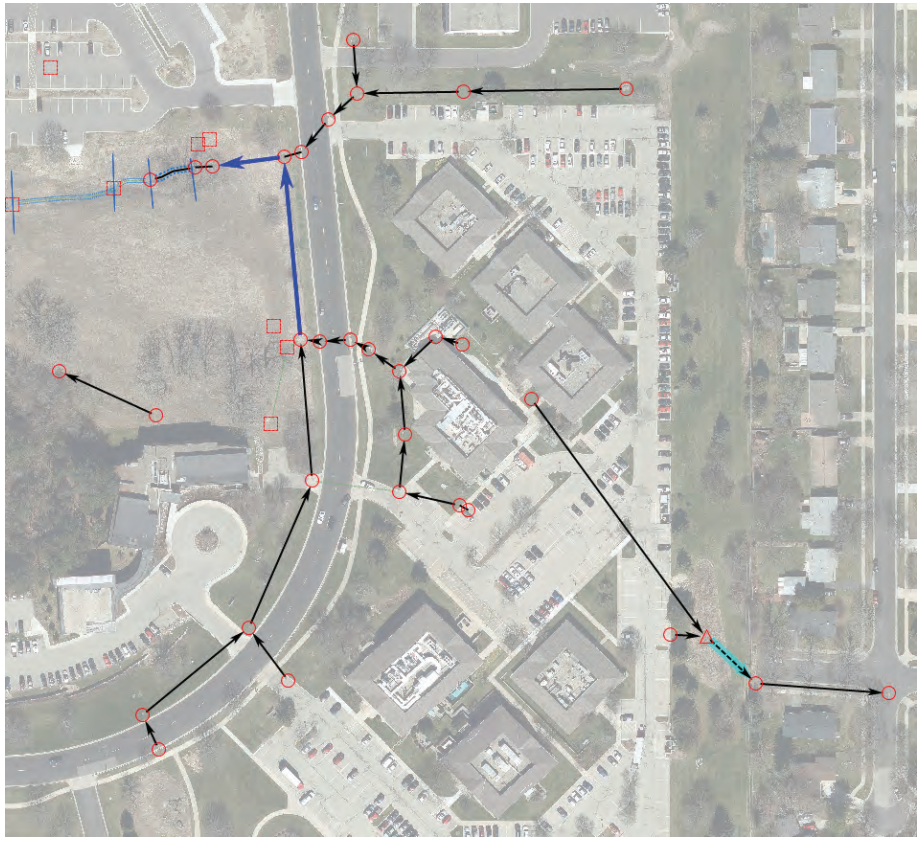
Alternative 1 – Upsize Site Drainage System

CONCLUSION: SITE DRAINAGE SYSTEM IMPROVEMENTS ALONE DO NOT SUBSTANTIALLY REDUCE FLOOD RISK.

Alternative 2 – Regional Drainage Improvements Only

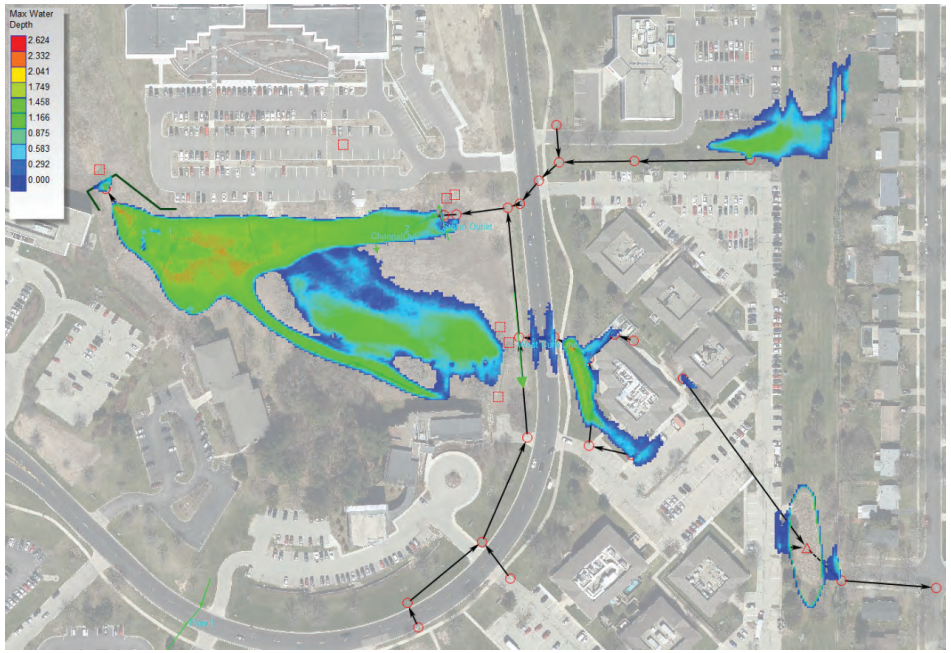


2A – Relief Culvert and Grading

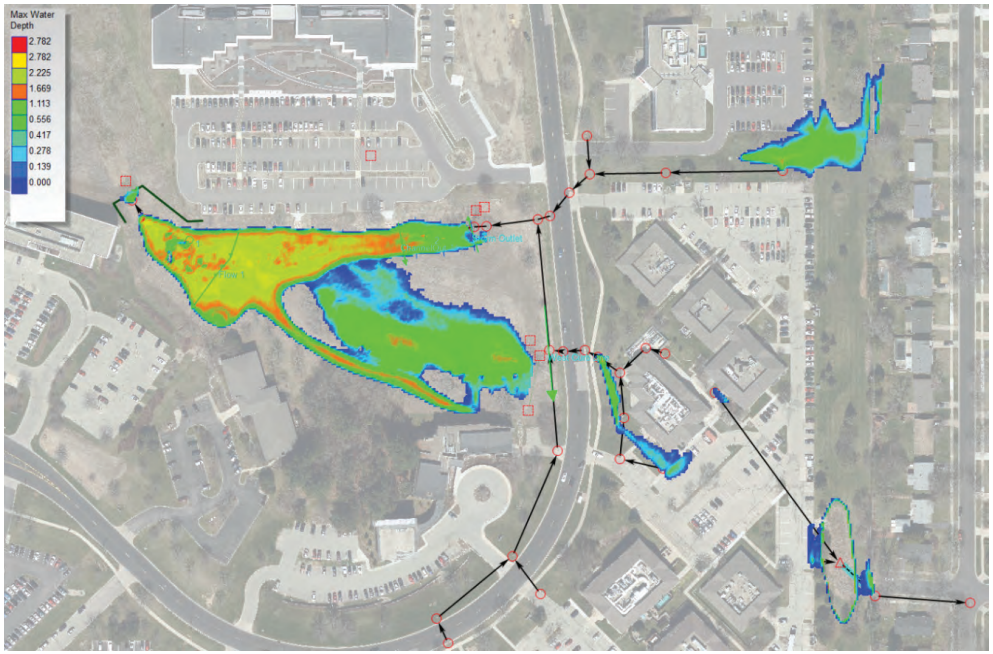


2B – Parallel Pipes and Structure Improvements

Alternative 2A Results (100-Year, 2-hour Duration Storm Event)



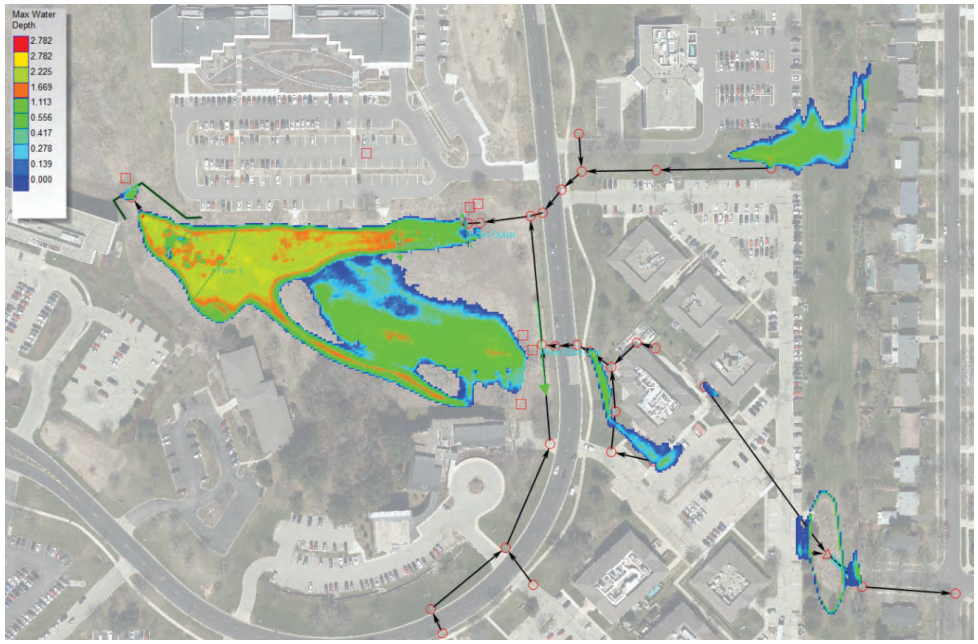
Base – Existing Storm Sewer Layout



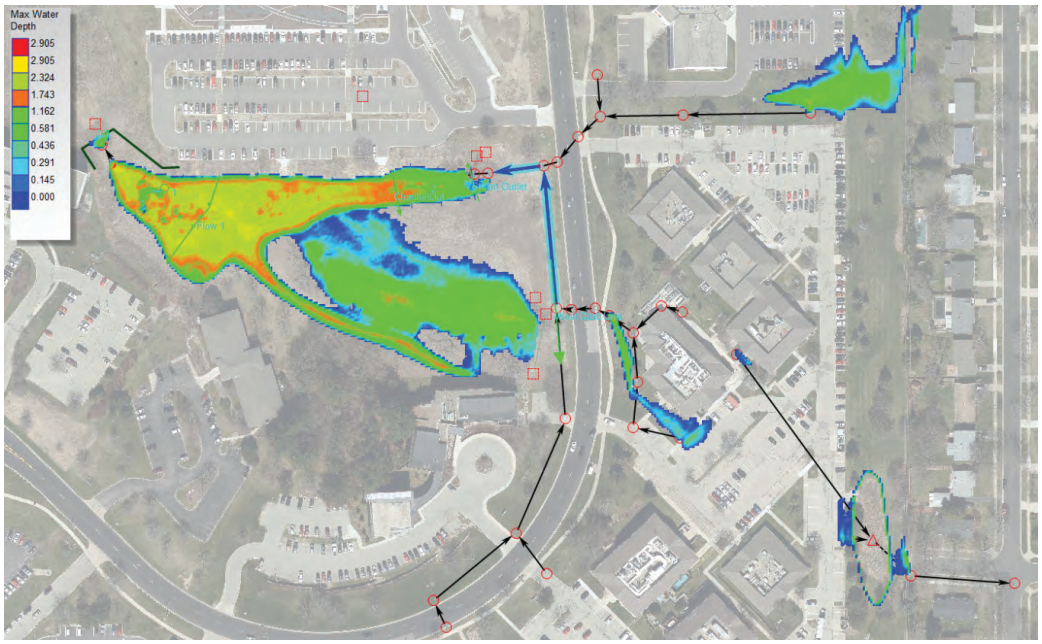
Alternative 2A – Relieve Culvert and Grading

CONCLUSION: SUBSTANTIAL IMPROVEMENT BUT LIMITED SAFETY FACTOR. NO IMPROVEMENT TO NE BUILDING FLOODING.

Alternative 2 Results (100-Year, 2-hour Duration Storm Event)



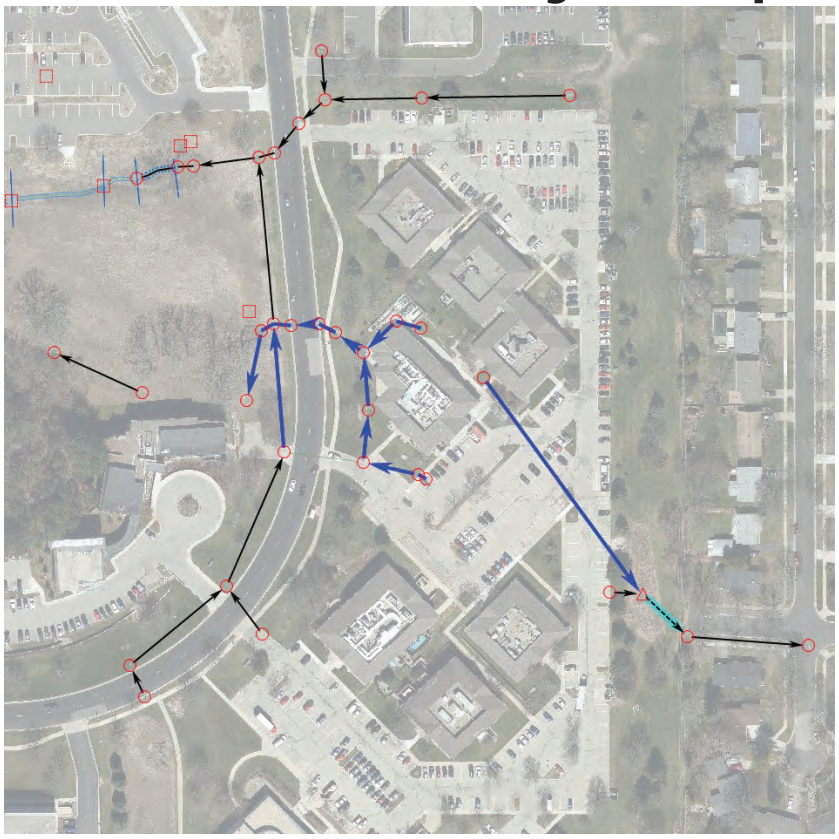
Base – Existing Storm Sewer Layout



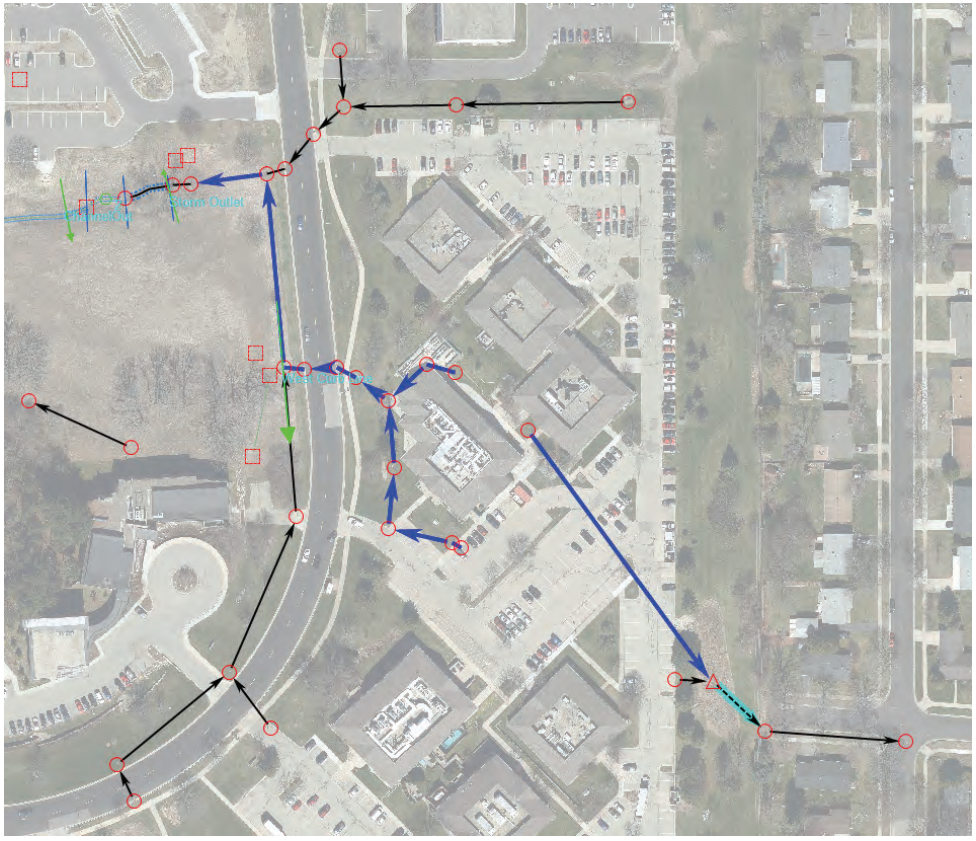
Alternative 2B – Parallel Relief Pipes

CONCLUSION: SIMILAR IMPROVEMENT TO ALTERNATIVE 2A

Alternative 3 – Site + Regional Improvements

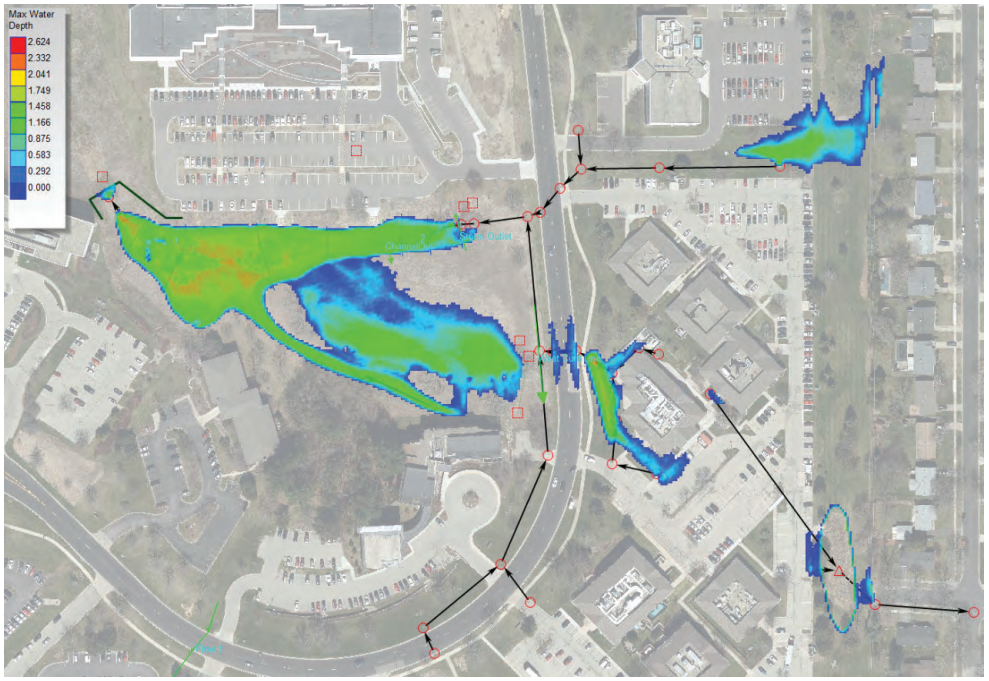


Alternative 3A – Upsize Science Drive Storm Sewer Capacity + Site System

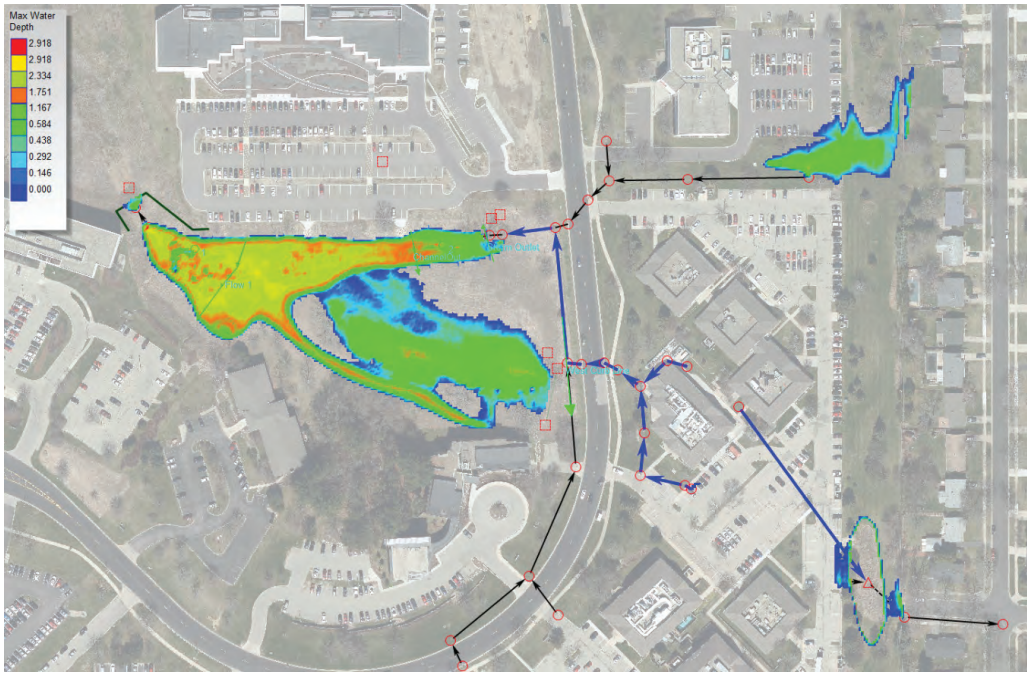


Alternative 3B – Upsize Science Drive Storm Sewer Capacity + Site System

Alternative 3 Results



Base – Existing Storm Sewer Layout

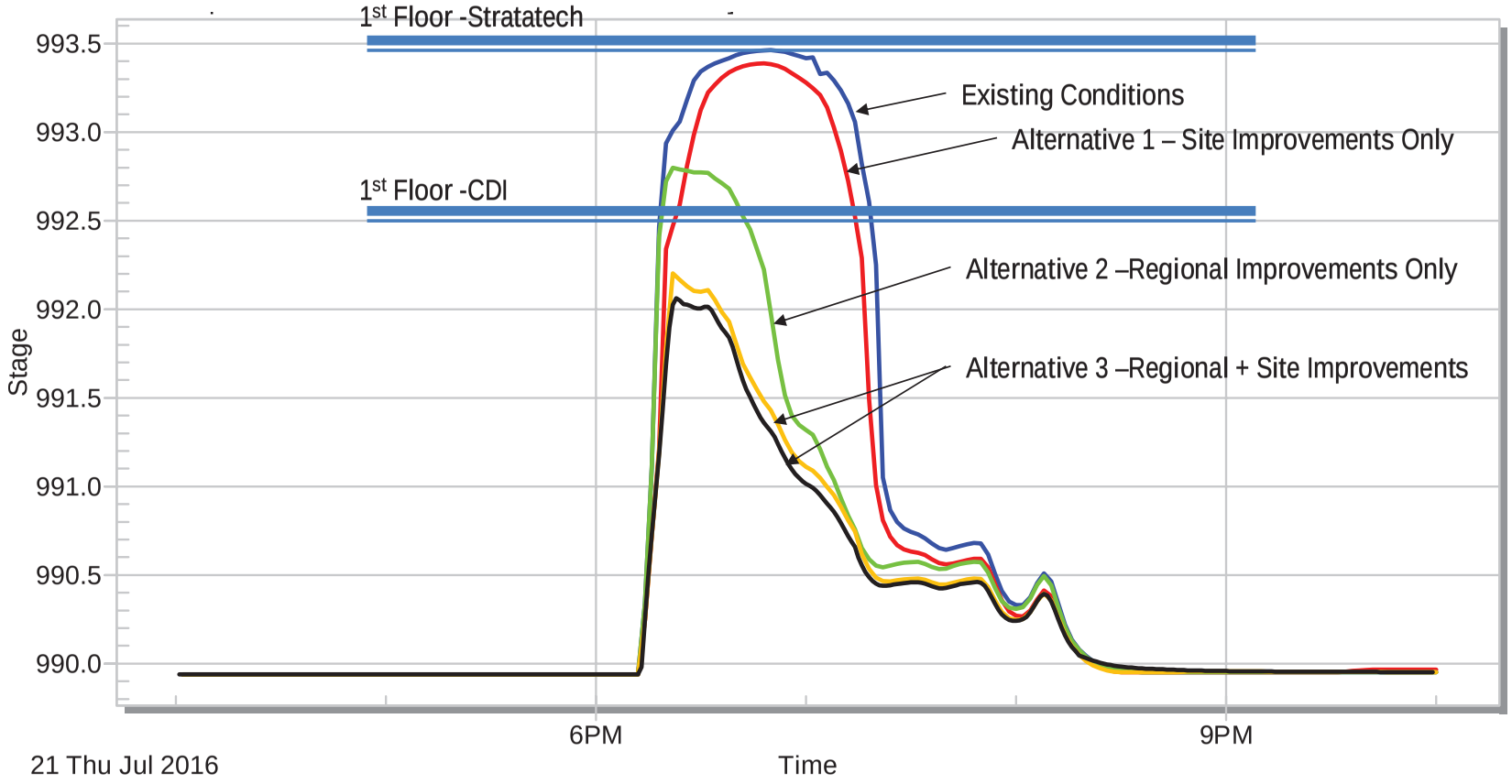


Alternative 3 – Site + Regional Improvements

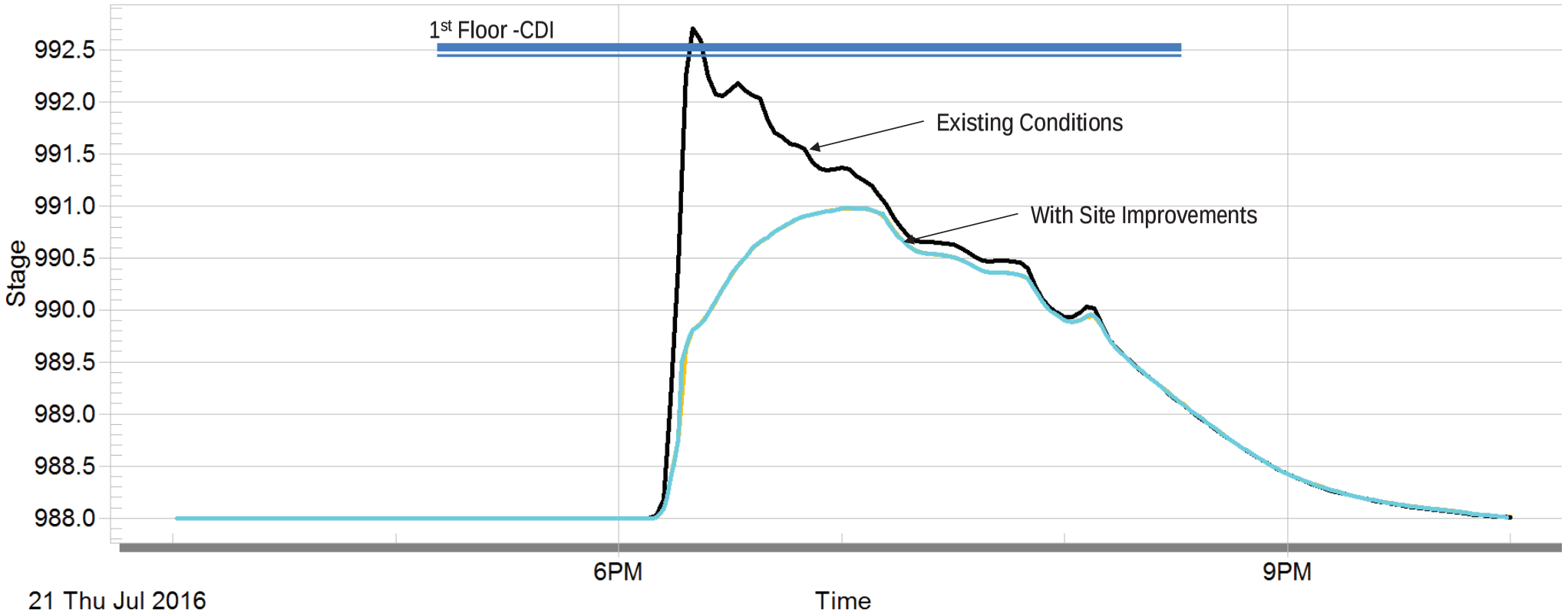
CONCLUSION: SUBSTANTIAL IMPROVEMENTS SEEN

UNIVERSITY RESEARCH PARK
UNIVERSITY OF WISCONSIN–MADISON

Alternatives Results



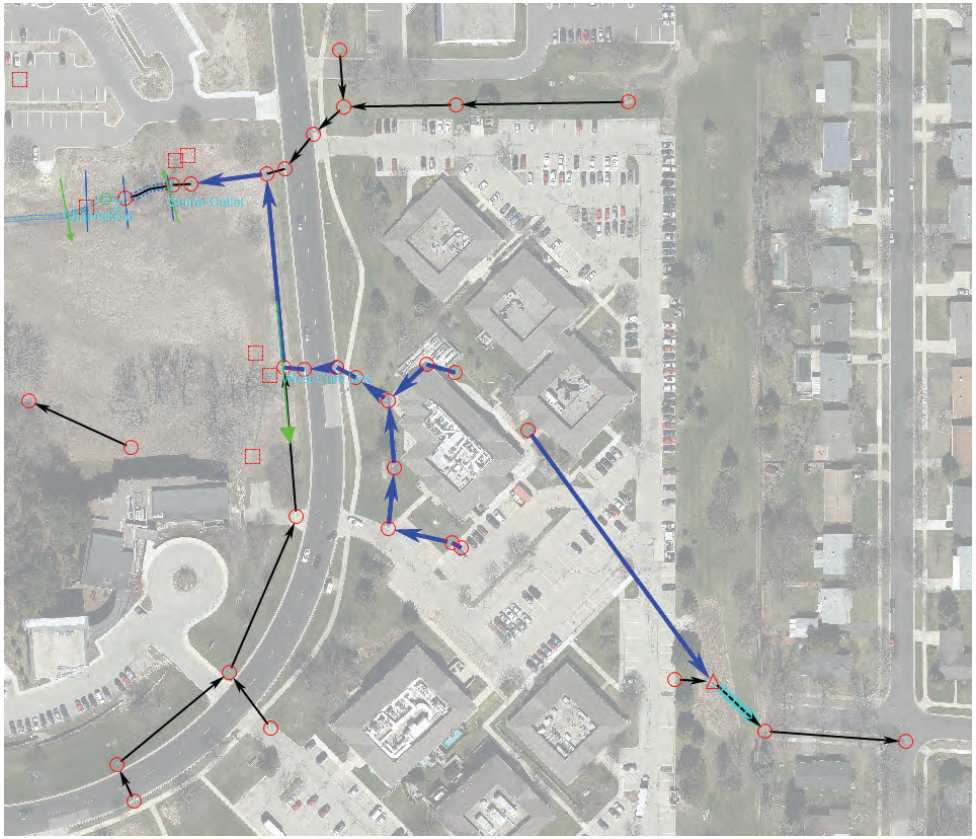
Alternatives – CDI Building



UNIVERSITY RESEARCH PARK
UNIVERSITY OF WISCONSIN–MADISON

Conclusions/Recommendations

- The July 21 storm approximated a 100-year flood. Recurrence is rare but not unprecedented during the life of a typical mortgage.
- Building door elevations are lower than Science Drive making them vulnerable to flooding if storm sewers fail.
- Adjacent ponds do not appear to significantly impact flooding at the site.
- Improvements to both site and regional storm sewers are necessary to provide and acceptable level of protection.



UNIVERSITY RESEARCH PARK
UNIVERSITY OF WISCONSIN–MADISON