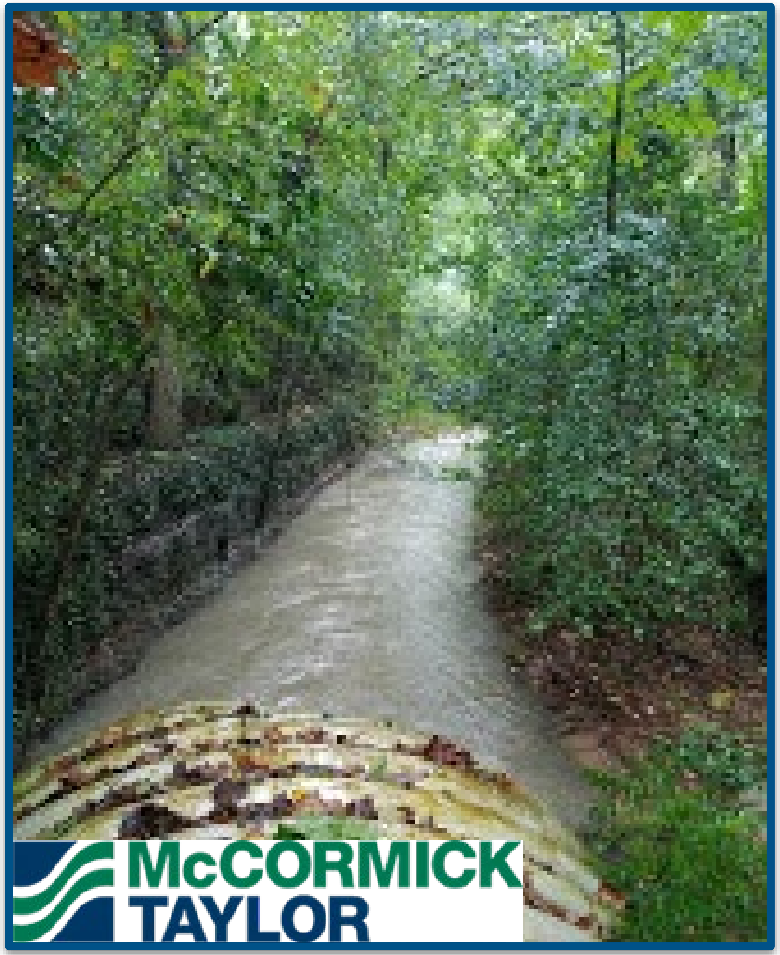
Restoring Predevelopment Hydrology with Smart Stormwater Controls in Aiken, South Carolina

Jason Hetrick, P.E., CFM, McCormick Taylor
Dayton Marchese, PE, Opti



Project Location

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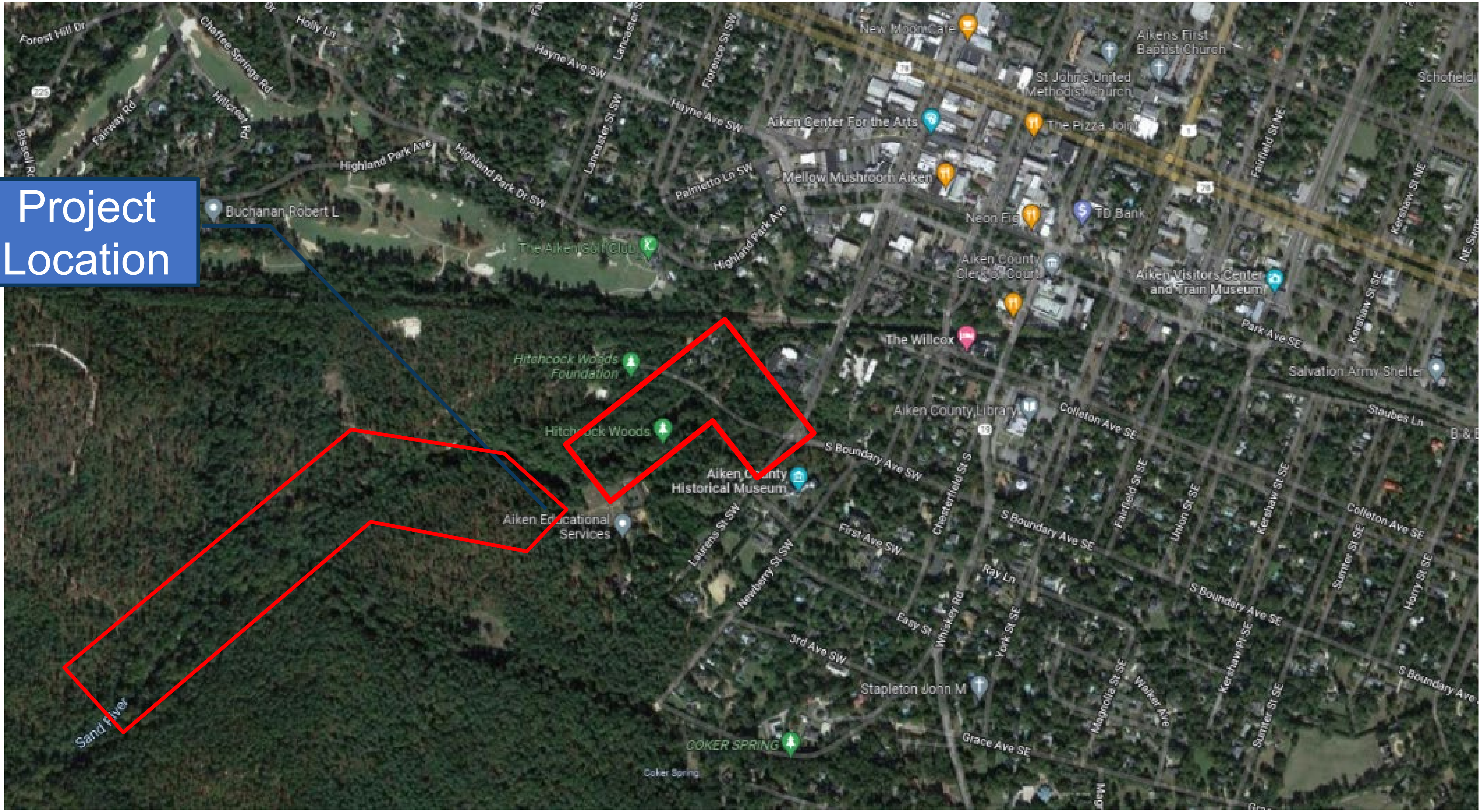
Project Location

Project Location



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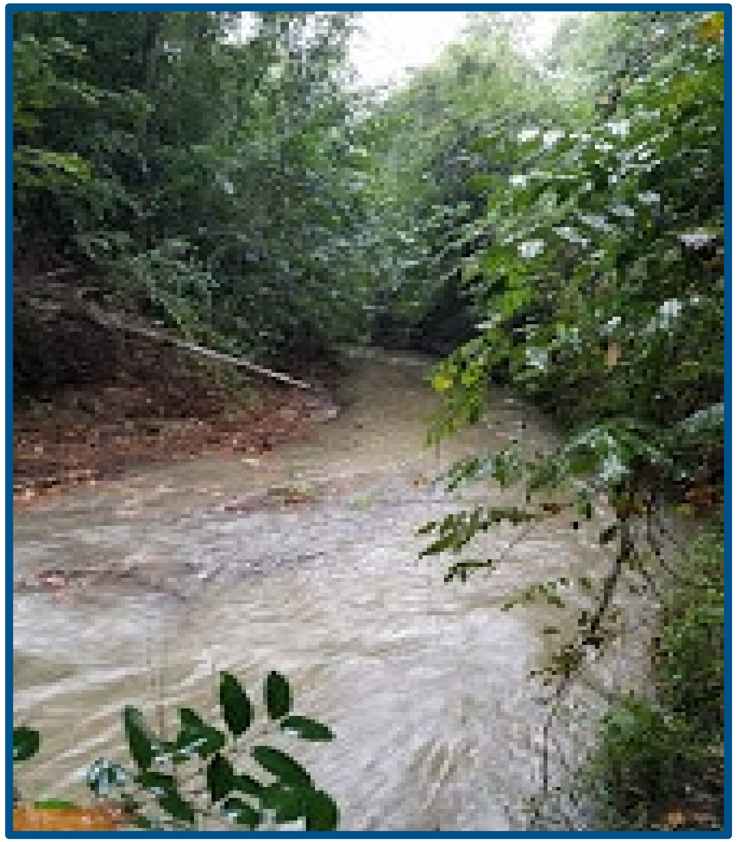
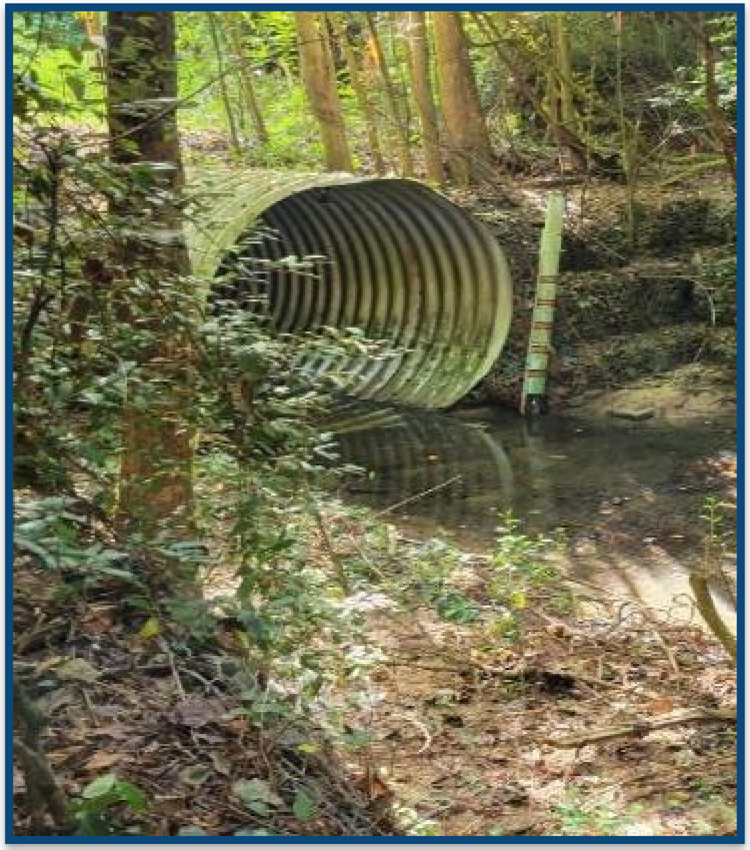
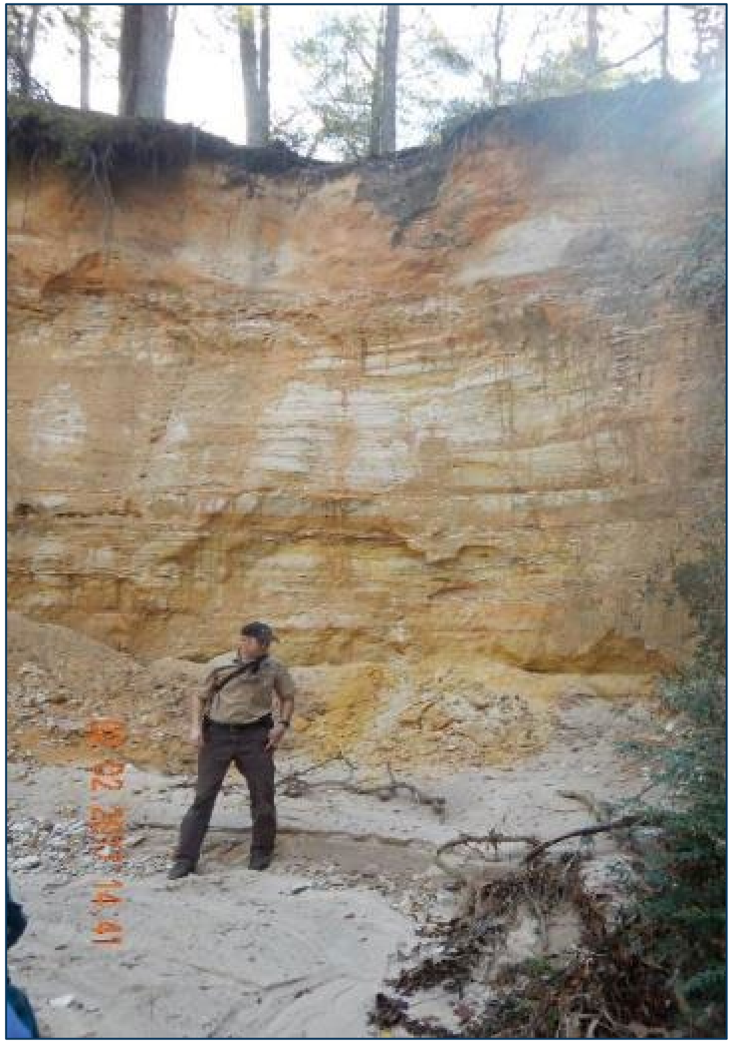
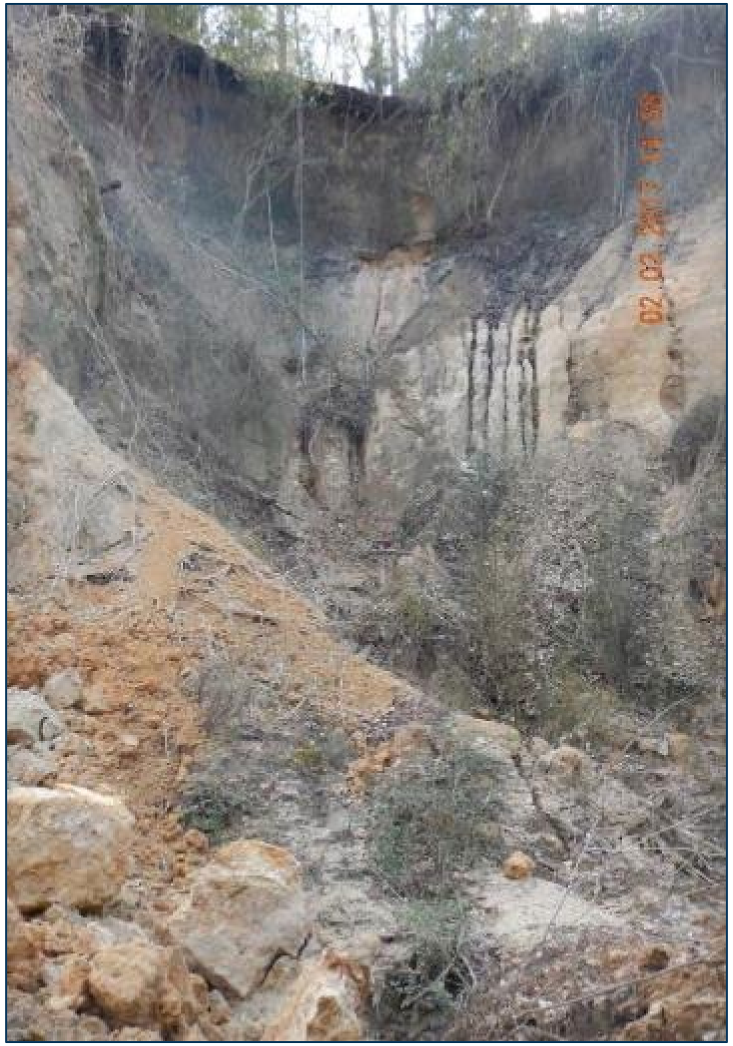
Point of Discharge





Erosion within the Sand River





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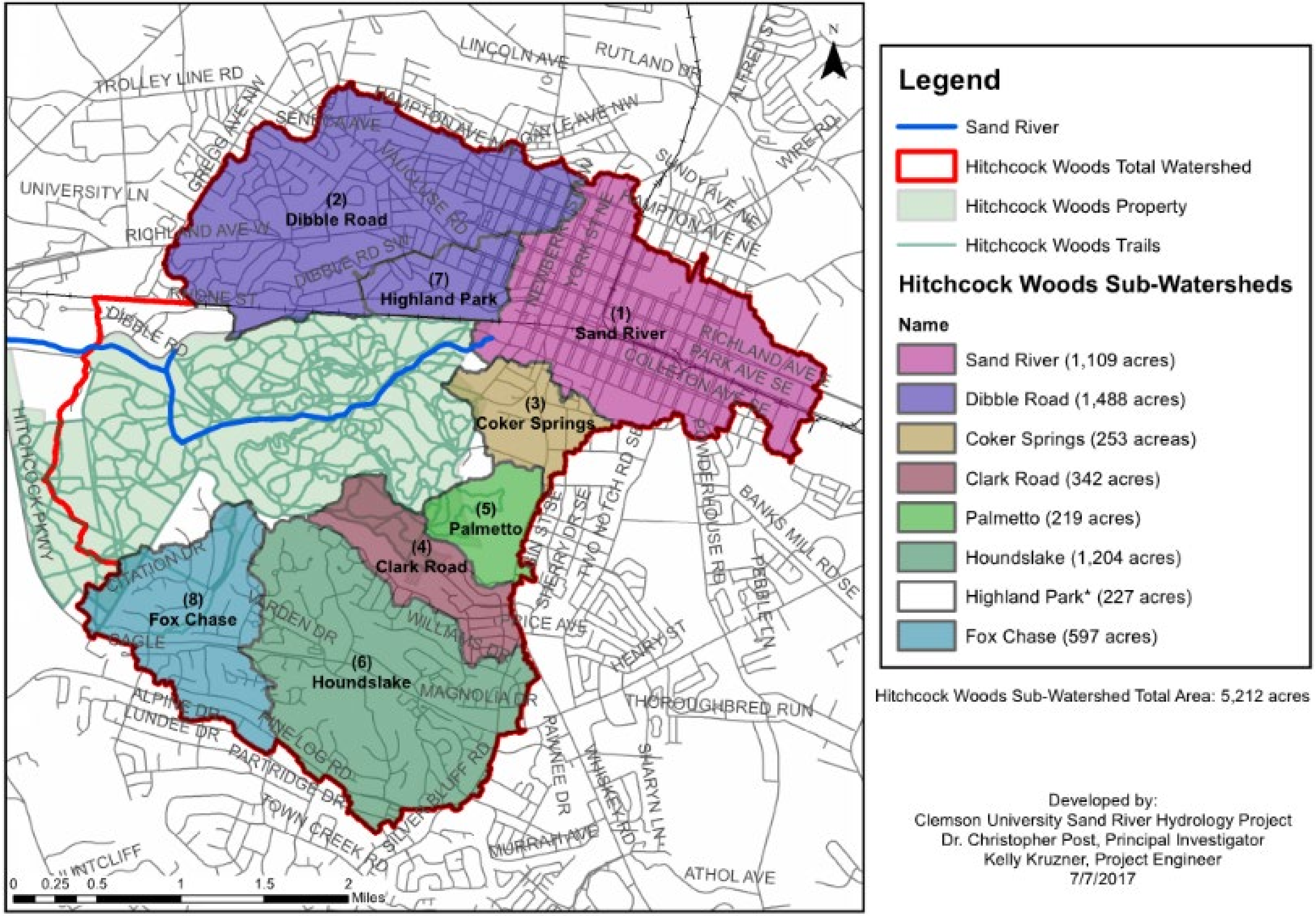
Hitchcock Woods Watersheds



Hitchcock Woods Sub-Watershed Total Area: 5,212 acres

Developed by:
Clemson University Sand River Hydrology Project
Dr. Christopher Post, Principal Investigator
Kelly Kruzner, Project Engineer
7/7/2017

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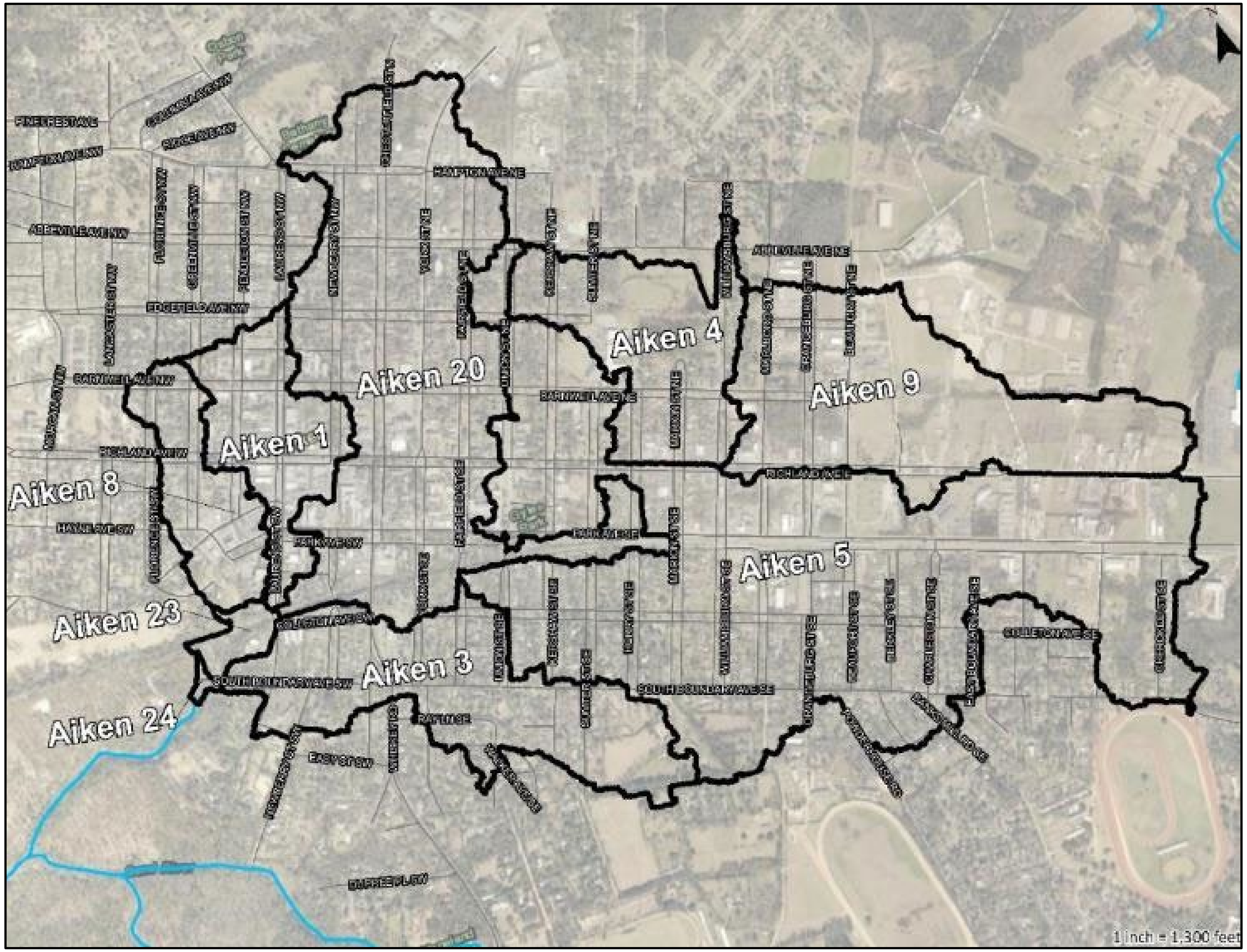
Subwatersheds



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Sand River Watershed Ownership of Impervious

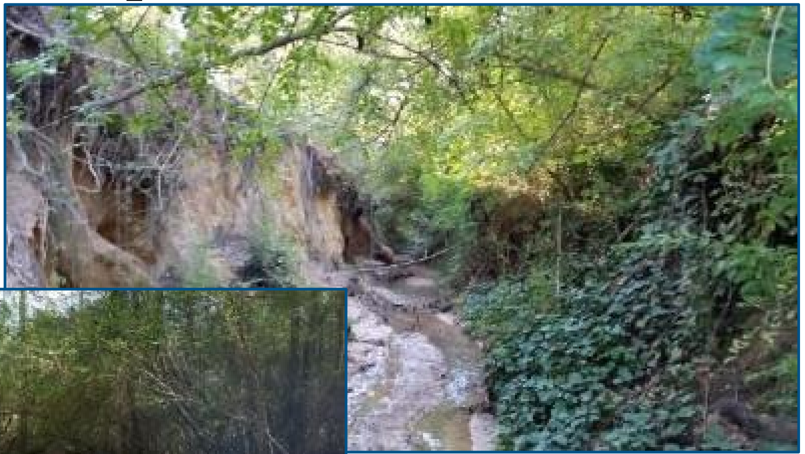
- Total area within project focus area: **1,217.5** acres
- Impervious area: **349** acres
- Percent of total area covered by impervious surfaces: **28.66%**

Research indicates that this percentage of impervious area results in a stream that is no longer able to support organisms

Source: Center for Watershed Protection

Implementation Plan Development

- Identify and delineate subsheds within overall watershed
- Determine current and “pre-developed” runoff characteristics for each design storm event
- Determine storage volumes for each design storm event
- Design storm selection criteria (how did we decide on a design storm)
  - Sand River Channel stability
- Type of stormwater facilities to be considered
- Available City property and ROW (i.e, existing and potential purchases)
- Conduct desktop analysis on available BMP locations
- Cost Benefit Analysis



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Part 654 Stream Restoration Design
National Engineering Handbook

Chapter 8 Threshold Channel Design

Table 8–3 Maximum permissible canal velocities

Original material excavated for canals	Mean velo after aging with — Clear water, no detritus (ft/s)	(m/s)
Fine sand (noncolloidal)	1.5	0.46
Sandy loam (noncolloidal)	1.75	0.53
Silt loam (noncolloidal)	2.0	0.61
Alluvial silt (noncolloidal)	2.0	0.61
Ordinary firm loam	2.5	0.76
Volcanic ash	2.5	0.76
Stiff clay (very colloidal)	3.75	1.14
Alluvial silt (colloidal)	3.75	1.14
Shales and hardpans	6.0	1.83
Fine gravel	2.5	0.76
Graded, loam to cobbles (when noncolloidal)	3.75	1.14
Graded silt to cobbles (when colloidal)	4.0	1.22
Coarse gravel (noncolloidal)	4.0	1.22
Cobbles and shingles	5.0	1.52

Part 654
National Engineering Handbook

Chapter 8 Threshold Channel Design

Table 8–4 Allowable velocities

Channel material	Mean channel velocity (ft/s)	(m/s)
Fine sand	2.0	0.61
Coarse sand	4.0	1.22
Fine gravel	6.0	1.83
Earth		
Sandy silt	2.0	0.61
Silt clay	3.5	1.07
Clay	6.0	1.83
Grass-lined earth (slopes <5%)		
Bermudagrass		
Sandy silt	6.0	1.83
Silt clay	8.0	2.44
Kentucky bluegrass		
Sandy silt	5.0	1.52
Silt clay	7.0	2.13
Poor rock (usually sedimentary)	10.0	3.05
Soft sandstone	8.0	2.44
Soft shale	3.5	1.07
Good rock (usually igneous or hard metamorphic)	20.0	6.08

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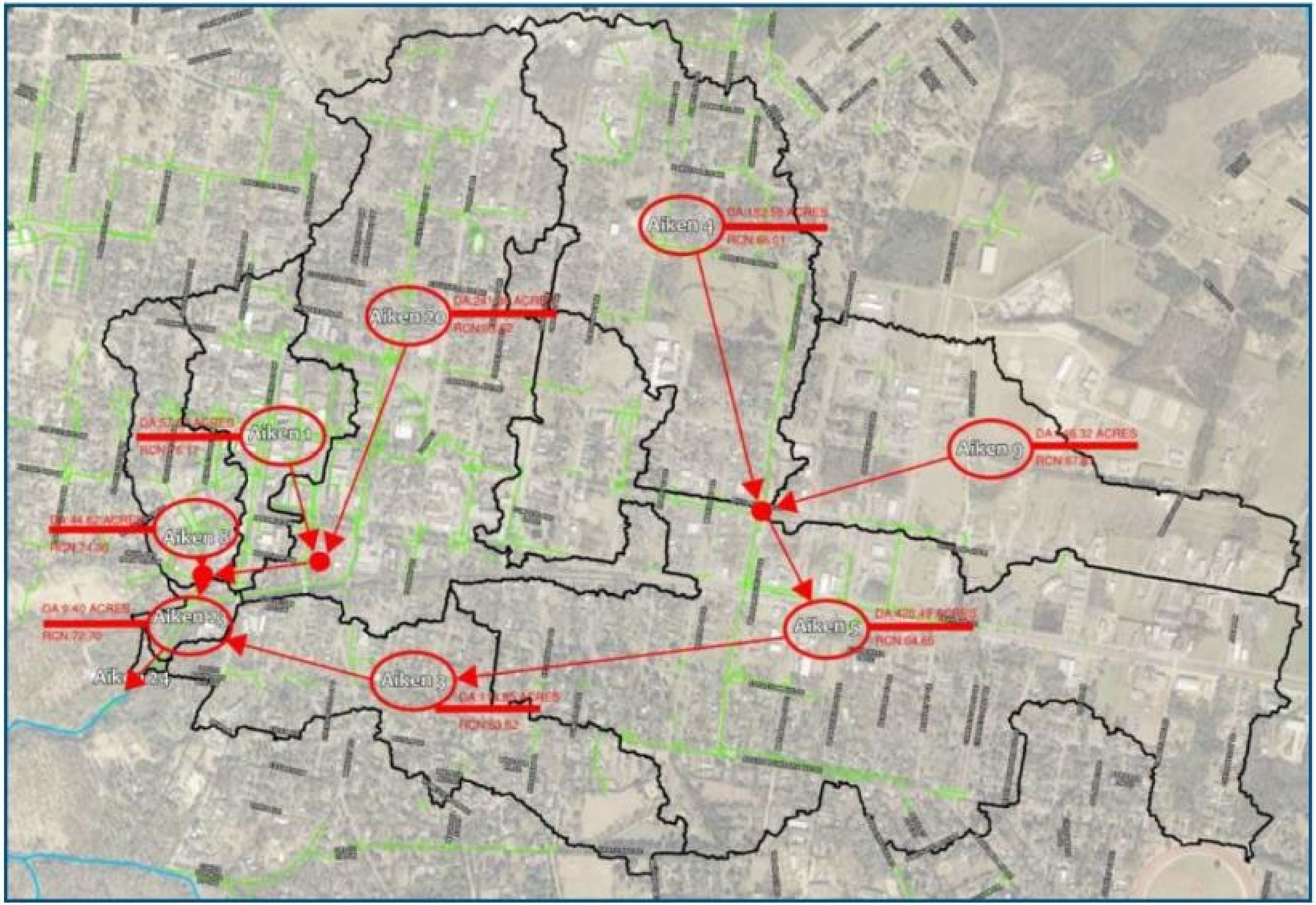
TR-20 SCHEMATIC



Discharge Rates: Existing vs Managed (Goal)

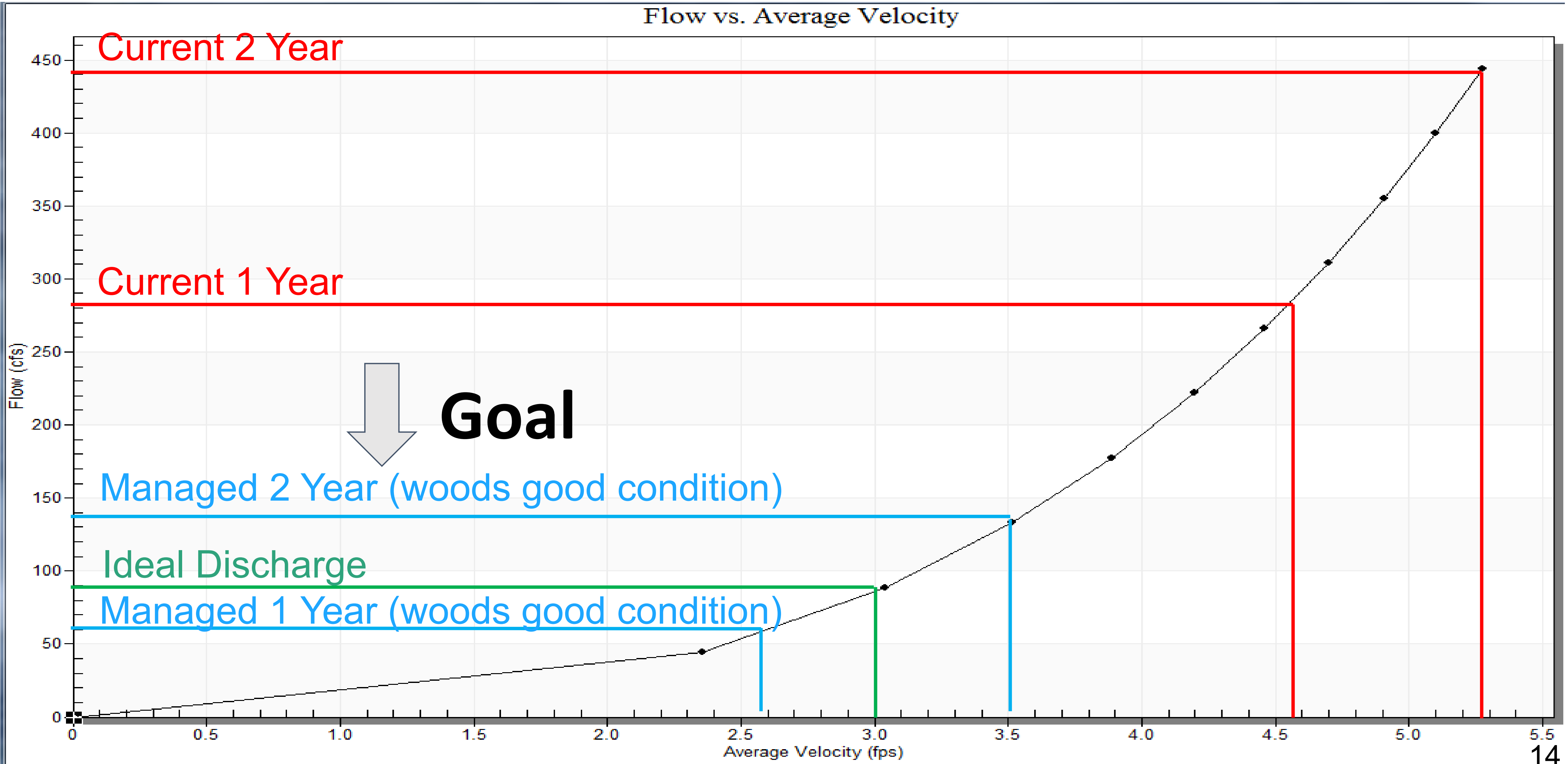
- Sand River Headwaters Outfall into Sand River

	CURRENT WATERSHED (cfs)							"Woods in Good Condition" WATERSHED (cfs)*						
DA ID	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
SR	279	444	735	1008	1436	1822	2256	59	134	299	477	784	1084	1438

Goals:

- Create a stormwater management system to replicate if Aiken was never built for certain rainfall amounts (mimics modern stormwater requirements)
- Reduce the 1-year storm runoff rate by 79%
- Reduce the 2-year storm runoff rate by 70%
- Reduce the 10-year storm runoff rate by 53%

Discharge Comparison



10-yr Storage Requirements

- Focus on providing management for the 10-yr event within Sand River Watershed (SRW)
- Goal is to achieve "pre-developed land use condition"
- Focus on implementation of BMPs throughout SRW
- Need to provide 58 acre-ft of storage
- That's 58 acres ponded at 1 foot deep! Or about 45 football fields!

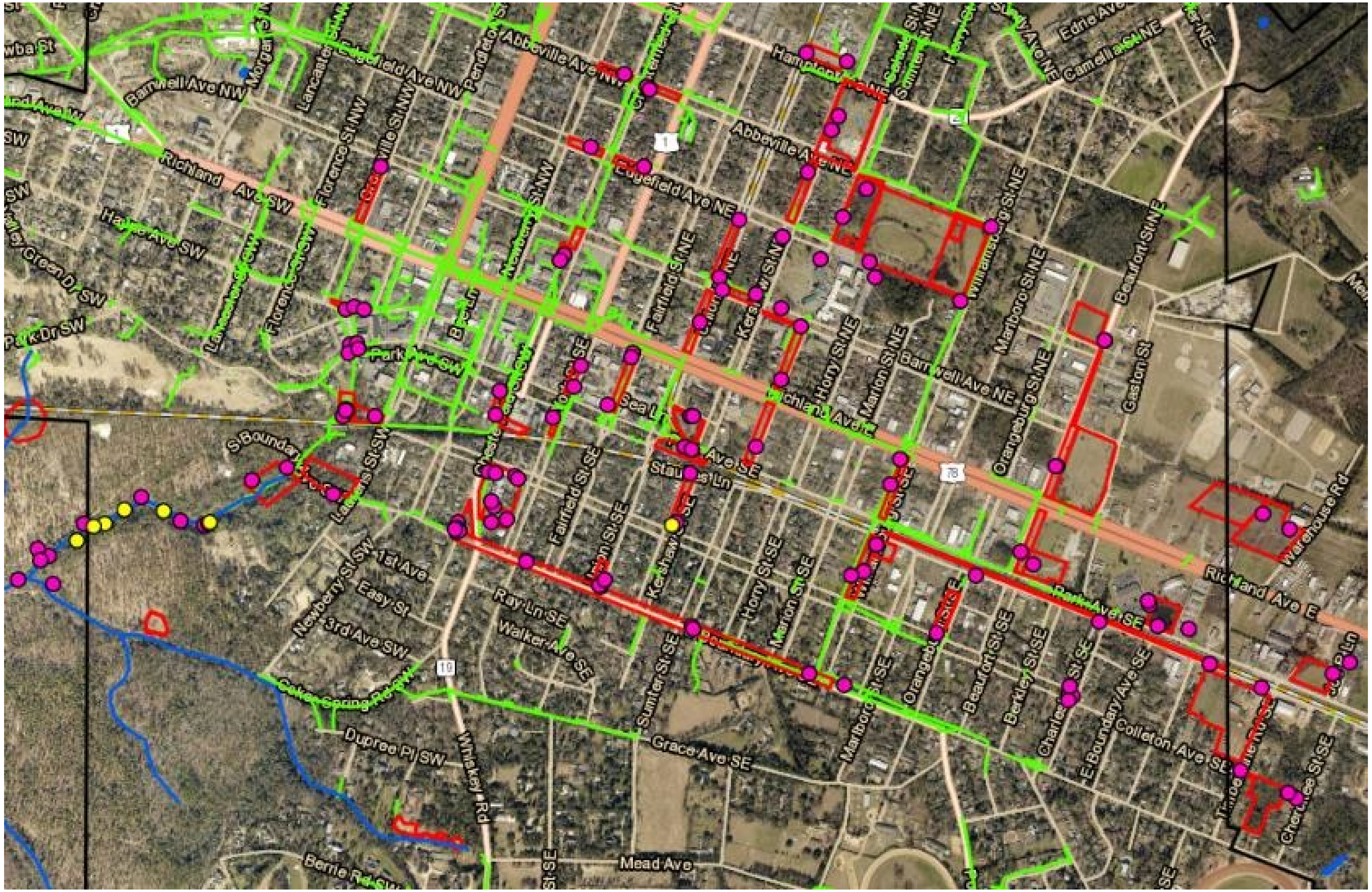
Sand River Watershed

Storage Volume Summaries					
	Total Storage (ac-ft)				
DA ID	1 Year	2 Year	5 Year	10 Year	25 Year
DA 1	2.82	3.46	4.14	4.77	5.57
DA 2	6.68	8.61	11.2	13.39	16.65
DA 3	1.73	2.26	3.29	4.14	5.42
DA 4	3.58	4.65	6.43	7.94	10.16
DA 5	6.67	9.07	12.8	16.32	21.31
DA 8	1.9	2.41	2.91	3.37	3.99
DA 9	4	5.31	7.06	8.55	10.61
DA 23	0.39	0.48	0.55	0.63	0.75
Total	27.77	36.25	48.38	59.11	74.46
OUTLET	26.76	35.06	47.46	58.22	74.12

Approach to the Sand River Stormwater Plan

- Utilize public owned ROW
- Analyze both above ground and below ground systems
- Development of a Cost Benefit Analysis
- Develop Conceptual Implementation Packages
- Identify other sites suitable for stormwater system installation

Desktop Analysis BMP Locations



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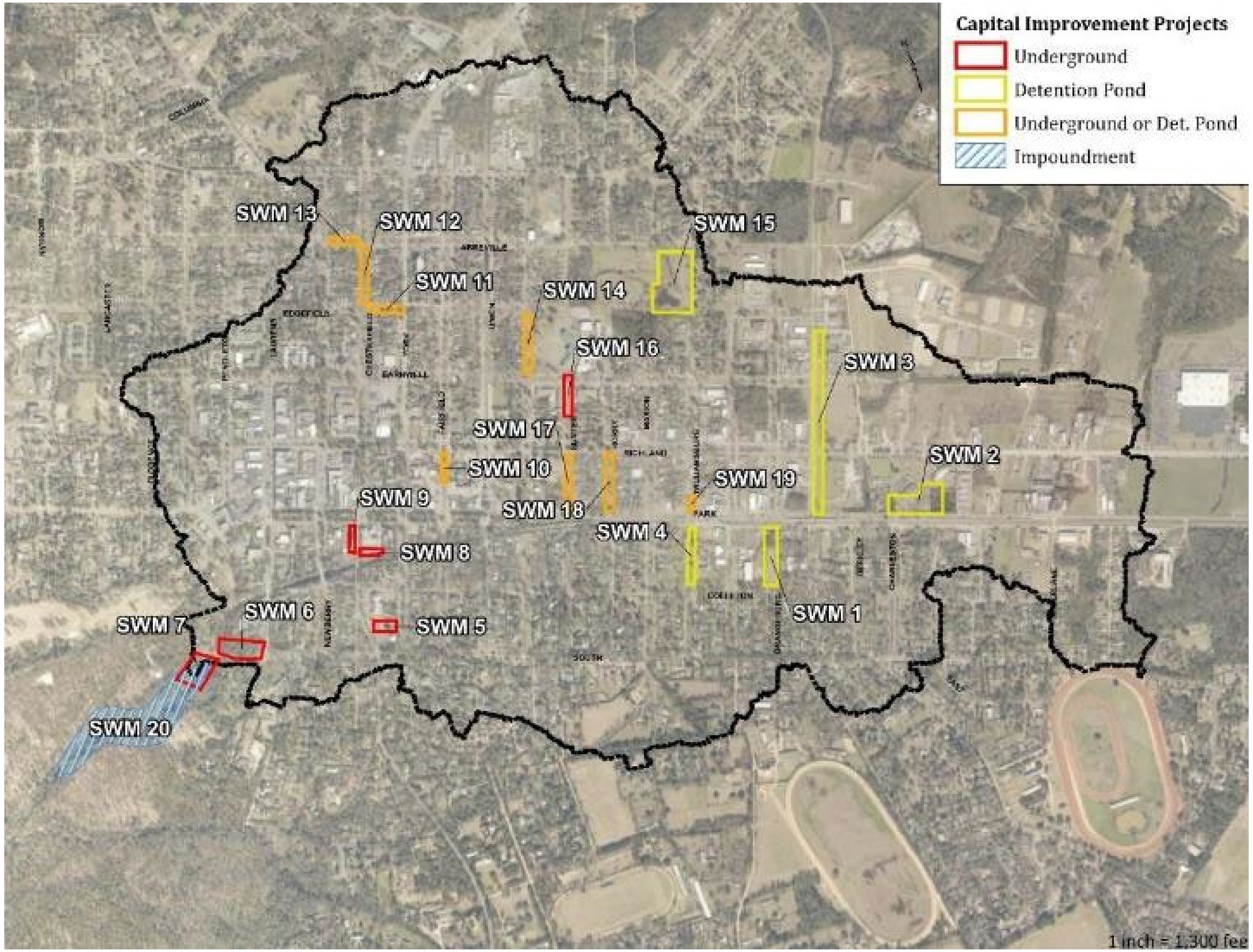
Final CIP Identification & Locations



Summary:

- Total Cost: Approximately $25 Million (PRE COVID Dollars)
- Volume Stored: Approximately 58 acre-feet

How To Reduce Costs:

- Utilize above ground detention facilities along medians where ever possible
- Consider ROW acquisition to reduce number of facilities required (one large facility versus many smaller ones)

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BMP 6 and 6A Project Implementation

- Two underground stormwater infiltration/detention vaults are capable of storing up to 25 acre-ft of stormwater runoff.
- Two integrated Opti smart control systems multiply the effectiveness of the storage an estimated 2 or 3 times.
- The City was awarded a 319 Grant totaling $326,000 to help fund the installation of the Opti control systems. The City matched 40% of the grant award.
- The remaining project funding came from multiple existing revenue sources and an SRF loan.

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BMP 6 AND 6A

BMP 6:

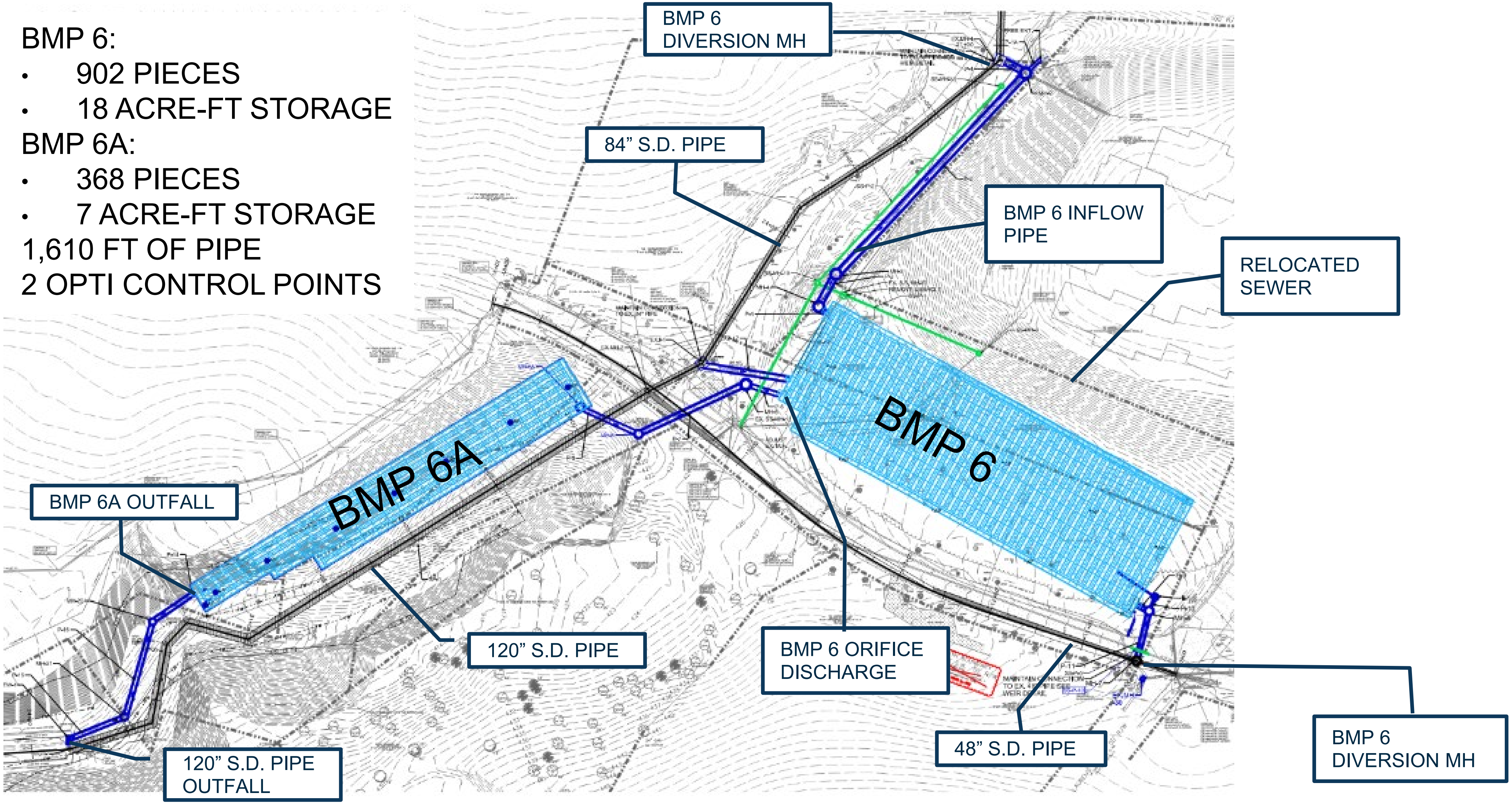
- 902 PIECES
- 18 ACRE-FT STORAGE

BMP 6A:

- 368 PIECES
- 7 ACRE-FT STORAGE

1,610 FT OF PIPE

2 OPTI CONTROL POINTS



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StormTrap DoubleTrap System

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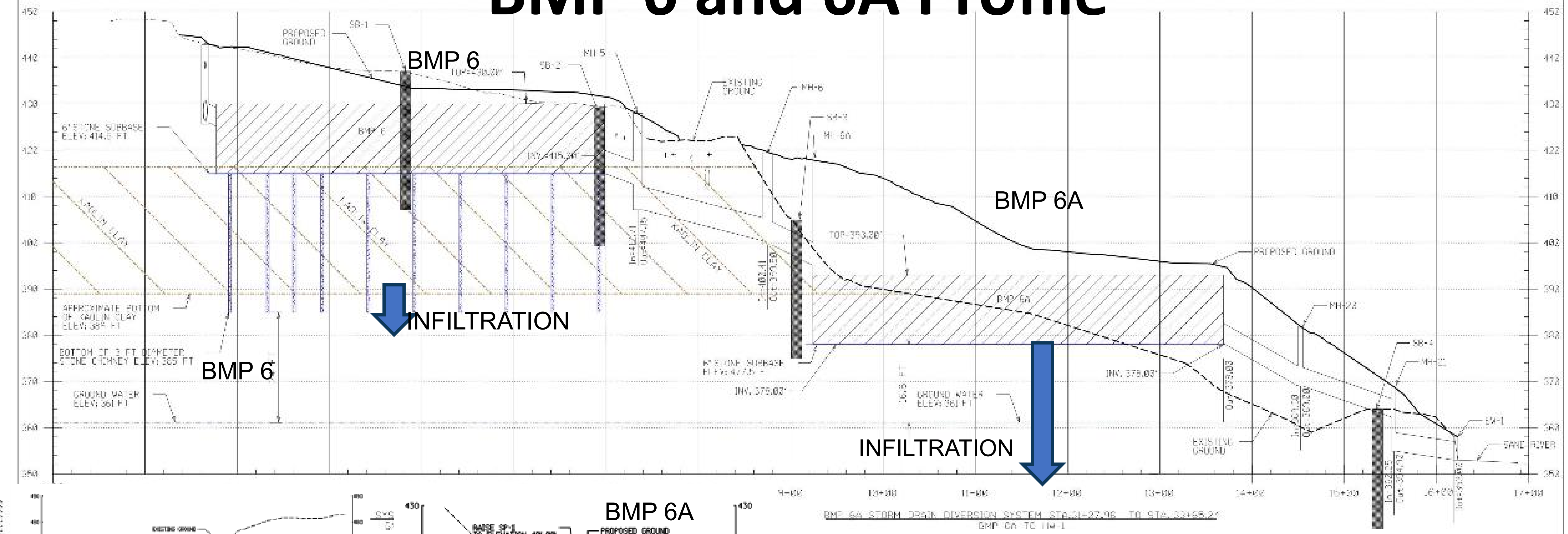
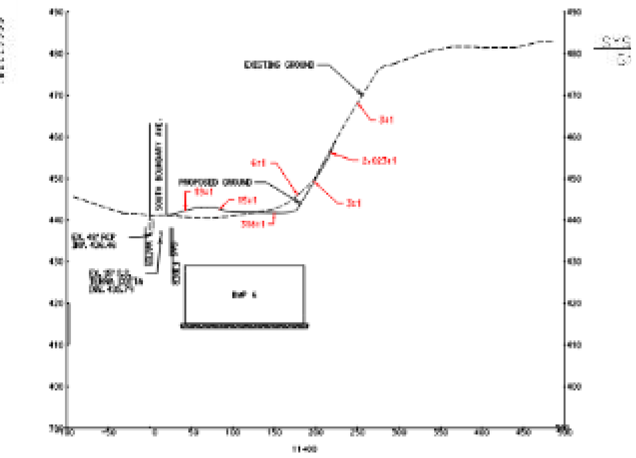
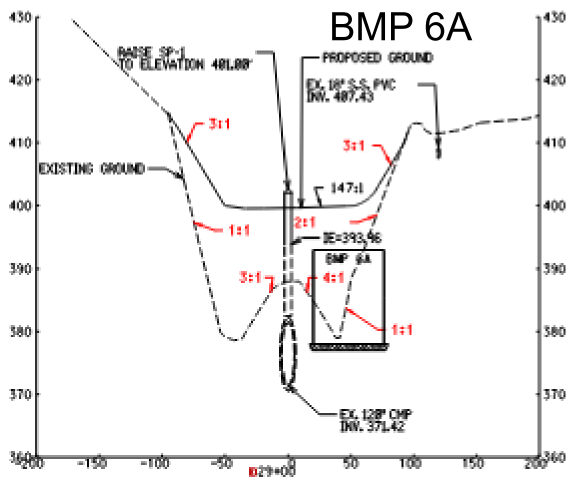
BMP 6 and 6A Profile







BMP 6:

- Avg. 25 ft depth of excavation
- Avg. 40 ft tall temporary shoring wall
- 36" x 36" "low flow orifice"

BMP 6A:

- Avg. 20 ft depth of excavation
- Avg. 30 ft tall temporary shoring wall
- 36" x 36" "low flow orifice"

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Opti Real-Time Control System

Challenge: How can we optimize BMPs 6 & 6A to maximize performance across a range of storm events?

Opportunity: Timing is everything!

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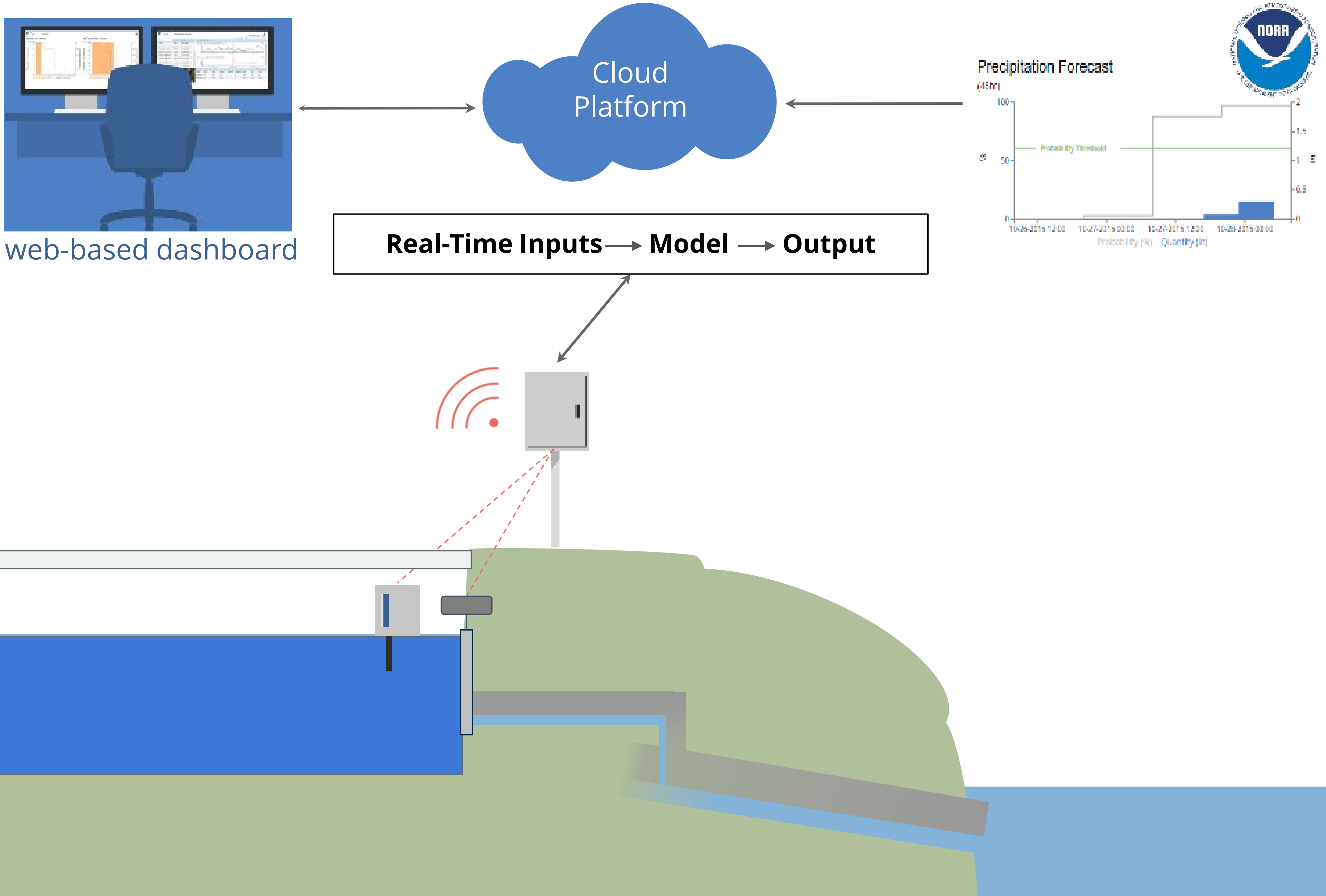
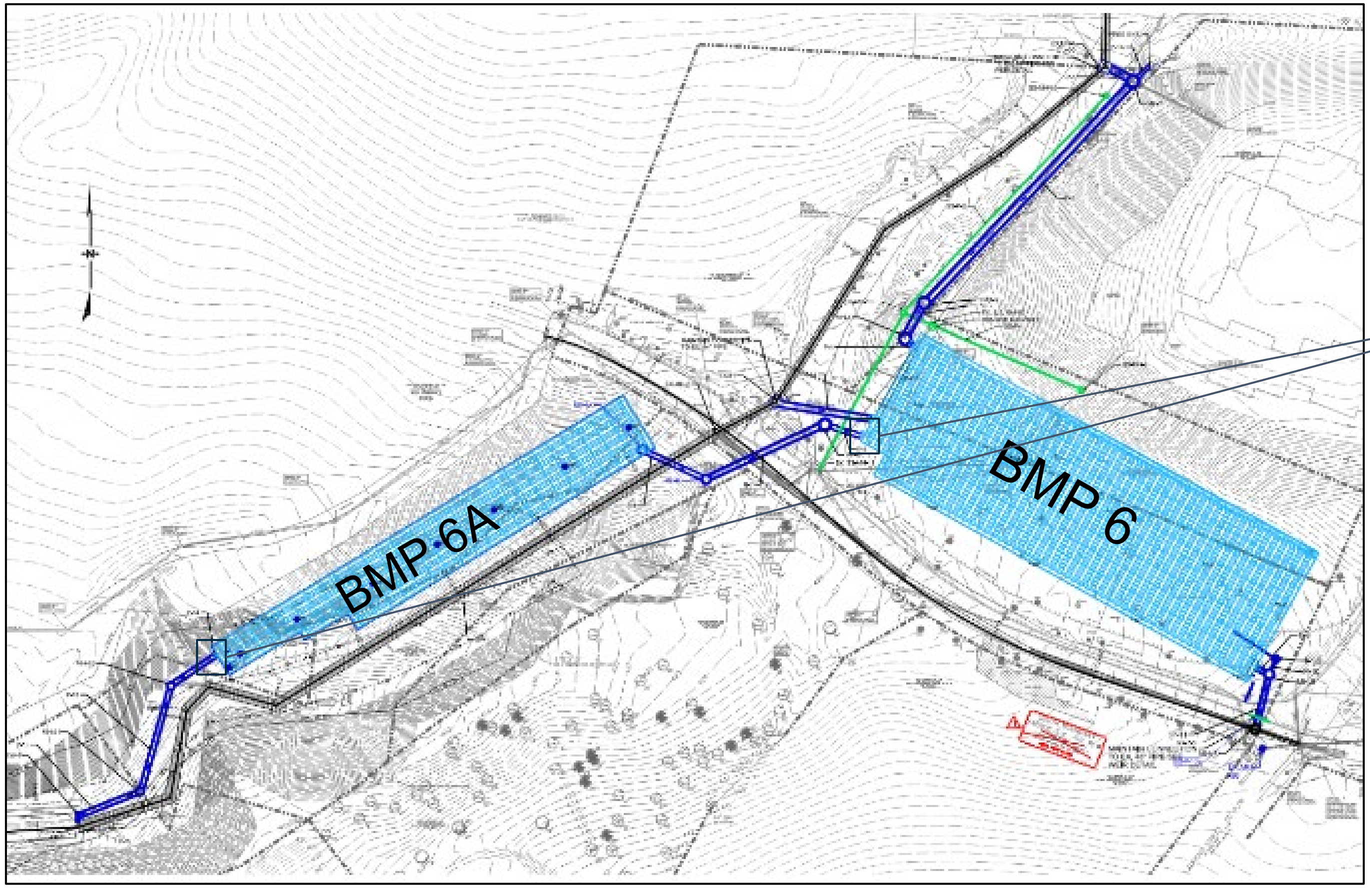
Product Configuration

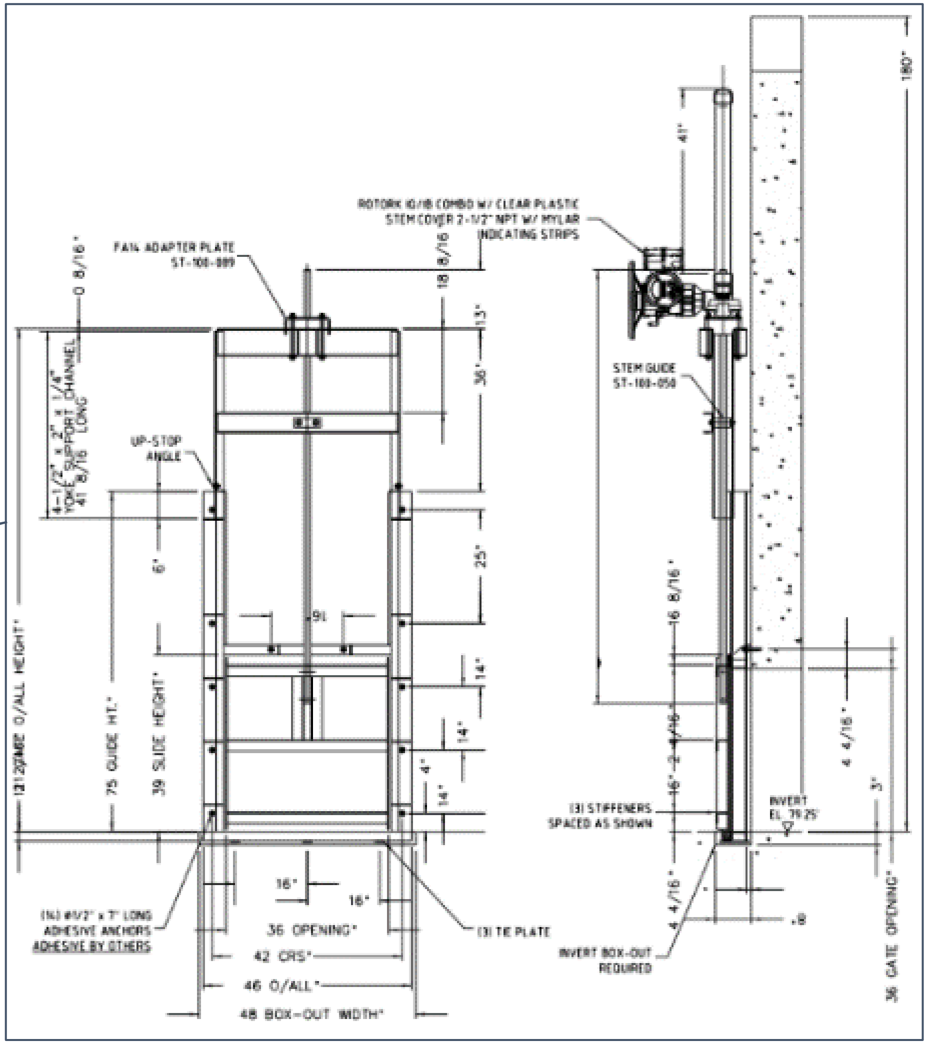
Example Parameters

- Watershed Area
- Impervious Area
- Gate dimensions
- Overflow Invert
- Peak Discharge
- Retention Period
- Precipitation Thresholds



Objectives: Minimize peak discharge and maximize infiltration by <u>coordinating control</u>





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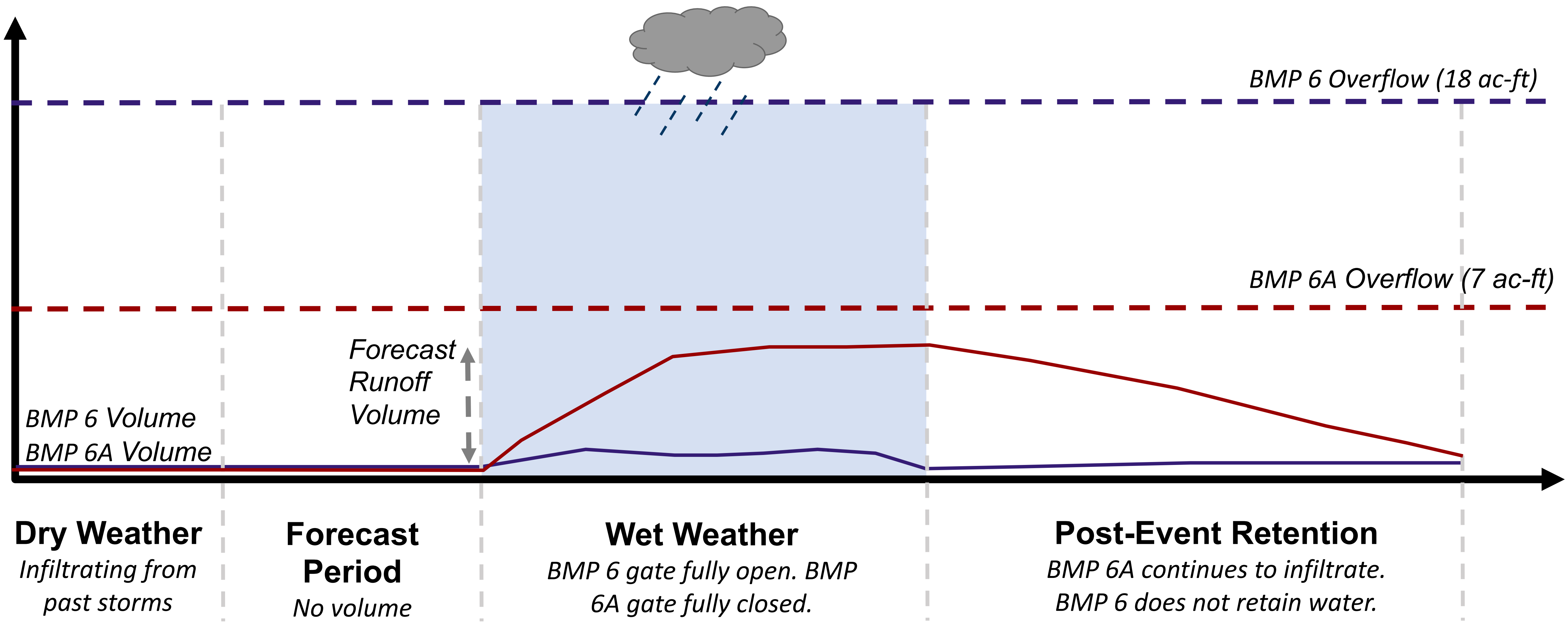
Small Storms (less than BMP 6A volume)



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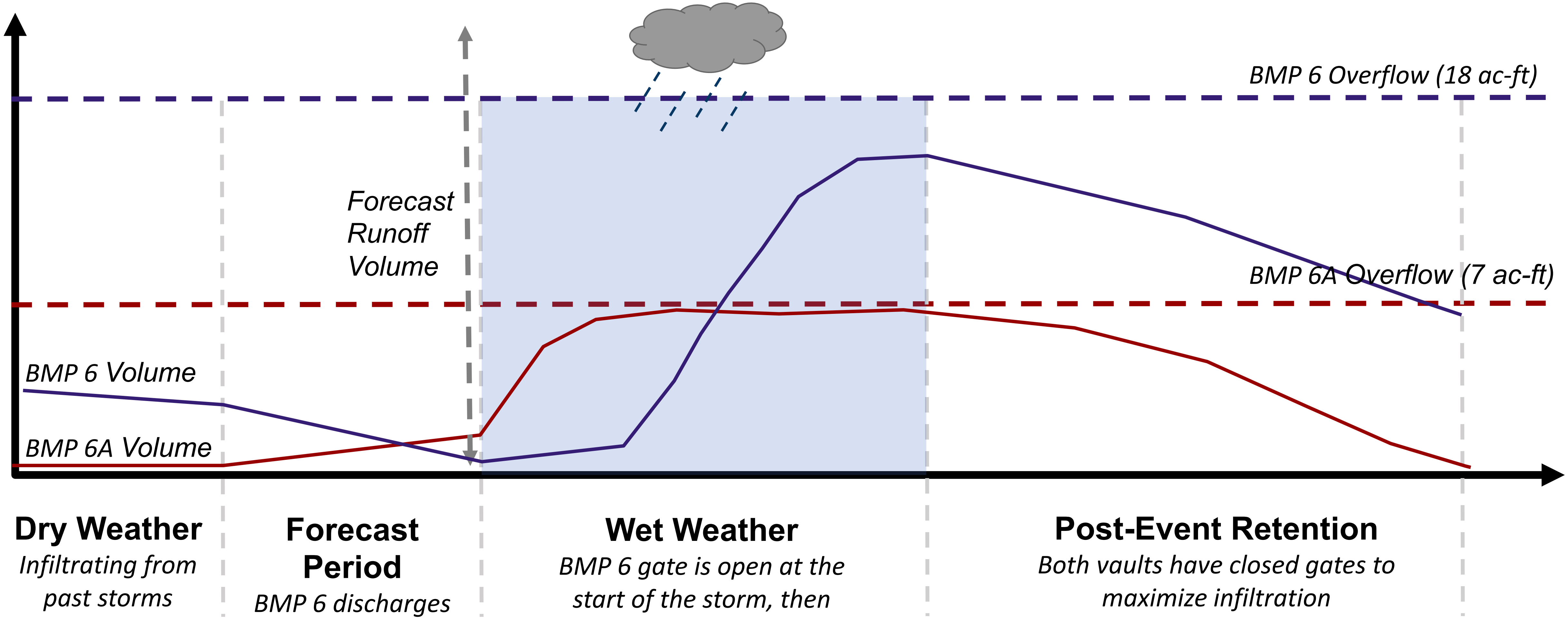
Mid-Sized Storms (less than combined volume)



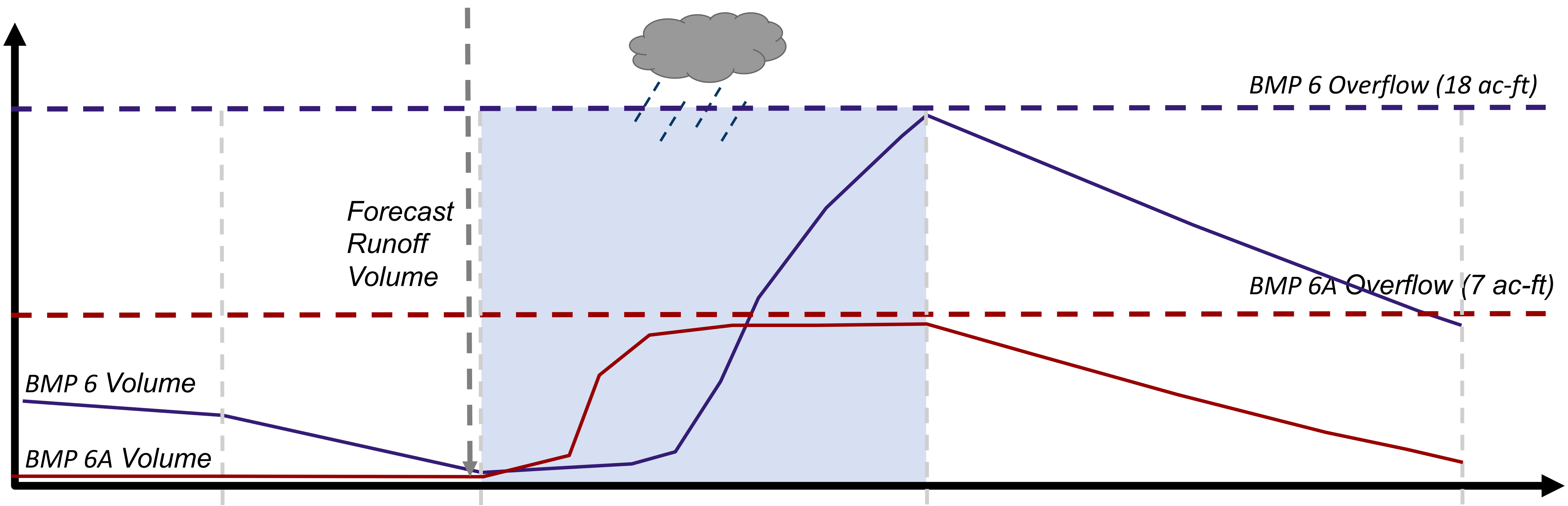
Dry Weather
Infiltrating from past storms

Forecast Period
BMP 6 discharges into BMP 6A

Wet Weather
BMP 6 gate is open at the start of the storm, then closes. BMP 6A gate stays closed.

Post-Event Retention
Both vaults have closed gates to maximize infiltration

Large Storms (greater than combined volume)



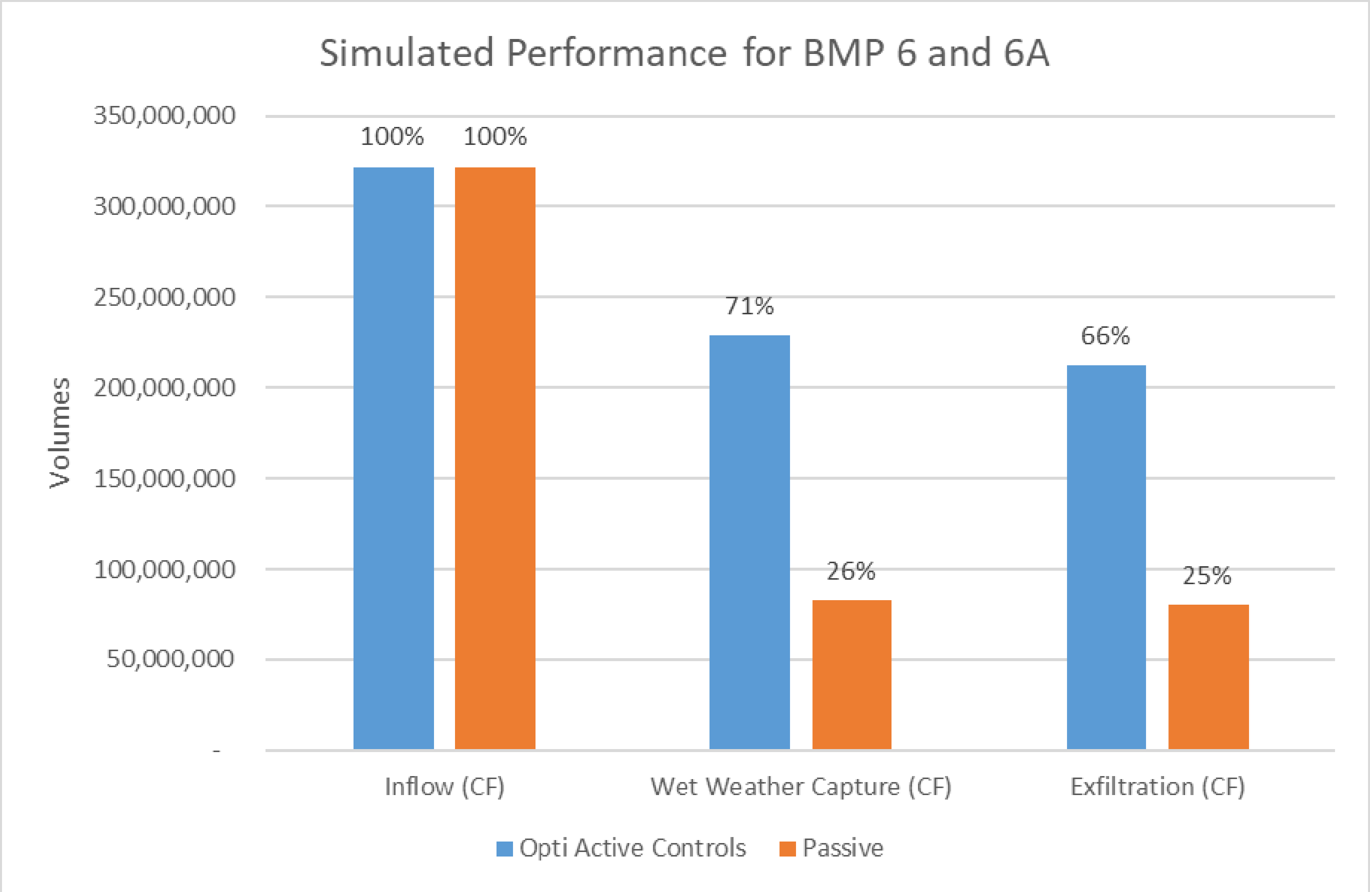
Dry Weather
Infiltrating from past storms

Forecast Period
BMP 6 discharges into BMP 6A, which passes flow to the Sand River

Wet Weather
Both gates are open at the start of the storm. When remaining storm can be fully captured, BMP 6A gate closes followed by BMP 6 gate

Post-Event Retention
Both vaults have closed gates to maximize infiltration

Improved Outcomes



Six-year simulated rainfall and continuous simulation model of 295 inches of precipitation (49 in/yr average).

- **2.7x** increase in wet weather capture, reducing flow during critical times
- **2.6x** increase in infiltration, improving water quality and reducing erosion
- **Millions of dollars in savings** by mitigating the need for upstream storage

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Site Enhancements

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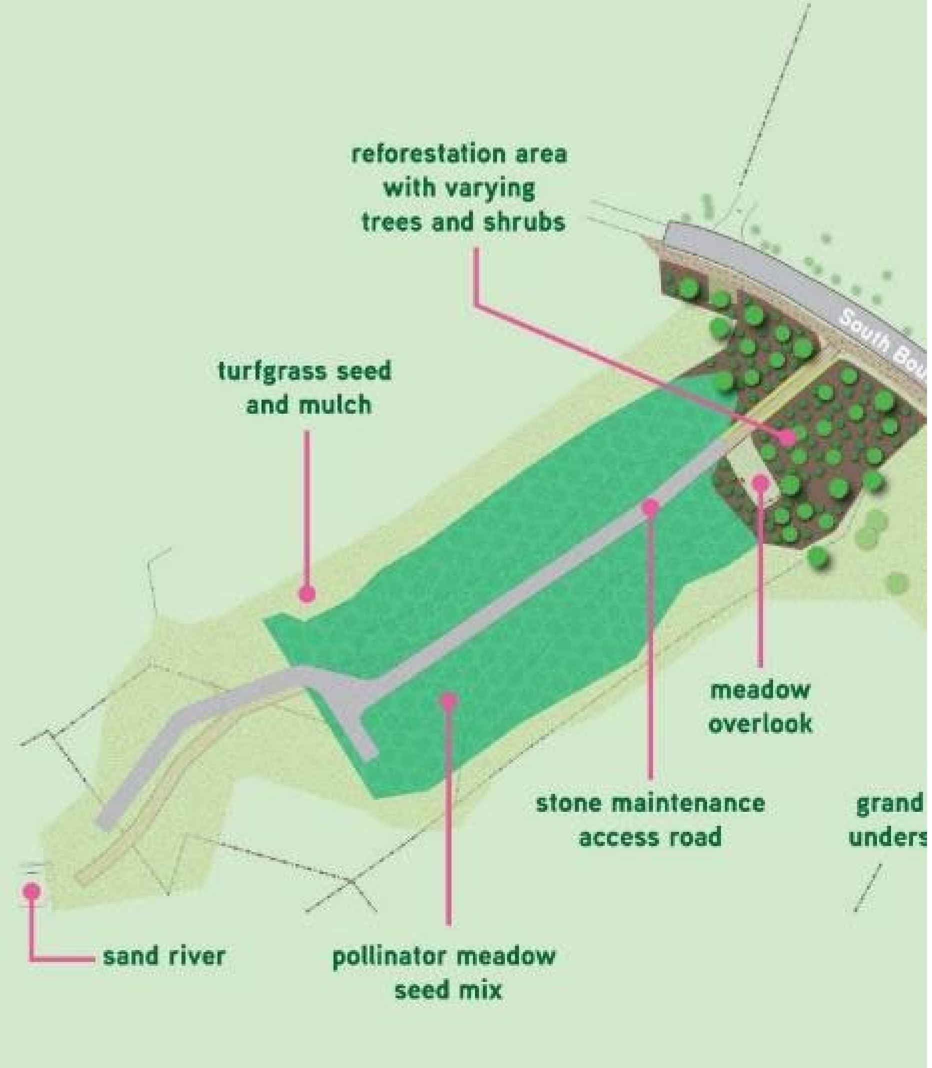
Site Enhancements

Site Enhancements



CONSTRUCTION PROGRESS 10/02/21

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CONSTRUCTION PROGRESS 1/26/22

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CONSTRUCTION PROGRESS 1/26/22 – BMP 6A

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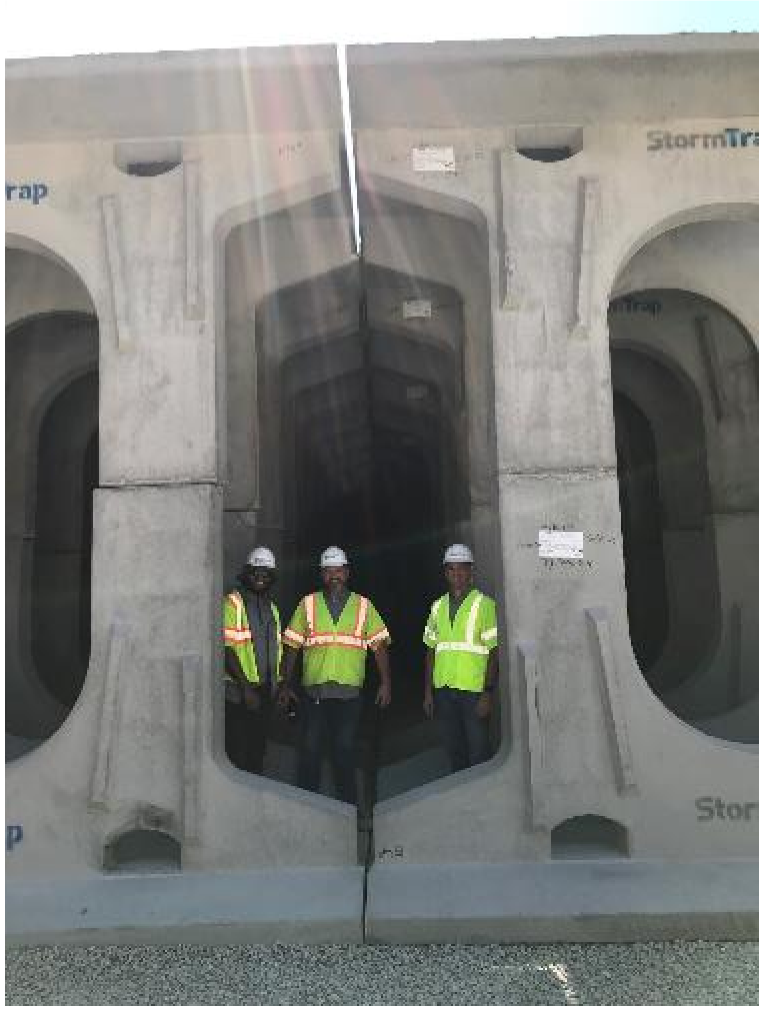
CONSTRUCTION PROGRESS 4/28/22 – BMP 6

CONSTRUCTION PROGRESS 5/25/22 - BMP 6



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CONSTRUCTION PROGRESS 8/9/22 - BMP 6

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CONSTRUCTION PROGRESS 9/14/22 - BMP 6

BMP 6A Before and Current

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BMP 6 Before and Current

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CONSTRUCTION PROGRESS VIDEO

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Summary

- Addressing the stormwater challenges in Aiken, SC and protecting the Sand River was estimated to require 58 ac-ft of storage and cost over $25M.

- Through innovative design and the use of adaptive control technology, the City is expected to meet their goals with only 25 ac-ft of optimized storage costing $15M.

- This project transforms a stormwater liability into a community park and asset.

  - Jason Hetrick, P.E., CFM, jmhetrick@mccormicktaylor.com
  - Dayton Marchese, P.E., dmarchese@optirtc.com
  - George Grinton, ggrinton@cityofaikensc.gov


COMMUNITY NEWS
SPORTS
155 YEARS
Aiken Standard
AIKENSTANDARD.COM
'Brilliance in engineering'
Plans call for stormwater project completion by Thanksgiving

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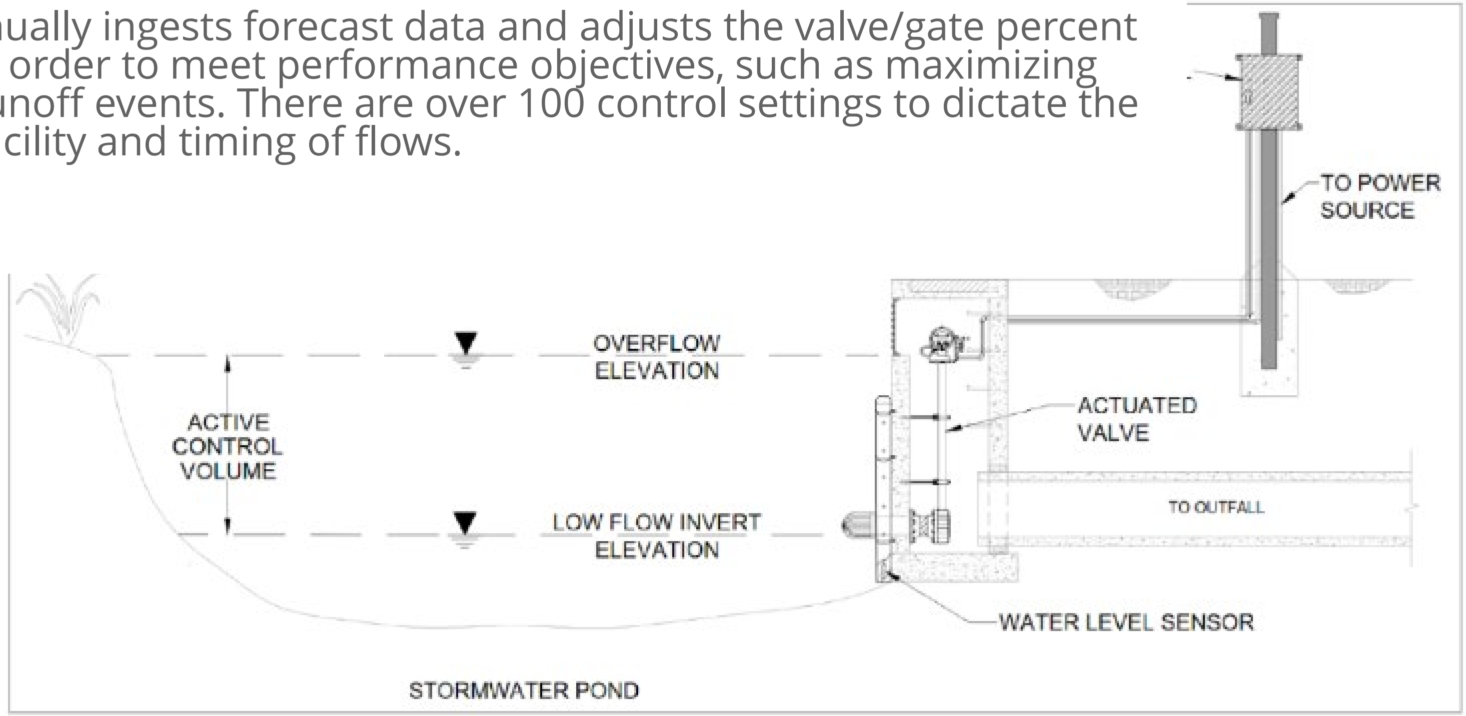
Supplementary Information

The Opti System

- The Opti system will use rain forecasting to allow for automated control of the low flow orifices within the vaults.
- The Opti system will keep the low flow orifices closed, forcing infiltration of the stormwater retained in the vaults.
- However, in the situation of a forecasted rain event, the low flow orifice will be activated up to 72 hours in advance, allowing for a managed dewatering of the vaults to allow for adequate storage for the pending rain event.
- Opti's technology continually ingests forecast data and adjusts the valve/gate percent open (or pump state) in order to meet performance objectives, such as maximizing capture of forecasted runoff events. There are over 100 control settings to dictate the discharge rate from a facility and timing of flows.



EFFECTIVENESS OF THE UNITS

Discharge into the Sand River Goal:

	CURRENT (cfs)							"Woods in Good Condition" (cfs)						
DA ID	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
SR	279	444	735	1008	1436	1822	2256	59	134	299	477	784	1084	1438

- Goal of the Sand River Implementation Plan:
  - From Downtown (84" pipe under the railroad) the 10-year woods in good condition event is 177 cfs
  - From S. Boundary St (48" pipe) the 10-year woods in good condition is 323 cfs
  - STORMTRAP units without Opti Control system effectively stores 25 acre-ft at one time

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Effectiveness of BMP 6 and 6A

- Opti will provide the opportunity to increase the infiltration of the stormwater in the vaults.
- Our expectation is that the enhanced system will manage the 5-year event (approximately 47 acre-ft)
- Infiltration will be achieved by keeping discharge valve closed for smaller events
- Larger events will achieve metered discharge, plus subtraction of 1-to-2-year event stormwater volume from the hydrograph

Outfall**			
Storm	Pre (cfs)	Post (cfs)	% Change
1-YR	217	125	- 42%
2-YR	354	240	- 32%
5-YR	596	540	- 9%
10-YR	824	824	0%
25-YR	1,182	1,182	0%
50-YR	1,476	1,476	0%
100-YR	1,868	1,476	0%

** Discharge does not consider influence of Opti System