APPENDIX 14

Arcadis Flow Characterization Study

Memo

ARCADIS

SUBJECT
Preliminary Modeling of SRP Impacts

TO
KISS Program Team

DATE
October 31, 2022

OUR REF
30151292

DEPARTMENT
[Department]

PROJECT NUMBER
LCA 602

COPIES TO
AECOM

NAME Jim Shelton

After the KISS model was expanded and calibrated using 2021 flow and rainfall data, Arcadis ran an extended simulation under both 2021 and projected 2050 new development sewer use conditions. This work was done without making any modifications to the physical KISS (i.e., no new pipes, pumps, or tanks) but did consider slowly increasing I&I and slowly decrease water consumption. To broadly assess peak flows to KIWWTP, we ran these under both open and closed system assumptions.

- A Close System run does nothing to the pipes and pumps. Overflows occur where they would occur if nothing was done to alleviate the HGLs. To broadly assess peak flows to KIWWTP, the peak hourly flow rates from all the overflow locations were added to the peak hourly flow rate to hit KIWWTP. This overestimates flow by adding all the peak overflows without consideration of flow transit time if/when the SSOs are captured/addressed. **This resulted in a peak hourly flow to KIWWTP of 207 MGD.**
- An Open System run replaces all the pipes in the system with large replacements so no flow overflows. This underestimates flow because the oversized pipes provide huge in-line storage that dampens out true peak flows. **This resulted in a peak hourly flow to KIWWTP of 178 MGD.**

The actual peak flow to KIWWTP is *likely between these two flow rates* and can only be determined by right-sizing the pipes and pumps. This work is being done now as part of the PSOA.

Ahead of doing the actual PSOA modelling, analyses were completed to roughly estimate the value and cost of a range of Source Reduction Program approaches using the *207 MGD Closed System Run* as a benchmark. For this work, sewers, cleanouts, and manholes were split into rehabilitation cohorts based on each of the 943 catchments' RDII characteristics. Where Night-Time Weiring (NTW) results were available, these data were also considered. Manholes in know floodplains were specifically identified as a separate group of assets. These were split into the cohorts shown below. Otherwise, data from each meter basin I&I characterization was used (Pink, Red, Orange, and Yellow).

INFLOW 1			INFLOW 2	RII 1			RII 2	CO
Stream based M	Peaking Factor >6 Basin MHs	PK>5 Basin Manholes	Peaking Factor <5 but >4 Sheet Flow MHs	Priority 1 Sewers	Priority 1A Sewers	Priority 1B Sewers	Priority 2 Sewers	Clean outs

The math for how each asset was characterized was presented in the August and September KISS meetings and is in the Subcatchment Data Summary spreadsheet and in the RDII Reductions SOP. These are summarized below:

	SEWERS				MANHOLES		Cleanouts	
	Basins with NTW results		Basins without NTW results					
PINK BASINS	NTW>10 gpd/lf	100% as Priority 1			75%	Peaking Factor >=6	75%	Peaking Factor >=6
	NTW>5 gpd/lf	100% as Priority 1A						
	RDII >8 gpd/lf or BI>45%	25% as Priority 1B	RDII >8 gpd/lf or BI>45%	30% as Priority 1, 10% as Priority 2				
RED BASINS	NTW>10 gpd/lf	100% as Priority 1			75%	Peaking Factor >=6	75%	Peaking Factor >=6
	NTW>5 gpd/lf	100% as Priority 1A						
	RDII >8 gpd/lf or BI>45%	25% as Priority 1B	RDII >8 gpd/lf or BI>45%	30% as Priority 1a, 10% as Priority 2				
ORANGE BASINS	NTW>10 gpd/lf	100% as Priority 1			50%	Peaking Factor >=5	50%	Peaking Factor >=5
	NTW>5 gpd/lf	100% as Priority 1A						
	RDII >4 gpd/lf or BI>33%	15% as Priority 1B	RDII >4 gpd/lf or BI>33%	25% as Priority 1B, 10% as Priority 2				
YELLOW BASINS			RDII >2 gpd/lf or BI>20%	5% as Priority 1B, 10% ad Priority 2	25%	Peaking Factor <5 but >4	25%	Peaking Factor <5 but >4

We modelled 4 different SRP scenarios (WMS 1 – 4).

1. WMS1 - Inflow 1+Inflow2 + CO + Priority 1+ Priority 1A+ Priority 1B
2. WMS2 - Inflow 1+Inflow2 + CO+ Priority 1+ Priority 1A+ Priority 1B + Priority 2
3. WMS3 - Inflow 1+ Priority 1+Priority 1A
4. WMS4 - Streambased MH + PF >6

The impact of these various reduction efforts using Closed Run model is shown in the below table.

Storm	2050 Total SSO Volume (MG)	2050 Number of Overflow Locations	2050 Peak Flow to KI (MGD)	Manholes Sealed	Sewer Rehab Miles	Approximately SRP Cost ($M)
Ida NOAA	38	79	207	0	0	$0
Ida NOAA WMS 1	25	52	164	9200	235	$94M
Ida NOAA WMS 2	23	47	161	9200	273	$113M
Ida NOAA WMS 3	28	63	176	5800	170	$62M
Ida NOAA WMS 4	34	69	192	4400	0	$2M

Of the Miles Sewer Rehab, 78 of these miles (UMT, LMT, and Alburtis) are already mainline rehabilitated; only their taps and risers remain to be grouted, and that work will be completed in the next two years.

If we ran a WMS scenario that sealed all leaking frames/covers/chimneys in basins with peaking factors greater than 4 (9200 manholes vs. the 4400 manholes in WMS 4), peak flow to KIWWTP would likely drop to ~185 MGD (these lower leaking basins will produce less peak flow reduction upon sealing).

The WMS 1 and WMS2 Sewer Rehab work has 15-20 MGD impact on the peak flow rate. Keep in mind that this work address RII much more than it impacts inflow, so the impact for RII work is reflected in both total RDII volume reduction and baseline infiltration reduction (allocation scavenging) than in peak flows.

Based on this work, ***Arcadis recommends the SRP benchmark be WMS 1.*** This work is:

1. Identify and make watertight 100% of manholes in floodplains
2. Identify and make watertight 75% of manholes in basins with peaking factors >6
3. Identify and make watertight 50% of manholes in basins with peaking factors <6 but >5
4. Identify and make watertight 25% of manholes in basins with peaking factors <5 but >4
5. Identify and make watertight 10% of manholes in basins with peaking factors <4
6. Identify and make watertight 5% of cleanouts in all basins
7. Rehabilitate all mains, taps, and risers for sewer with NTW >5 gpd/lf
8. Identify and rehabilitate 25% of mains, taps, and risers for sewers with RDII >8 gpd/lf or BI>45%
9. Identify and rehabilitate 25% of mains, taps, and risers for sewers with RDII >8 gpd/lf or BI>45%
10. Identify and rehabilitate 15% of mains, taps, and risers for sewers with RDII >4 gpd/lf or BI>33%
11. Identify and rehabilitate 5% of mains, taps, and risers for sewers with RDII >2 gpd/lf or BI>20%

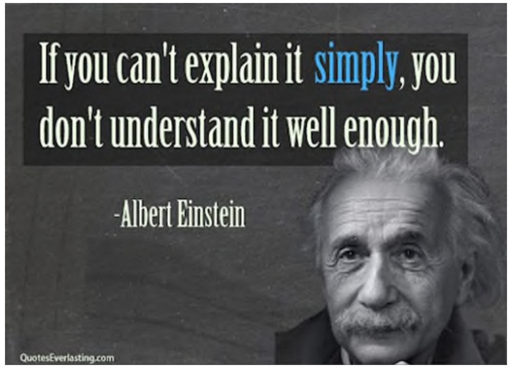
- Items 1-5 will be identified via specific manhole inspection program of 100% of system manholes.
- Item 6 will be identified via yard inspections of 100% of system properties.
- Item 7 are already identified.
- Items 8-11 will be identified via multiple rounds of NTW or micrometering.

KLINE’S ISLAND SEWER SYSTEM (KISS) 2021 MODEL

Calibration Overview – LCA Board

August 8, 2022

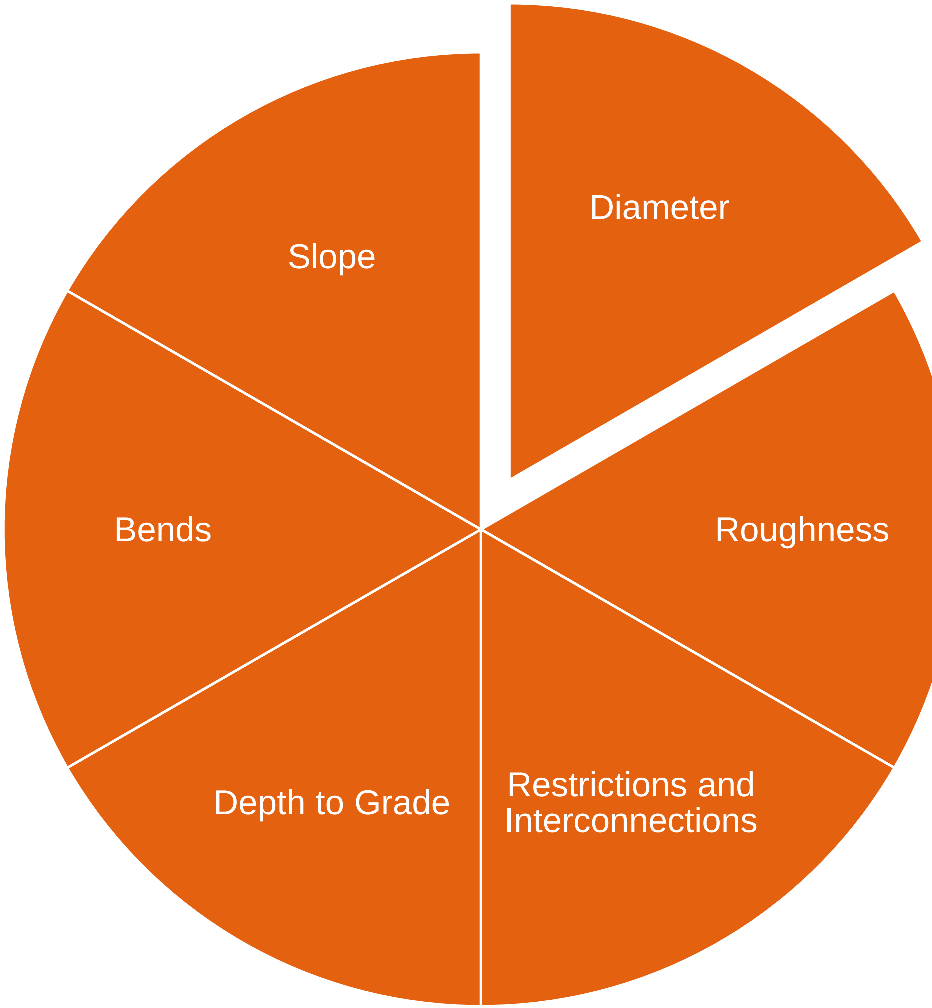
ARCADIS
Design & Consultancy for natural and built assets



- What is a dynamic hydraulic sewer model?
- What is a model used for?
- What are steps to modeling?
- Where is model strong and weak?
- What are the things we are doing now with the calibrated model?
- What are future modeling efforts?

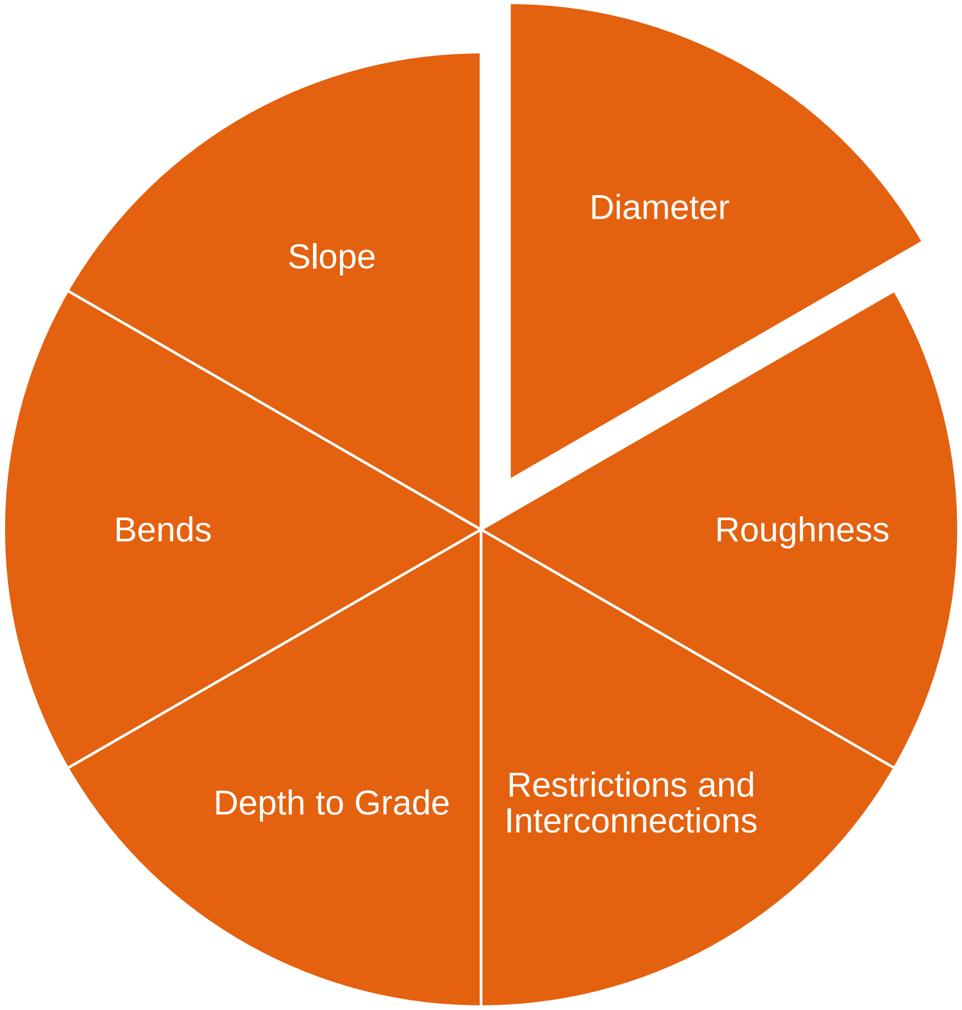
What is a dynamic hydraulic sewer model?

A sewer model is a digital twin of sewer system

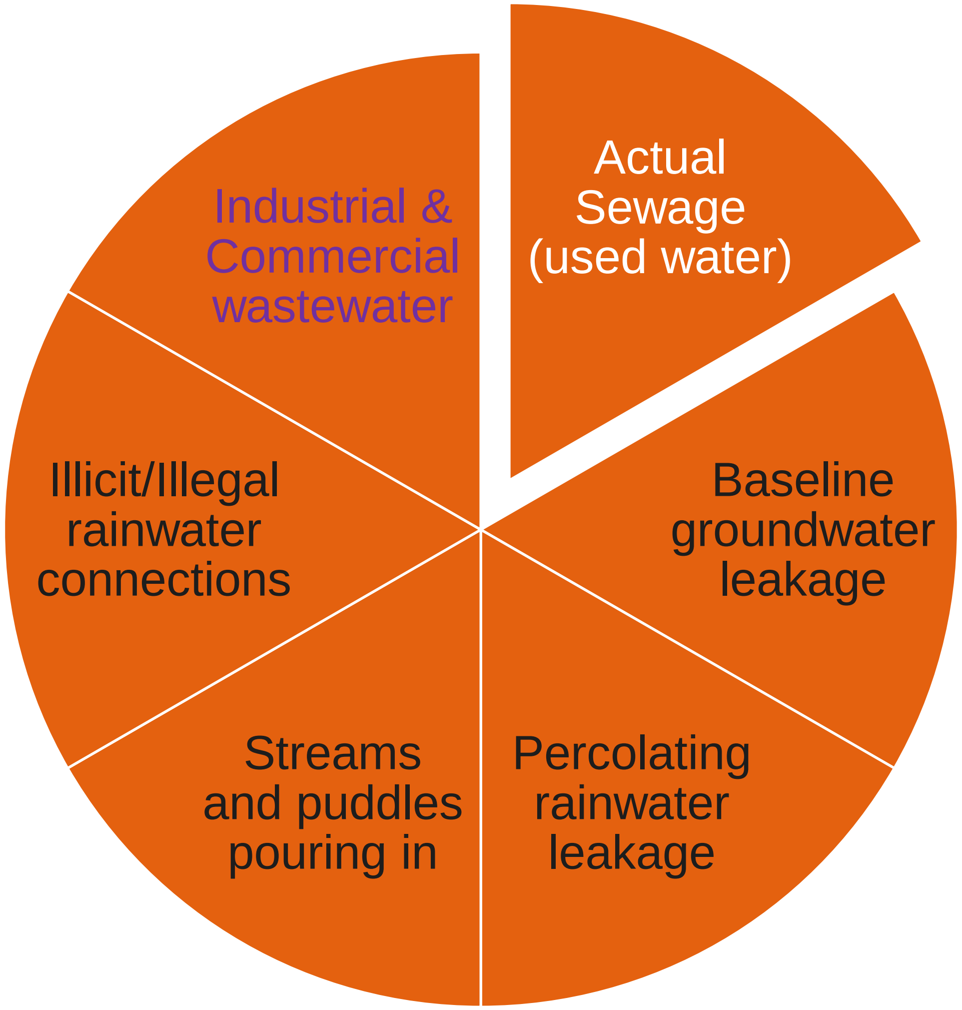


Physical Attributes of Pipes

A sewer model is a digital twin of sewer system



Physical Attributes of Pipes



What's in the Pipe

ARCADIS Design & Consultancy for natural and built assets

What is a model used for?

Current Performance

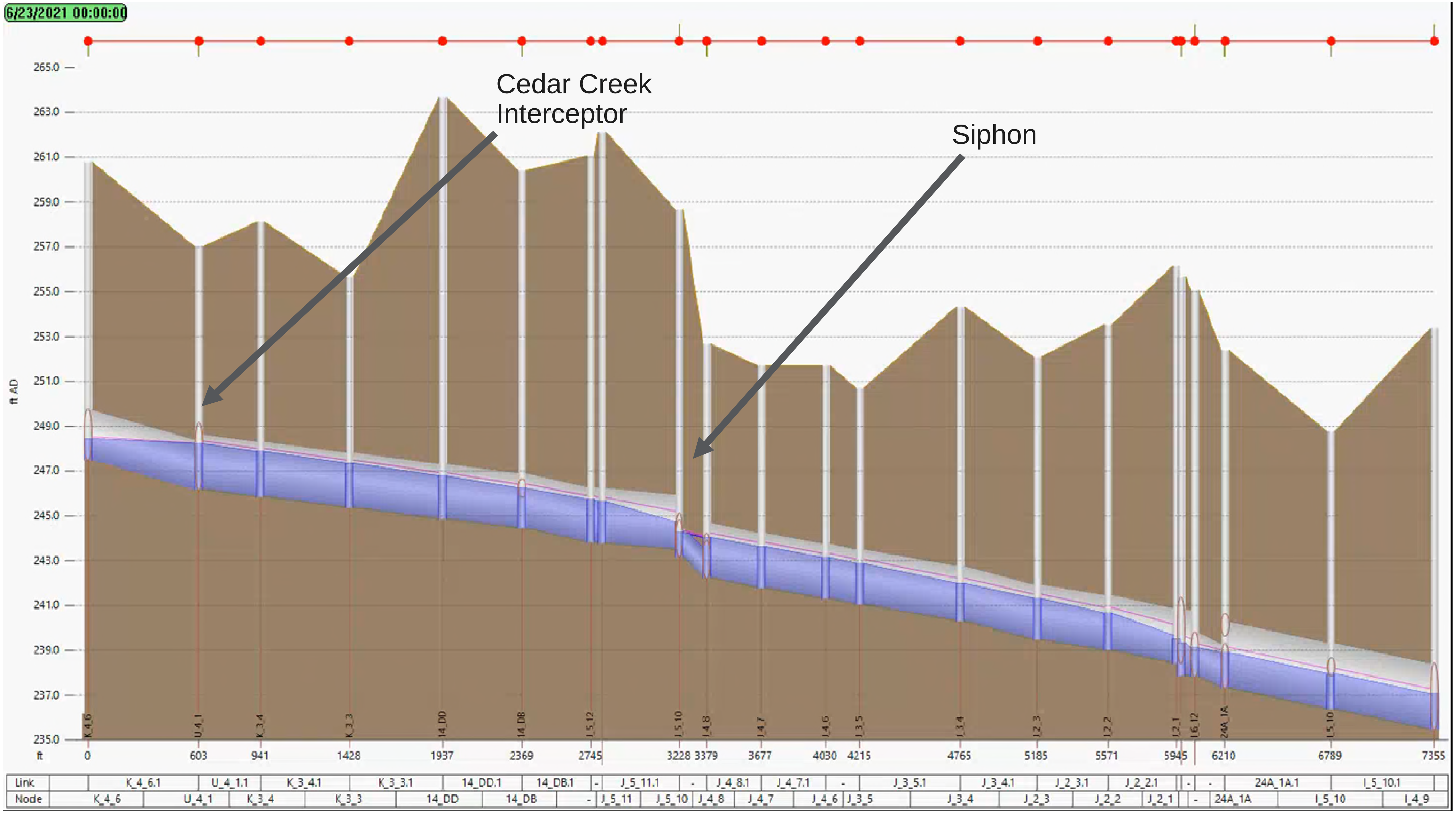
- Blockages
- Flow restrictions
- Undersized pipes
- Available capacity
- Pump station demand
- Basement backups
- Dry weather backups
- Wet weather overflow locations, volumes, and durations
- Inflow locations
- Reliability

What is response to large rain events?

How does it handle extended wet periods?

How good is its Level of Protection?

Current performance is function of base load and rainfall frequency/intensity



6/23/2021 00:00:00
Cedar Creek Interceptor
Siphon
ft AD
265.0
263.0
261.0
259.0
257.0
255.0
253.0
251.0
249.0
247.0
245.0
243.0
241.0
239.0
237.0
235.0
ft
0
603
941
1428
1937
2369
2745
3228
3379
3677
4030
4215
4765
5185
5571
5945
6210
6789
7355
Link
K_4_6.1
U_4_1.1
K_3_4.1
K_3_3.1
14_DD.1
14_DB.1
-
J_5_11.1
-
J_4_8.1
J_4_7.1
-
J_3_5.1
J_3_4.1
J_2_3.1
J_2_2.1
-
-
24A_1A.1
I_5_10.1
Node
K_4_6
U_4_1
K_3_4
K_3_3
14_DD
14_DB
-
J_5_11
J_5_10
J_4_8
J_4_7
J_4_6
J_3_5
J_3_4
J_2_3
J_2_2
J_2_1
-
24A_1A
I_5_10
I_4_9

Future Performance

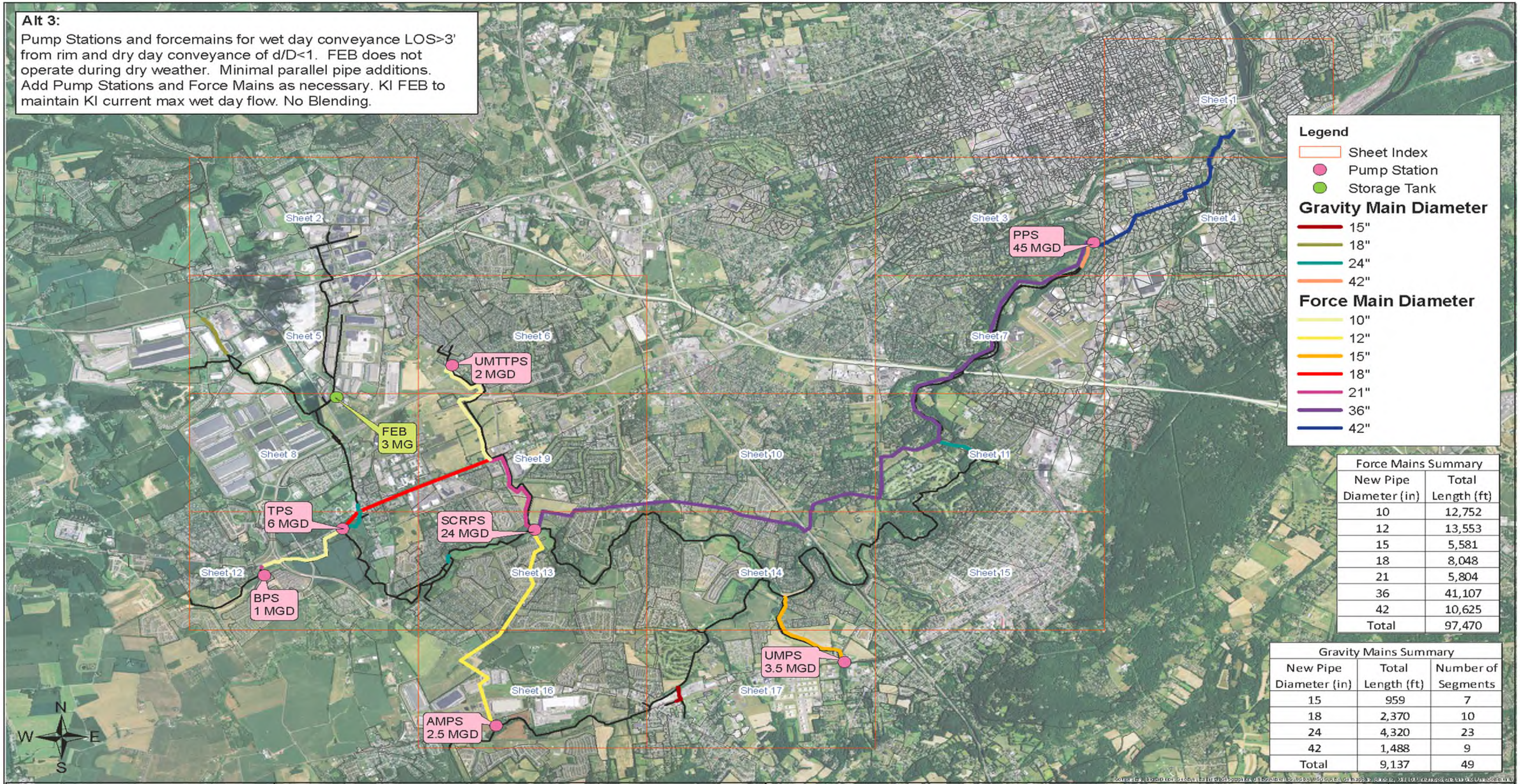
- Converting farms to houses and warehouses
- Revelopment
- Expanding service area
- Adding more hauled waste
- Losing industry
- Adding industry
- Aging (leaking) pipes
- Weather changes
- Water conservation

Future infrastructure needs

- Estimating reductions from sewer collection system rehab
- Estimating reductions from private property leakage reductions
- What and where are conveyance capacity improvements needed
- When to install capacity improvements
- Replacement vs parallel
- Correctly sizing interceptors, pump station, tanks
- Determining impact on treatment plants
- Determining impact on downstream signatories

Alternative analyses are like experimenting to find best formula

Alt 3:
Pump Stations and forcemains for wet day conveyance LOS>3' from rim and dry day conveyance of d/D<1. FEB does not operate during dry weather. Minimal parallel pipe additions. Add Pump Stations and Force Mains as necessary. KI FEB to maintain KI current max wet day flow. No Blending.



Force Mains Summary

New Pipe Diameter (in)	Total Length (ft)
10	12,752
12	13,553
15	5,581
18	8,048
21	5,804
36	41,107
42	10,625
Total	97,470

Gravity Mains Summary

New Pipe Diameter (in)	Total Length (ft)	Number of Segments
15	959	7
18	2,370	10
24	4,320	23
42	1,488	9
Total	9,137	49

ARCADIS

Lehigh County Authority
Sanitary Sewer Capacity Assurance and Rehabilitation Program

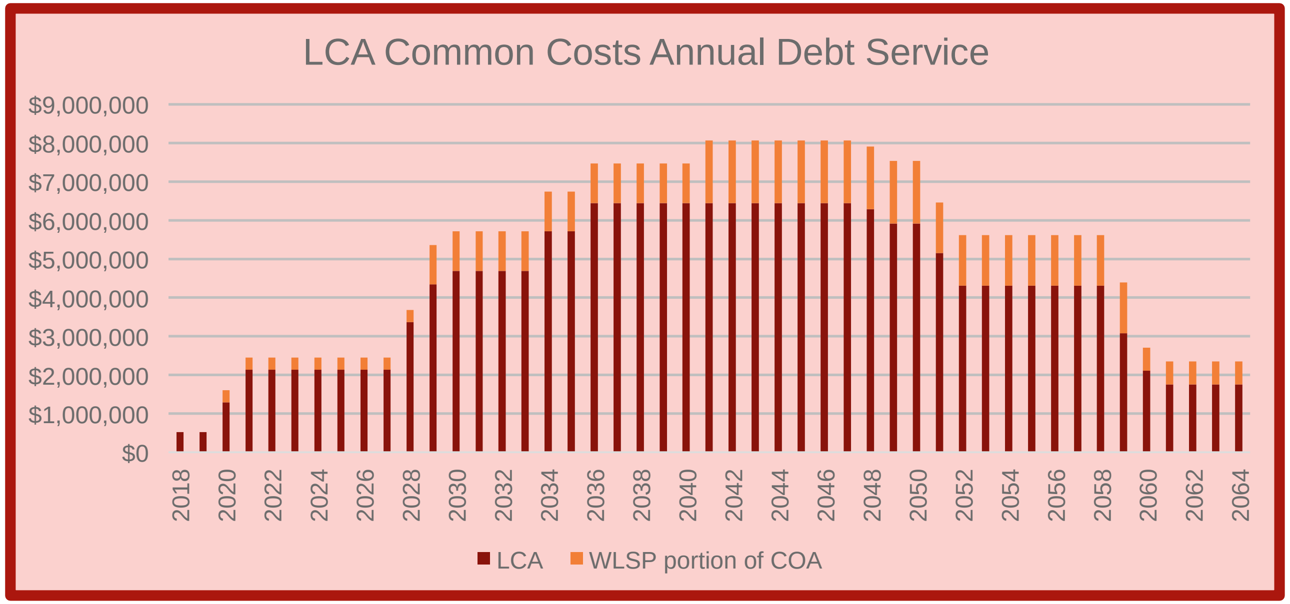
00247545 - ALTERNATIVE 3 - KISS MODEL - 2040 FORCE MAINS

ARCADIS

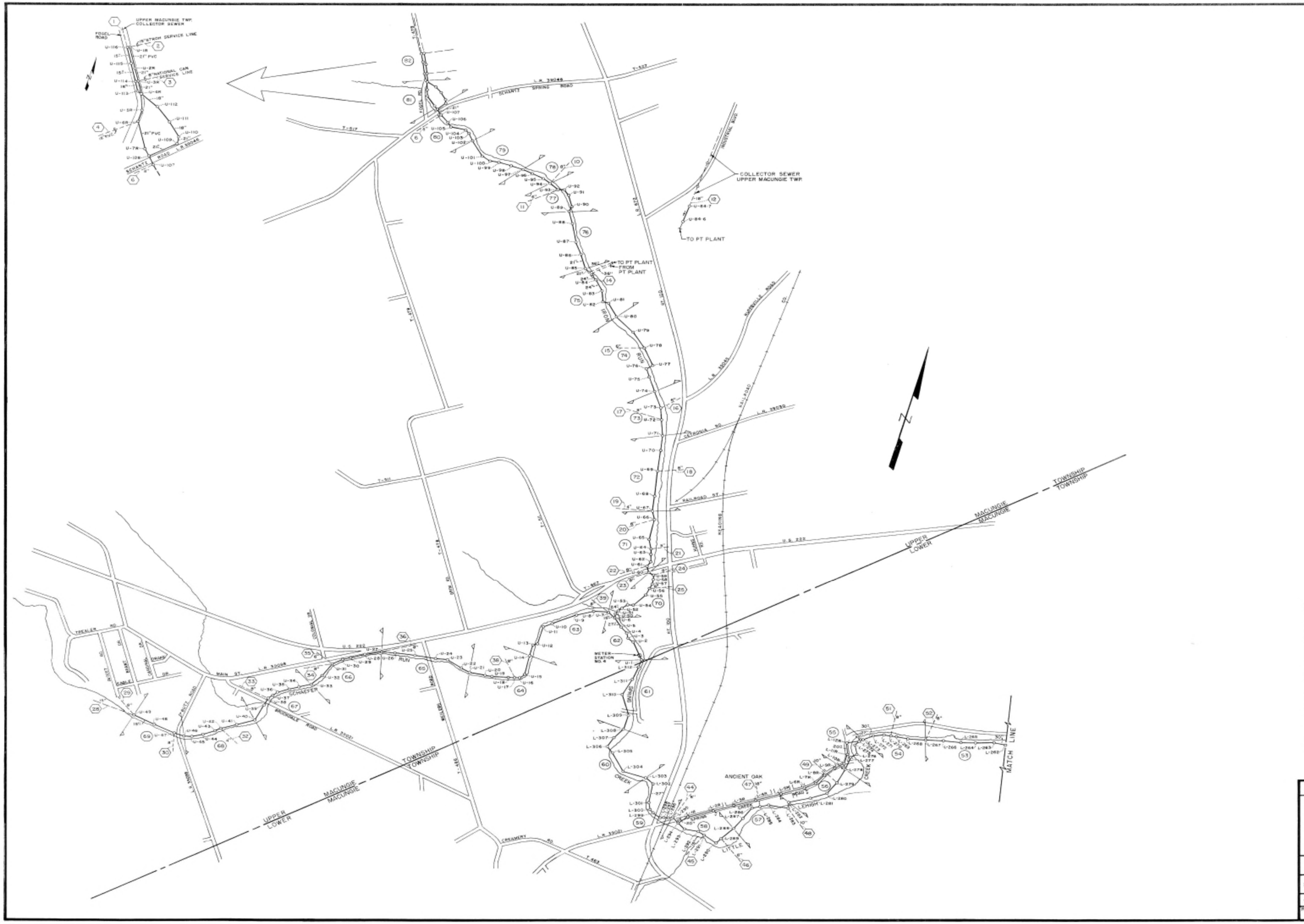
May 2015

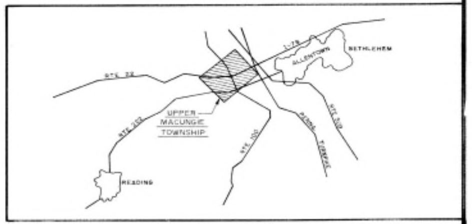
Capital Planning and Cash Flow

	Spend Year	LCA's Portion of Spend Year Capital
WLI Trunkline Rehab	2016	$ 820,000
Park Pump Station Refurbishment	2018	$ 2,842,991
WLI Main Rehab 2	2018	$ 3,446,050
Park Force Main Refurbishment	2019	$ 3,201,057
Park Force Main Extension	2020	$ 2,551,597
Phase 1 COA EQ Tanks	2020	$ 5,657,041
Park Force Main	2027	$ 23,554,139
Park Pump Station	2028	$ 18,816,676
Phase 2 COA EQ Tanks	2029	$ 14,129,738
Kecks Bridge Park Interceptor	2030	$ 27,779,985
Upper Milford Relief Trunk Line	2032	$ 7,424,496
AMTL Relief Trunk Line	2034	$ 8,879,518
Ancient Oaks Interceptor	2036	$ 37,146,122
Phase 3 COA EQ Tanks	2040	$ 12,977,609



What are steps to modeling?

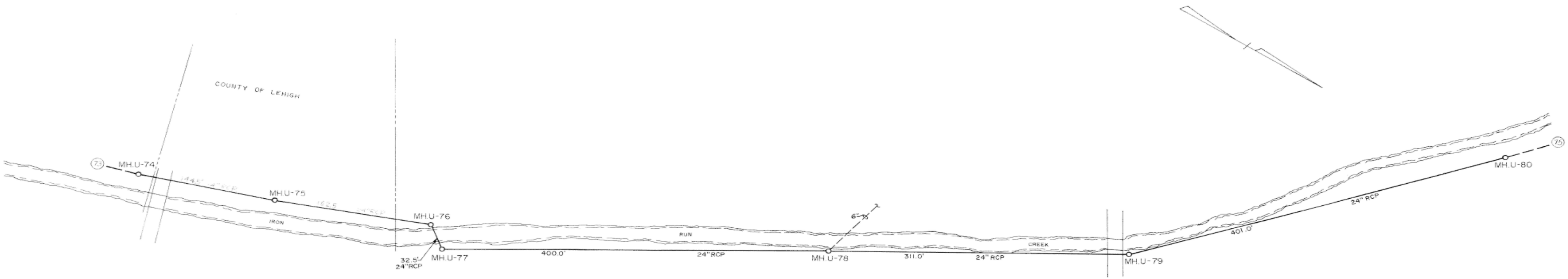




LOCATION MAP

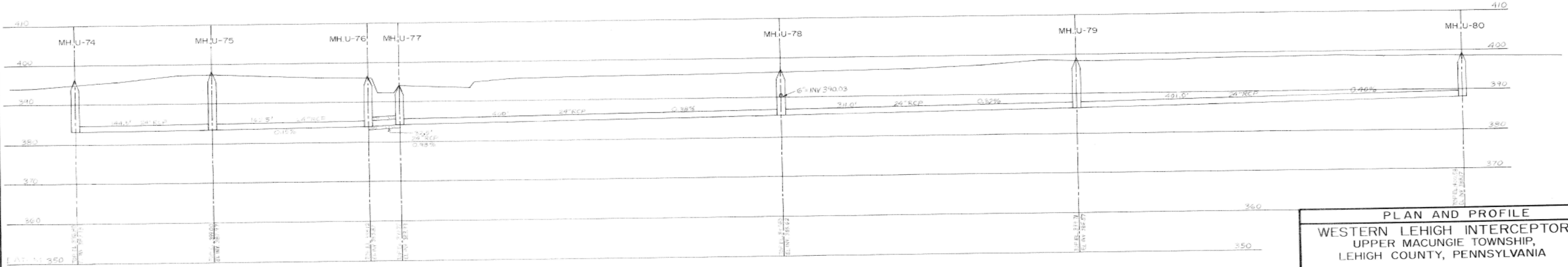
LEHIGH COUNTY AUTHORITY
INTERCEPTOR SEWER

SCALE: 1" = 800'	LEHIGH COUNTY AUTHORITY P. O. BOX 3348 1053 SPRUCE ROAD WESCOSVILLE, PENNA. 18106		PROJECT NO.
DWN. BY: C.R.D.			DATE: JUNE 1991
CKD. BY: S.R.	REV.1 1/7/92 C.R.D. ADDED SEWER CONNECTION NUMBERS	REV.2	DWG. NO.
REV.3	REV.4	REV.5	REV.6 SHEET



PLAN

SCALE: 1" = 50'



PROFILE

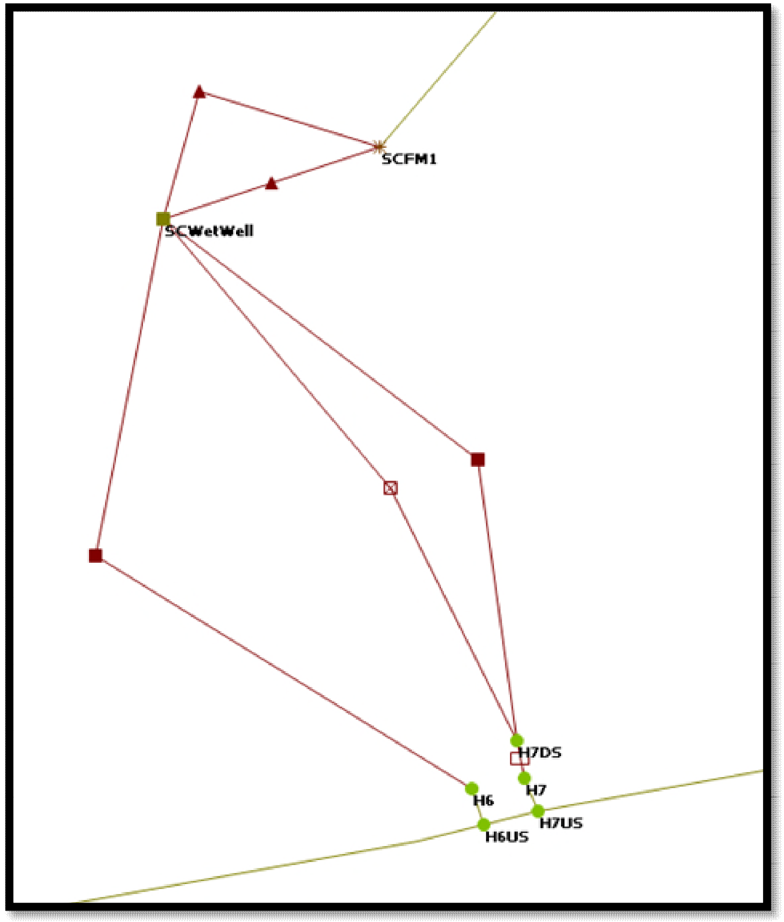
SCALE: HORIZ. - 1" = 50'
VERT. - 1" = 10'

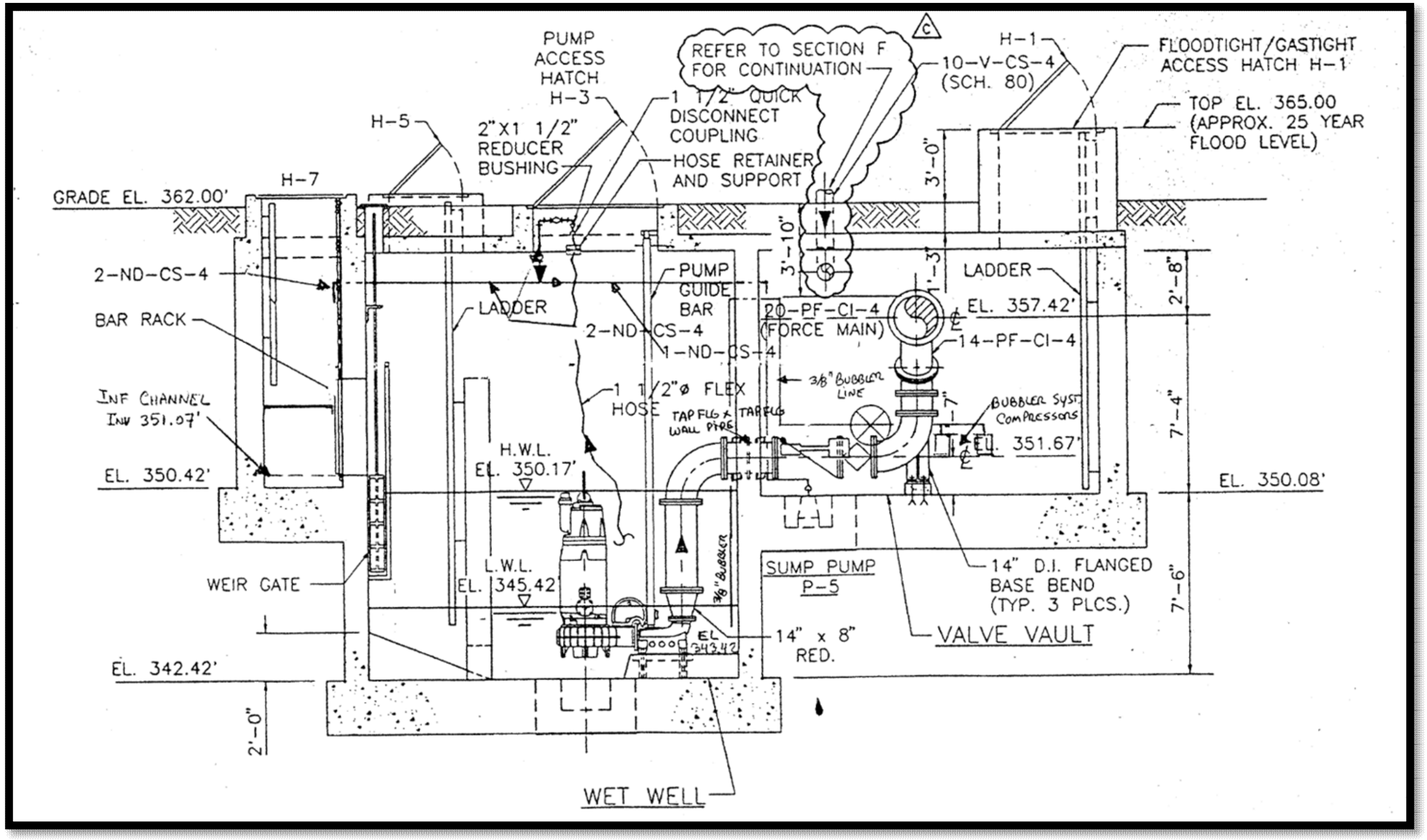
NOTE:
PIPELINE INVERTS & SLOPES ARE BASED ON L.C.A. FIELD SURVEY, COMPLETED SUMMER OF 1989. SEE SHEET NO. FOR ORIGINAL AS-BUILT INFORMATION.

(13 OF 21)

PLAN AND PROFILE		
WESTERN LEHIGH INTERCEPTOR UPPER MACUNGIE TOWNSHIP, LEHIGH COUNTY, PENNSYLVANIA		
SCALE AS SHOWN	LEHIGH COUNTY AUTHORITY P. O. BOX 3348 1053 SPRUCE ROAD WESCOSVILLE, PA. 18106	PROJECT NO.
DWN BY: C.R.D.		DATE 5/2/91
CKD BY: S.R.	REV.1 / REV.2	DWG. NO.
REV.3	REV.4 / REV.5 / REV.6	SHEET NO. 74 OF 85

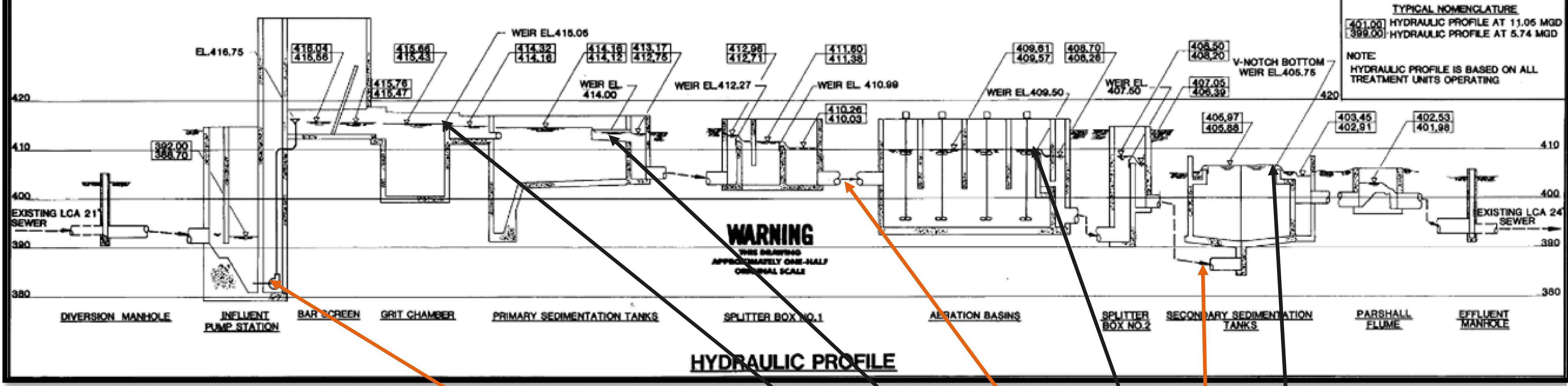
Spring Creek Pump Station



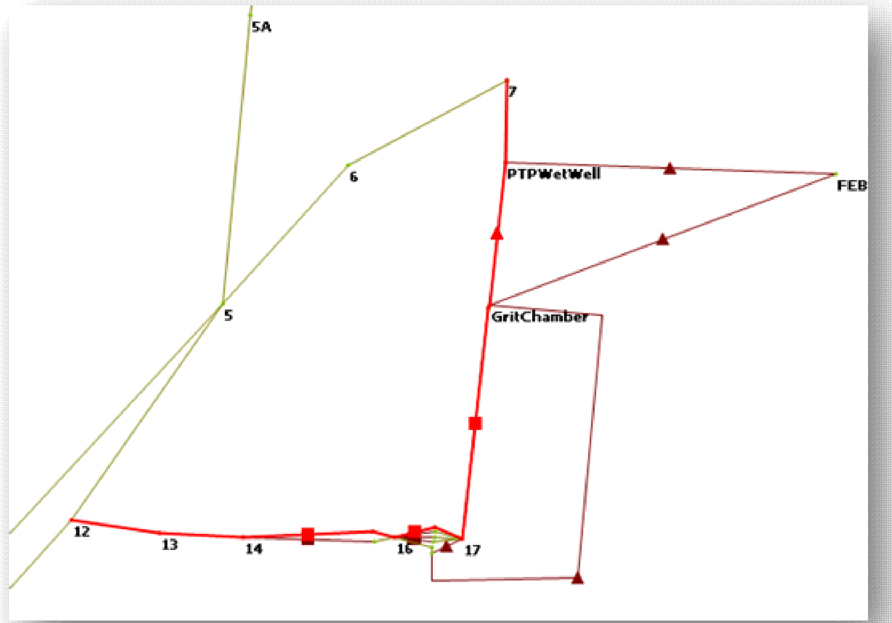


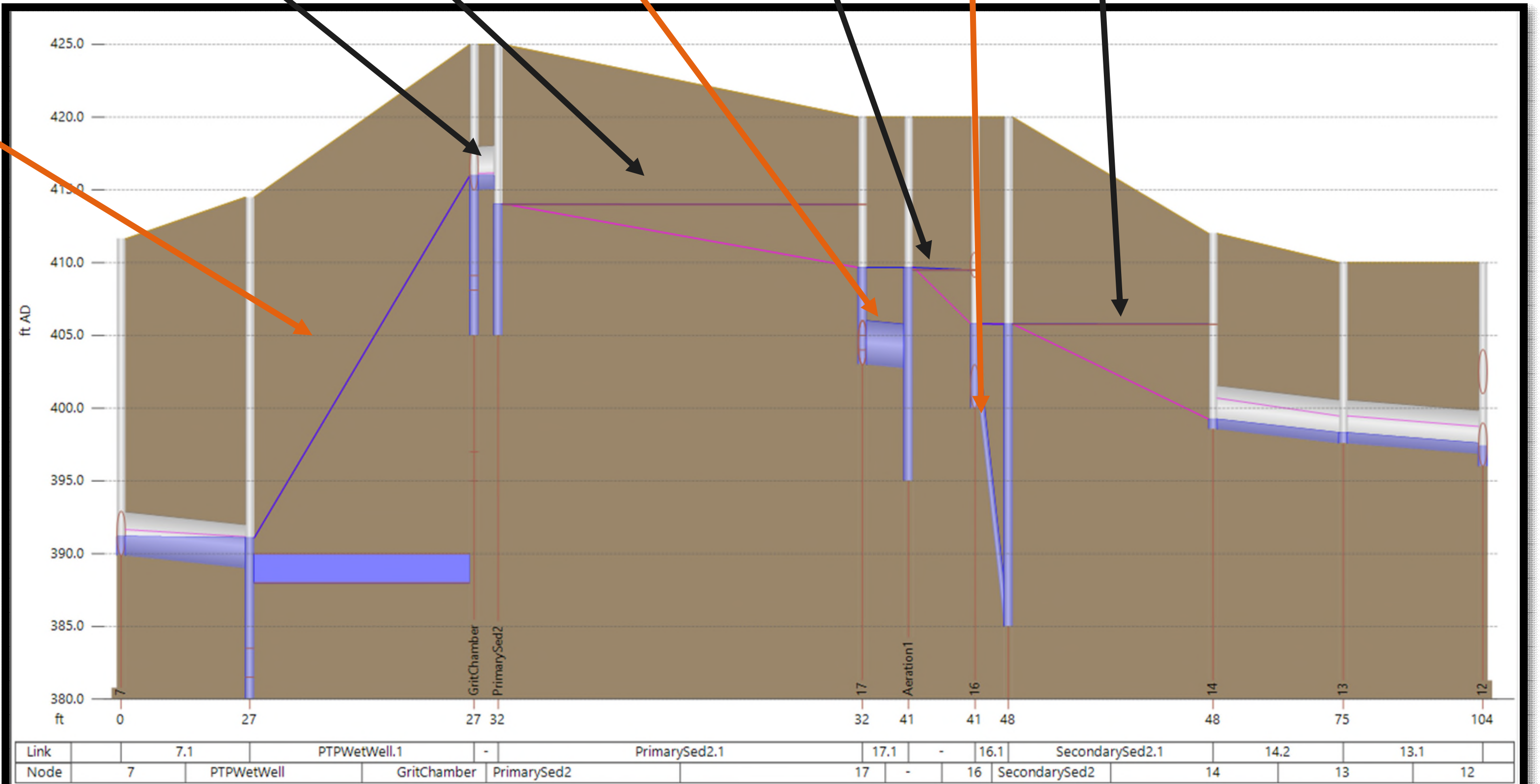
No RTC Control

Wet Well and Pump Curves

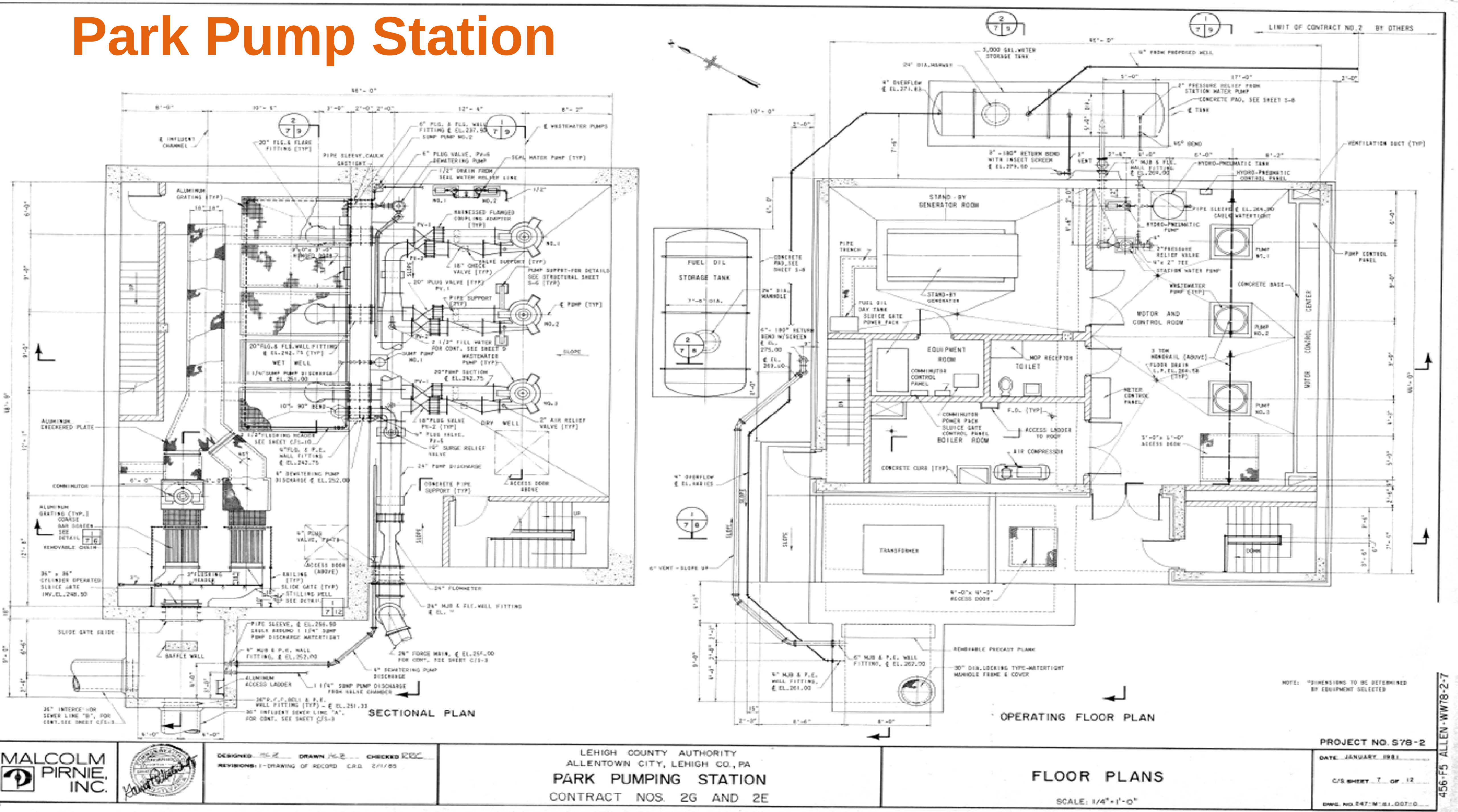


Pretreatment Plant

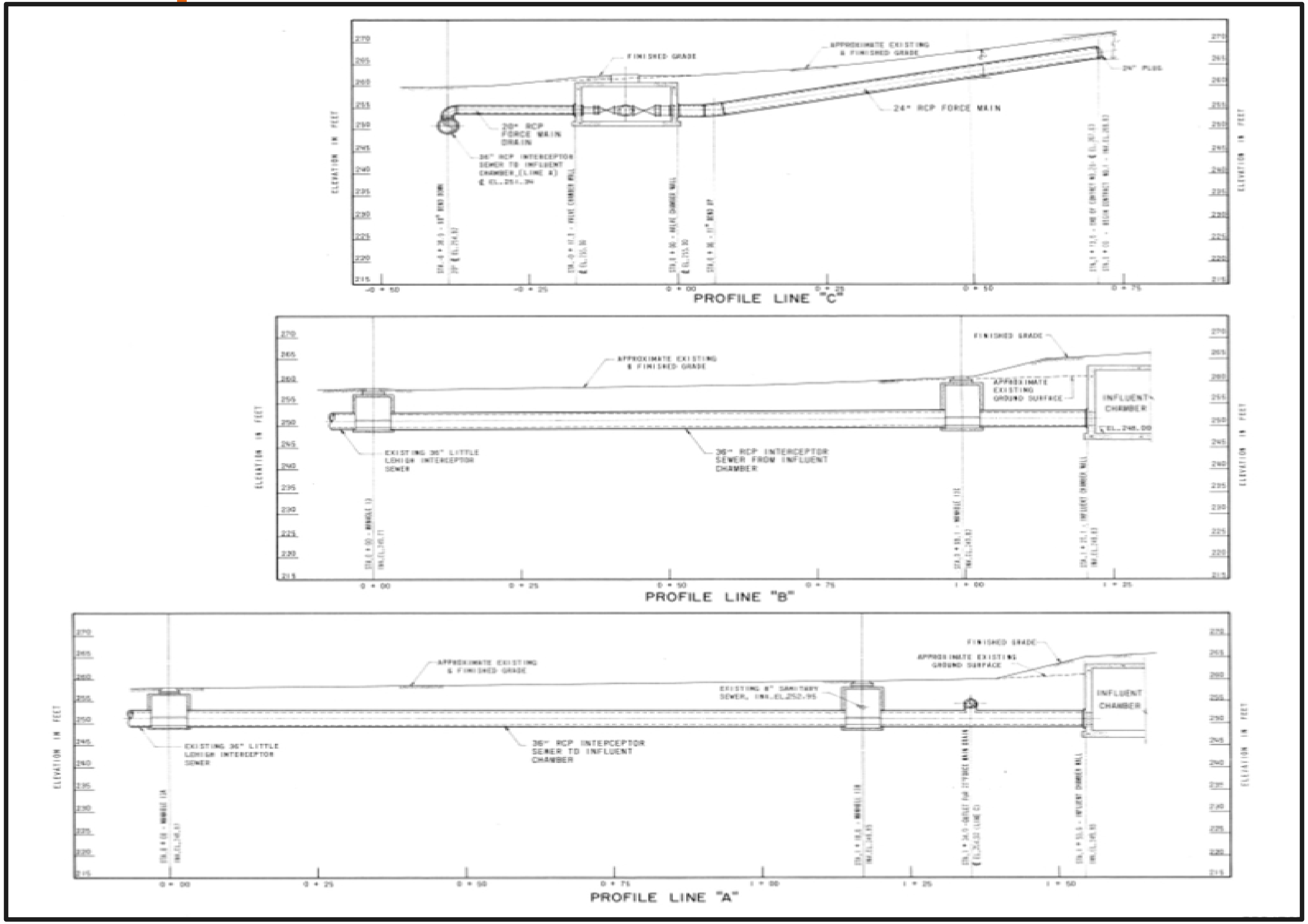




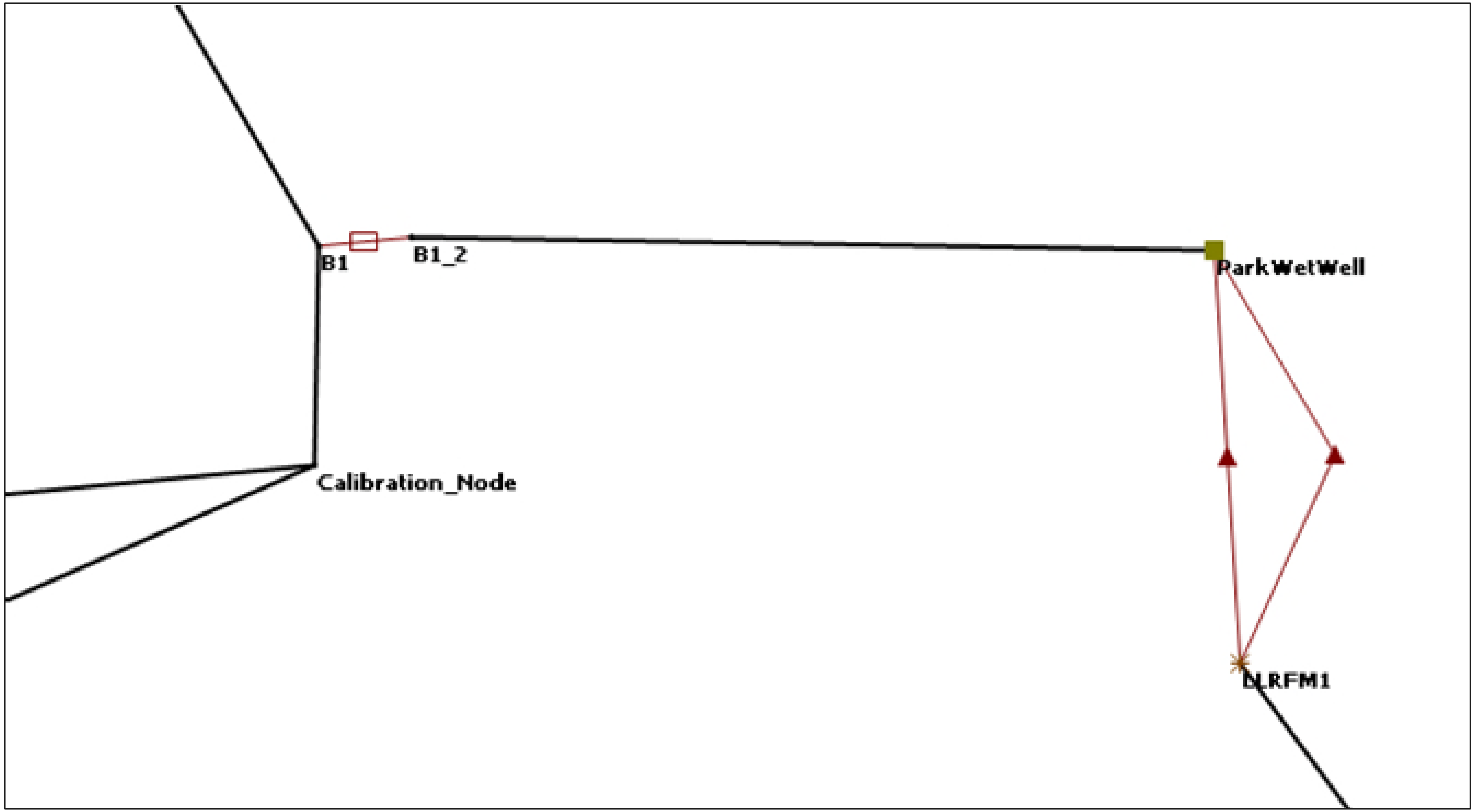
Park Pump Station



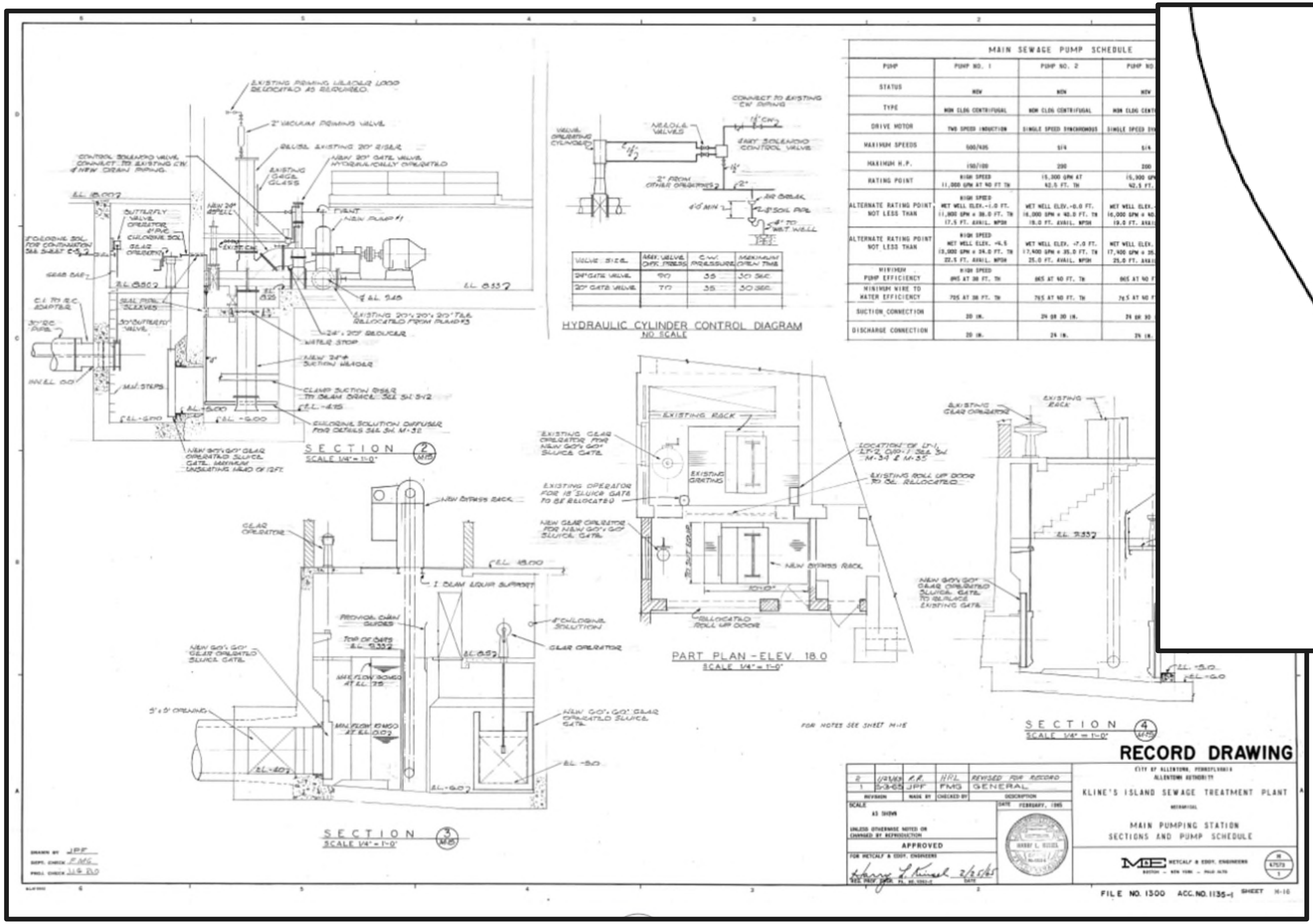
Park Pump Station

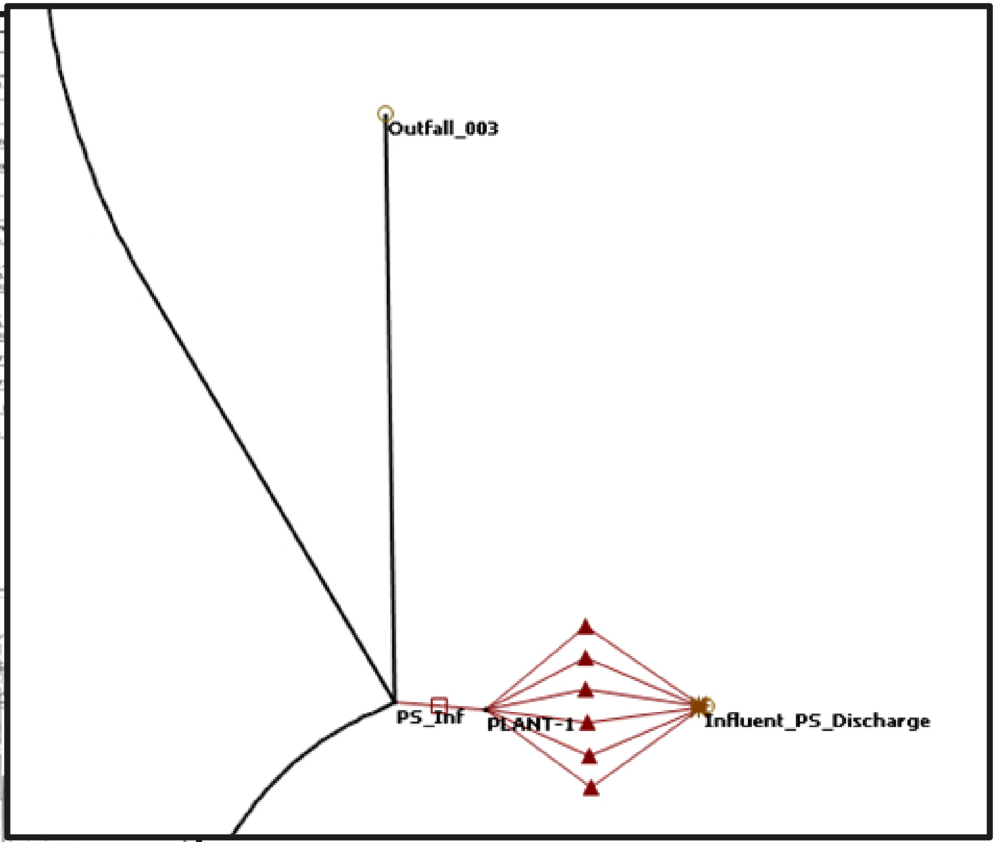


Park Pump Station



ARCADIS Design & Consultancy for natural and built assets





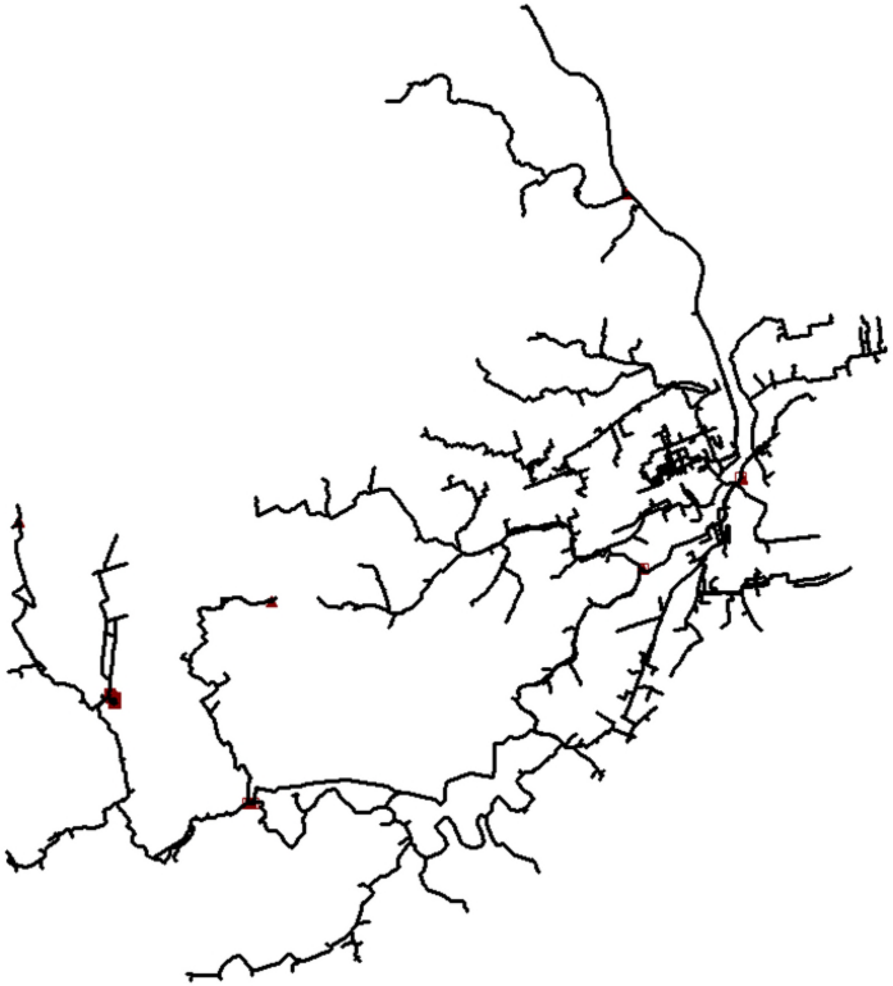
Kline’s Island Main Lift Station

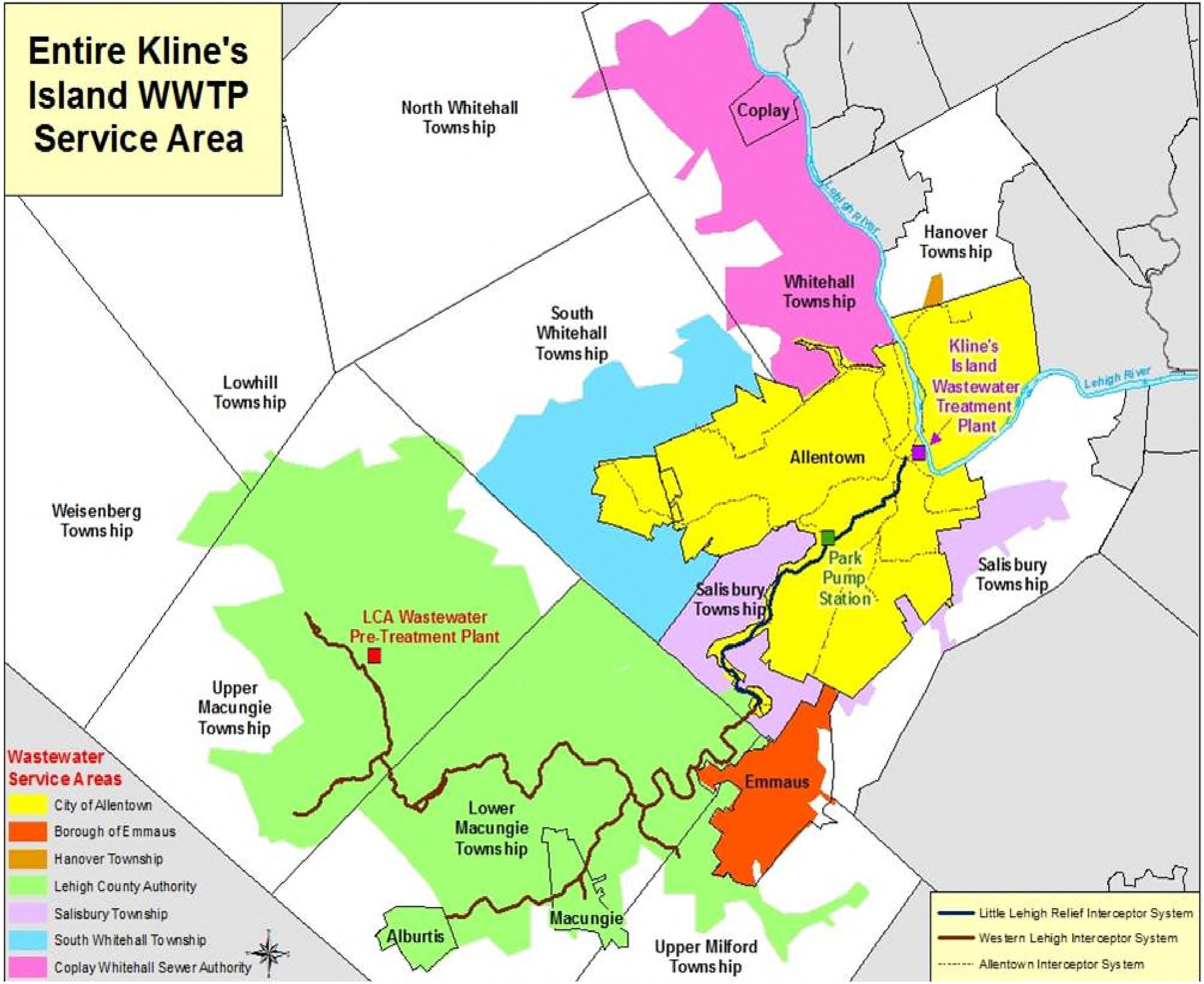
As-Is vs. Should Be

<u>Key components are not operated or are not able to be operated according to typical or design-intent control logic</u>

- FEB
  - Completely manual on and off
  - Fill rate is function of effluent flow meter, which is impacted by submergence
- Spring Creek Pump Station
  - Wet well gates are continually broken, so left in open position
  - Interceptor flow level control logic not working
- Park Pump Station
  - Wet Well sluice gate actuator is not compatible with control logic, so preset manually by operator
  - Pumps run longer than necessary to reduce surges at KI WWTP
- KI Main Lift Station
  - Turning on of auxiliary pump station is manual
  - Rock media recirc and sludge digester reject are manual operations

Model Extents

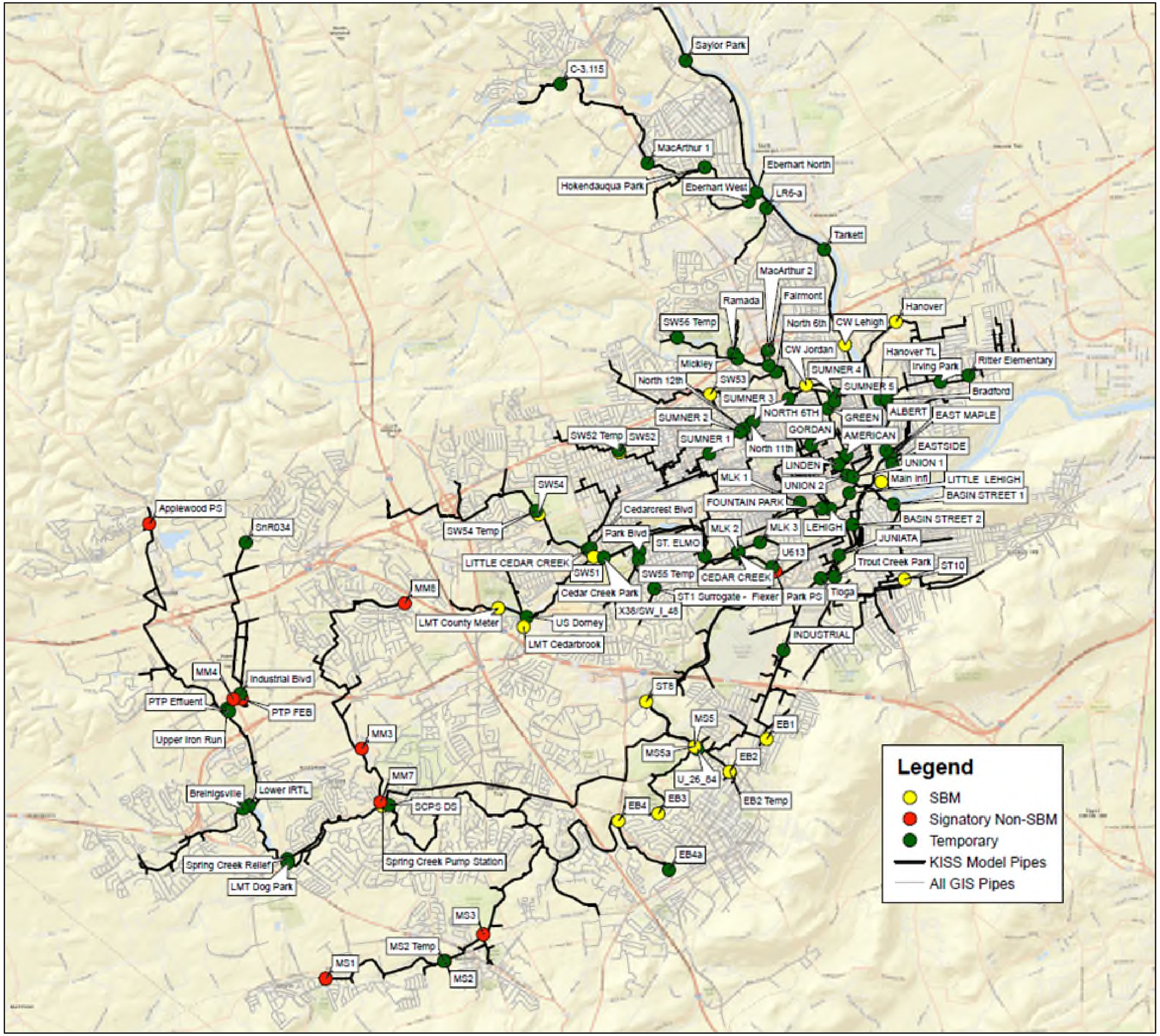




2021 Flow Meters for Calibration

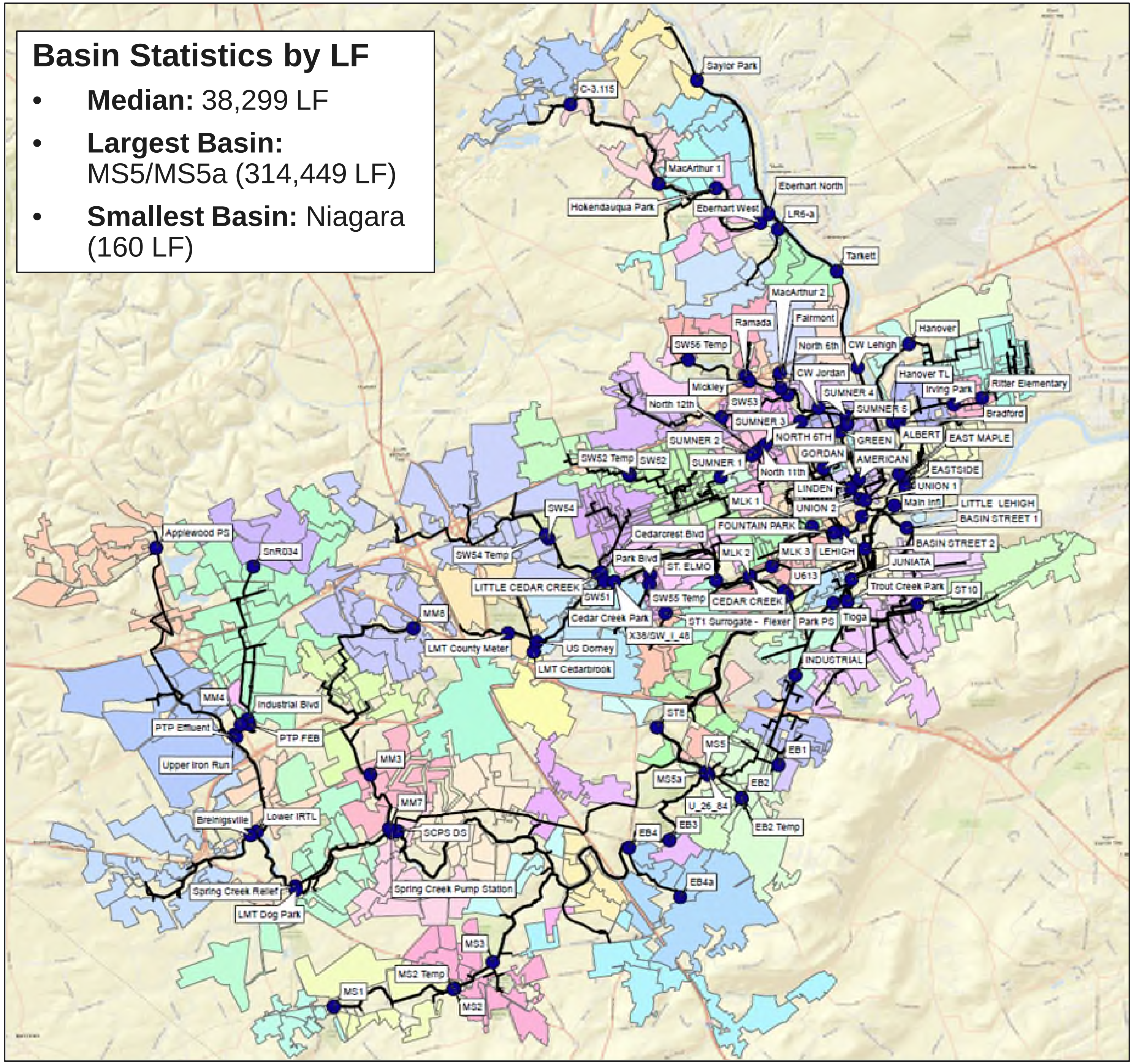
- Signatory Billing Meters
- Signatory Non-Billing Meters
- Temporary Stations

- 97 total meters used for calibration



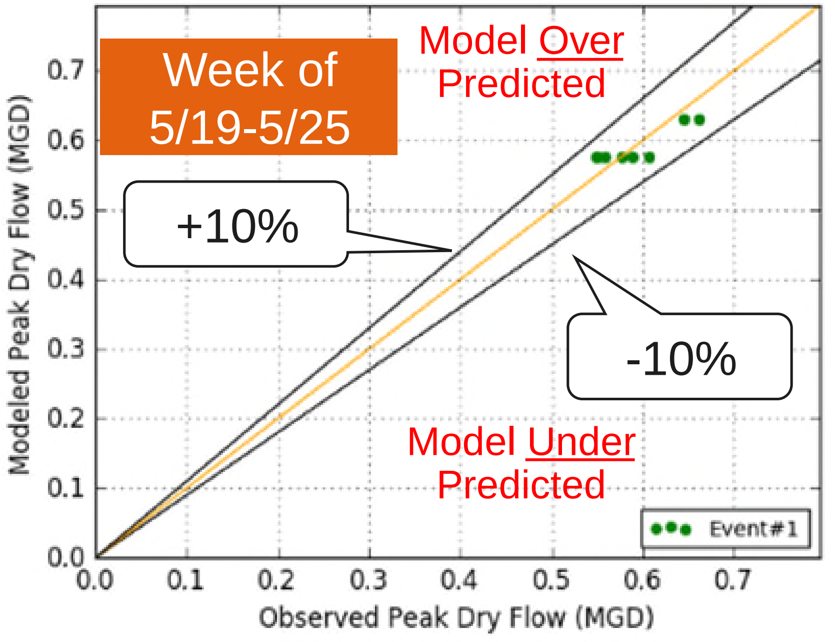
Basins and Catchments

- 87 Basins in model
- 933 Catchments in model
- Catchments broken out by area, type of user, and location (bottomlands)

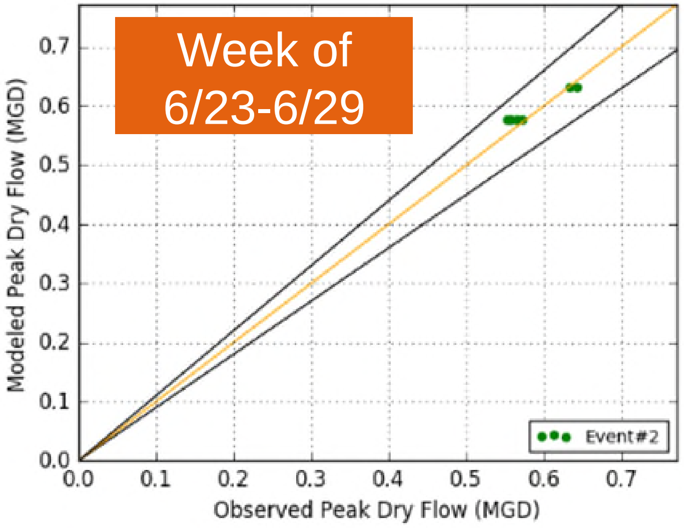


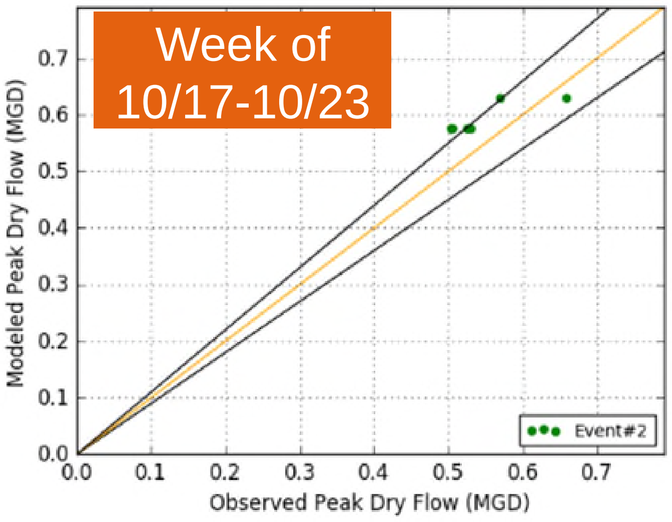
Dry Weather Calibration Guidelines

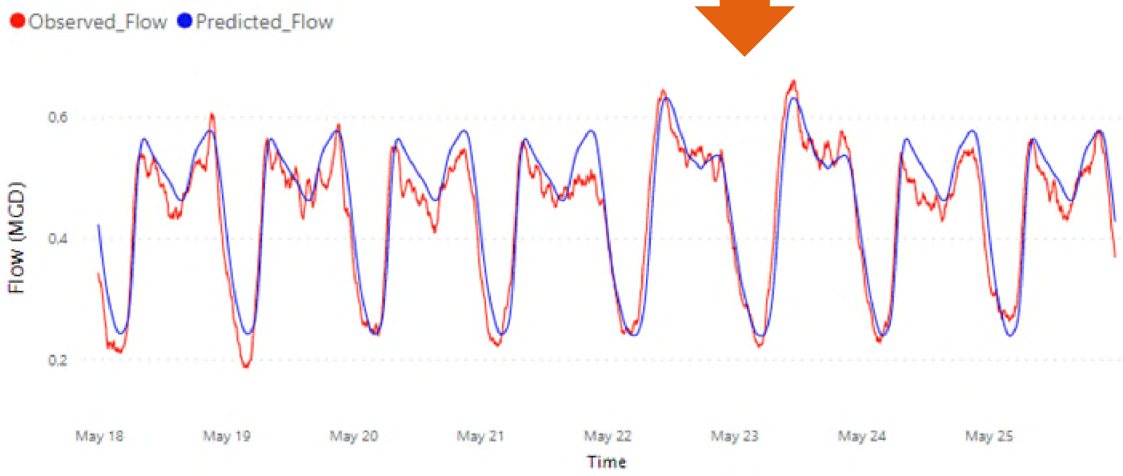
Parameter	Guidelines
Peak Flow Rate	-10% to +10% of measured
Flow Volume	-10% to +10% of measured
Peak Depth	± 0.33 ft at non-surcharged locations -0.33 ft to +1.67 ft at surcharged locations
Shape	The shape of modeled and metered curves should be similar for flow.



MacArthur 1 (C-3.57)







Dry Weather Flow Calibration

Modeler
All

Meter
MacArthur_1

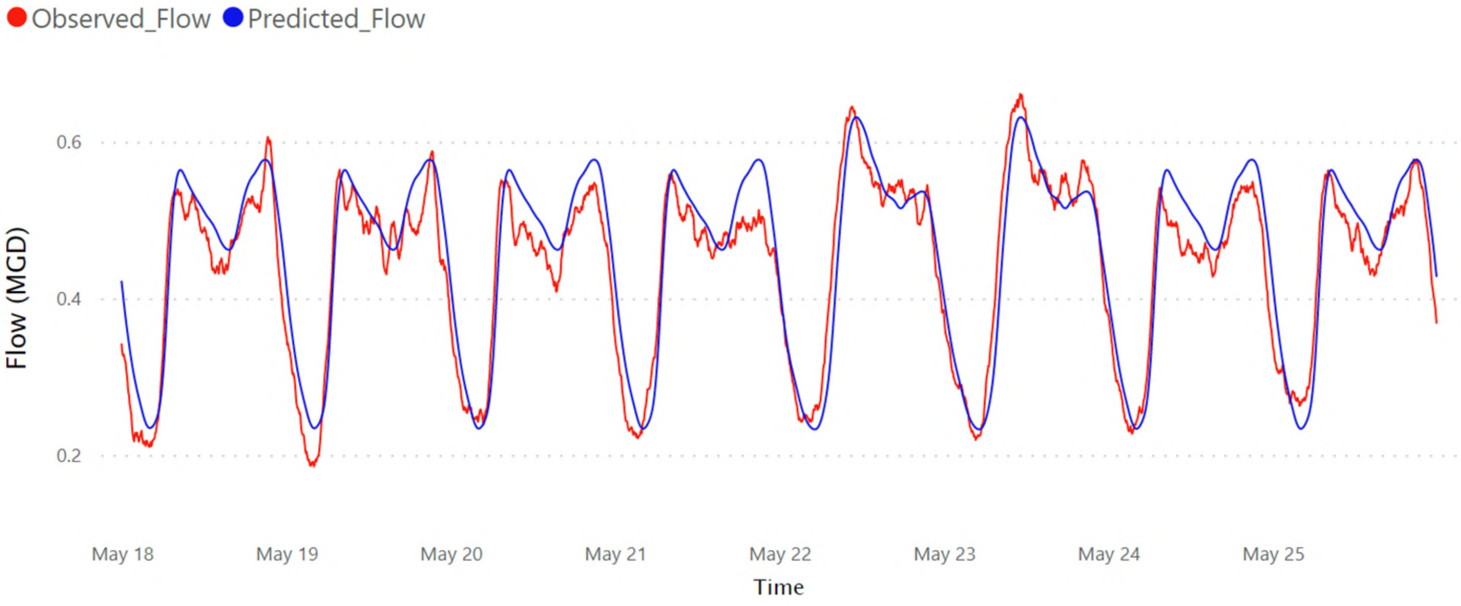
5/18/2021 5/25/2021

EDU
2077

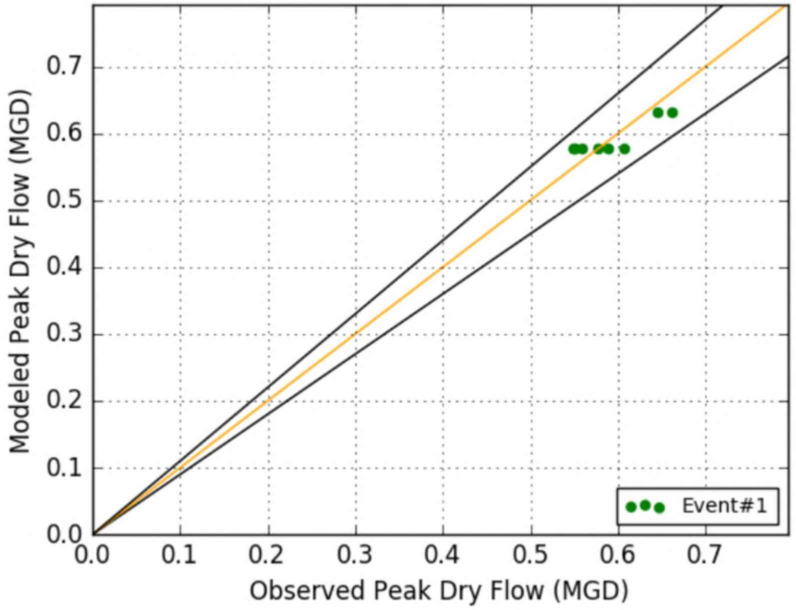
Meter Location

Power BI Dashboard

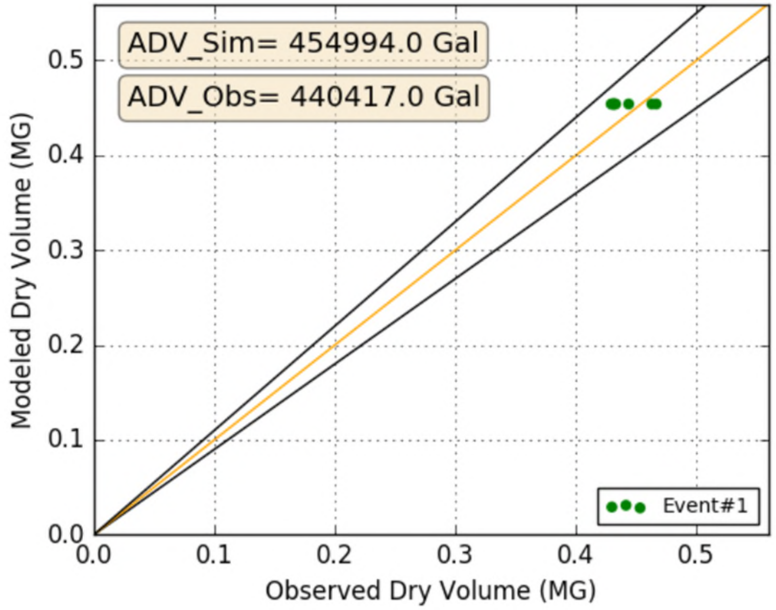
Event#1 Start 05/18/2021 End 05/25/2021



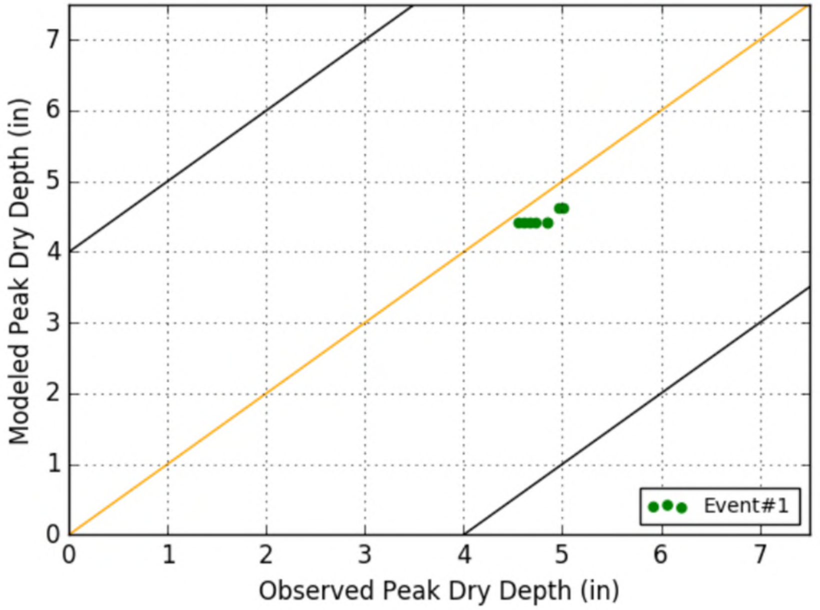
Peak Flow (MGD), -/+ 10%



Volume (MG) -/+ 10%



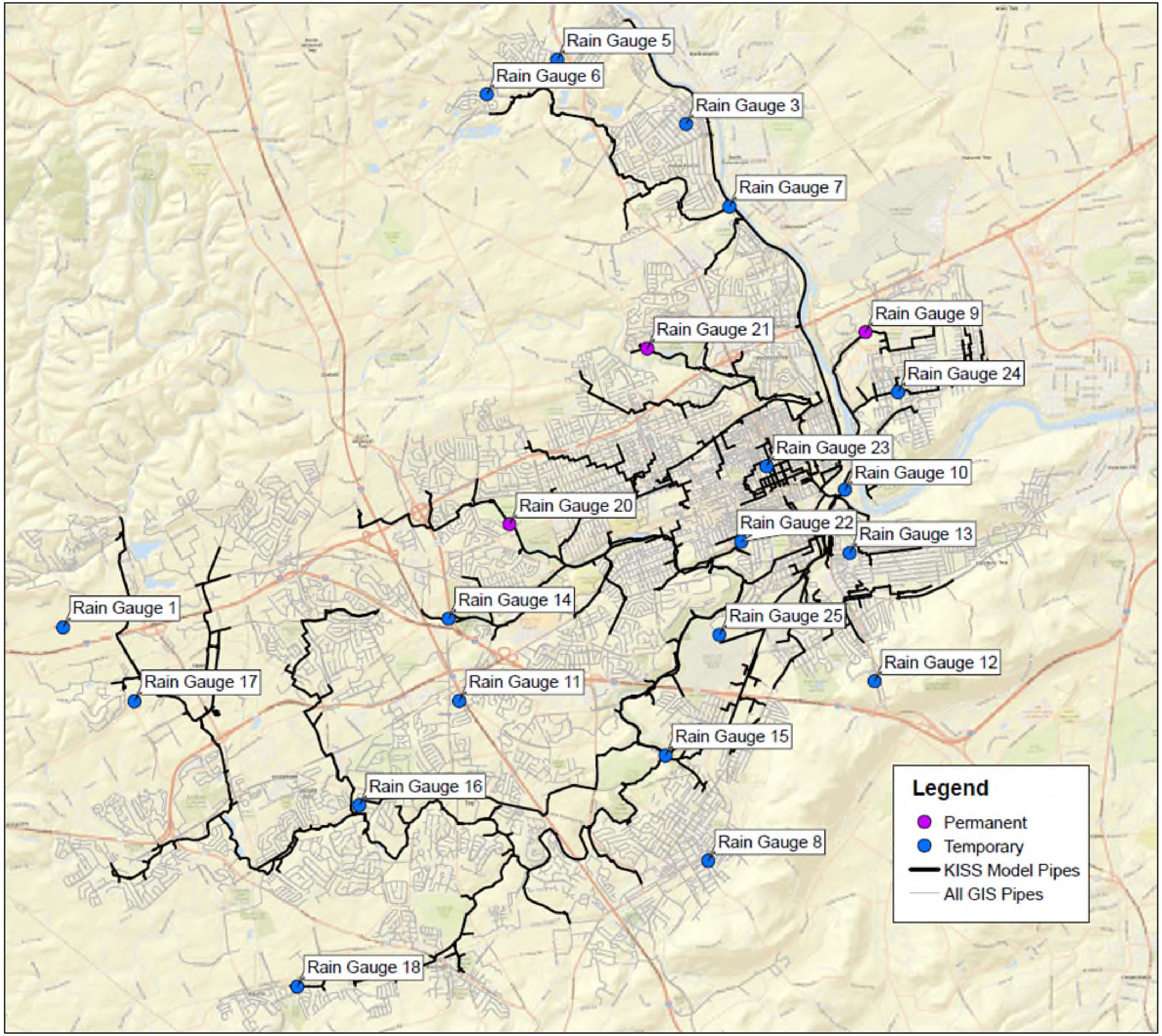
Peak Depth (in), -/+ 4 inches



But sometimes, it rains

Rain Gauge Data Source and Locations

- 29 total rain gauges
- Permanent gauges
- Temporary gauges



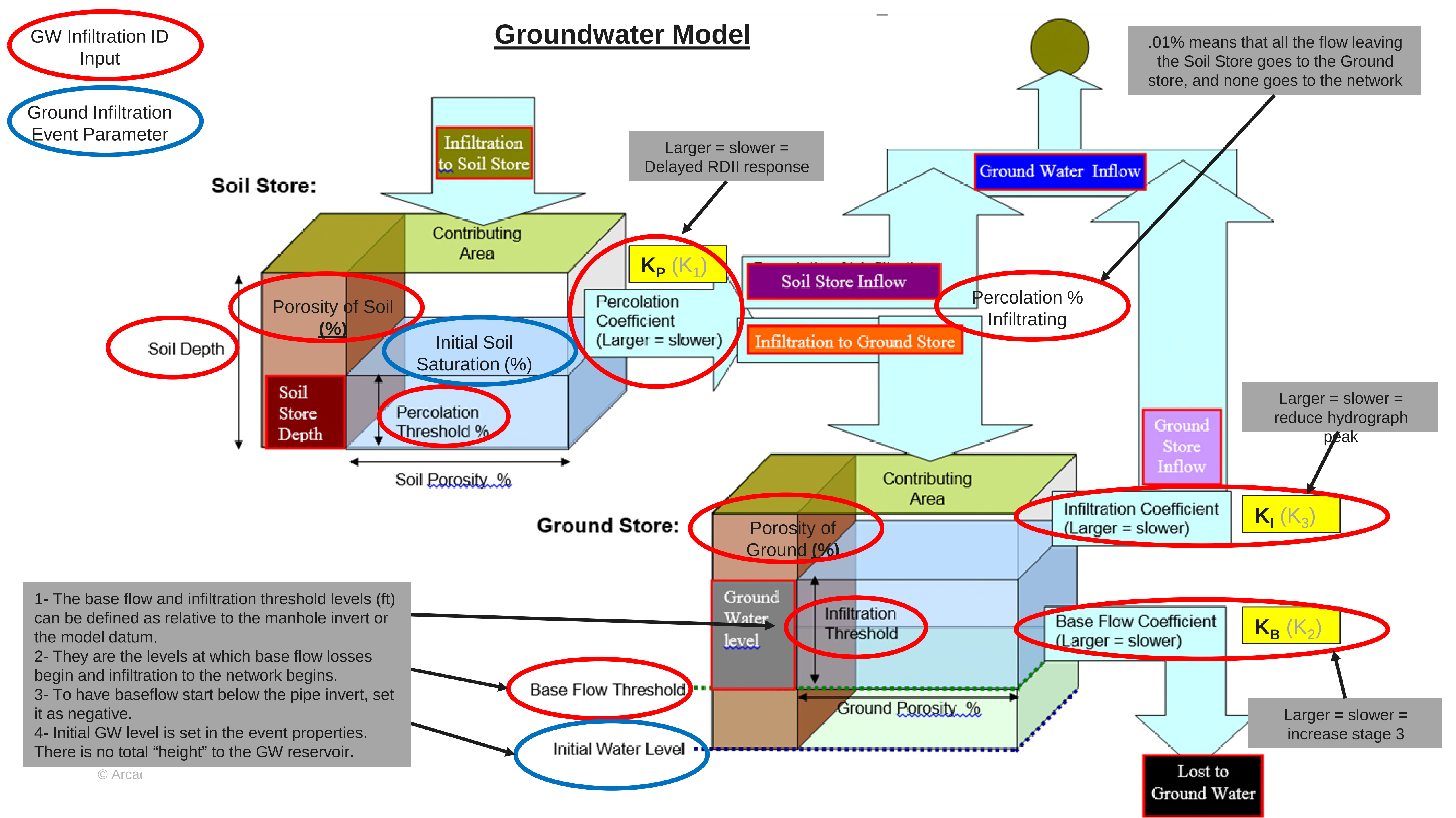
ICM Catchments Grid - Rainfall derived inflow and infiltration (RDII)

Catchment
Land use ID
Runoff area 1 (%)
Runoff area 2 (%)
Runoff area 3 (%)
Runoff area 4 (%)
Ground infiltration ID
Rainfall profile
Evaporation profile

Land use
Land use ID
Runoff surface 1
Default area 1 (%)
Runoff surface 2
Default area 2 (%)
Runoff surface 3
Default area 3 (%)
Runoff surface 4
Default area 4 (%)

Runoff Surface
Runoff surface ID
Runoff routing value
New UK depth (ft)
Initial loss value (ft)

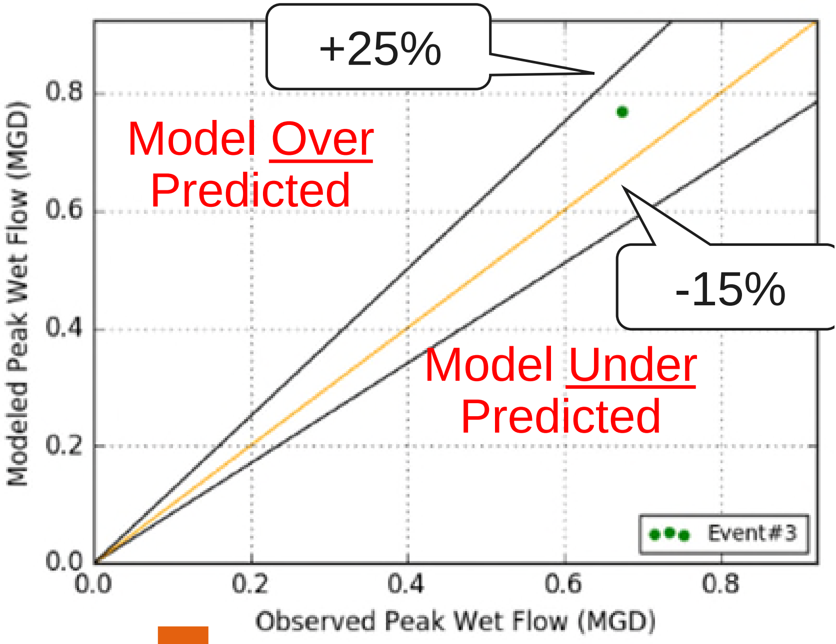
Ground infiltration
Ground infiltration ID
Percolation coefficient
Percolation percentage infiltrating
Percolation threshold
Infiltration coefficient
Baseflow coefficient
Baseflow threshold level (ft)
Infiltration threshold level (ft)



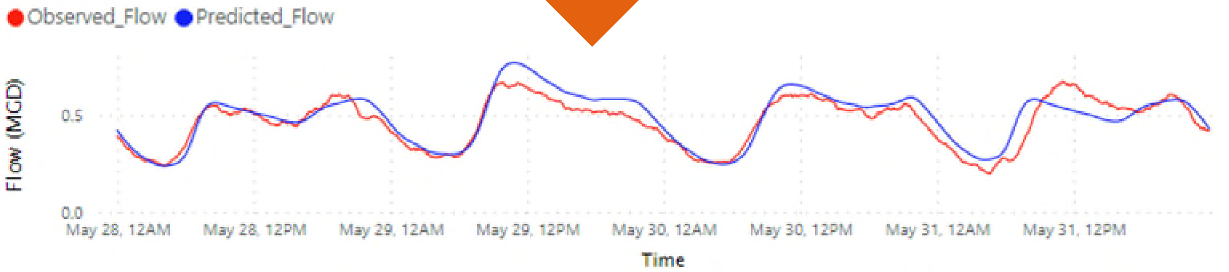
Groundwater Model
GW Infiltration ID Input
Ground Infiltration Event Parameter
Soil Store:
Infiltration to Soil Store
Contributing Area
Porosity of Soil (%)
Soil Depth
Initial Soil Saturation (%)
Soil Store Depth
Percolation Threshold %
Soil Porosity %
Larger = slower = Delayed RDII response
K_P (K_1)
Percolation Coefficient (Larger = slower)
Soil Store Inflow
Infiltration to Ground Store
Percolation % Infiltrating
Ground Water Inflow
.01% means that all the flow leaving the Soil Store goes to the Ground store, and none goes to the network
Ground Store:
Contributing Area
Porosity of Ground (%)
Ground Water level
Infiltration Threshold
Ground Porosity %
Ground Store Inflow
Larger = slower = reduce hydrograph peak
Infiltration Coefficient (Larger = slower)
K_I (K_3)
Base Flow Coefficient (Larger = slower)
K_B (K_2)
Larger = slower = increase stage 3
Lost to Ground Water
Base Flow Threshold
Initial Water Level
1- The base flow and infiltration threshold levels (ft) can be defined as relative to the manhole invert or the model datum.
2- They are the levels at which base flow losses begin and infiltration to the network begins.
3- To have baseflow start below the pipe invert, set it as negative.
4- Initial GW level is set in the event properties. There is no total "height" to the GW reservoir.

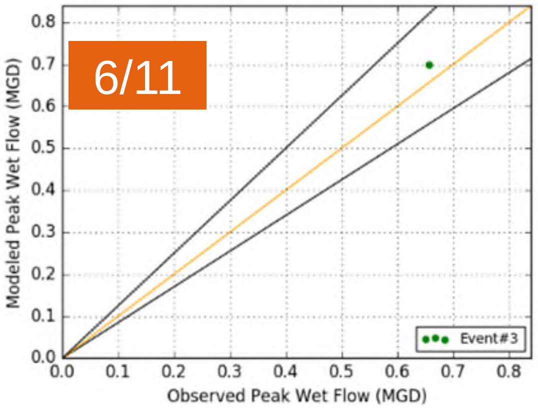
Wet Weather Calibration Guideline

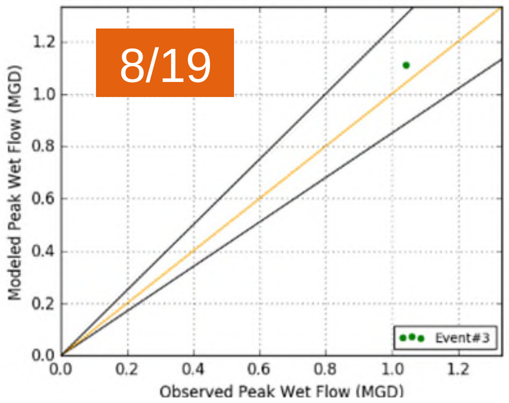
Parameter	WaPUG (Used in 2021)
Peak Flow Rate	-15% to +25% of measured
Flow Volume	-10% to +20% of measured
Peak Depth	No Change
Shape	No Change

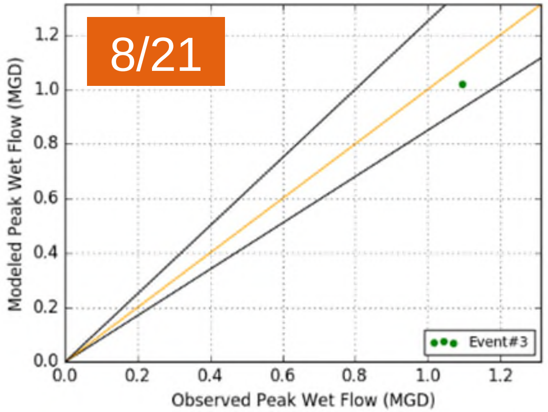


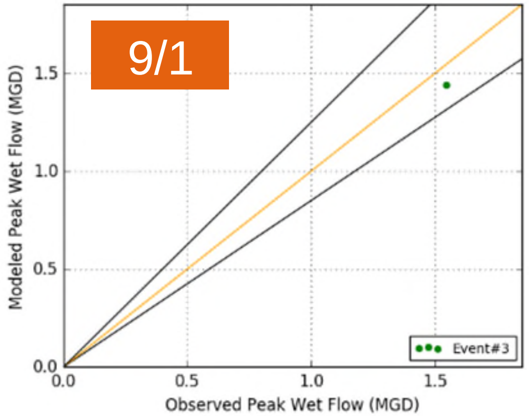
MacArthur 1 (C-3.57)

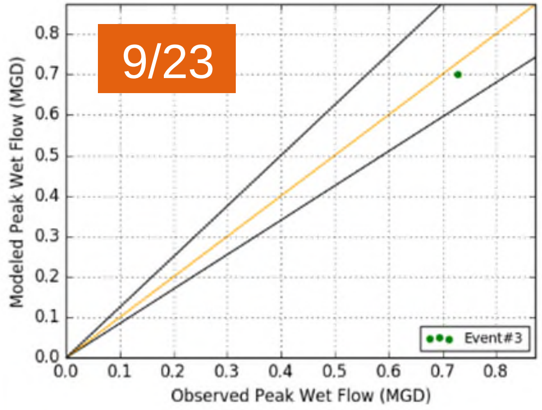


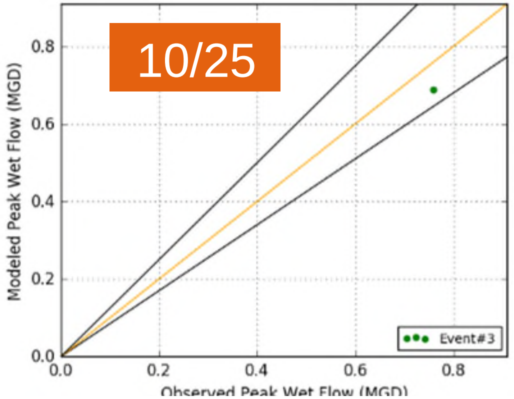












Wet Weather Flow Calibration

Modeler

All

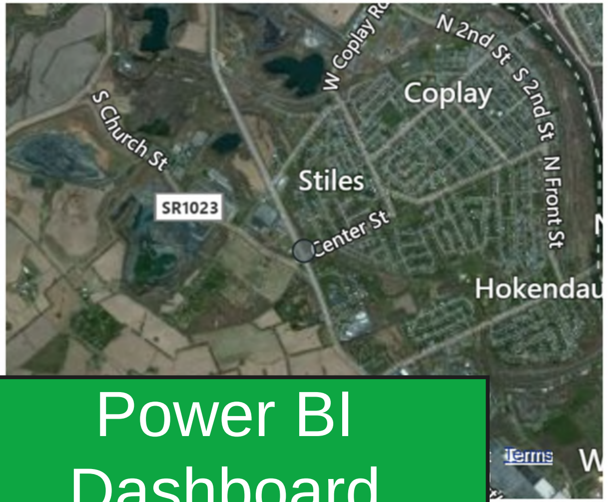
Meter

MacArthur_1

Date

8/22/2021 8/24/2021

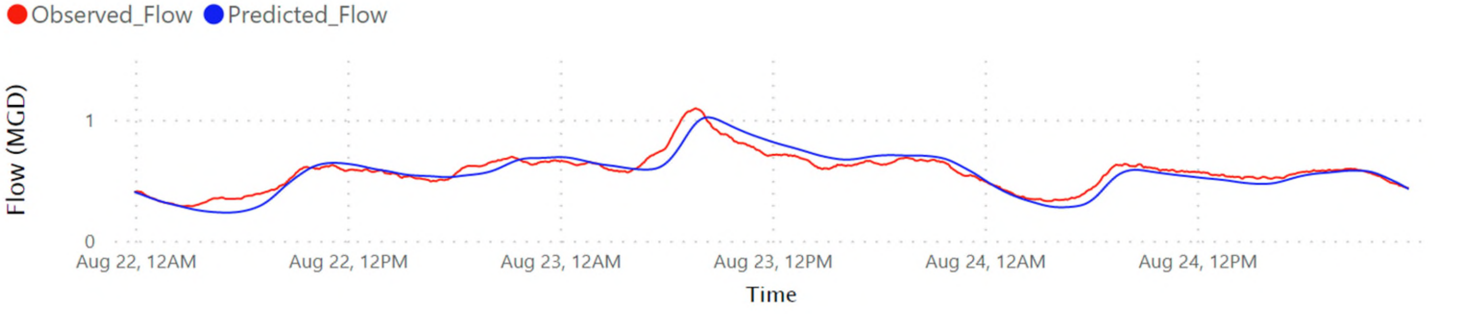
Meter Location



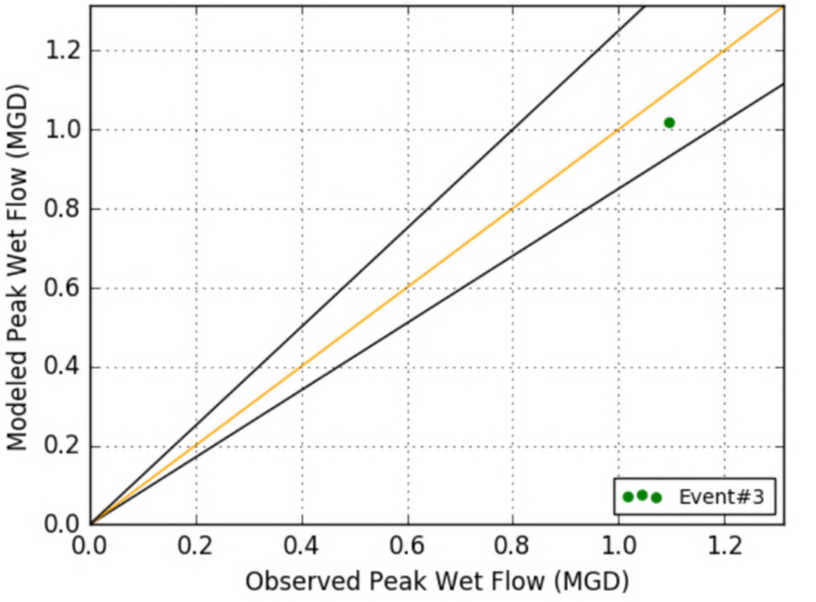
Power BI Dashboard

Event#4

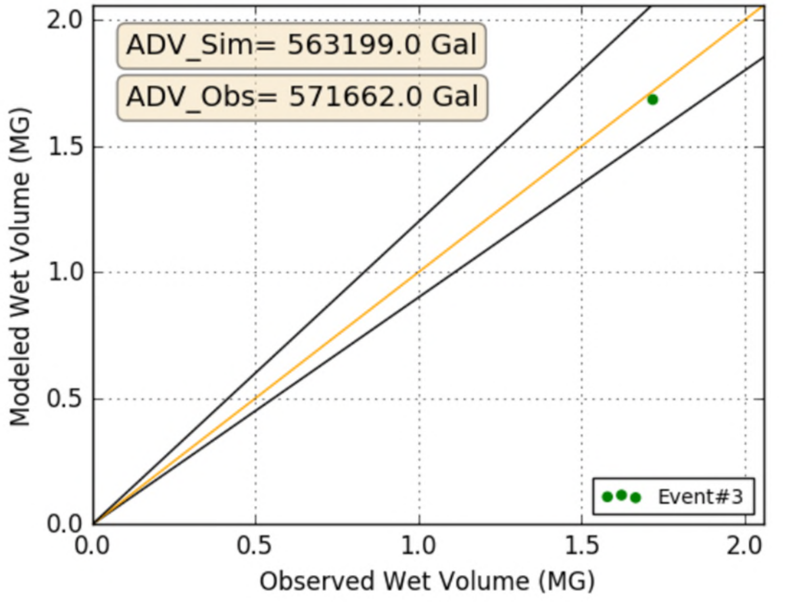
Start 08/22/2021 End 08/24/2021



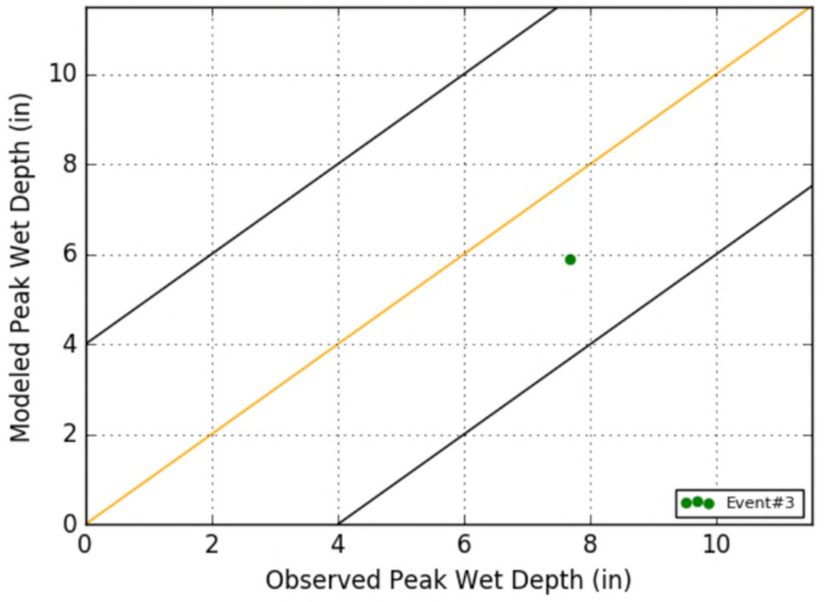
Peak Flow (MGD), -15% to +25%



Volume (MG) -10% to +20%

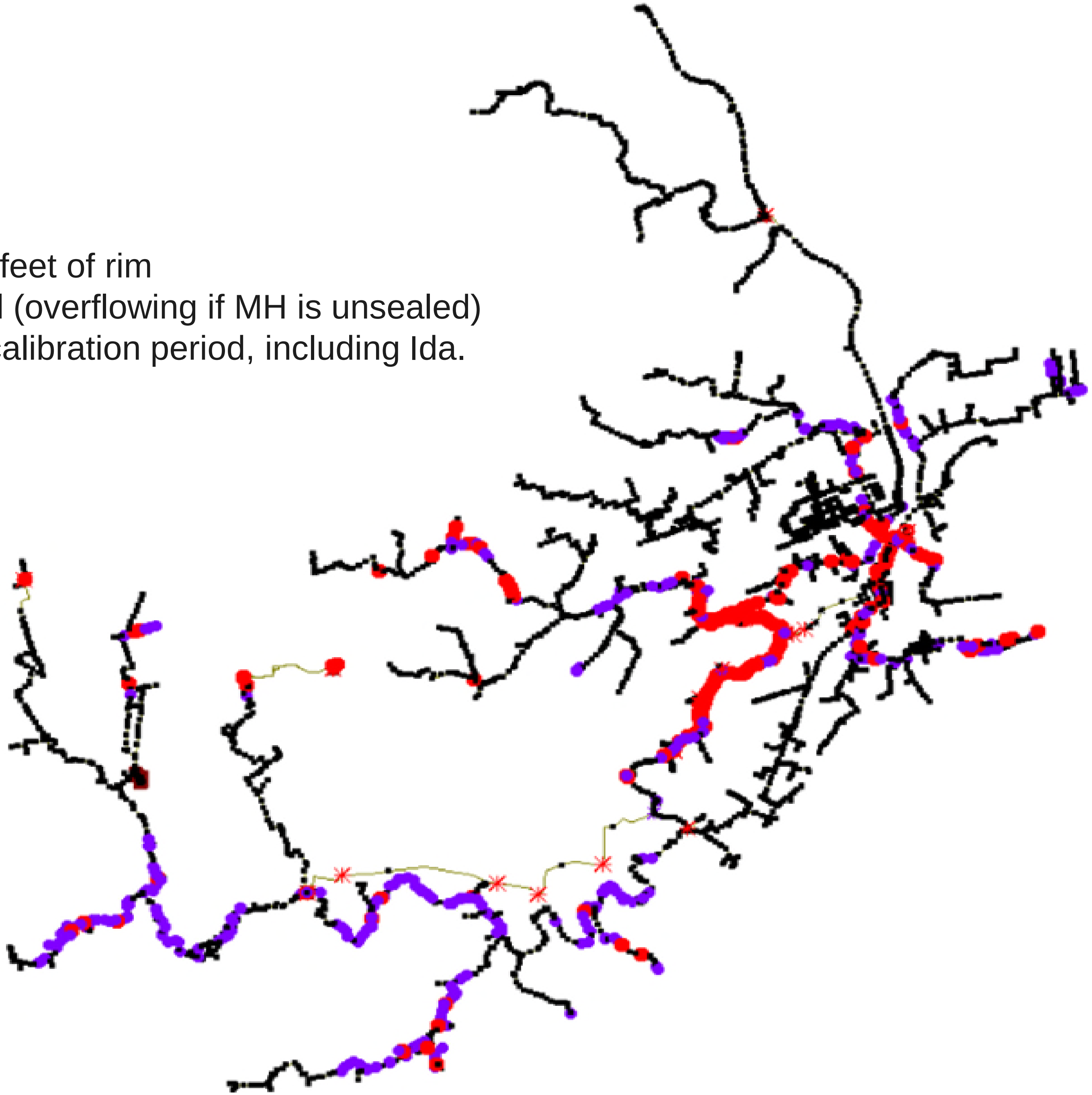


Peak Depth (in), -/+ 4 inches



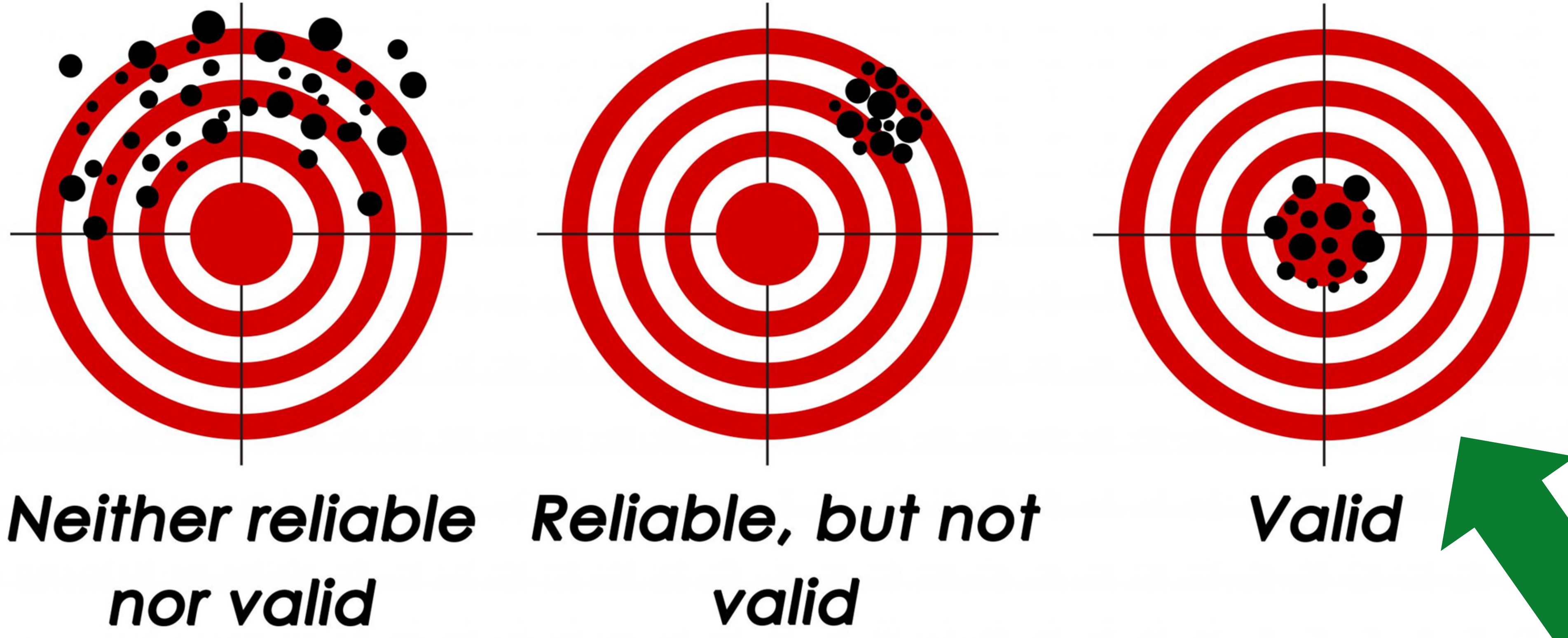
Results

Purple is within 3 feet of rim
Red is at rim level (overflowing if MH is unsealed)
This is for entire calibration period, including Ida.



Where are KISS model's strengths and weaknesses?

WLSP PORTION OF MODEL

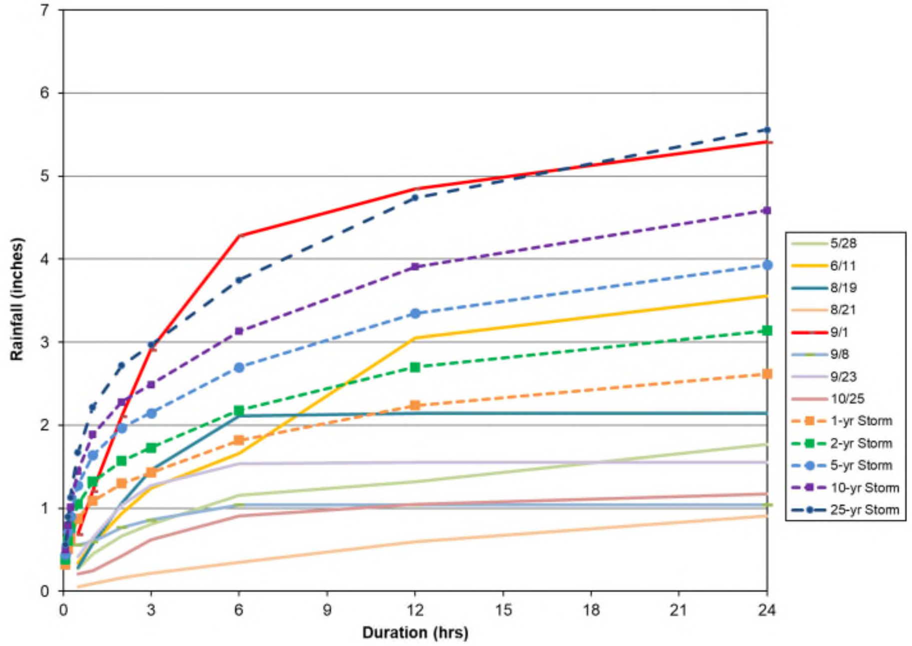


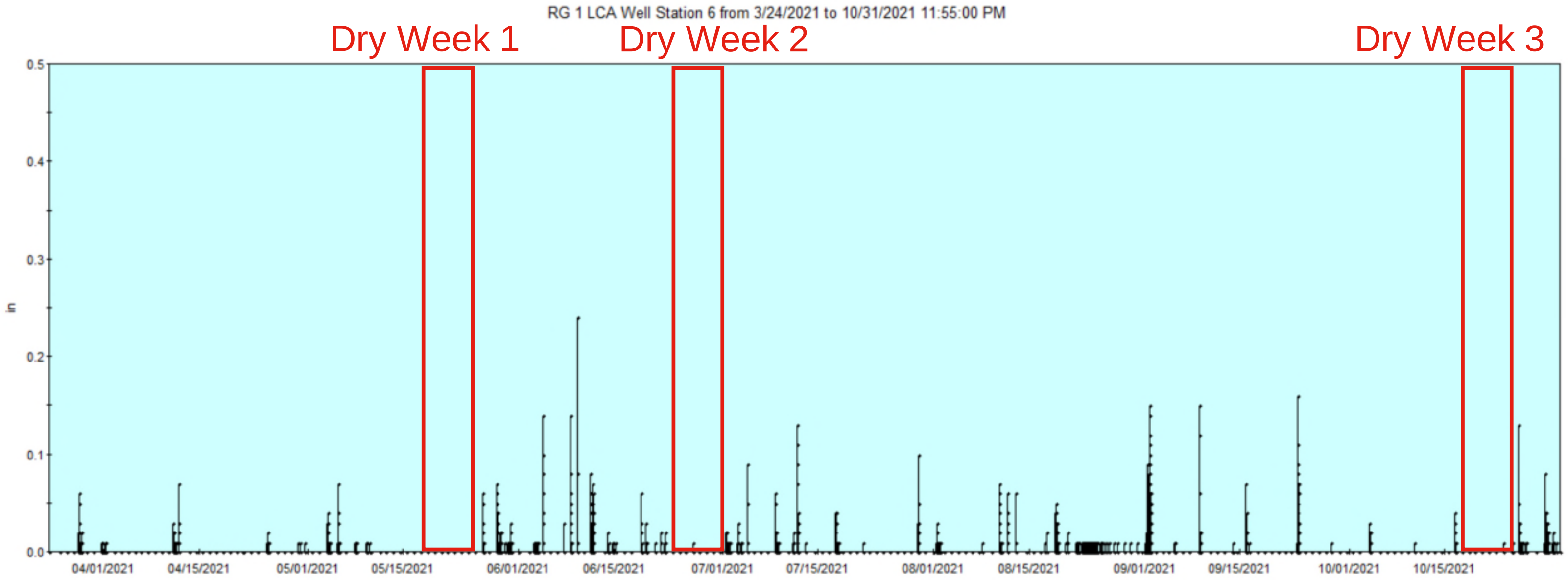
CITY MODEL

ENTIRE KISS MODEL

Strengths – Great Dry and Wet Weather Periods

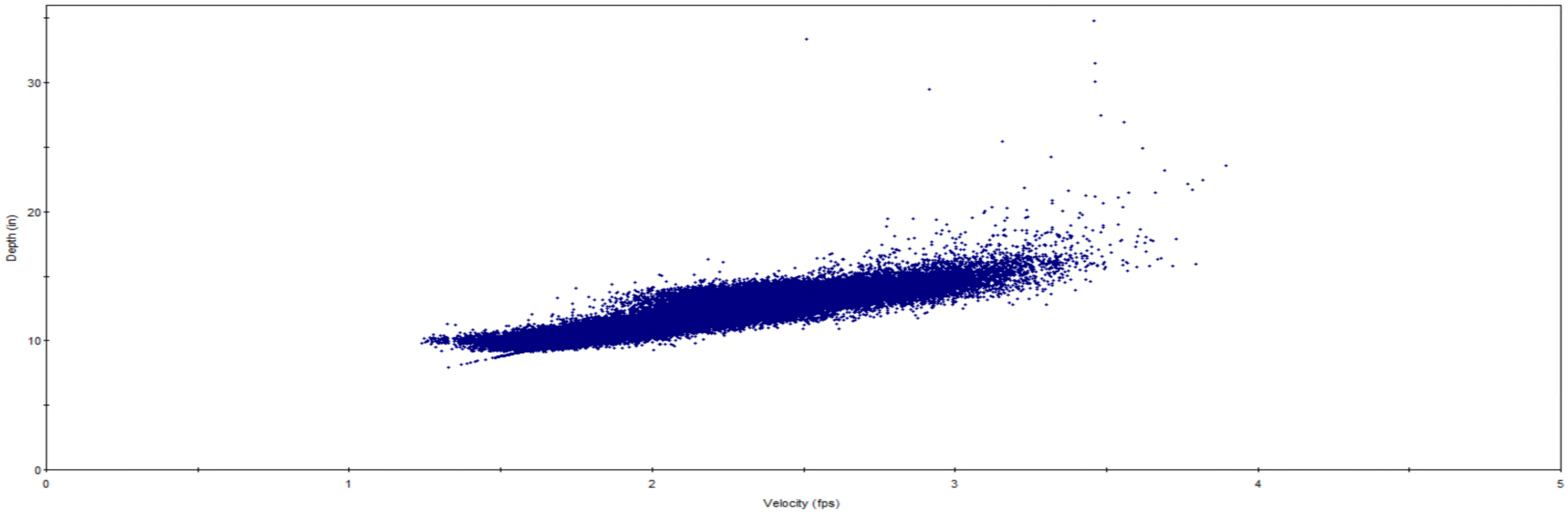
- Multiple significant storms for calibration during metering period
- Due to large groundwater fluctuation throughout the year, able to use several periods for dry weather calibration to calibrate groundwater module well





Strengths – Flow Meter Data Validation

- Very high quality flow data
  - Independent meter installation checks led to ~15% of meters being replaced or reset, adding of meters, and abandoning of meters
  - 4 rounds of data validation led to high data confidence
  - Majority of data (temporary and permanent) collected in 5-minute increments for very good data resolution

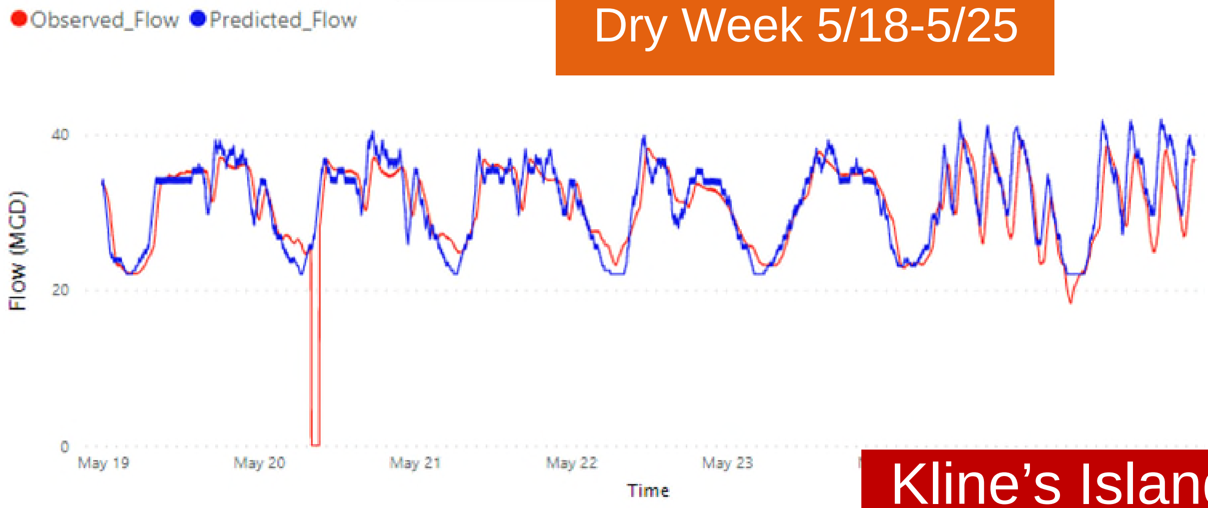


Strengths – Strong Knowledge of System

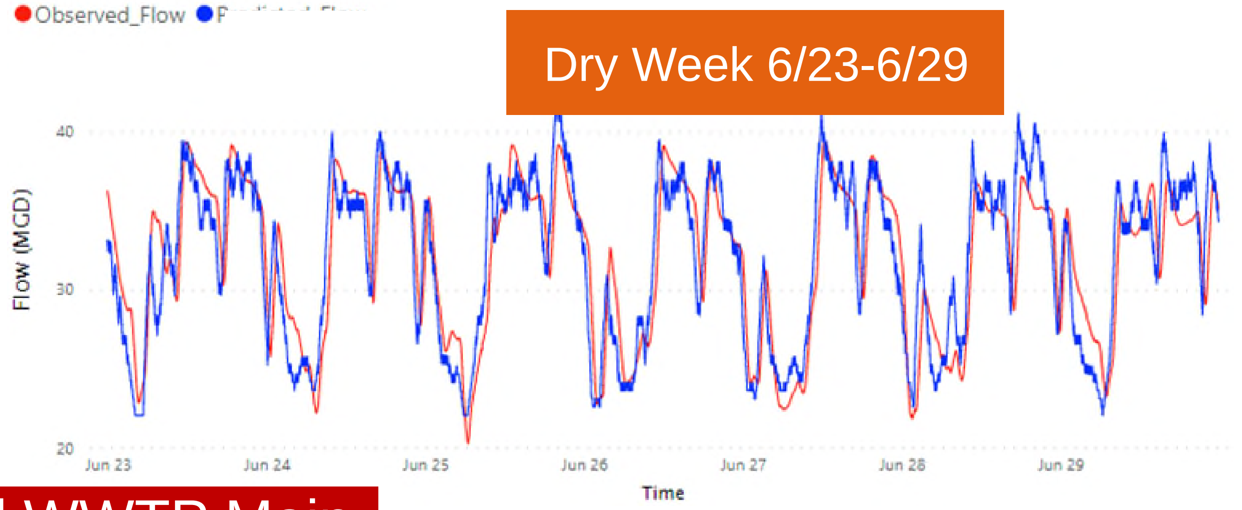
- Strong hydraulic knowledge of KISS systems incorporated into model
  - Interceptors are typically watertight, so bottomland catchments were delineated separately
  - Calibration upstream of WTP finally sound - knowledge of downstream siphons and system hydraulics
  - Industrial flow data used extensively
  - Operations of FEB and pump stations during calibration well documented

Strengths – Strong Dry Weather Calibration

Dry Week 5/18-5/25

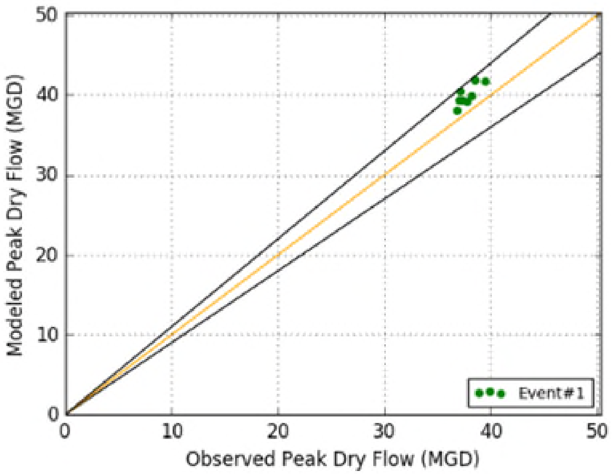


Dry Week 6/23-6/29

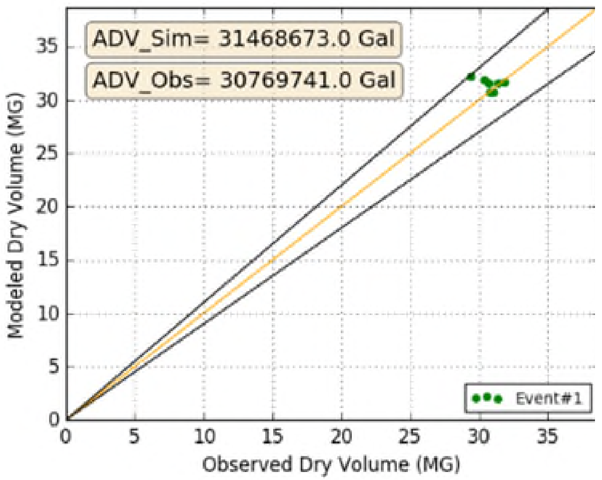


Kline's Island WWTP Main Influent- Excellent Match

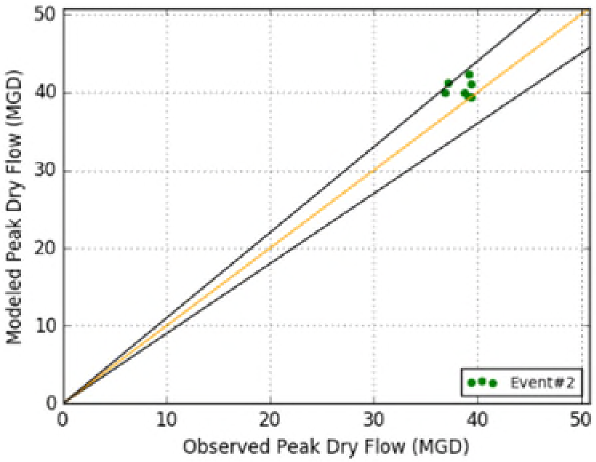
Peak Flow



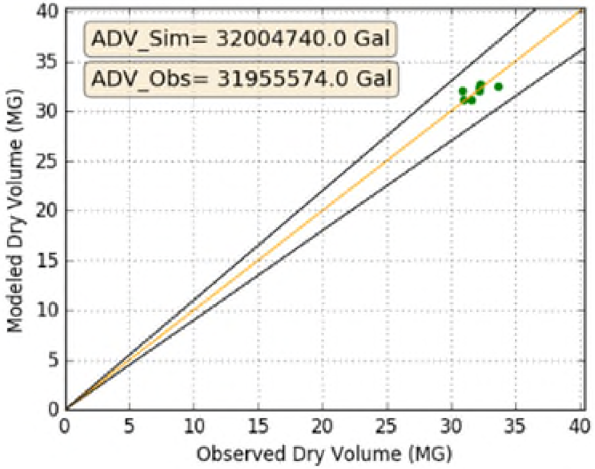
Volume



Peak Flow

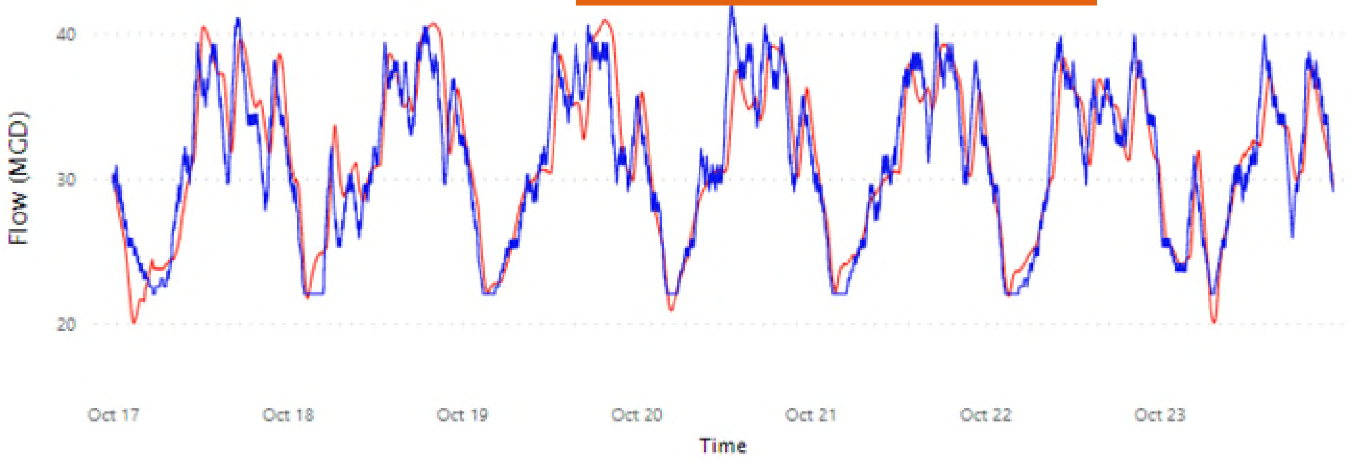


Volume



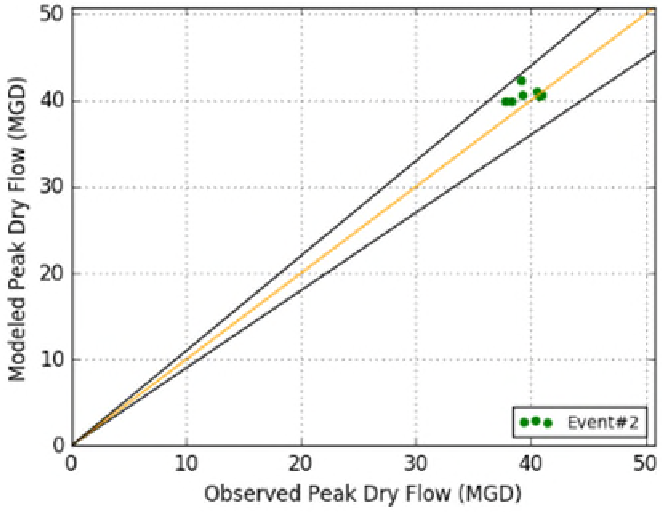
Strengths – Strong Dry Weather Calibration

Dry Week 10/17-10/23

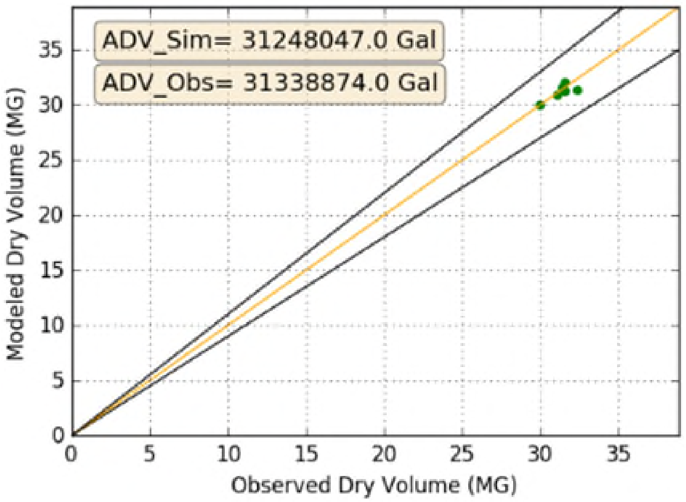


Kline’s Island WWTP Main Influent- Excellent Match

Peak Flow



Volume

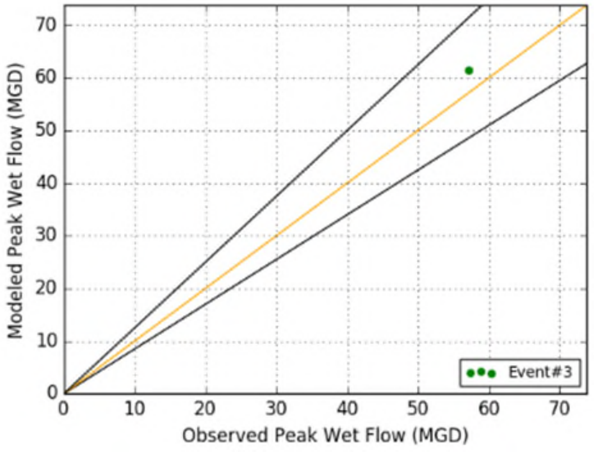


Strengths – Strong Storm Calibrations

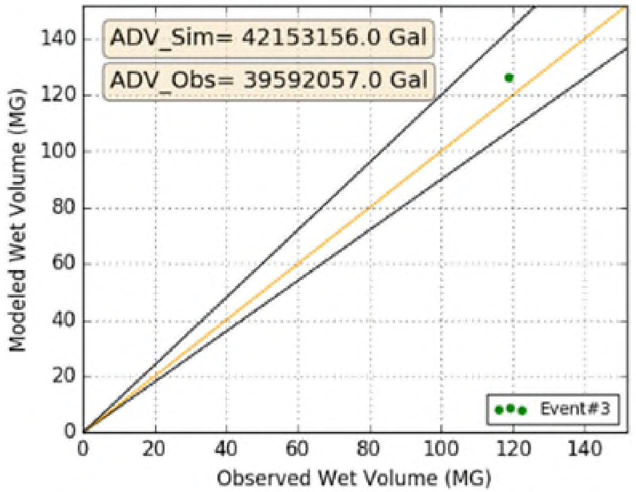
6/11

Kline’s Island WWTP Main Influent- Excellent Match

Peak Flow



Volume



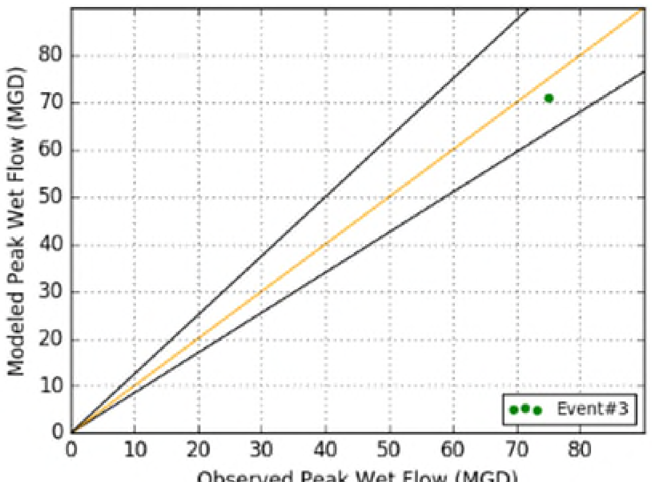
Strengths – Strong Storm Calibrations

8/19

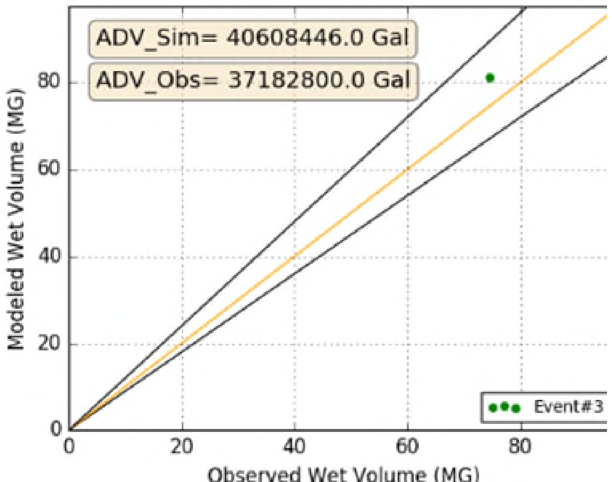
8/21

Kline's Island WWTP Main Influent- Excellent Match

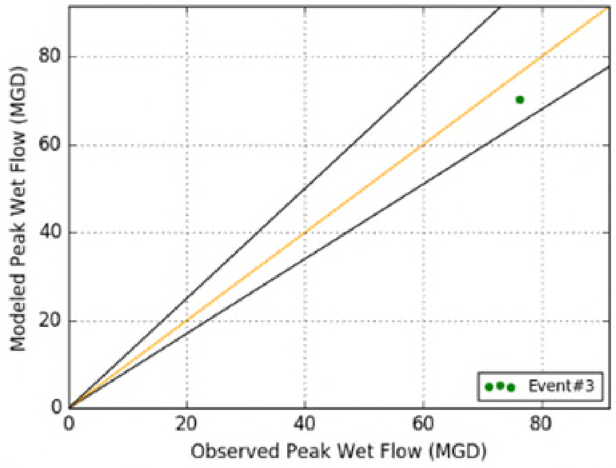
Peak Flow



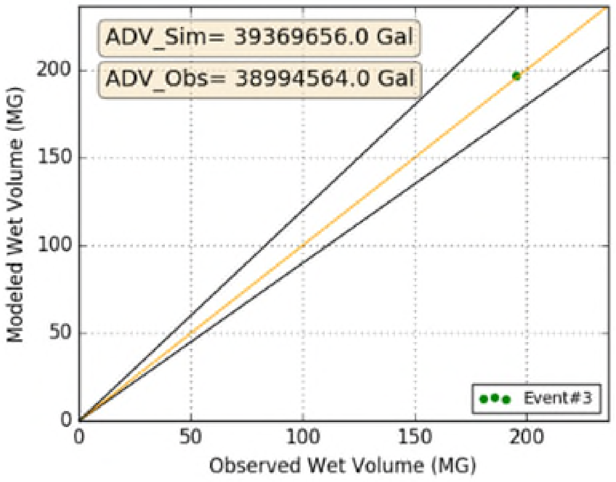
Volume



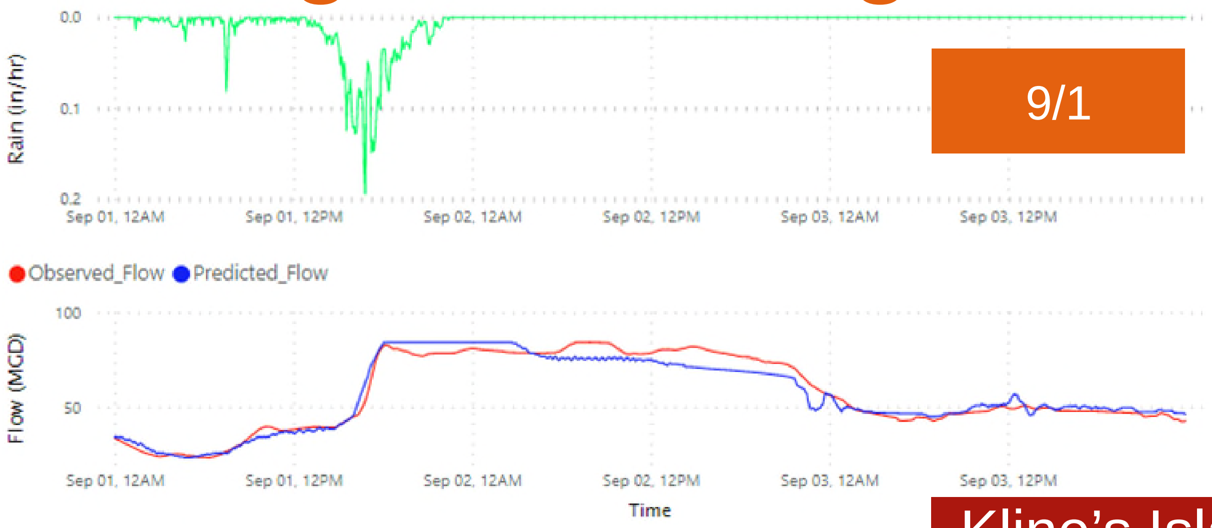
Peak Flow



Volume

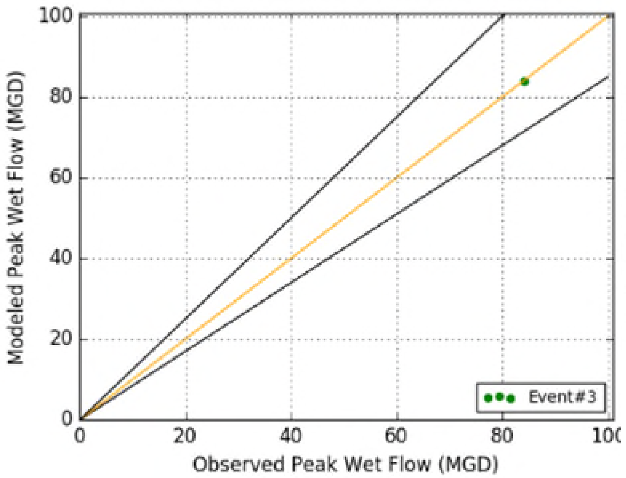


Strengths – Strong Storm Calibrations

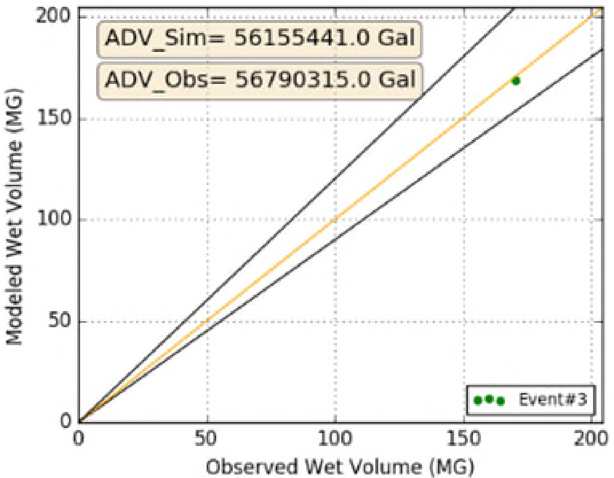


Kline's Island WWTP Main Influent- Excellent Match

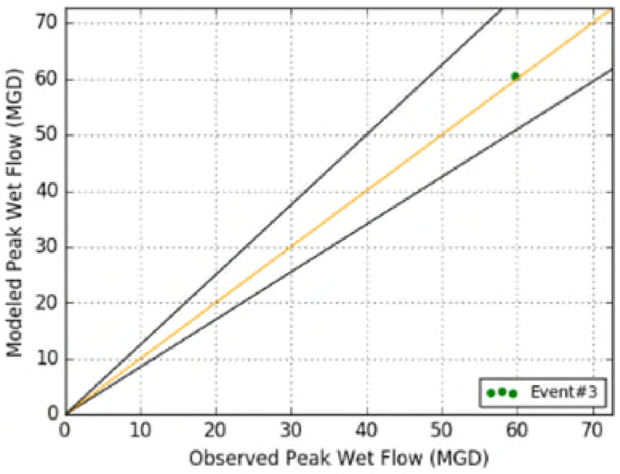
Peak Flow



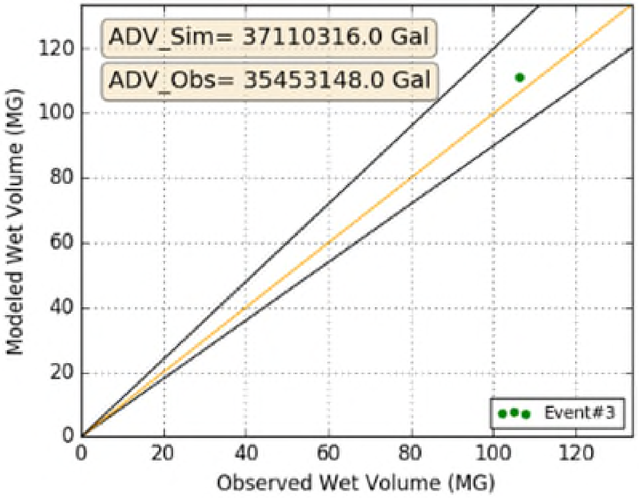
Volume



Peak Flow

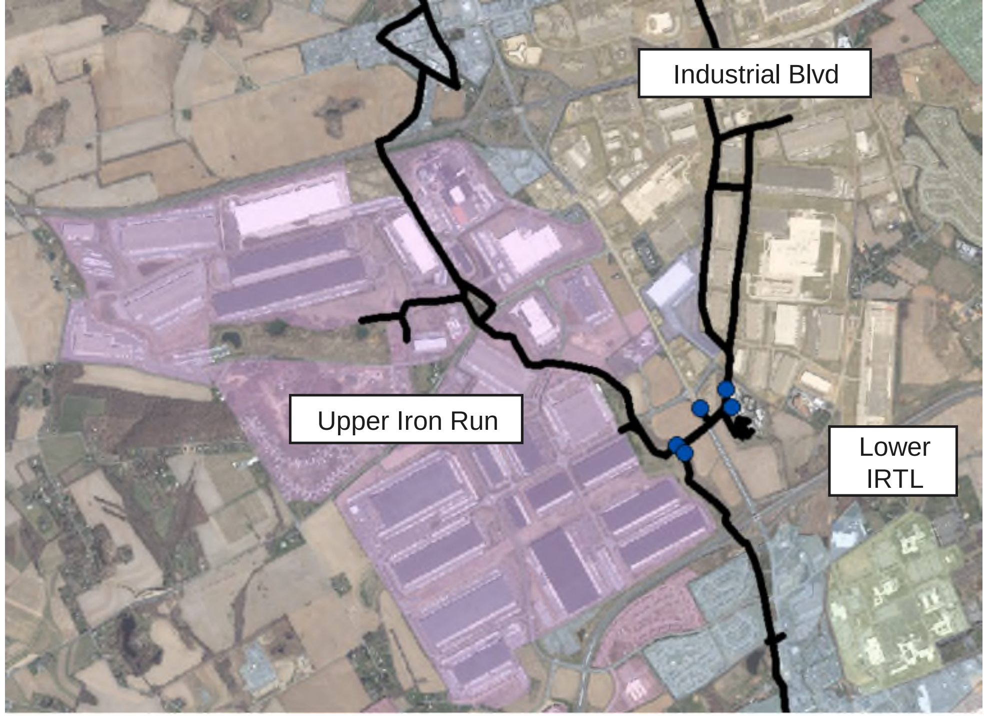


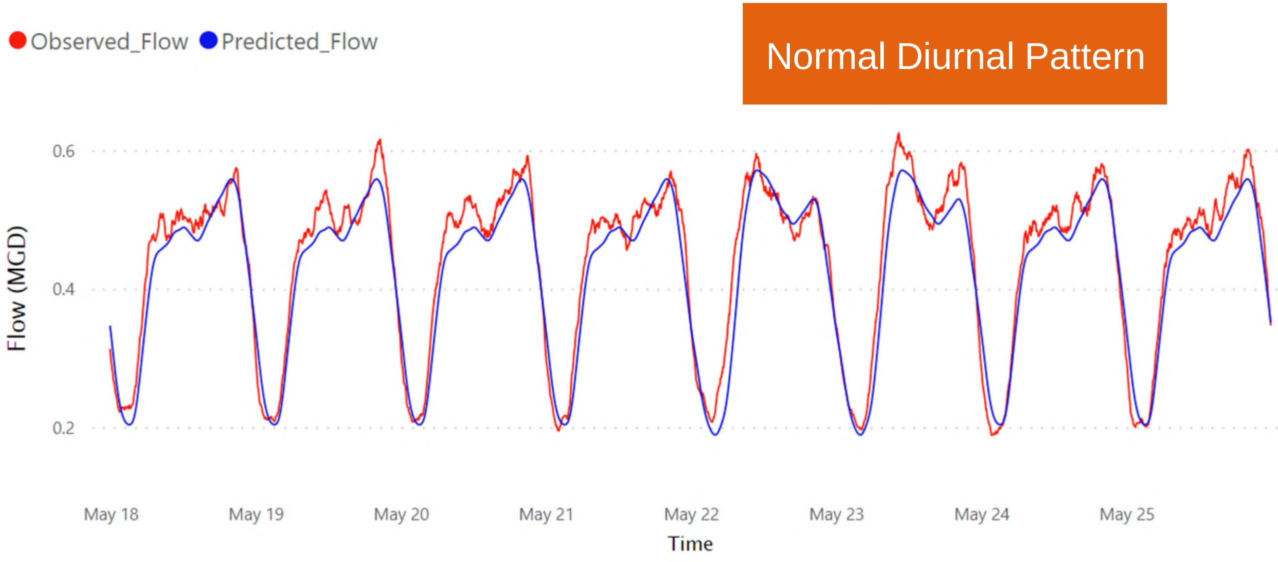
Volume

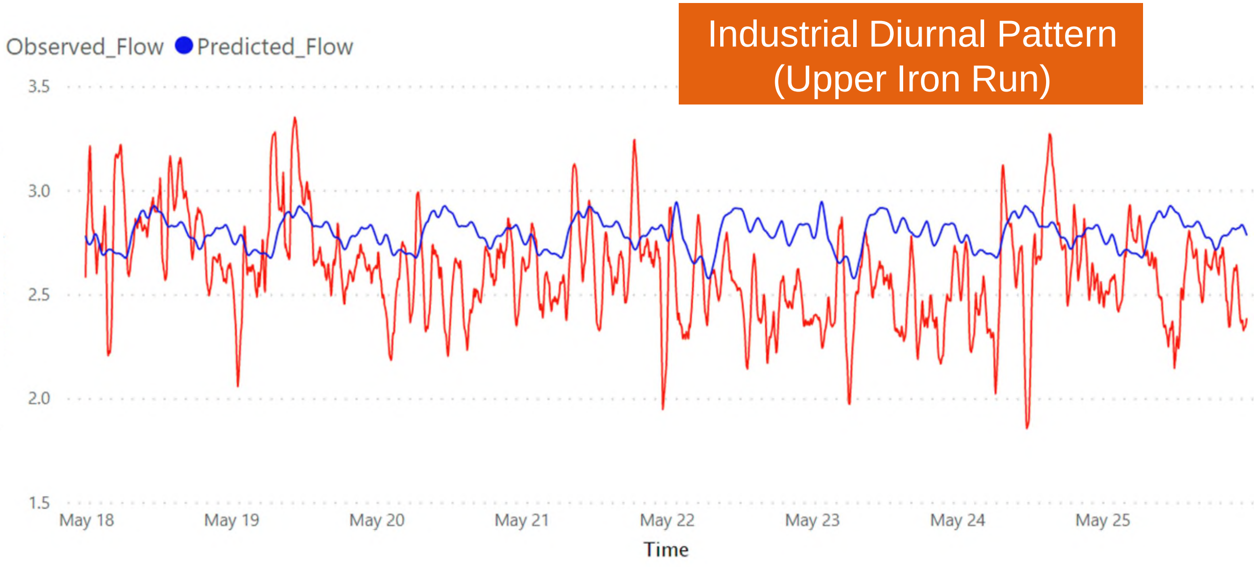


Weakness – Highly Erratic Industrial Flows

- Industrial flows do not have pattern
  - Impacts Lower Iron Run Trunkline, Industrial Blvd, Upper Iron Run, EB2 (Cintas)
- Can only match volumes, not peaks or troughs from due to inconsistent industrial batch discharges
- Used average flow – means actuals during storms could be higher or lower…as much as 2 MGD at PTP

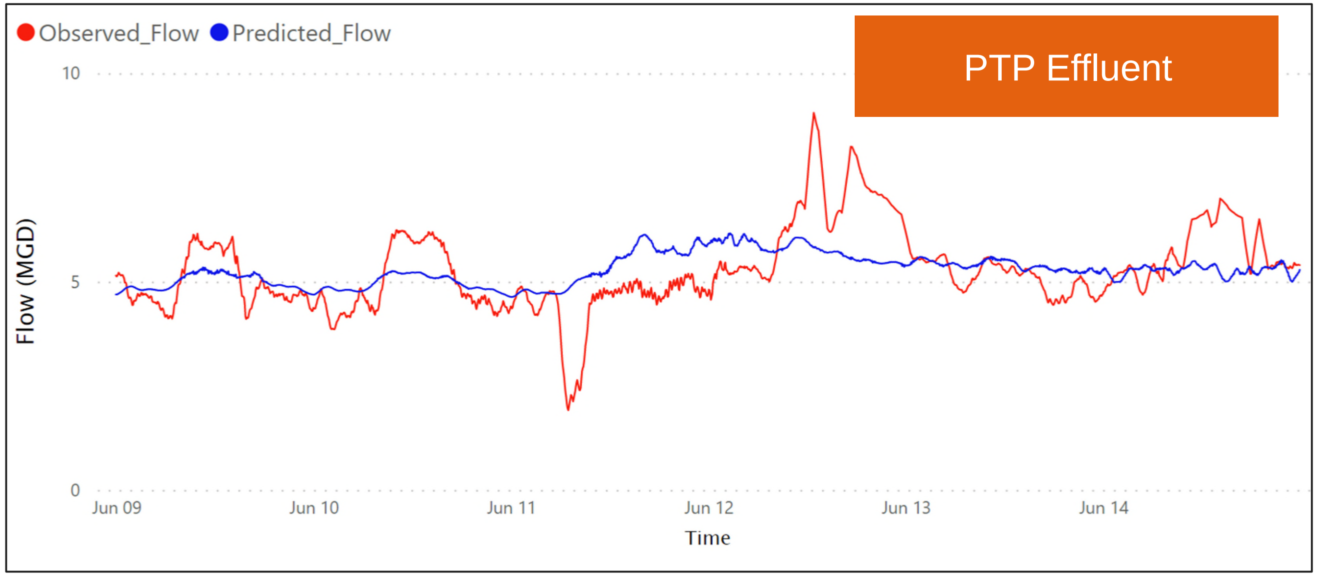


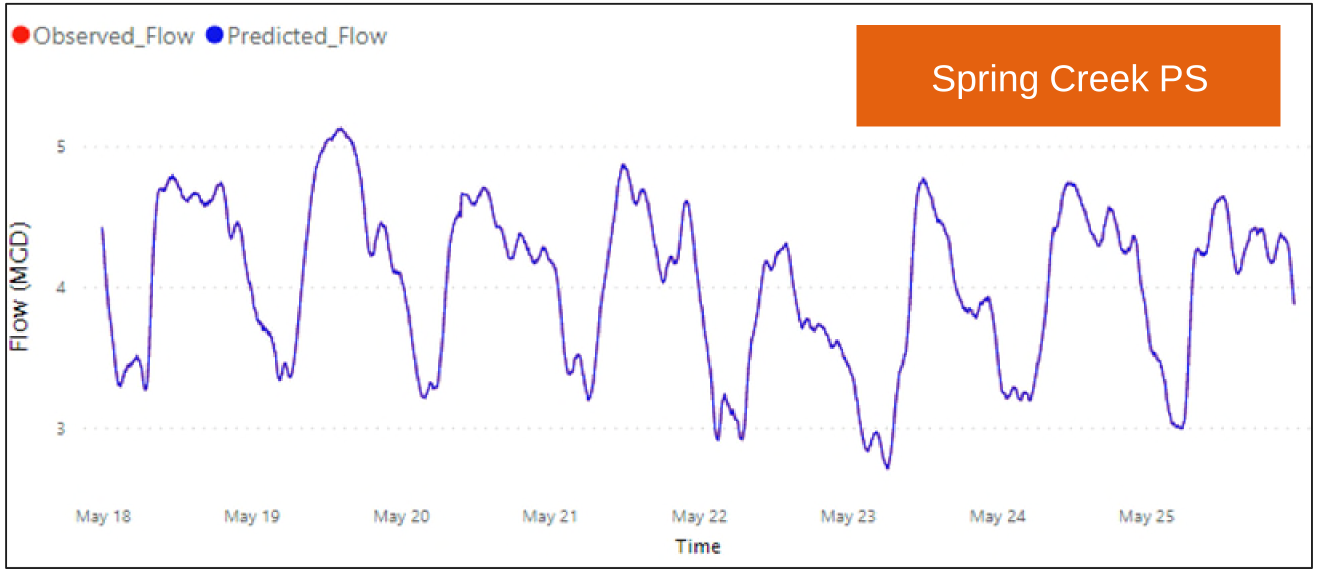




Weakness – Operating Logic

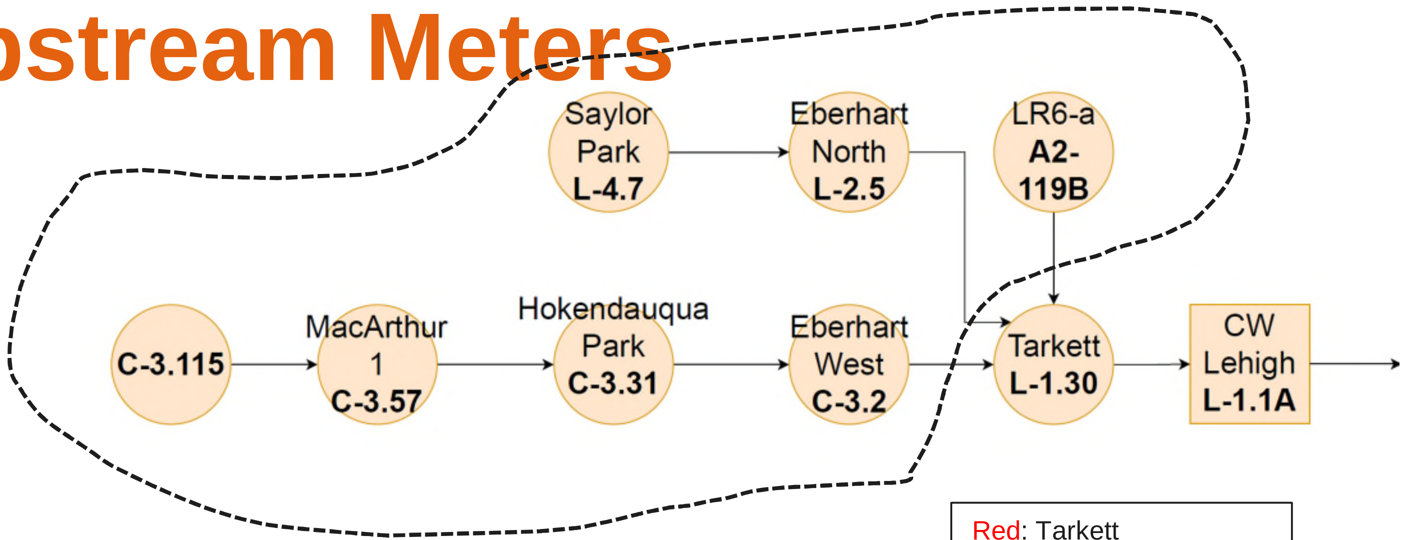
- Human operation for FEB Fill/Drain, Spring Creek Pump Station, Park Pump Station, and Kline's Island Wastewater Treatment Plant can't be replicated in model
  - Operation currently does not follow optimal real-time control logic

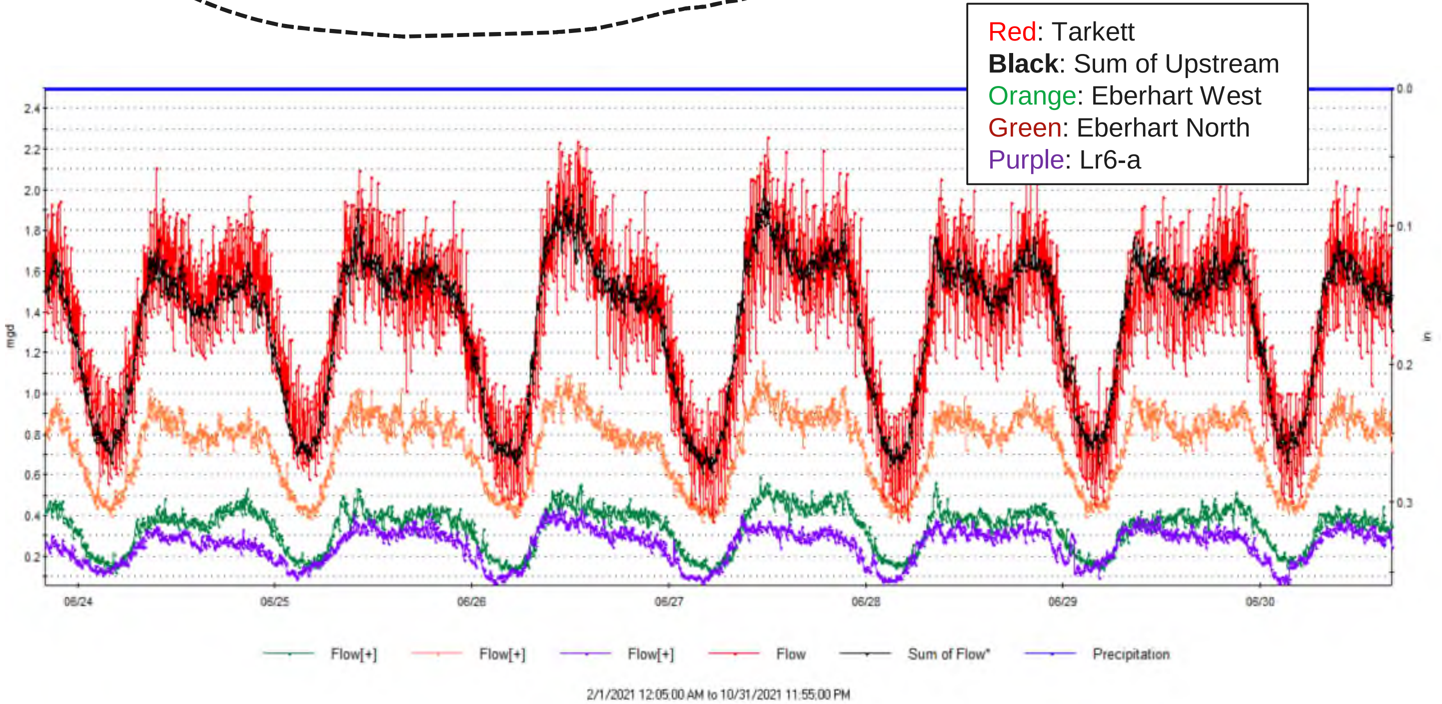




Minor Weakness – Upstream Meters

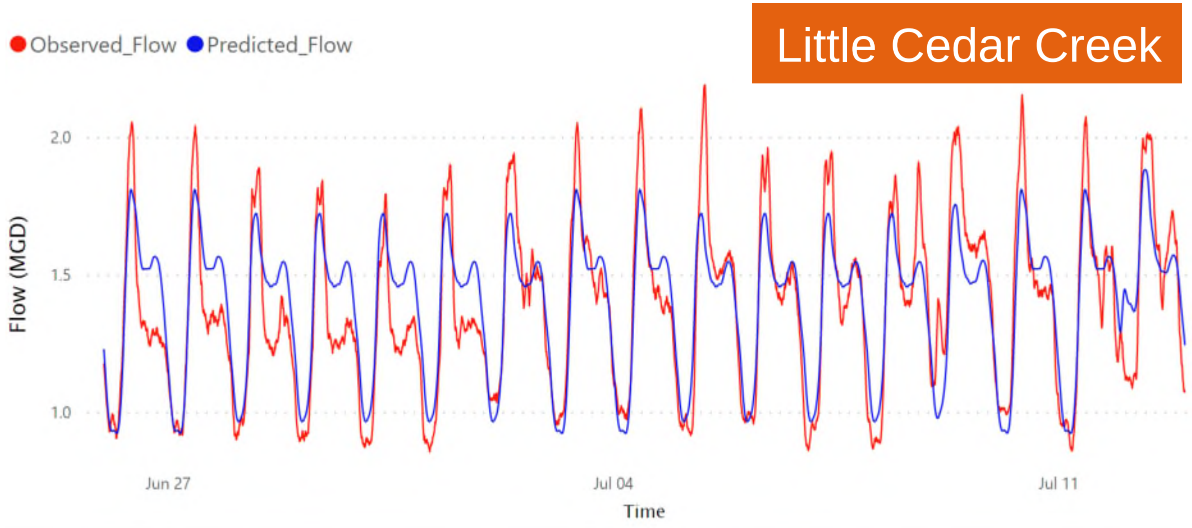
- Multiple meters installed in series at various locations
  - When upstream flows are >95% of flow at meter, reliability is lower
    - – Generally, very well handled in the model

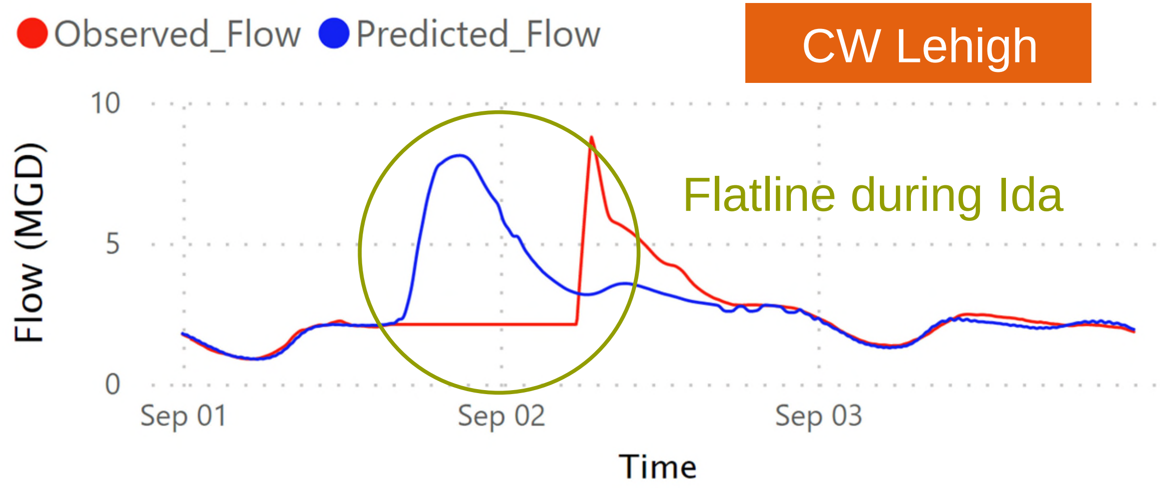




Minor Weakness –Meter Maintenance and Data Issues

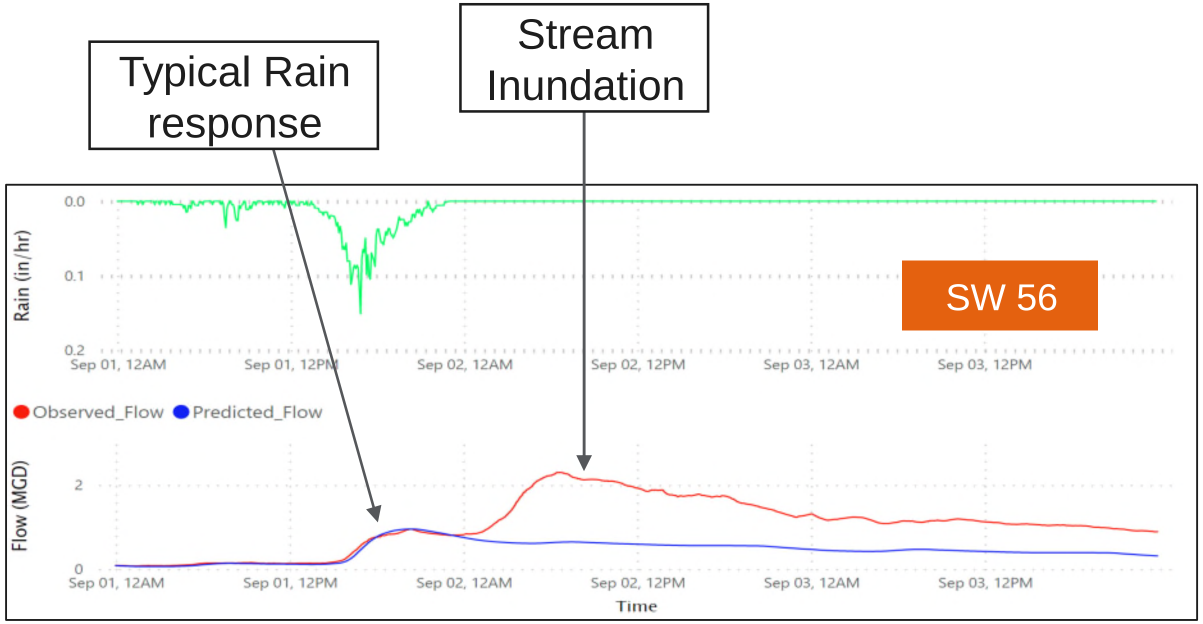
- Applewood PS installed late in monitoring period and data was irregular
  - Used legacy meter UMT01 data instead
- MM4 found to be unreliable
- MS5 partially blocked for two quarters, MS5/MS5a data fluctuates
- SW54 and Little Cedar Creek patterns are inconsistent and peaky, high amount of leakage
- Meters often flatlined or surcharged during larger storms (Hurricane Ida)
- Data quality issues with permanent meters *especially*

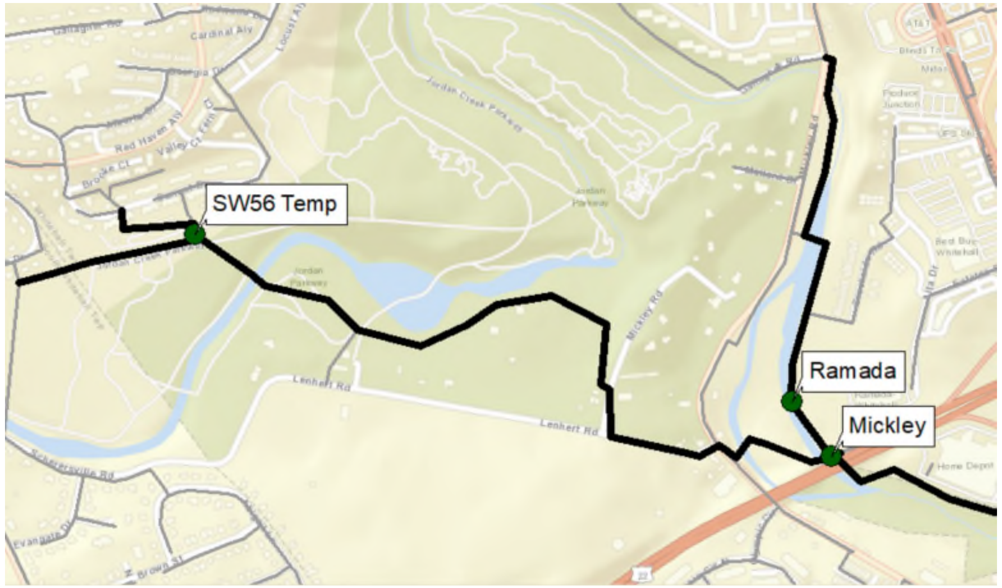


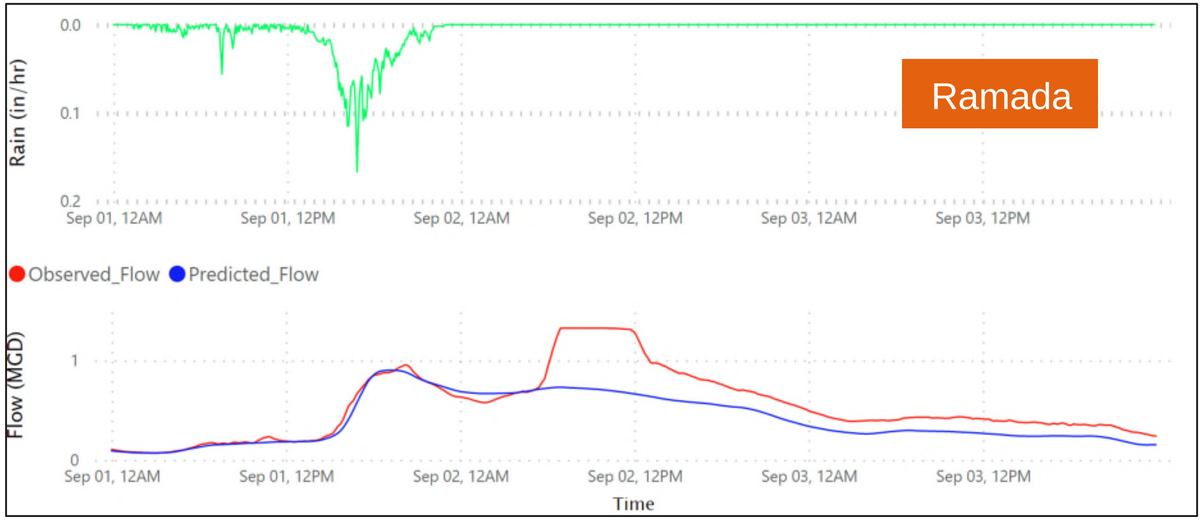


Weakness – Stream Inundation

- Inflow flooding from streams creates a second non-rainfall peak following large storms (Ida)
- Impossible to model without stream data and multiple flooding events ($$$$)
  - i.e. SW56 Temp and Ramada







Minor Weakness – Misc.

- Depth of flow at U8 (Breinigsville) is ~1' higher dry and wet weather than the model shows
- Depth of flow at L293 (LMT Dog Park) is 3'-4' higher than the model shows during large events
- U_26_84 dry weather data are good, but wet weather are impacted by MS5 siphons and high flows. Used wet weather characteristics of EB2a

U_26_84 Event 1

Improvements

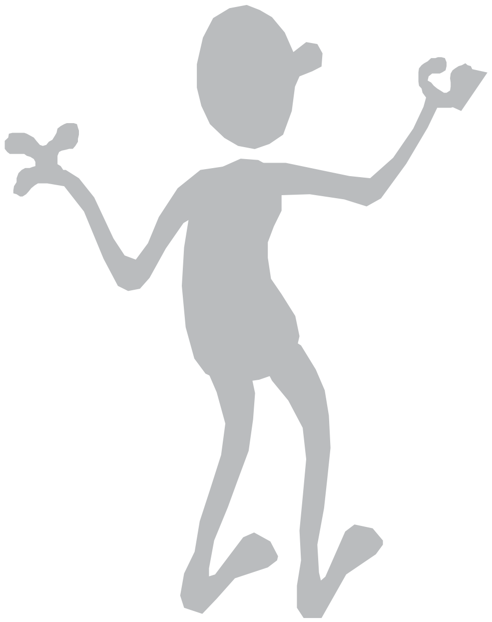
- Extreme surcharging in WLI from Schantz Road to Spring Creek Pump Station in 2019 calibrations led to muted wet weather responses during rainfall and lower confidence levels
  - 2021 flows were not as surcharged, and this uncertainty has been removed

Improvements

- LCA wet weather and dry weather flows to City interceptors
- Park Pump Station split of flows to Little Lehigh Interceptor
- Spring Creek Pump Station split of flows to Western Lehigh Interceptor
- Split in flow at South Whitehall junction box in Cedarcrest Park
- Little Lehigh Interceptor from Hump Bridge to KI

- Huge improvements over 2009 model
- Handles extreme variations in weather/groundwater (New Normal)
- Very well calibrated to 10 year storms (with caveats….)

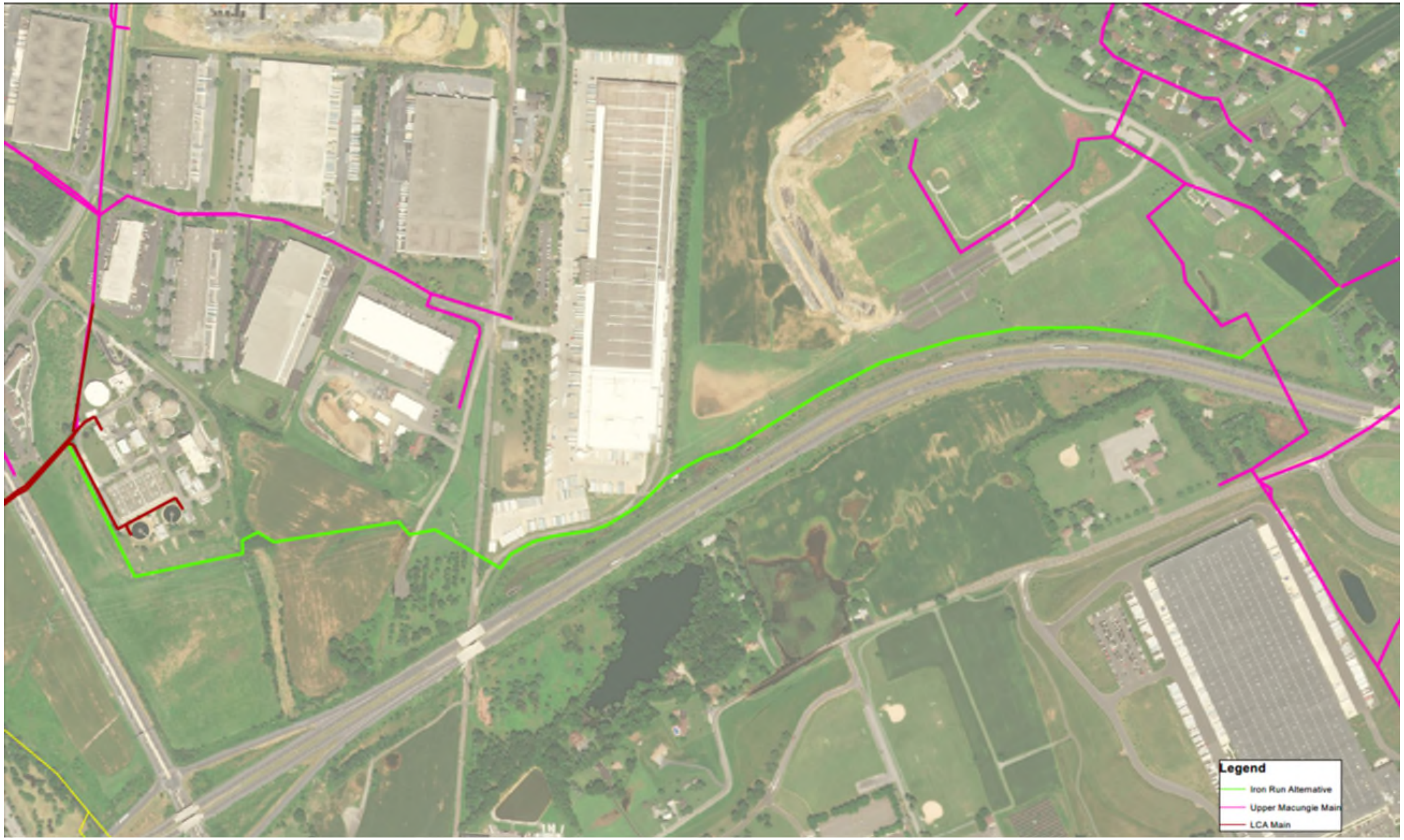
Thinks that need to be accounted for when using *Model for Design*



1. Industrial flow vary by 2 MGD from model
2. Depths and flow balances at major flow splits subject to fouling
3. In-line storage is both insignificant and significant, depending rain and pumps
4. Overflow locations wrt bolted covers
5. Stream inundation (inflow) issues during >5 year events (both unmeasured SSO and extreme inflow)
6. Depth of flow at flow convergences and turns >45°
7. Impact of manhole frame and cover sealing in floodplains

What are the things we are doing now with the calibrated model?

Confirm sizing of Interim Relief Pumping from PTP to UMT Trunk Line

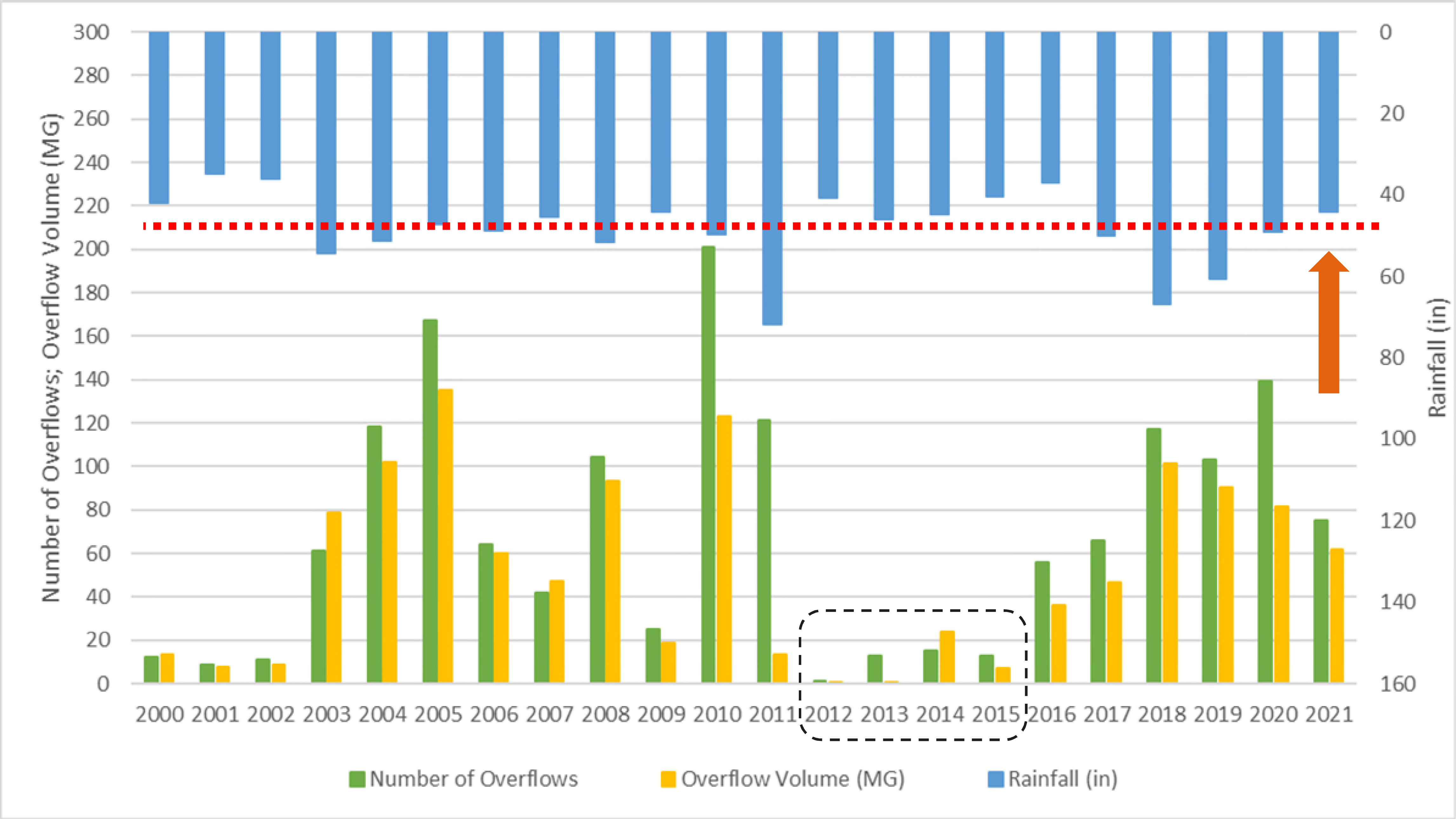


Fall 2022

Design Storm Evaluation

- 22 year model run to evaluate historic storm impact to flow
  - 2000-2022 rainfall
  - Evaluate flows from all large events
  - Pick typical 3 year, 5 year, 10 year, and 20 year storm event to facilitate alternative
  - Full 24 year run will determine ultimate performance of selected solution(s)

July 2022


Number of Overflows; Overflow Volume (MG)
Rainfall (in)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Number of Overflows
Overflow Volume (MG)
Rainfall (in)

22 years of Storms

Duration	Average recurrence interval (years)						
	1	2	5	10	25	50	100
5-min	0.324 (0.291-0.359)	0.385 (0.347-0.427)	0.452 (0.407-0.500)	0.502 (0.451-0.555)	0.563 (0.503-0.621)	0.607 (0.539-0.669)	0.655 (0.578-0.723)
10-min	0.516 (0.464-0.572)	0.615 (0.554-0.681)	0.722 (0.650-0.799)	0.803 (0.721-0.887)	0.897 (0.801-0.989)	0.966 (0.858-1.07)	1.03 (0.915-1.14)
15-min	0.645 (0.580-0.714)	0.772 (0.696-0.855)	0.913 (0.822-1.01)	1.01 (0.909-1.12)	1.13 (1.01-1.25)	1.22 (1.08-1.35)	1.31 (1.15-1.44)
30-min	0.882 (0.793-0.976)	1.06 (0.959-1.18)	1.29 (1.16-1.43)	1.46 (1.31-1.62)	1.67 (1.49-1.85)	1.83 (1.63-2.02)	1.99 (1.76-2.20)
60-min	1.10 (0.988-1.22)	1.33 (1.20-1.48)	1.66 (1.49-1.83)	1.90 (1.71-2.10)	2.23 (1.99-2.45)	2.48 (2.20-2.73)	2.74 (2.42-3.02)
2-hr	1.31 (1.18-1.46)	1.58 (1.43-1.76)	1.98 (1.78-2.20)	2.29 (2.05-2.54)	2.73 (2.43-3.02)	3.09 (2.73-3.42)	3.46 (3.04-3.84)
3-hr	1.44 (1.29-1.61)	1.74 (1.56-1.94)	2.17 (1.95-2.42)	2.50 (2.24-2.79)	2.98 (2.65-3.31)	3.36 (2.97-3.73)	3.78 (3.31-4.19)
6-hr	1.82 (1.65-2.03)	2.19 (1.99-2.44)	2.72 (2.45-3.02)	3.15 (2.83-3.49)	3.77 (3.37-4.18)	4.29 (3.80-4.74)	4.86 (4.27-5.37)
12-hr	2.25 (2.04-2.51)	2.71 (2.45-3.02)	3.37 (3.05-3.75)	3.93 (3.53-4.37)	4.76 (4.24-5.26)	5.47 (4.83-6.04)	6.26 (5.47-6.91)
24-hr	2.63 ([illegible])	3.17 ([illegible])	3.96 ([illegible])	4.63 ([illegible])	5.60 ([illegible])	6.43 ([illegible])	7.32 ([illegible])

- 2 storms >8”
- 7 storms >5”
- 22 storms > 3.17”
- 34 storms > 2.63”

Top 30 storms over 22 years

Event Start Time	Event End Time	Storm Name	Airport Rainfall (Inches)	Peak Hourly Intensit	Rain Duration (Hours)	Atlas 14 Event Return Perio
10/7/2005	10/9/2005	Tammy	9.7	1.2	42	351
9/30/2010	10/1/2010	Nicole	8.1	2.1	31	259
6/25/2006	6/28/2006	Non-tropical	5.8	1.0	67	9.7
7/10/2010	7/10/2010	Alex	5.7	2.6	6	405
9/4/2011	9/7/2011	Lee	5.6	0.6	58	10.2
8/27/2011	8/28/2011	Irene	5.0	0.8	24	12.8
8/4/2020	8/4/2020	Isaias	5.0	1.3	13	28
9/17/2004	9/18/2004	Ivan	4.3	1.1	19	10.6
9/1/2021	9/1/2021	Ida	4.2	1.0	21	5.5
8/13/2011	8/14/2011	Gert	4.1	1.0	28	5.4
7/21/2003	7/23/2003	Non-tropical	3.9	1.3	33	4.2
9/28/2008	9/28/2008	Kyle	3.8	0.8	15	7.6
4/2/2005	4/3/2005	Winter	3.7	0.4	37	2.0
10/10/2002	10/12/2002	Kyle	3.7	0.3	46	2.1
4/29/2014	5/1/2014	Non-tropical	3.6	0.3	40	1.9
2/12/2008	2/13/2008	Winter	3.5	0.3	29	3.0
11/2/2018	11/3/2018	Non-tropical	3.5	1.3	22	2.9
12/10/2008	12/12/2008	Non-tropical	3.4	0.4	56	1.6
7/12/2004	7/12/2004	Non-tropical	3.4	0.7	11	4.4
8/3/2018	8/4/2018	Non-tropical	3.3	0.9	17	4.1
8/18/2021	8/19/2021	Fred	3.2	1.4	4	34
4/15/2007	4/16/2007	Non-tropical	3.2	0.3	37	1.3
9/28/2011	9/29/2011	Ophelia	3.1	1.6	24	2.0
9/14/2003	9/16/2003	Isabel	3.0	0.9	32	2.5
2/23/2016	2/24/2016	Winter	3.0	0.9	36	1.8
7/23/2008	7/24/2008	Non-tropical	3.0	0.9	13	2.8
8/28/2013	8/28/2013	Non-tropical	2.9	1.6	4	20
11/22/2011	11/23/2011	Winter	2.9	0.4	30	1.6
11/30/2020	11/30/2020	Non-tropical	2.8	0.7	13	2.2

- 2 storms >8”
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- 22 storms > 3.17”
- 34 storms > 2.63”

Top 30 storms over 22 years

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10/7/2005	10/9/2005	Tammy	9.7	1.2	42	351
9/30/2010	10/1/2010	Nicole	8.1	2.1	31	259
8/18/2021	8/19/2021	Fred	3.2	1.4	4	34
8/18/2017	8/18/2017	Non-tropical	2.3	2.2	1	32
8/4/2020	8/4/2020	Isaias	5.0	1.3	13	28
8/28/2013	8/28/2013	Non-tropical	2.9	1.6	4	20
8/27/2011	8/28/2011	Irene	5.0	0.8	24	12.8
9/17/2004	9/18/2004	Ivan	4.3	1.1	19	10.6
9/4/2011	9/7/2011	Lee	5.6	0.6	58	10.2
6/25/2006	6/28/2006	Non-tropical	5.8	1.0	67	9.7
8/21/2018	8/22/2018	Non-tropical	2.4	1.0	3	8.0
9/28/2008	9/28/2008	Kyle	3.8	0.8	15	7.6
9/1/2021	9/1/2021	Ida	4.2	1.0	21	5.5
8/13/2011	8/14/2011	Gert	4.1	1.0	28	5.4
7/12/2004	7/12/2004	Non-tropical	3.4	0.7	11	4.4
7/1/2017	7/1/2017		1.6	1.2	1	4.3
7/21/2003	7/23/2003	Non-tropical	3.9	1.3	33	4.2
8/3/2018	8/4/2018	Non-tropical	3.3	0.9	17	4.1
6/23/2011	6/24/2011		2.1	1.4	3	4.0
2/12/2008	2/13/2008	Winter	3.5	0.3	29	3.0
11/2/2018	11/3/2018	Non-tropical	3.5	1.3	22	2.9
7/23/2008	7/24/2008	Non-tropical	3.0	0.9	13	2.8
10/16/2019	10/16/2019		2.3	0.6	9	2.6
9/14/2003	9/16/2003	Isabel	3.0	0.9	32	2.5
11/30/2020	11/30/2020	Non-tropical	2.8	0.7	13	2.2
7/11/2019	7/11/2019	Barry	2.8	1.4	10	2.2
7/25/2011	7/25/2011		2.2	1.2	6	2.2
7/30/2015	7/30/2015		1.4	0.9	1	2.2
10/10/2002	10/12/2002	Kyle	3.7	0.3	46	2.1

- 11 storms >10 year Atlas 14 frequency
- 15 storms >5 year Atlas 14 frequency

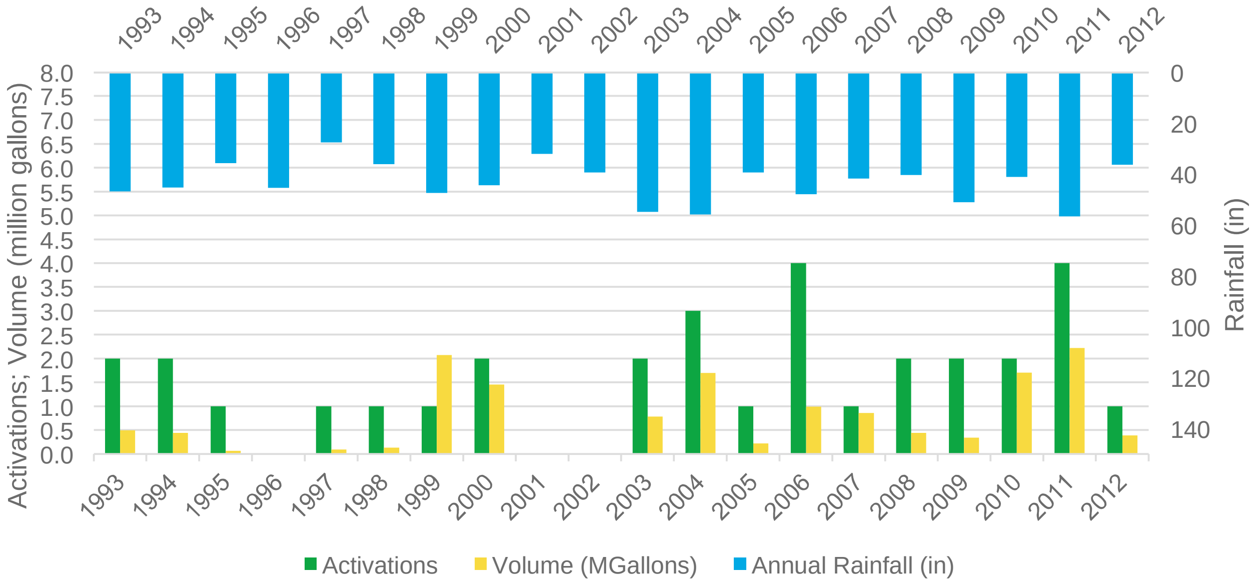
Event Start Time	Storm Name	Airport Rainfall (Inches)	# MH SSOs	MH SSO Ran	MH SSO Frequen	Peak Flow Total (MG	Peak Flow Rank	Peak Flow Frequenc	Overflow Volume (MG)	Overflow Volume Rank	SSO Volume Frequen	Event Ra
10/7/2005	Tammy	9.7	121	1	17.2	238	1	28.7	94	1	26.1	1
8/4/2020	Isaias	5.0	87	3	8.6	200	3	13.1	47	3	5.6	2
7/10/2010	Alex	5.7	108	2	13.2	216	2	18.3	37	5	4.1	3
9/30/2010	Nicole	8.1	78	4	7.2	181	4	8.7	75	2	14.0	4
9/17/2004	Ivan	4.3	58	5	4.8	163	5	5.9	42	4	4.8	5
11/2/2018	Non-tropical	3.5	50	6	4.1	161	6	5.6	36	6	3.9	6
9/1/2021	Ida	4.2	42	8	3.5	155	7	5.0	31	8	3.3	7
4/2/2005	Winter	3.7	31	11	2.8	129	10	2.9	31	7	3.4	8
9/28/2008	Kyle	3.8	42	9	3.5	145	8	4.1	24	11	2.7	9
2/23/2016	Winter	3.0	28	12	2.6	129	9	2.9	22	13	2.5	10
2/12/2008	Winter	3.5	27	14	2.6	124	14	2.6	30	9	3.2	11
11/30/2020	Non-tropical	2.8	28	13	2.6	127	11	2.8	20	19	2.3	12
6/25/2006	Non-tropical	5.8	24	18	2.4	115	19	2.2	29	10	3.1	13
8/13/2018	Non-tropical	2.6	19	21	2.2	120	15	2.4	24	12	2.6	14
11/27/2004	Non-tropical	2.4	25	16	2.5	124	13	2.6	18	20	2.2	15
8/3/2018	Non-tropical	3.3	25	15	2.5	116	17	2.2	20	18	2.3	16
6/20/2003	Non-tropical	2.7	22	19	2.3	120	16	2.4	20	17	2.4	17
7/11/2019	Barry	2.8	25	17	2.5	125	12	2.7	15	26	2.0	18
7/22/2019	Non-tropical	2.6	15	23	2.0	112	21	2.0	17	22	2.2	19
8/27/2011	Irene	5.0	50	7	4.1	116	18	2.2	8	42	1.6	20
8/18/2017	Non-tropical	2.3	19	22	2.2	112	22	2.0	16	25	2.0	21
4/29/2014	Non-tropical	3.6	9	30	1.8	100	27	1.6	21	15	2.4	22
12/10/2008	Non-tropical	3.4	9	31	1.8	97	30	1.5	20	16	2.4	23
9/14/2003	Isabel	3.0	10	28	1.8	99	28	1.5	18	21	2.2	24
8/18/2021	Fred	3.2	13	25	1.9	113	20	2.1	11	33	1.7	25
12/16/2000	Winter	2.5	11	26	1.9	108	25	1.8	14	28	1.9	26
7/12/2004	Non-tropical	3.4	15	24	2.0	112	23	2.0	11	32	1.8	27
8/21/2018	Non-tropical	2.4	11	27	1.9	109	24	1.9	13	29	1.9	28
4/15/2007	Non-tropical	3.2	7	33	1.7	91	35	1.3	21	14	2.5	29
9/28/2004	Jeanne	2.6	7	35	1.7	94	31	1.4	16	24	2.1	30

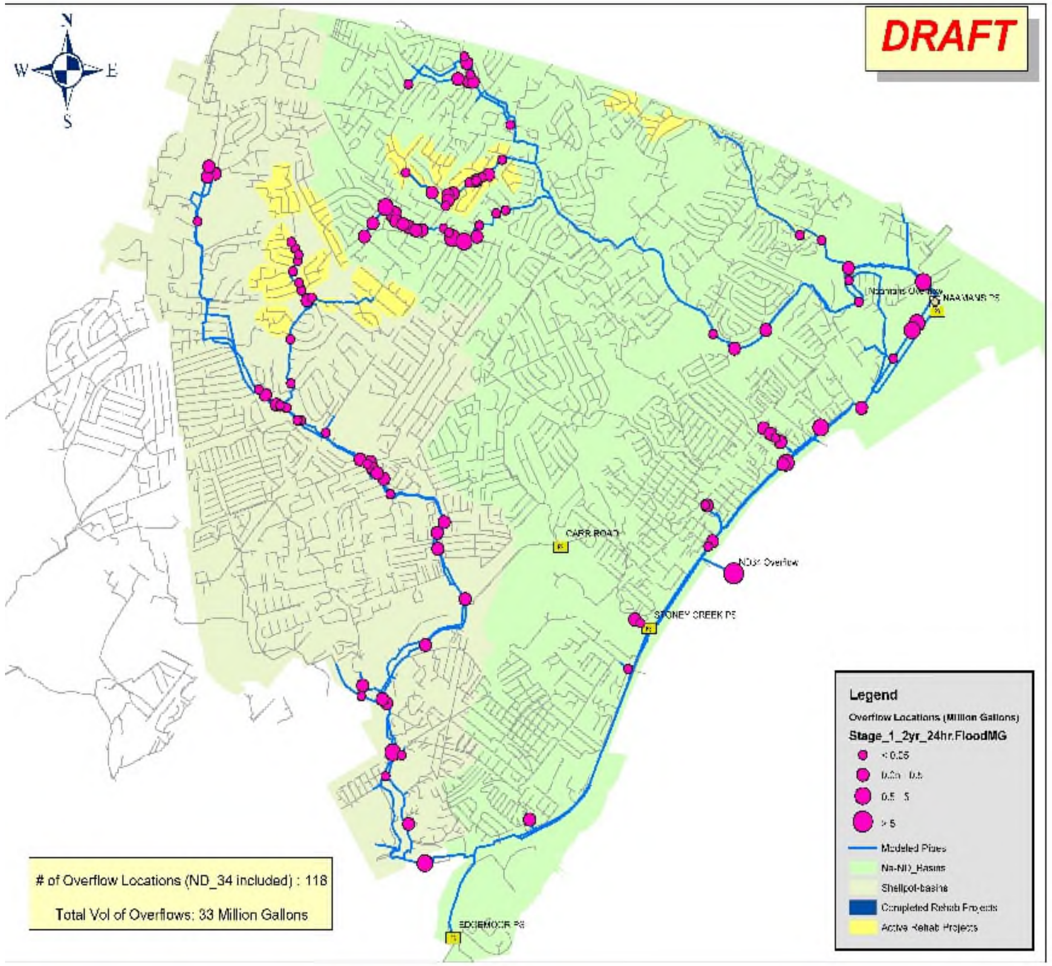
Event Start Time	Storm Name	Airport Rainfall (Inches)	# MH SSOs	MH SSO Frequen	Peak Flow Total (MG	Peak Flow Frequenc	Overflow Volume (MG)	SSO Volume Frequen	Event Ra	Event Description
10/7/2005	Tammy	9.7	121	17.2	238	28.7	94	26.1	1	> 20 year event
8/4/2020	Isaias	5.0	87	8.6	200	13.1	47	5.6	2	10 year event
7/10/2010	Alex	5.7	108	13.2	216	18.3	37	4.1	3	10 year event
9/30/2010	Nicole	8.1	78	7.2	181	8.7	75	14.0	4	10 year event
9/17/2004	Ivan	4.3	58	4.8	163	5.9	42	4.8	5	5 year event
11/2/2018	Non-tropical	3.5	50	4.1	161	5.6	36	3.9	6	5 year event
9/1/2021	Ida	4.2	42	3.5	155	5.0	31	3.3	7	
4/2/2005	Winter	3.7	31	2.8	129	2.9	31	3.4	8	3 year event
9/28/2008	Kyle	3.8	42	3.5	145	4.1	24	2.7	9	3 year event
2/23/2016	Winter	3.0	28	2.6	129	2.9	22	2.5	10	3 year event
2/12/2008	Winter	3.5	27	2.6	124	2.6	30	3.2	11	3 year event
11/30/2020	Non-tropical	2.8	28	2.6	127	2.8	20	2.3	12	
6/25/2006	Non-tropical	5.8	24	2.4	115	2.2	29	3.1	13	
8/13/2018	Non-tropical	2.6	19	2.2	120	2.4	24	2.6	14	
11/27/2004	Non-tropical	2.4	25	2.5	124	2.6	18	2.2	15	
8/3/2018	Non-tropical	3.3	25	2.5	116	2.2	20	2.3	16	
6/20/2003	Non-tropical	2.7	22	2.3	120	2.4	20	2.4	17	
7/11/2019	Barry	2.8	25	2.5	125	2.7	15	2.0	18	
7/22/2019	Non-tropical	2.6	15	2.0	112	2.0	17	2.2	19	
8/27/2011	Irene	5.0	50	4.1	116	2.2	8	1.6	20	
8/18/2017	Non-tropical	2.3	19	2.2	112	2.0	16	2.0	21	
4/29/2014	Non-tropical	3.6	9	1.8	100	1.6	21	2.4	22	
12/10/2008	Non-tropical	3.4	9	1.8	97	1.5	20	2.4	23	
9/14/2003	Isabel	3.0	10	1.8	99	1.5	18	2.2	24	
8/18/2021	Fred	3.2	13	1.9	113	2.1	11	1.7	25	
12/16/2000	Winter	2.5	11	1.9	108	1.8	14	1.9	26	
7/12/2004	Non-tropical	3.4	15	2.0	112	2.0	11	1.8	27	
8/21/2018	Non-tropical	2.4	11	1.9	109	1.9	13	1.9	28	
4/15/2007	Non-tropical	3.2	7	1.7	91	1.3	21	2.5	29	
9/28/2004	Jeanne	2.6	7	1.7	94	1.4	16	2.1	30	

Existing System Performance

August - September 2022

- Without changes to system, under 4 design storms, what are flows and SSO with:
  - No new flows added
  - 2050 flow added





Existing System Performance

- Without changes to system, what are dry day levels in interceptors:
  - No new flows added
  - 2050 flow added

August - September 2022

What’s next?

Alternative Scenarios

Storage

a. Cedar Creek Park Tank
b. Spring Creek Tank
c. Lehigh Interceptor West Tank
d. Jordan Creek Tank
e. Kecks Bridge Tank
f. Emmaus Cedarcreek Boulevard Tank
g. Trout Creek Tank
h. Sumner Tank
i. Alburtis Macungie Tank
j. Hump Bridge Tank
k. U6 Tank
l. Breniegsville Tank

Gravity Conveyance

a. Replacements with larger pipes
b. Parallels of existing pipes
c. Removal of bottlenecks
    - Water Treatment Plant siphons
    - Confluence of Jordan Creek and Little Lehigh Interceptors
    - Eastside Interceptor Lehigh River siphon

Pumped Conveyance

a. Spring Creek Pump Station (as is and upgrade, and with various current and potential force mains discharging to LLRI (as currently), to Little Sister Pump Station, or to ahead of, at, or inside KIWWTP)
b. Little Sister Pump Station (with force main alignments and discharge points ahead of, at, and inside KI WWTP)
c. PTP Direct Discharge Pump Station and force main to Lehigh River outside KI WWTP
d. PTP Pump Station and force main to KI WWTP headwork or inside KI WWTP
e. Fogelsville Pump Station and forcemain capture ~1/2 the PTP flow before PTP treatment and conveying it to the Upper Macungie Trunk Line north of Grange Road
f. Various other pump stations and force mains, including but not limited to:
    - Breinigsville Pump Station and Force Main
    - Kecks Bridge Pump Station and Force Main
    - Cedar Creek Pump Station and Force Main
    - Jordan Creek Pump Station and Force Main
    - Lehigh River West Pump Station and Force Main
    - Lehigh River East Pump Station and Force Main
    - Eberhart Pump Station Expanse and Force Main extension

Alternative Scenarios

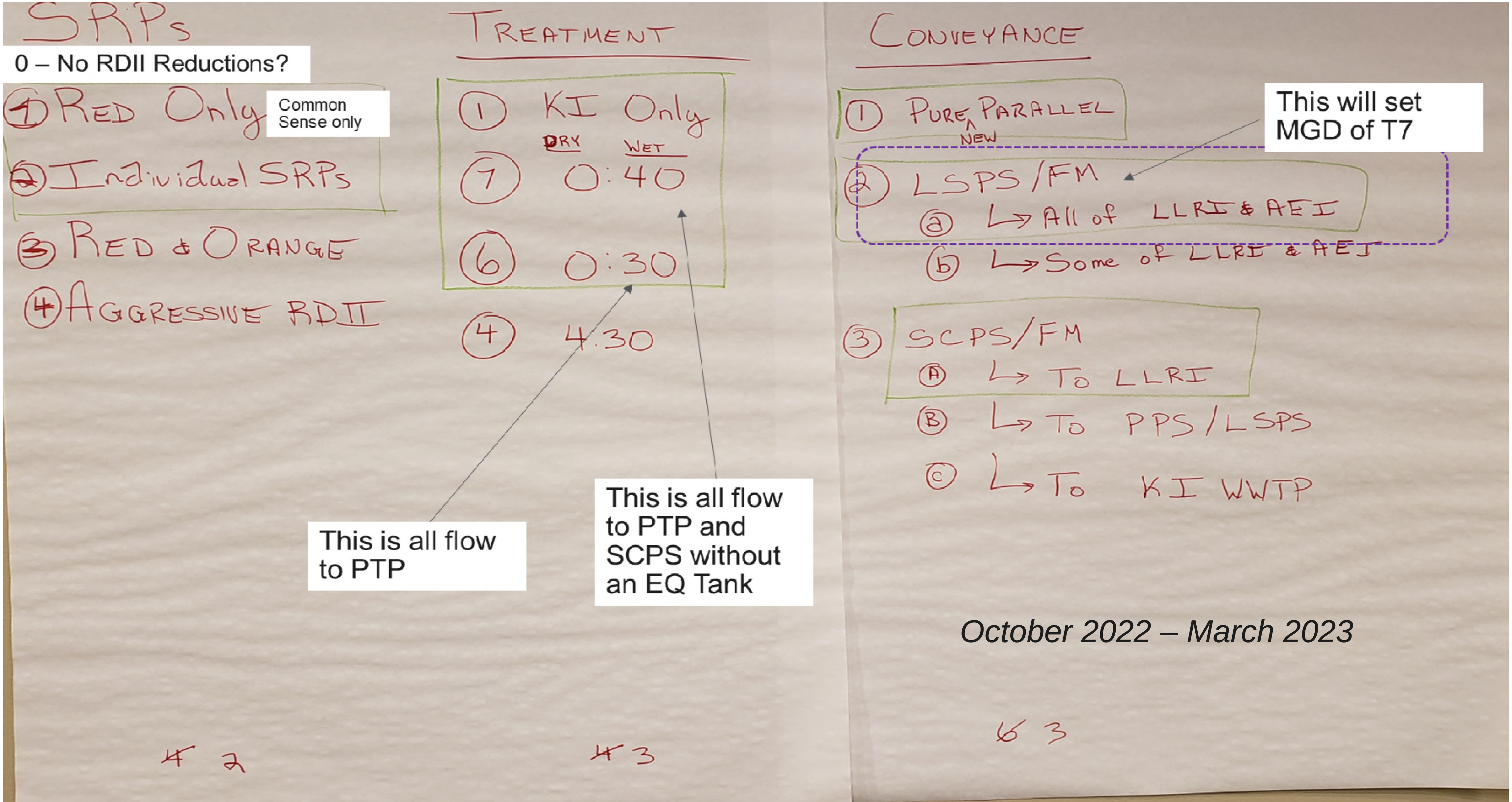
Source Reductions

a. Common-sense SRPs to significantly reduce peak inflow from the worst inflow-impacted areas of the KISS collection system
b. Common-sense SRPs to significantly reduce baseline infiltration and rainfall induced infiltration from the worst leaking areas of the KISS collection system
c. Signatory-proposed SRPs idiosyncratic to each Signatories' individual ideas about appropriate leakage rates and the need to control them
d. Moderate SRPs to eliminate leakage from catchments with high inflow and infiltration leakage
e. Aggressive public SRPs to eliminate leakage from catchments with moderately high and high inflow and infiltration leakage
f. Private lateral and private sump pump programs to increase I&I removals

Treatment

a. Variations on treatment at Kline's Island
b. Variations on full NPDES treatment as a direct discharge from PTP to Lehigh River (discharge to Jordan Creek and discharge via land application were reviewed and dismissed during SCAPR/AO work).
c. Variations on partial treatment at PTP (8:30, 4:30, 0:30, and 0:40 dry:wet schemes) with multiple possible discharge points, including:
   – Iron Run
   – Spring Creek Pump Station wet well
   – Upper Macungie Trunkline
   – Park Pump Station wet well
   – Kline'ss Island headworks
   – Kline's Island expanded headworks
   – Kline's Island treatment system

Preliminary Screening of Alternatives



Operating Guidelines

- Interceptor pressurization / hydraulic grade line limits
- Pump station operation rules
- Basement protection rules
- Interceptor Parallel versus Enlargement
- Primacy rights to City Interceptors

July 2022 – August 2022

Final Alternative Analyses

- Revised/Finalized Source Reduction Plan(s)
- Revisions to operating guidelines
- Capital, O&M, Energy (carbon footprint), and Net Present Worth
- Design storm sensitivy
- Climate change considerations
- Sequence of construction

April 2023 – February 2024

Selection of Solution

- Short list of options
- Final proof of performance via 24 year simulation
- Project Sequence and Schedule
- Cash Flow Demand
- Who pays?
- Regionalization?
- Bond and Finance Strategy Development
- Rate Analyses

March 2024 – December 2024

Achieving Consensus on Solution

- Stakeholder vetting
  - LCA Board
  - Signatory Boards
  - PADEP
  - Activists
  - Developers
  - County
  - Customers

December 2024 – March 2025

Ratification

- Each board's formal adoption and signature

OR

- Dissenter's submit their own independent plan to PADEP

March 2025 – June 2025

ARCADIS Design & Consultancy for natural and built assets

Discussion

KISS Sewer Meters (106 Total)

- Signatory Billing Meter (21)
- Signatory Non SBM (12)
- Temporary (73)

KISS Sewer Basins

KISS Basin Boundaries

Lehigh County Authority

LEHIGH COUNTY AUTHORITY

ACT 537 / KISS BASINS

LEHIGH COUNTY, PENNSYLVANIA

Remarks:

The differing colors for the KISS Sewer Basin layer are only used to help delineate the extent of each basin.

LEHIGH COUNTY AUTHORITY GIS

DATE: 11/20/2024 *SCALE: 1:28,500*

CREATED: AKW *CHECKED:*

Baseline Infiltration % Adjusted for Data Issues

< 20%	33 - 45 %
20 - 33 %	> 45%

Lehigh County Authority

LEHIGH COUNTY AUTHORITY

KISS I&I SUMMARY

LEHIGH COUNTY, PENNSYLVANIA

Remarks:

LEHIGH COUNTY AUTHORITY GIS

DATE: 4/4/2022 *SCALE: 1:44,000*

CREATED: *CHECKED:*

Lehigh County Authority

Average Peaking Factor

- < 4
- 4 - 5
- 5 - 6
- 6 - 10
- > 10
- No Study Conducted

Interceptor Main 18" and Over

LEHIGH COUNTY AUTHORITY

KISS I&I SUMMARY

LEHIGH COUNTY, PENNSYLVANIA

Remarks:

I&I studies were not able to be conducted in gray boundary areas

LEHIGH COUNTY AUTHORITY GIS

DATE: 4/6/2022 *SCALE: 1:44,000*

CREATED: *CHECKED:*

Lehigh County Authority

Length Normalized RDII

- < 2
- 2 - 4
- 4 - 8
- > 8

LEHIGH COUNTY AUTHORITY

KISS I&I SUMMARY

LEHIGH COUNTY, PENNSYLVANIA

Remarks:

LEHIGH COUNTY AUTHORITY GIS

DATE: 4/4/2022 *SCALE: 1:44,000*

CREATED: *CHECKED:*

METER	SIGNATORY	SEWER METER BASIN	Basin Length (LF)	Approximate MHs	*BASELINE INFILTRATION RANK*	RAINFALL-DERIVED INFILTRATION RANK	*INFLOW RANK*	*WORST RANK*
ALBERT_Net	City	Temporary	9,059	45	3	1	1	1
CEDAR CREEK RI_Net	SWT	Temporary	15,526	70	1	26	44	1
UNION 2_Net	City	Temporary	11,428	57	54	2	15	2
LITTLE CEDAR CREEK_Net	City	Temporary	40,306	202	2	10	31	2
EB4	EB	Emmaus SBM #4	45,240	204	18	17	2	2
LITTLE LEHIGH_Net	City	Temporary	20,278	101	45	3	19	3
SW54	SWT	SWT SBM #54	168,942	761	72	29	3	3
North 6th 2_Net	City	Temporary	12,585	63	7	4	22	4
Irving Park_Net	City	Temporary	25,186	126	4	21	29	4
EB2_Net	EB	Emmaus SBM #2	17,737	80	64	15	4	4
Hanover TL_Net	City	Temporary	48,683	243	5	32	41	5
MLK 3_Net	City+ST	Temporary	20,987	105	58	5	34	5
MM3 aka Phase 3_Net	UMT	Non-SBM Permanent	87,238	393	50	18	5	5
SUMNER 5_Net	City	Temporary	18,509	93	10	6	18	6
North 12th	City	Temporary	48,091	240	6	81	83	6
MLK 2_Net	City+ST	Temporary	35,573	178	20	19	6	6
Tioga_Net	City	Temporary	26,815	134	33	7	74	7
Ritter Elementary	City	Temporary	59,725	299	42	14	7	7
Trout Creek Park	City	Temporary	141,700	709	8	47	59	8
North 6th_Net	CWSA	Temporary	47,742	215	81	8	71	8
MS2/MS2 Temp_Net	LMT	LCA MS #2 (non-billing)	52,177	235	37	31	8	8
BASIN STREET 2_Net	City	Temporary	39,222	196	12	9	50	9
SUMNER 4_Net	City	Temporary	19,914	100	9	30	39	9
ST10	ST	Salisbury SBM #10	104,982	473	16	20	9	9
U_26_84 (ST6)	ST	Salisbury SBM #6	34,414	155	53	48	10	10
CW Lehigh_Net	CWSA	CWSA SBM Lehigh	43,946	198	66	11	13	11
Eberhart West_Net	CWSA	Temporary	46,901	211	32	78	11	11
Spring Creek PS + SCPS DS_Net	LMT	LCA Spring Creek FM SBM	116,879	526	11	12	55	11
Tarkett_Net	CWSA	Temporary	47,775	215	67	49	12	12
EASTSIDE	City	Temporary	11,651	58	14	13	73	13
Industrial Blvd_Net	UMT		125,630	566	13	56	82	13
MM8	UMT	Non-SBM Permanent	150,953	680	60	40	14	14
JUNIATA_Net	City	Temporary	32,229	161	15	16	69	15
SW51	SWT	SWT SBM #51	44,592	201	24	25	16	16
EB3	EB	Emmaus SBM #3	15,447	70	77	41	17	17
US Dorney	SWT	Temporary	55,608	250	17	35	53	17
EB4a	EB	Emmaus SBM #4	99,644	449	19	50	36	19
Bradford	City	Temporary	36,318	182	29	42	20	20
AMERICAN_Net	City	Temporary	49,094	245	51	39	21	21
ST. ELMO_Net	City	Temporary	83,039	415	21	44	32	21
Park Blvd	City	Temporary	15,894	79	22	60	60	22
Fairmont_Net	CWSA	Temporary	8,191	37	34	22	46	22
MS1	Alburtis	LCA SBM #1 (non-billing)	48,046	216	88	43	23	23
LEHIGH	City	Temporary	8,685	43	87	23	37	23
ST1 Surrogate	ST	Salisbury SBM #10	32,860	148	23	84	87	23
MS3_Net	Macungie	LCA SBM #3 (non-billing)	91,552	412	74	57	24	24
SW56	SWT	SWT SBM #56	31,158	140	28	24	38	24
EAST MAPLE	City	Temporary	64,042	320	59	38	25	25
BASIN STREET 1	City+ST	Temporary	63,689	318	25	37	35	25
SUMNER 3_Net	City	Temporary	23,509	118	39	46	26	26
Mickley_Net	CWSA	Temporary	29,896	135	26	67	81	26
SUMNER 2_Net	City	Temporary	14,633	73	35	27	68	27
CW Jordan_Net	CWSA	CWSA SBM Jordan	49,937	225	27	64	47	27
Eberhart North_Net	CWSA	Temporary	73,780	332	49	76	27	27
LMT County	LMT	LMT SBM County	59,949	270	80	58	28	28
Upper Iron Run_Net	UMT	Temporary	95,666	431	71	28	54	28
UNION 1_Net	City	Temporary	41,990	210	48	52	30	30
MacArthur 1_Net	CWSA	Temporary	42,100	190	30	68	86	30
Hokendauqua Park_Net	CWSA	Temporary	56,778	256	31	51	51	31
PPS+U613	City	Temporary	44,778	224	46	33	43	33
EB1	EB	Emmaus SBM #1	11,444	52	61	53	33	33
PPS+U613	ST	Temporary	48,511	219	47	34	45	34
INDUSTRIAL	City	Temporary	55,875	279	79	36	40	36
SUMNER 1_Net	City	Temporary	124,566	623	36	63	58	36
GORDAN	City	Temporary	57,915	290	38	74	80	38
North 11th	City	Temporary	10,369	52	40	73	84	40
Breinigsville	UMT	Temporary	147,759	666	41	72	88	41
FOUNTAIN PARK_Net	City	Temporary	30,066	150	73	45	42	42
ST8	ST	Salisbury SBM #8	40,862	184	43	70	62	43
SnR034	UMT	Temporary	52,256	235	44	85	78	44
MM7 aka Mill Creek_Net	UMT	Non-SBM Permanent	61,397	277	75	59	48	48
MacArthur 2	CWSA	Temporary	40,047	180	82	66	49	49
Cedarcrest Blvd	City	Temporary	75,410	377	83	69	52	52
GREEN	City	Temporary	10,851	54	52	75	85	52
MLK 1	City	Temporary	59,512	298	55	54	70	54
EB2a	EB	Emmaus SBM #2	68,562	309	76	55	63	55
LINDEN	City	Temporary	27,721	139	56	65	72	56
SW52	SWT	SWT SBM #52	65,448	295	65	77	56	56
Ramada	CWSA	Temporary	32,089	145	57	80	77	57
SW55	SWT	SWT SBM #55	71,764	323	70	62	57	57
SW53	SWT	SWT SBM #53	72,963	329	62	61	61	61
MS5 Total_Net	LMT	LCA SBM #5	457,785	2062	63	88	65	63
LMT Dog Park + Spring Creek Relief	LMT	Temporary	31,619	142	78	71	64	64
Hanover	HT	Hanover SBM	20,384	92	86	82	66	66
Saylor Park	CWSA	Temporary	40,493	182	69	83	67	67
LR6-a	CWSA	Temporary	53,472	241	68	79	76	68
C-3.115	CWSA	Temporary	83,665	377	84	86	75	75
LMT Cedarbrook	LMT	LMT SBM Cedarbrook	48,183	217	85	87	79	79