Inflow and Infiltration

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Public Utilities Department

Raleigh's History with I&I

- **Our initial system was designed in 1888.**

76 REPORT OF SEWERAGE COMMITTEE.

The "separate system," I may say, possesses manifold advantages over the combined; the size of pipe required being very much smaller in the separate than in the combined, makes the first cost very much in its favor. The

- **Treatment began in the 1950's**

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Why do we hate it?

- Possible SSO's.
- Capital improvements may be needed to convey flows
- Cost of pumping and treating stormwater
- Peaking factors at our wastewater plants picture of EQ basin
- Capacity that we have do deal with, but doesn't relate to billed flows

You have to find it to fix it.

- Short of replacing your entire system and turning your community into a construction zone, you have to find your I&I.
- Stepwise approach can save a lot of money.
- Flow monitoring can narrow the scope.

What are you measuring?

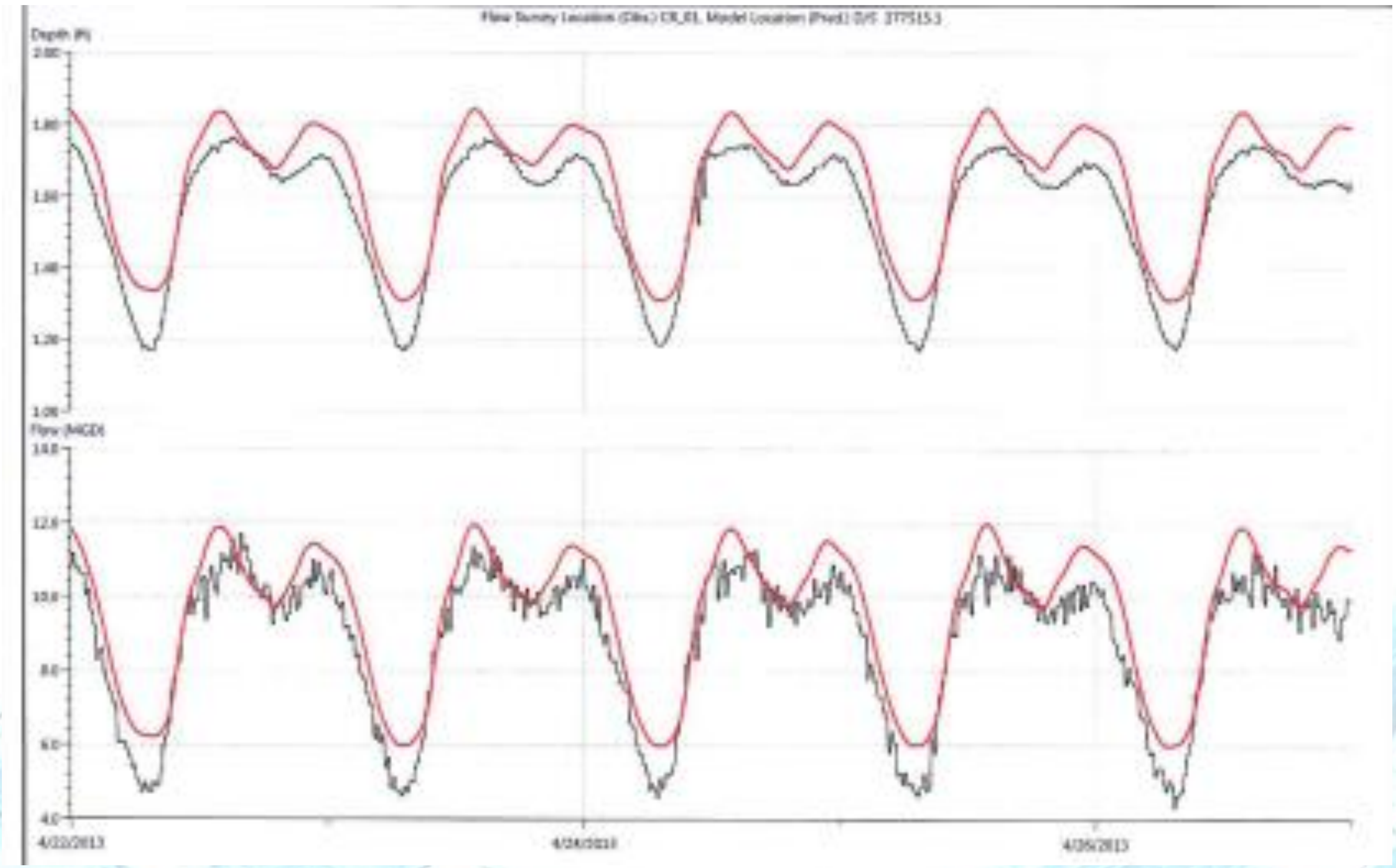
- Variety of technologies, but all are measuring velocity and depth
- These two parameters are used to calculate flow within the pipe
- In order to find Inflow and Infiltration, you have to compare to a “Normal” Day
- No two storms are alike:
  - http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nc

Some Definitions:

- Ground Water Infiltration (GWI)
  - Volume of infiltration on a dry weather day
  - You find GWI by analyzing the minimum flows in the early morning hours of dry weather days.
- Rainfall Dependent Inflow and Infiltration (RDI/I)
  - Difference in volume between the Average Dry weather day, and the Rainfall event.

Breaking down the data:

- **Eyeball**



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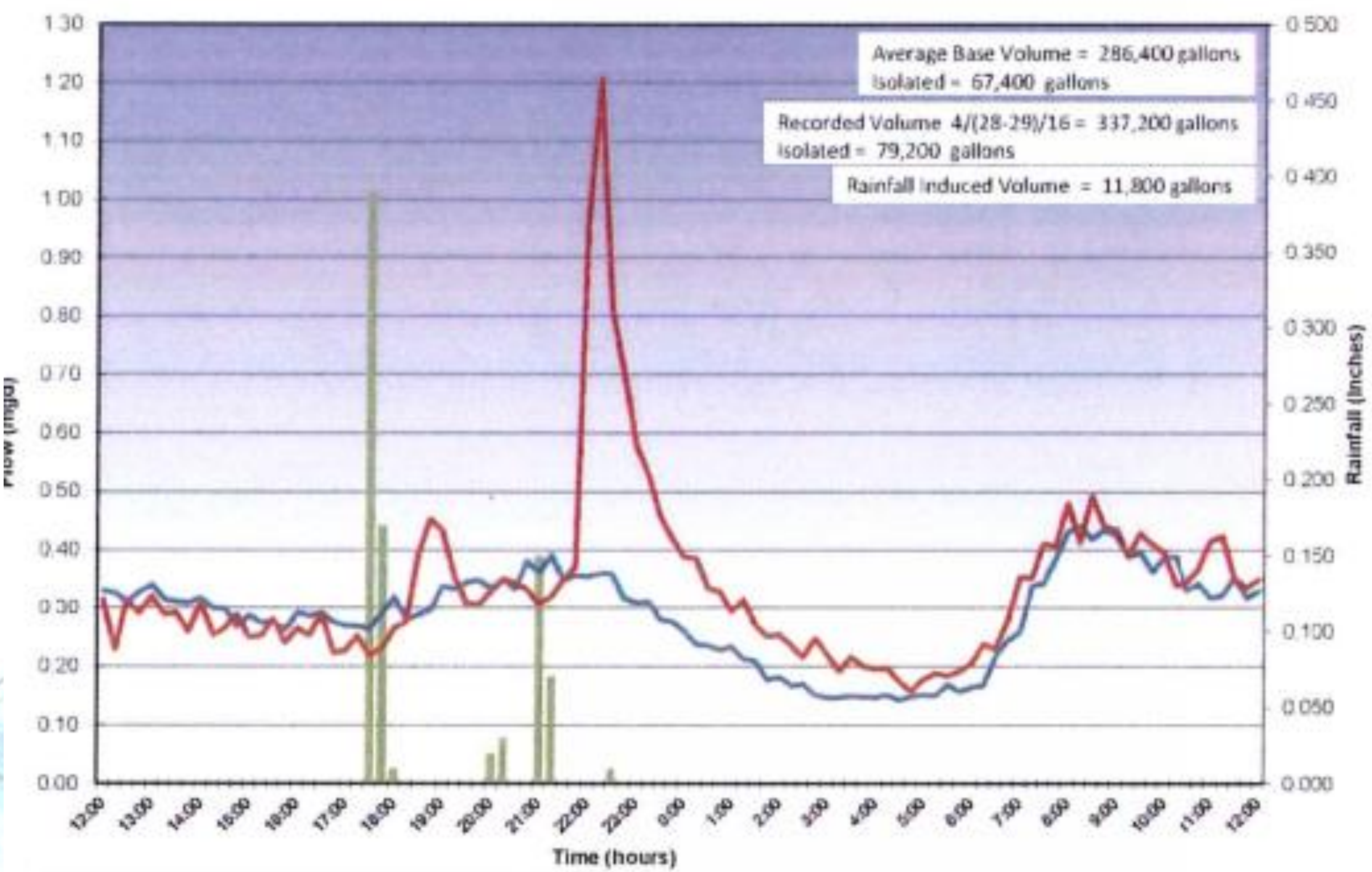

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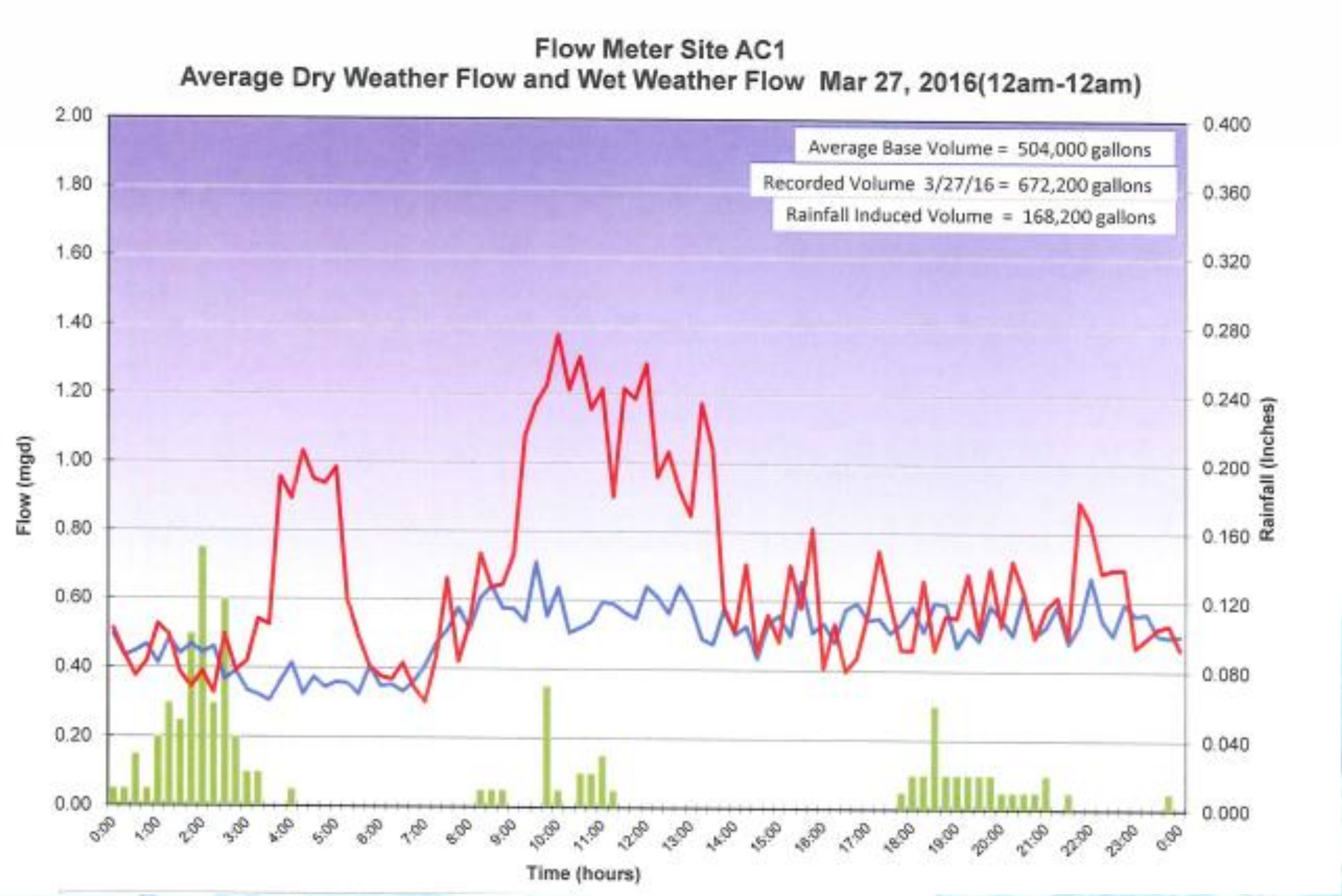
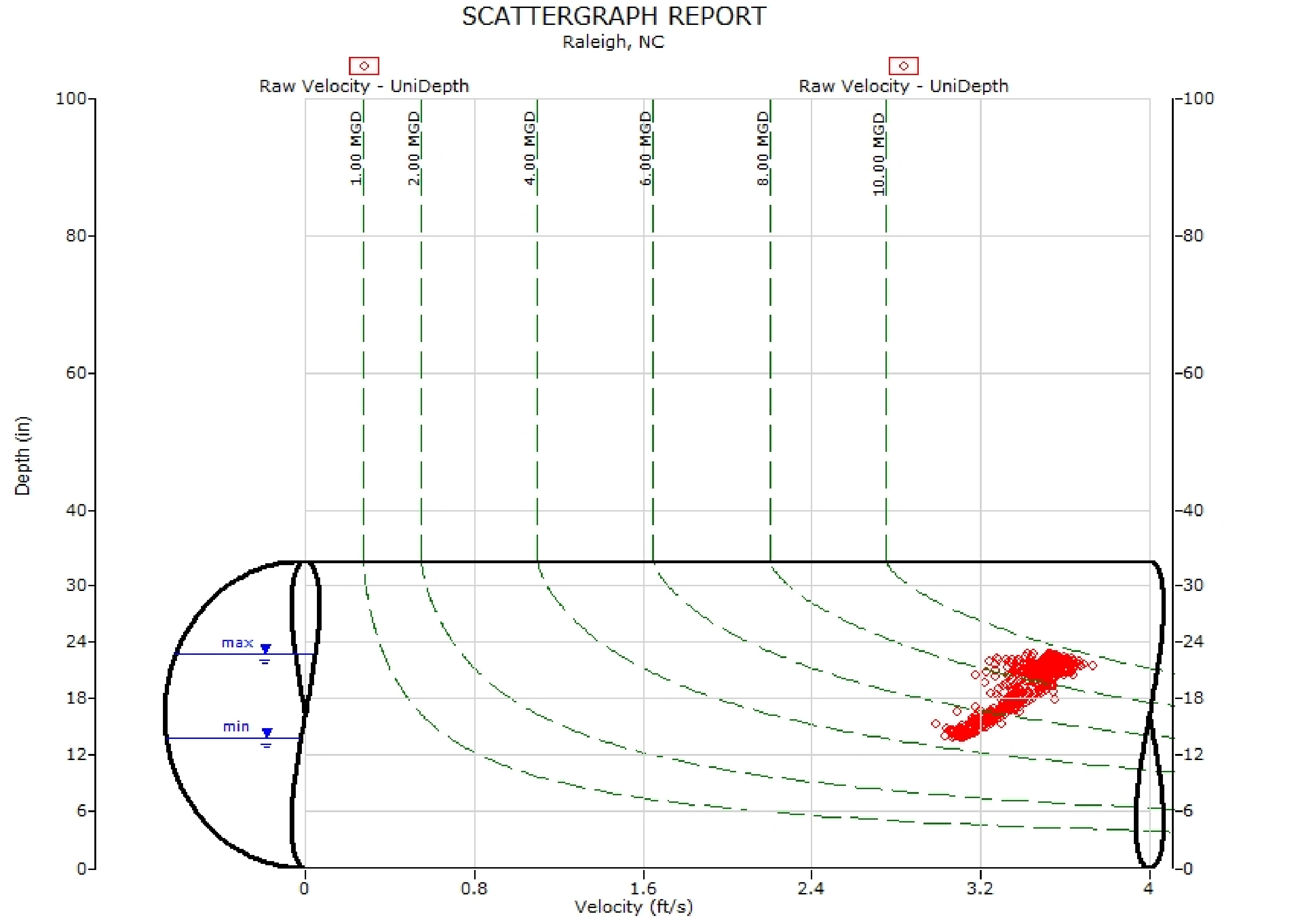


Breaking down the data :

- **Scatter Plots**



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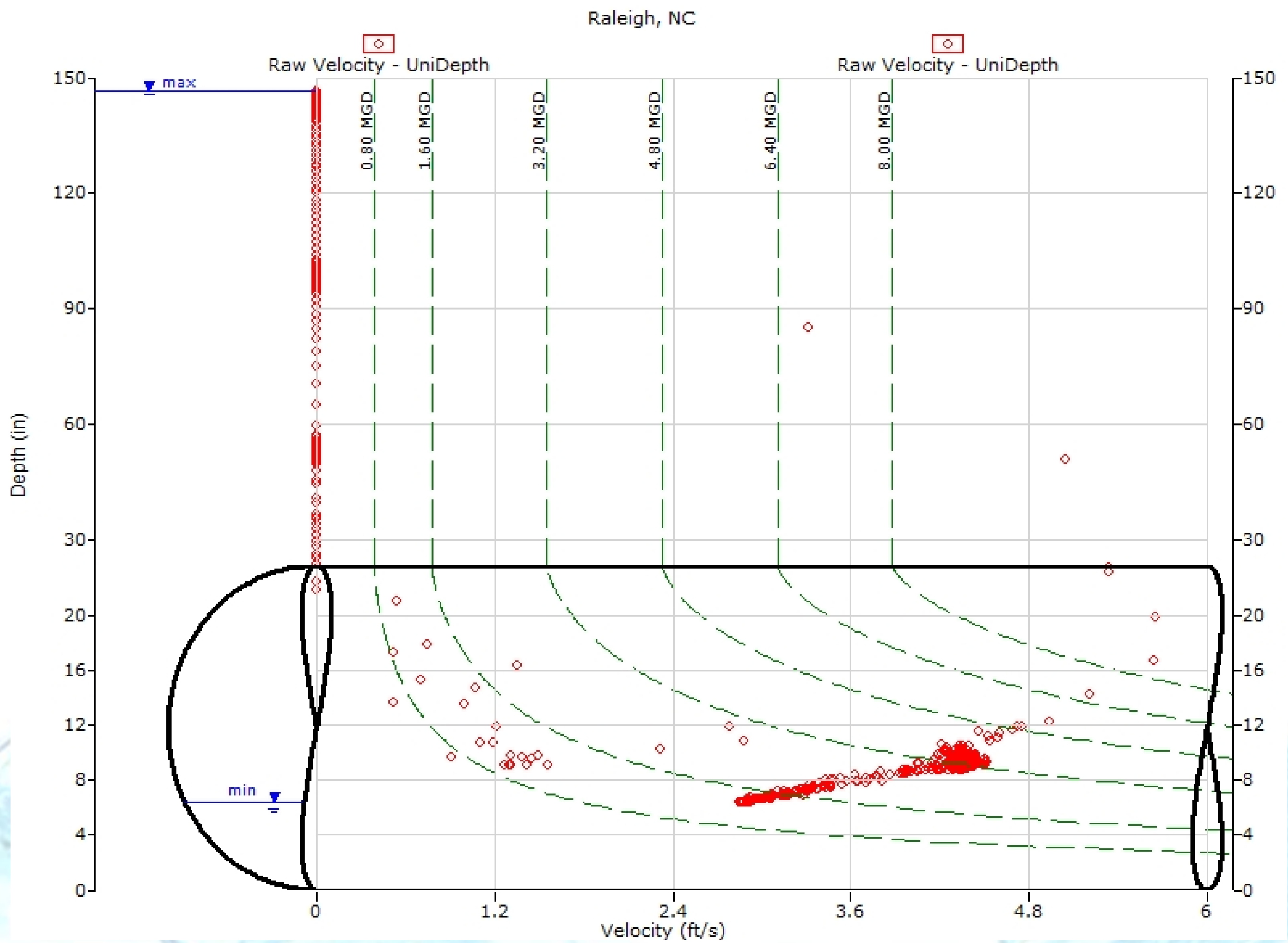


Breaking down the data :

- **Peaking Factors**

Table 3.1 – RDI/I Rankings

Sub-basin No.	Average Base Dry Day 24-Hour Flow (ABF) (gallons)	Maximum Wet Weather 24-Flow (gallons)	Maximum Total RDI/I Contribution (gallons)	Wet vs Dry Weather Flow Peaking Factor (PF)	RDI/I Ranking Volume/PF
AC-1	504,000	688,000	184,000	1.36	6/6
AC-2	285,600	530,000	244,400	1.85	4/3
BC-1	264,300	718,000	453,700	2.71	2/2
BC-2	476,900	773,000	296,100	1.62	3/4
CC-1	328,600	1,133,000	805,000	3.45	1/1
PC-1	545,600	784,000	238,400	1.44	5/5
PC-2	532,400	690,600	158,200	1.30	7/7
PC-3	795,200	846,300	51,100	1.06	8/8

Breaking down the data :

- **GWI- compared to size of the drainage basin**

Table 3.2 – Groundwater Infiltration Rankings

Sub-basin No.	Length of Gravity Piping (linear feet)	Apparent Infiltration (gallons per day)	Gallons of Infiltration (gal-inch-diameter/mile)	Infiltration Ranking Volume/IDM
AC-1	126,144	226,000	1,056	2/1
AC-2	147,866	54,000	222	8/8
BC-1	107,933	86,000	527	6/4
BC-2	152,637	143,000	602	4/3
CC-1	115,912	68,000	397	7/6
PC-1	230,026	189,000	461	3/5
PC-2	148,505	104,000	386	5/7
PC-3	229,536	291,000	767	1/2

Breaking down the data :

- **R-values/RTK**

RDII RESPONSE	T	K
Fast	0.1 – 3	0.1 – 2
Medium	3 – 6	2 – 4
Slow	6+	4+

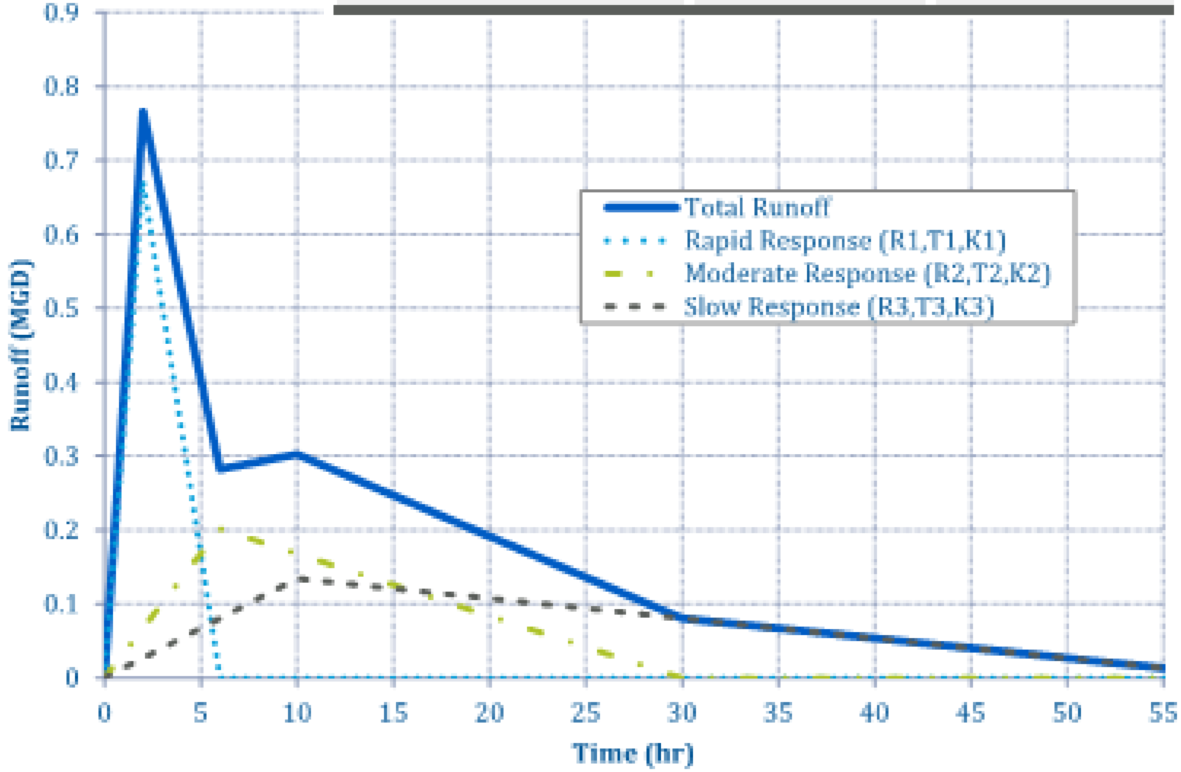
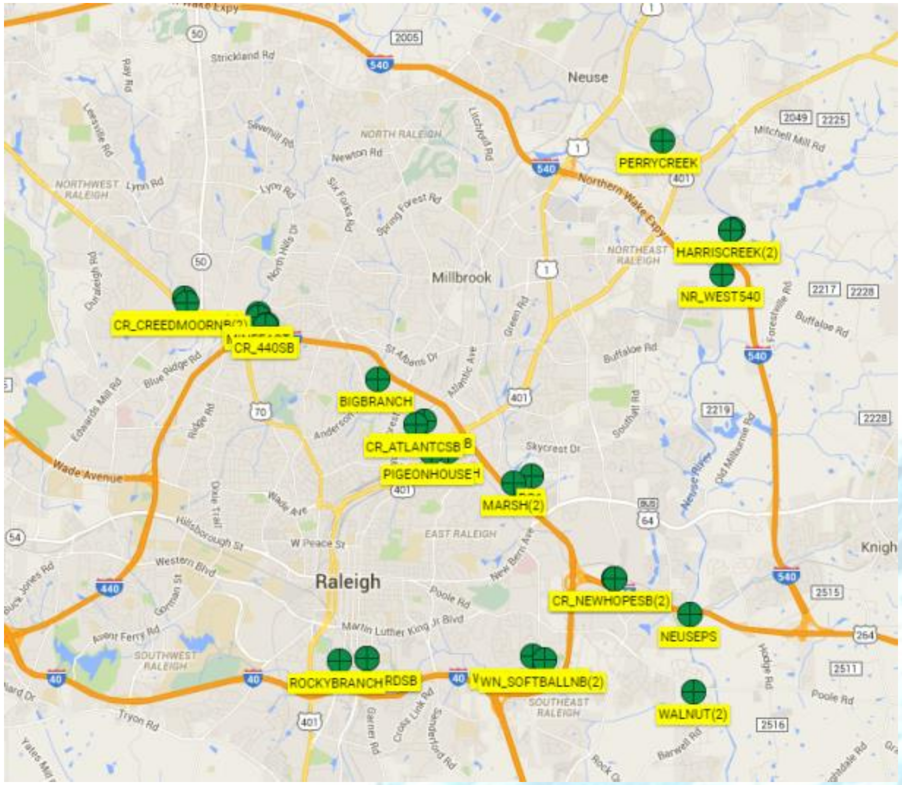


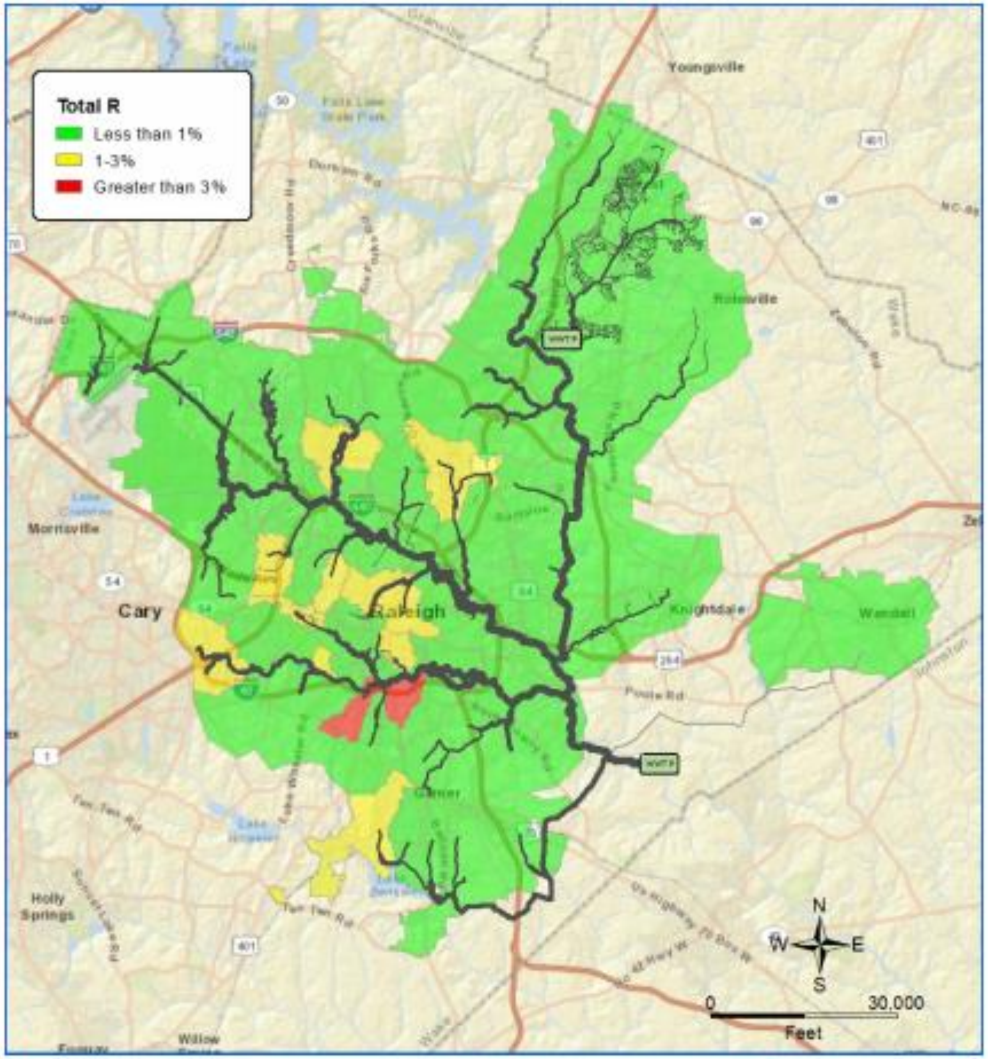
Figure 2-18 RTK Runoff Calculation Process

Raleigh’s Current Efforts

- **Permanent Flow monitor Network**
- **Sewer model/Capacity Study**
- **Temporary projects**



Project Example- Upper Pigeon House



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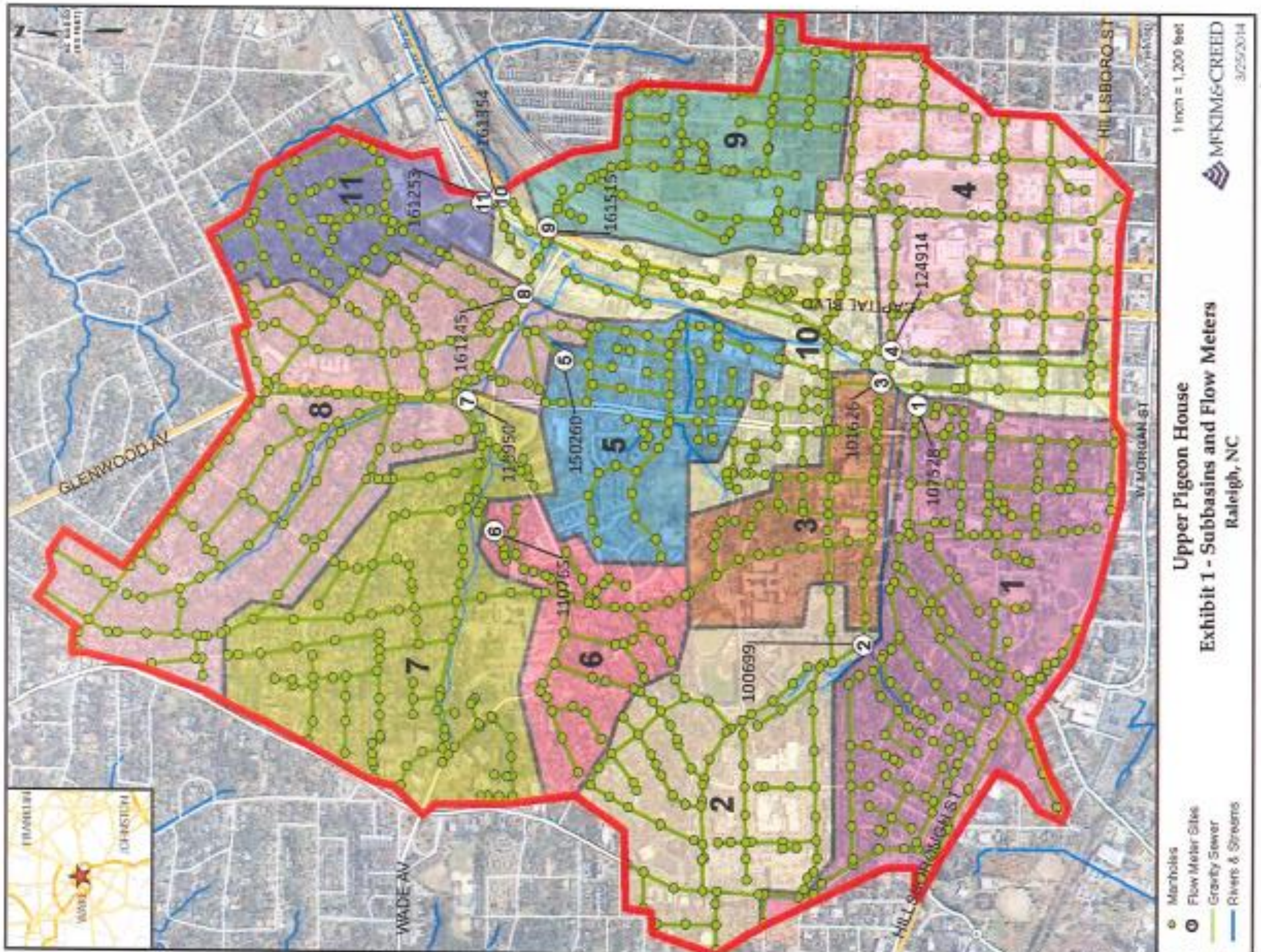

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1	191,000	372,000	181,000	1.9	6/10
2	74,000	308,000	234,000	4.2	5/4
3	94,000	454,000	360,000	4.8	3/3
4	188,000	316,000	128,000	1.7	8/11
5	92,000	381,000	289,000	4.1	4/5
6	134,000	254,000	120,000	1.9	9/10
7	51,000	102,000	51,000	2.0	11/8
8	131,000	1,079,000	948,000	8.2	1/2
9	79,000	174,000	95,000	2.2	10/7
10	139,000	511,000	372,000	3.7	2/6
11	19,600	188,100	168,500*	9.6	7/1

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Sub-basin No.	Length of Gravity Piping (linear feet)	Apparent Infiltration (gallons per day)	Gallons of Infiltration (gal-inch-diameter/mile)	Infiltration Ranking
1	38,233 (6"-10")	58,000	1,121	5
2	19,358 (6"-12")	16,000	671	8
3	17,383 (6"-12")	74,000	2,899	2
4	21,147 (6"-10")	83,000	2,671	3
5	12,014 (6"-10")	13,000	791	7
6	10,058 (6"-10")	49,000	3,475	1
7	22,706 (6"-10")	11,000	424	10
8	38,525 (6"-15")	45,000	954	6
9	13,833 (6"-10")	25,000	490	9
10	12,736 (6"-15")	22,000	1,214	4
11	10,766 (6"-8")	1,000	64	11

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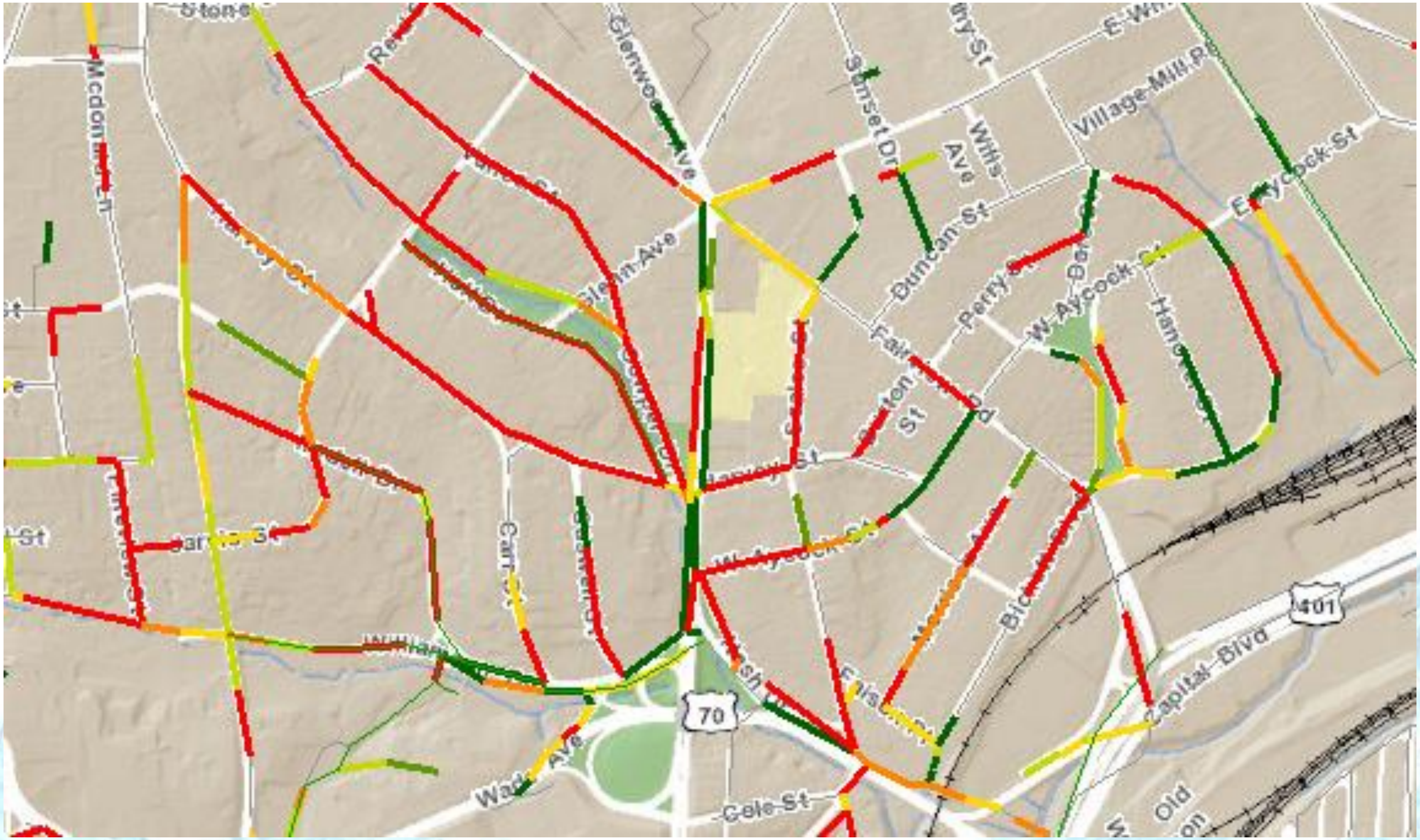

Decisions to Make:

- Flow monitoring contract options
  - Who owns the monitors?
  - Who maintains the monitors?
  - Who hosts the data?
  - What does the data integrate with?
  - Who analyzes the data?

Raleigh's Decisions:

- **Flow monitoring contract options**
  - **Who owns the monitors - Vendor**
  - **Who maintains the monitors- Vendor**
  - **Who hosts the data? - Vendor**
  - **What does the data integrate with? - SCADA**
  - **Who analyzes the data? – City, Consulting Engineers**

What Technology

- Flow monitoring Technologies
  - Non-contact (relatively clean data)
  - Traditional (Submerged sensor)
  - Lift stations
  - Other (smart covers, etc.)

Other Things of Note

- Groundwater levels and time of year influence response to storms
- Manhole selection is very important to good data
- You can’t have too many meters

Questions?

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