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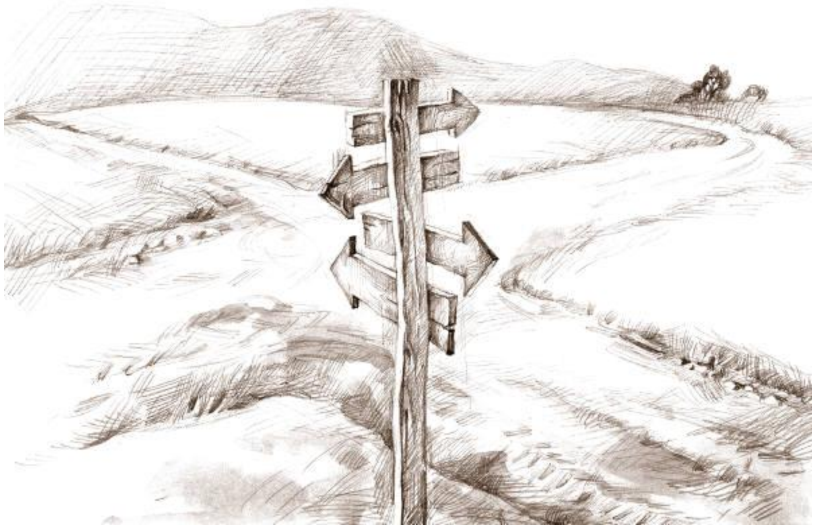
Underground Construction Technology
International Conference & Exhibition

A Road Map for Sewer Rehab *



A ten-step strategic plan

PRESENTED BY

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** A significant portion of this work was conducted*

Do we ***REALLY*** have an I/I Problem?

IS SEWER REHABILITATION EFFECTIVE ?

WHAT LEVEL OF REDUCTION DO WE REASONABLY EXPECT ?

HOW DO WE ACHIEVE SUCCESS ?

I/I INDICATOR – BOD INFLUENT

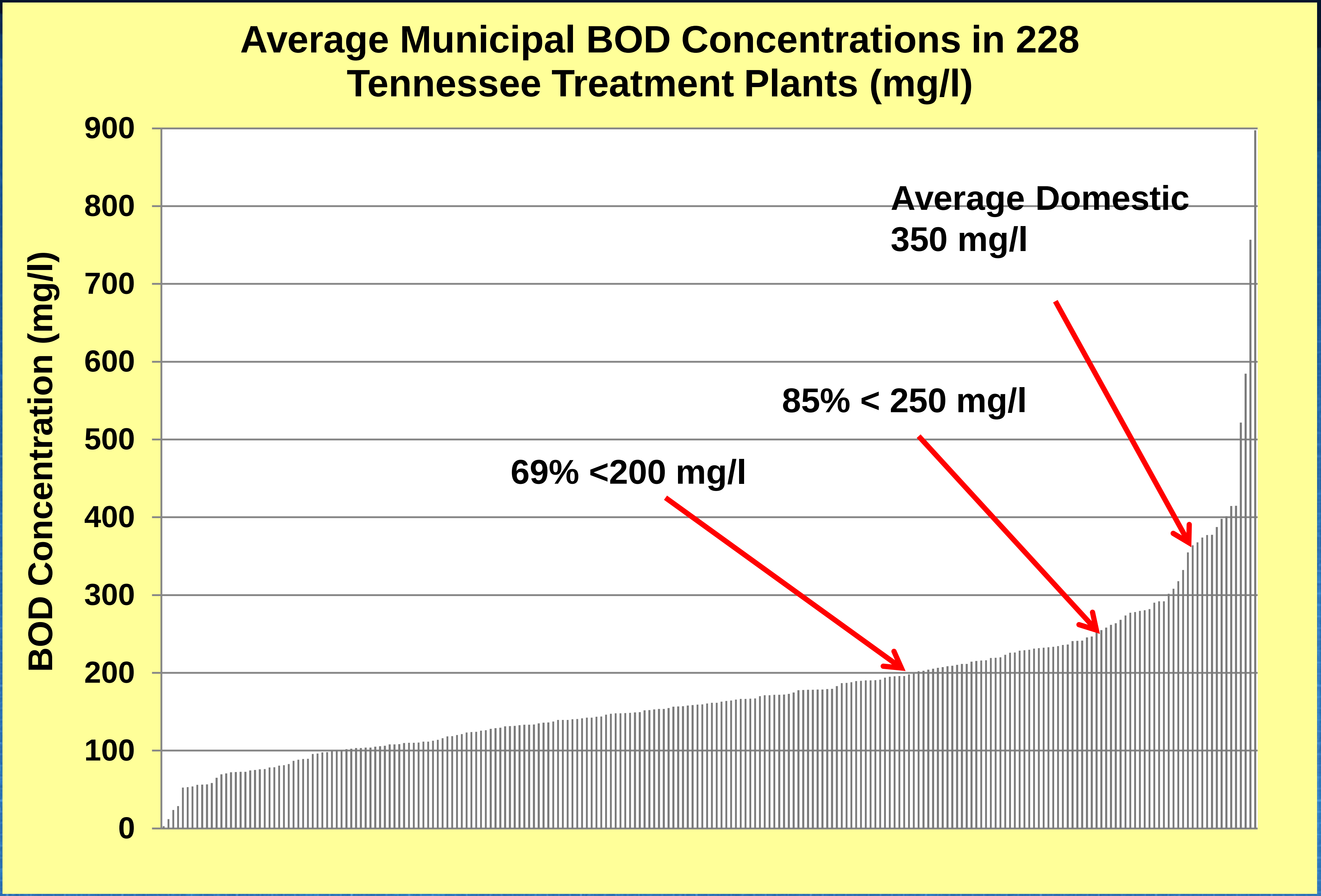
Domestic Sewage "Strength":

Weak	**100 – 150 mg/l**
Medium	**150 – 200 mg/l**
Strong	**200 - 250 mg/l**

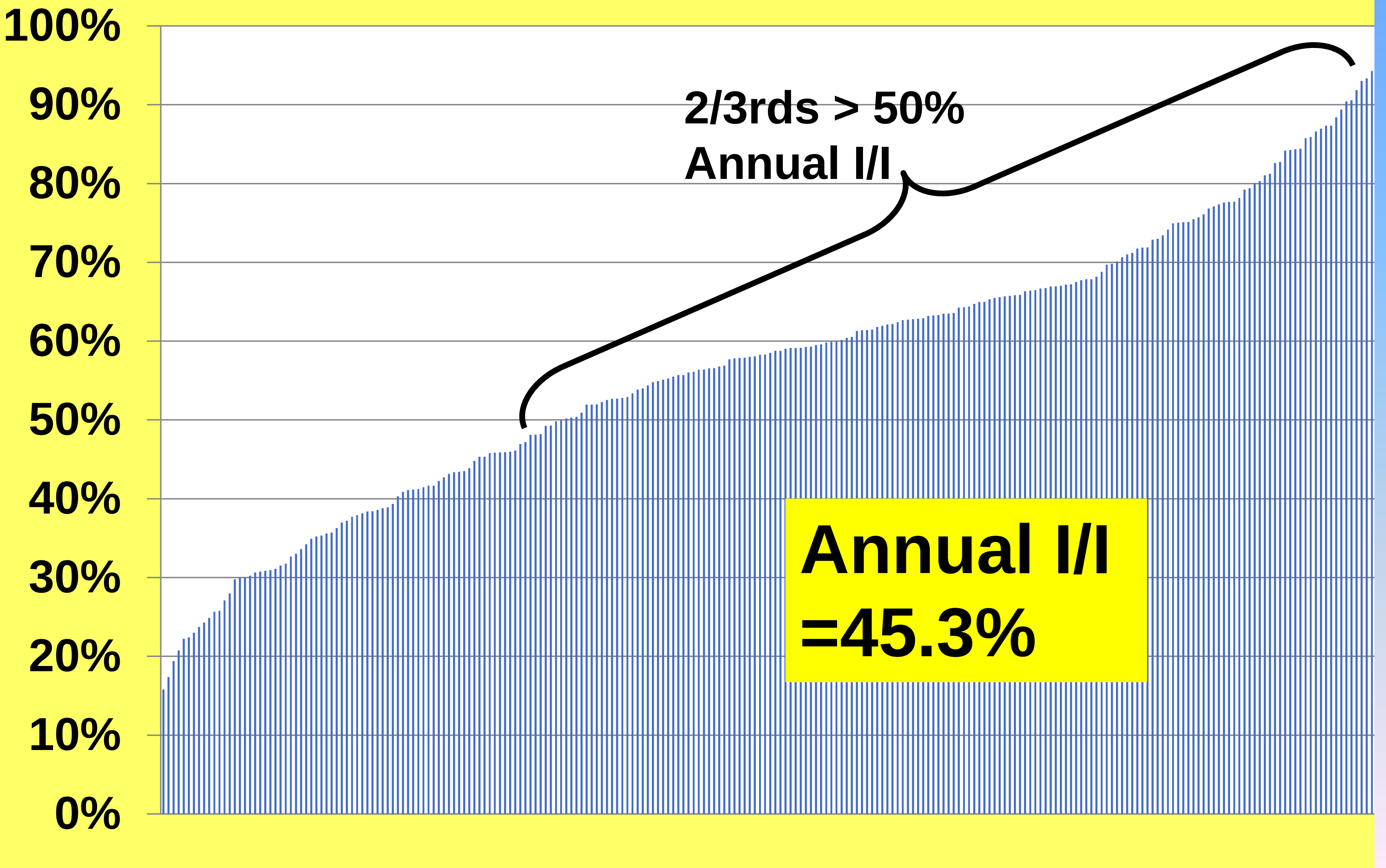
Strength of Domestic Sewage:

~ 350 mg/l

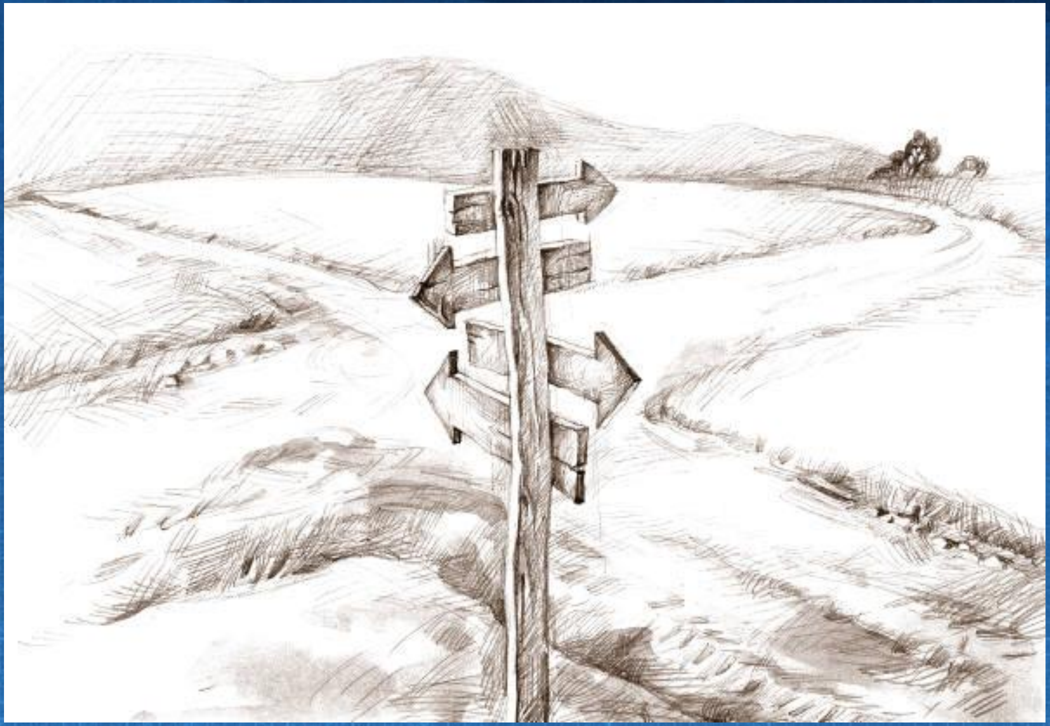
Magnitude of the I/I Problem



Annual % I/I in 238 POTW's Influent



So, what approach do you use to achieve I/I reduction?

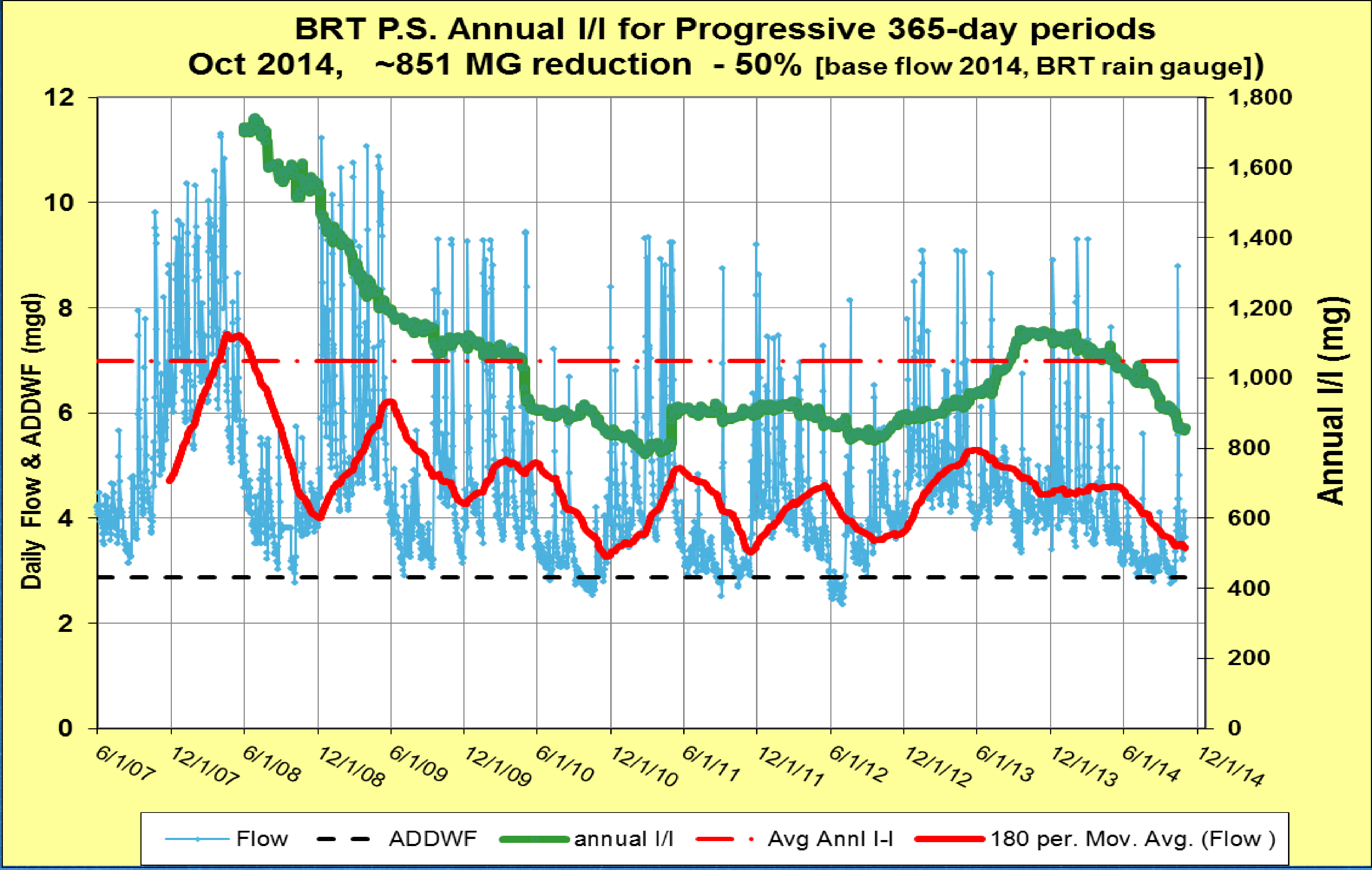


All roads look relatively equal if there is no track record of success.

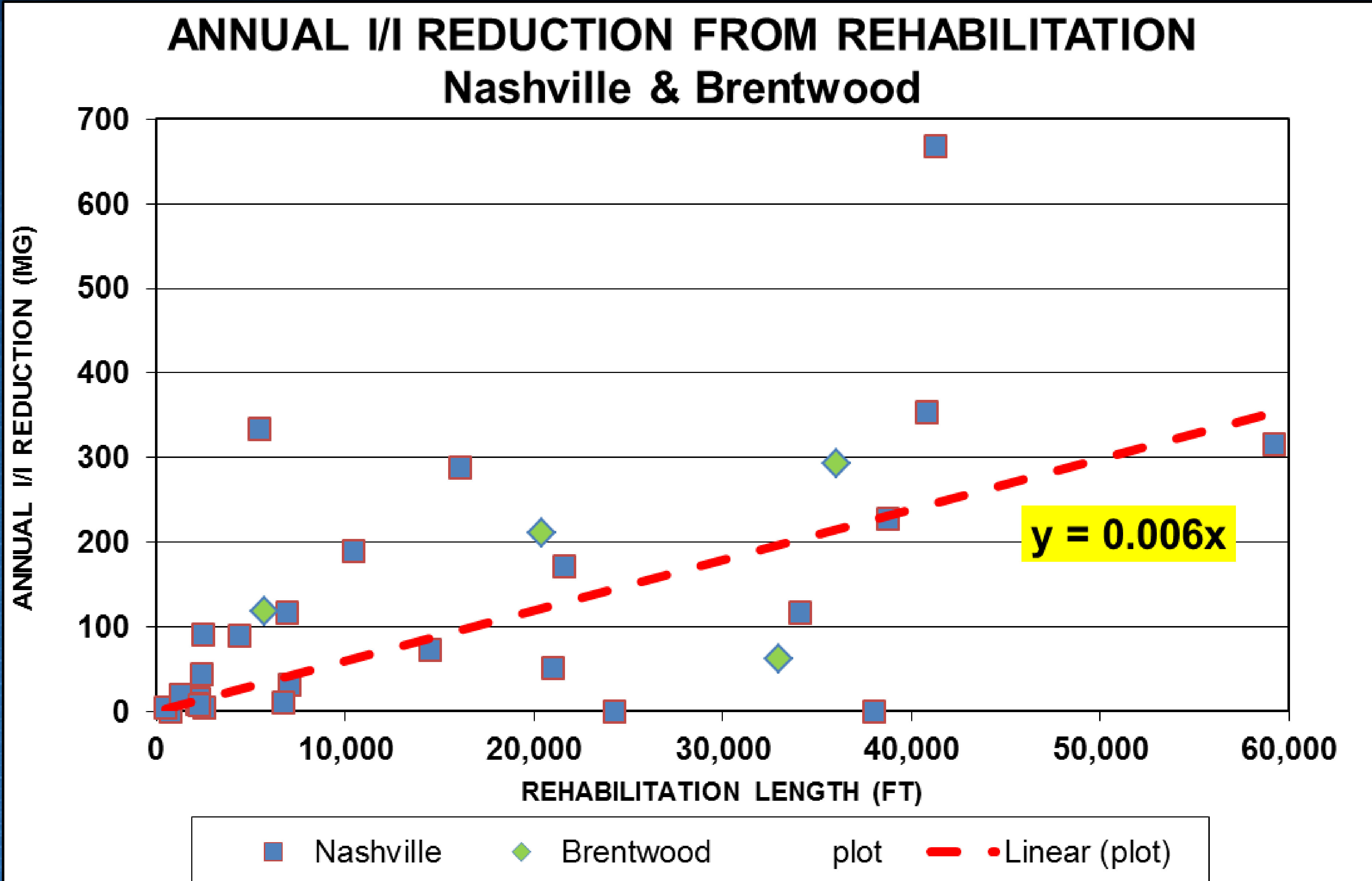
Successful Sewer Rehabilitation

- Based on **actual field results** in Nashville & Brentwood
- **Largest published database** for measured I/I reduction in the US
- Analyzed **126 miles of rehabilitation** (282 miles total - ~ 11% system)
- **I/I cut in half**
- **123 overflows eliminated**
- EPA commends **stream improvements**

REHABILITATION EFFECTIVENESS



REHABILITATION EFFECTIVENESS



Effectiveness (a "rule of thumb")

15-20%
(Minimum)
REHABILITATION INTENSITY

(including MH & laterals,
& in deteriorated areas)

→

~ 6 million Gallons annually

(Per 1,000 ft. Lining
or Replacement)

Successful Rehab Factors

- Define goals
- Extensive flow monitoring & standard procedures for analysis
- System approach – lateral & manhole rehabilitation
- “Targeting” – stop water migration
- Accountability – verify desired results

Ten Step Strategy

- Identify Goals
- Select Target Area
- Quantify Problem
- Locate Defects
- Select Pipe Segments
- Estimate Cost-Benefit
- Design & Install
- Verify Performance
- Follow-up Flow Monitoring
- Calculate O & M Savings

1 – Identify Community Goals

"Eliminate overflows and basement backups"

- Period of time: 2 years?, 5 years?
- Relate time to rainfall event return interval
- No overflows legally sanctioned

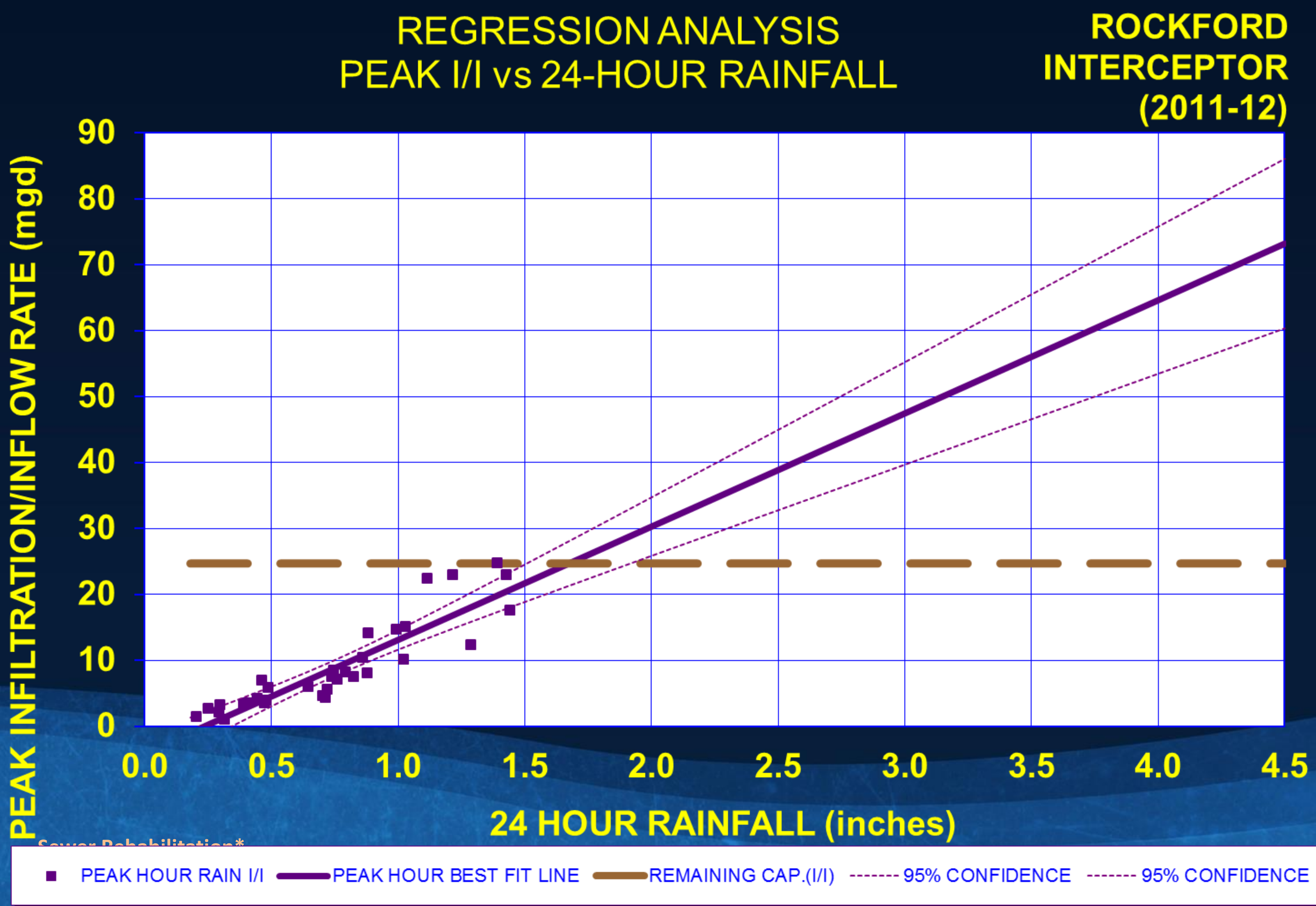
2 – Select (and Characterize) Target Area

- Flow monitoring network (~100,000 L.F.) – subdivide the system
- Identify capacity problems
- Calculate observed & potential I/I
- Hydraulic model
- **Prioritize tributary areas**

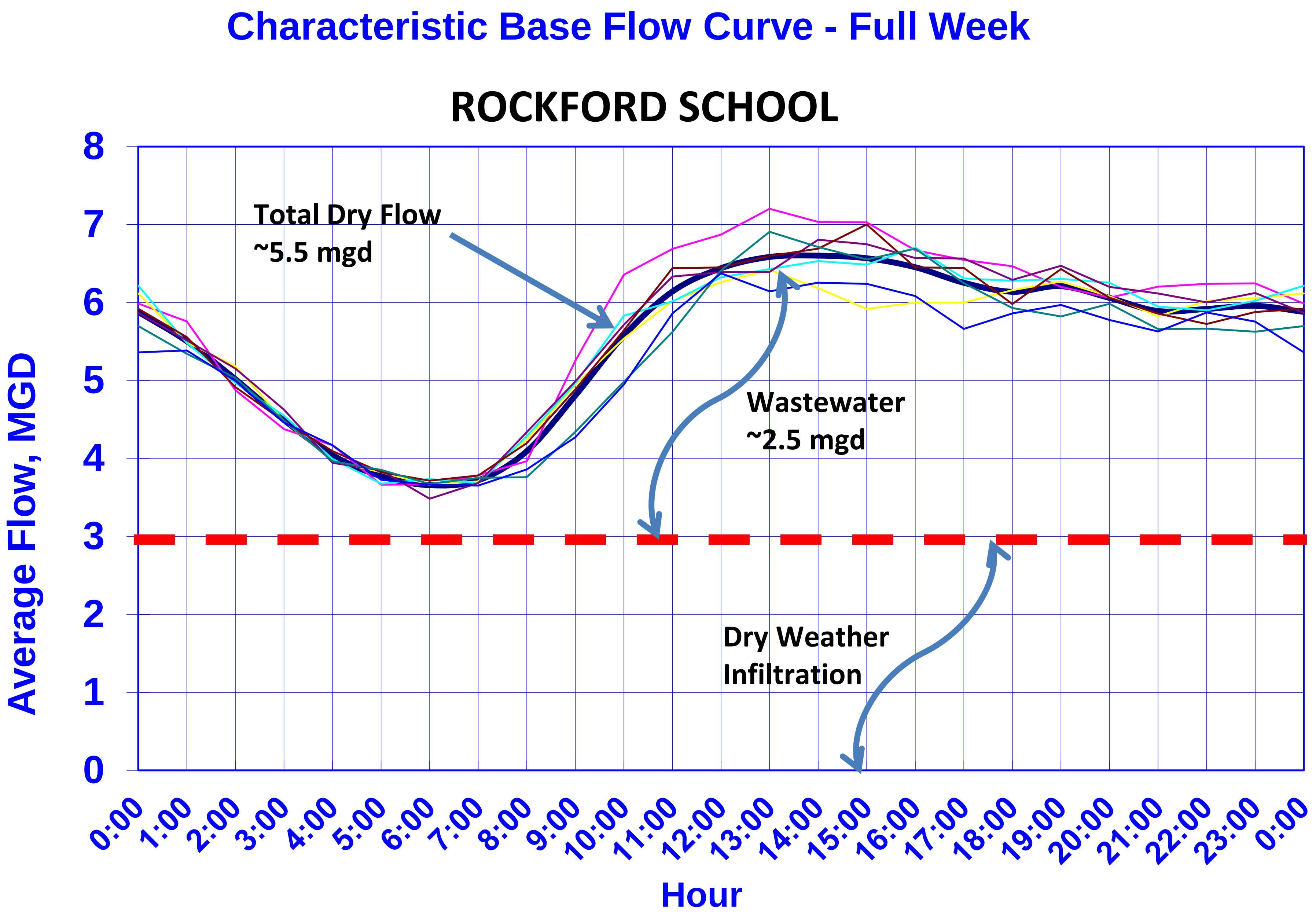
Results of the Flow Monitoring

- Three Perspectives
  - Wet Weather
  - Dry Weather
  - Year-round (Annual I/I)

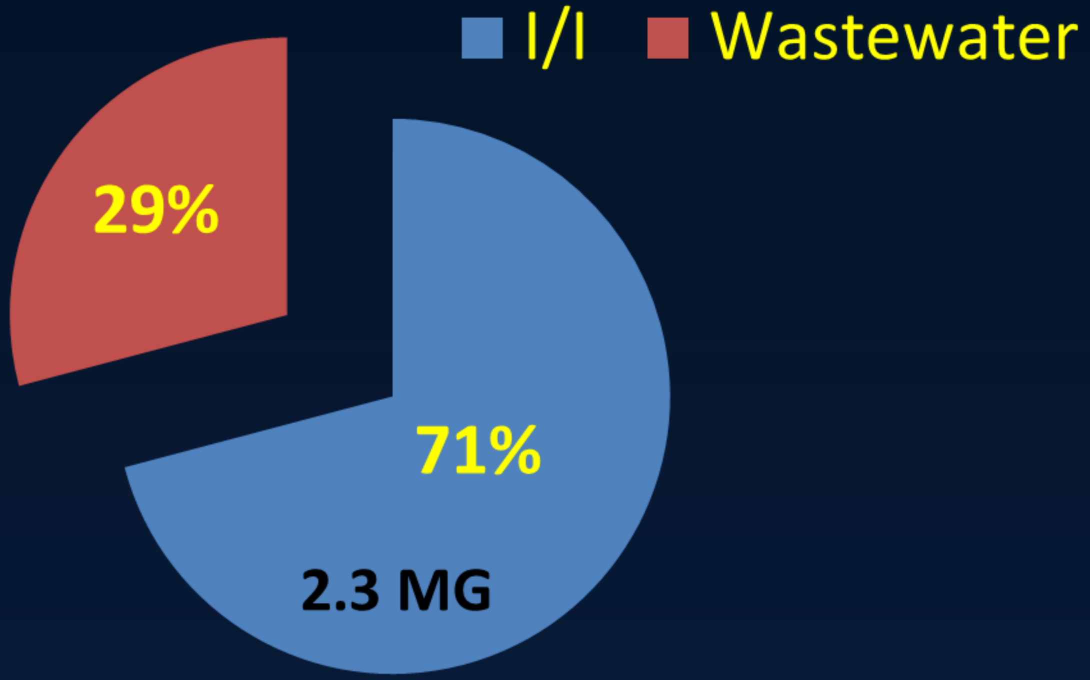
Wet Weather Problem



Dry Weather Problem



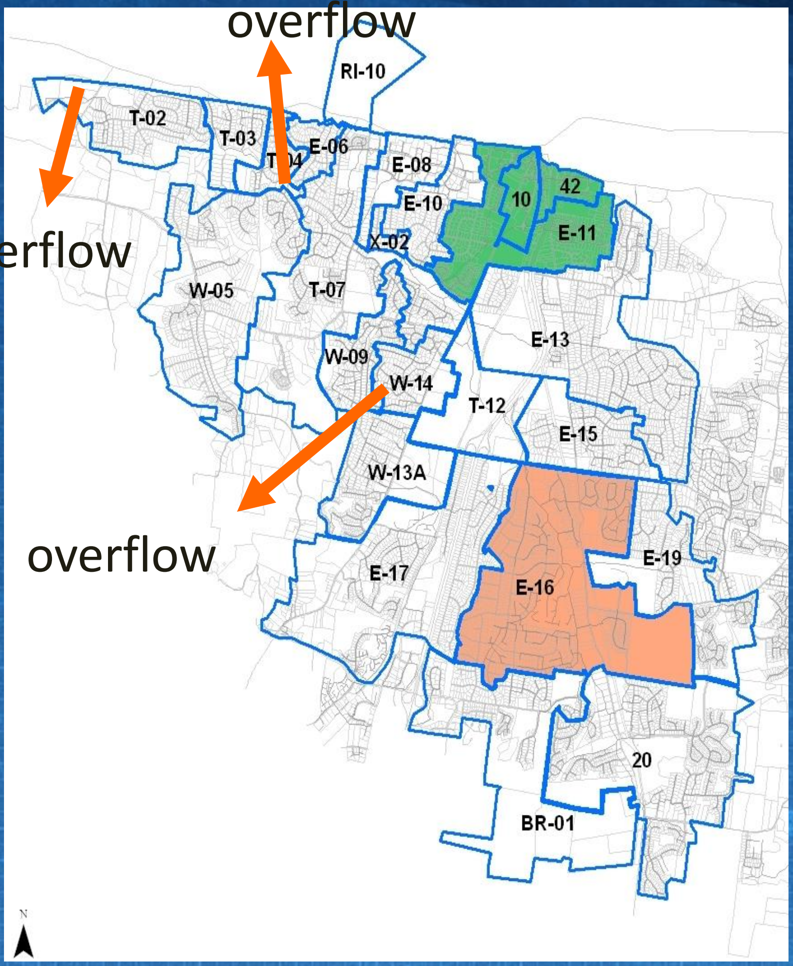
Year-Round Problem



Nearly ¾ of Annual Flow is Rainwater or Groundwater

(this equates to 2.4 gal I/I per gallon of wastewater)

2 – Select Target Area (Cont.) Divide System For Monitoring



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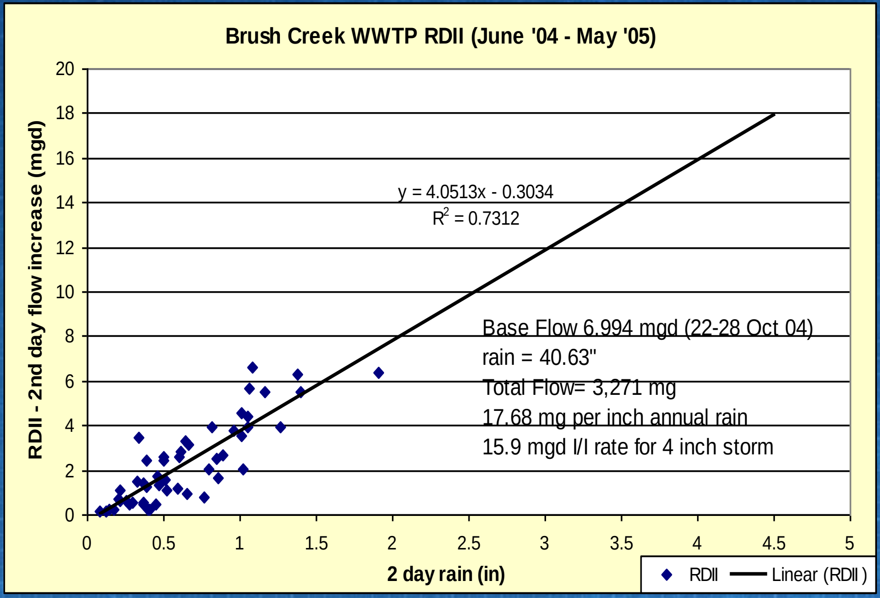
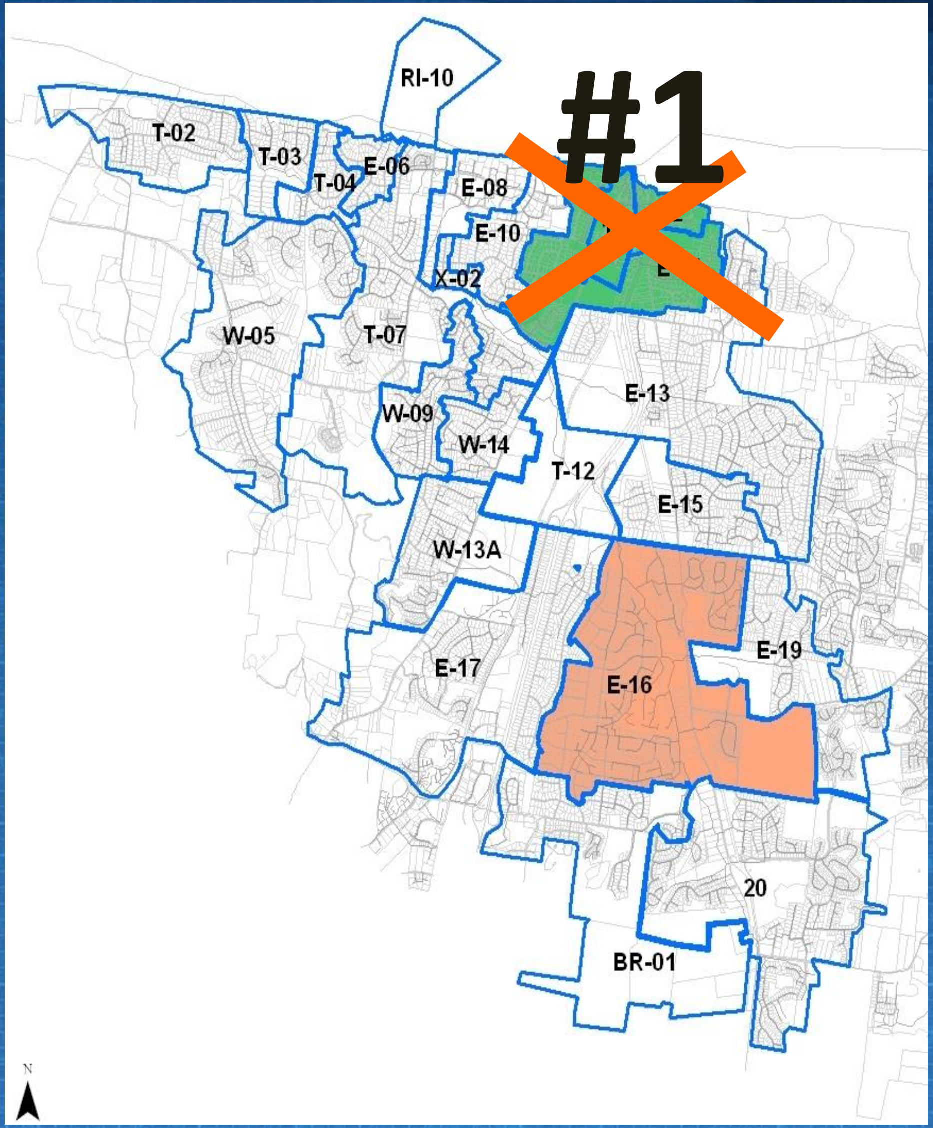


I/I measurements based solely on Treatment Plant influent data will usually underestimate system I/I due to overflow losses and hindered flow.

2 – Select Target Area (Cont.)
Total System: Pick Priority Area



Criteria:

- Overflows
- Annual I/I
- Peak I/I
- Condition

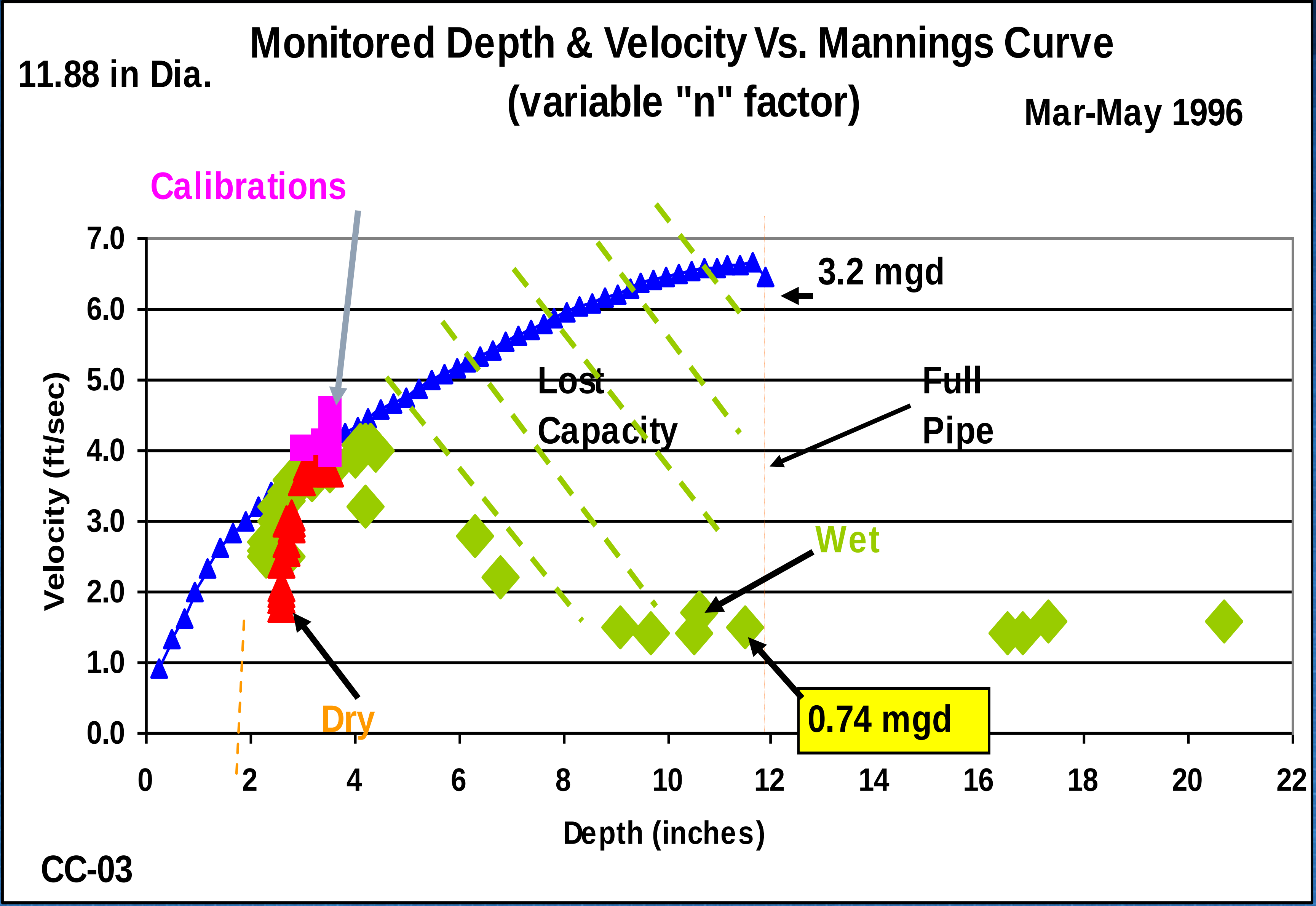
Knock it Out !

3 - Quantify Problem Conditions
(refine the process for the target areas)

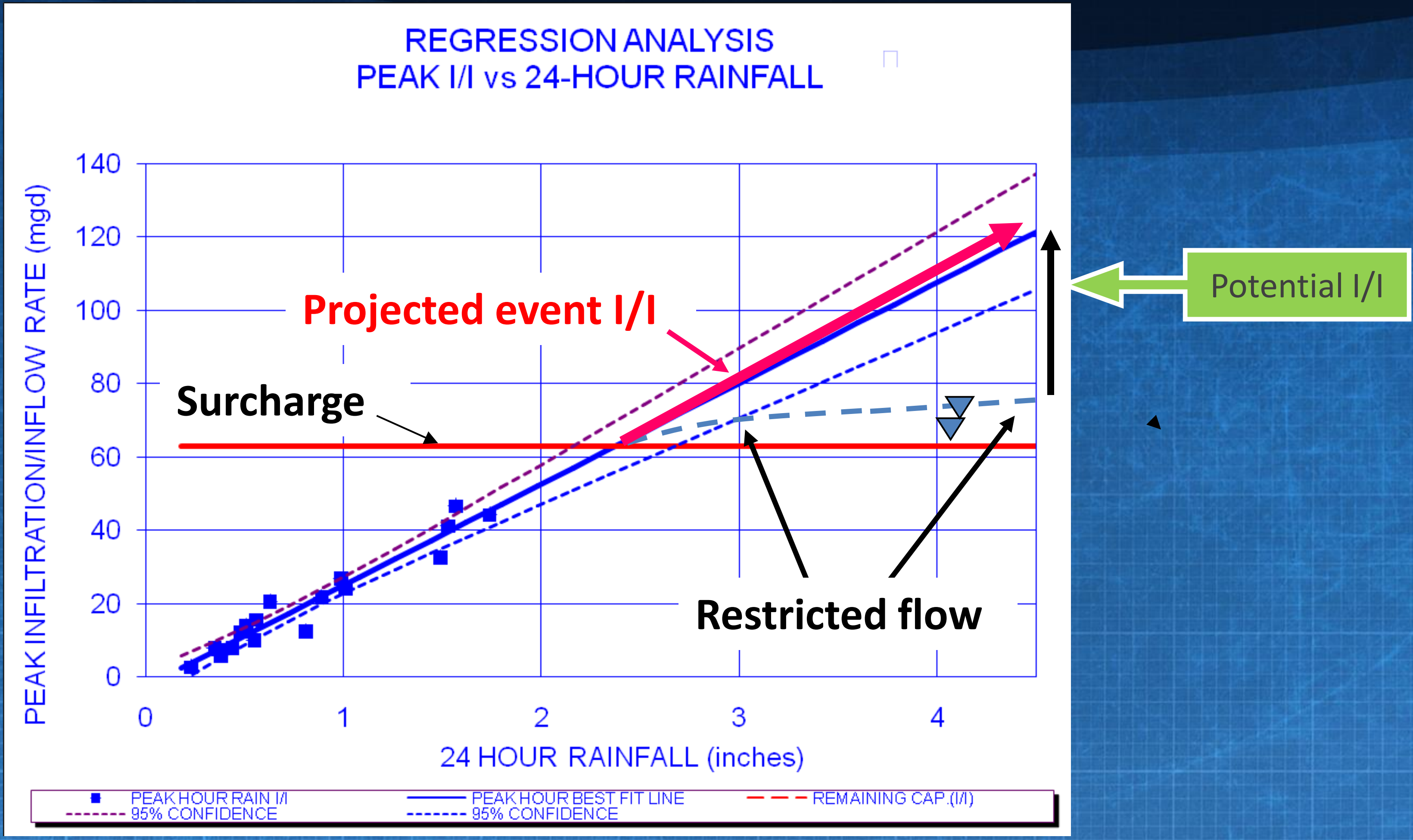
- Intensive monitoring in top priority tributary areas (8,000 - 15,000 LF)
- Observed and potential I/I
- Additional capacity problems

3 - Quantify Problem Conditions (cont.)

Hydraulic Capacity Analysis



Quantify the I/I (Observed and Potential)



r =0.97, 95% CONF. = 26%

3 - Quantify Problem Conditions (cont.)
"Potential" I/I

- I/I which cannot enter the sewer because the pipe is already overloaded!
- Obscures overall I/I removal goals
- Monitor depth & velocity
- Extrapolated

Monitoring in the upper reaches of a basin (upstream of significant hindered flow conditions) allows a more realistic estimate of I/I !

Data Interpretation

- **Need to standardize criteria**
- 24-hour rainfall more reliable than peak hour rain for predicting peak design I/I
- **AMC –** Antecedent Moisture Condition is critical for selecting valid rainfall events
- **Hindered flow -** Potential I/I There are ways to correct for this, however the analyst must be aware of this condition
- Underestimating the peak flow can result in the inadequate design of new facilities

Which type rainfall pattern puts the most stress on the system – for a standard return interval, design storm?

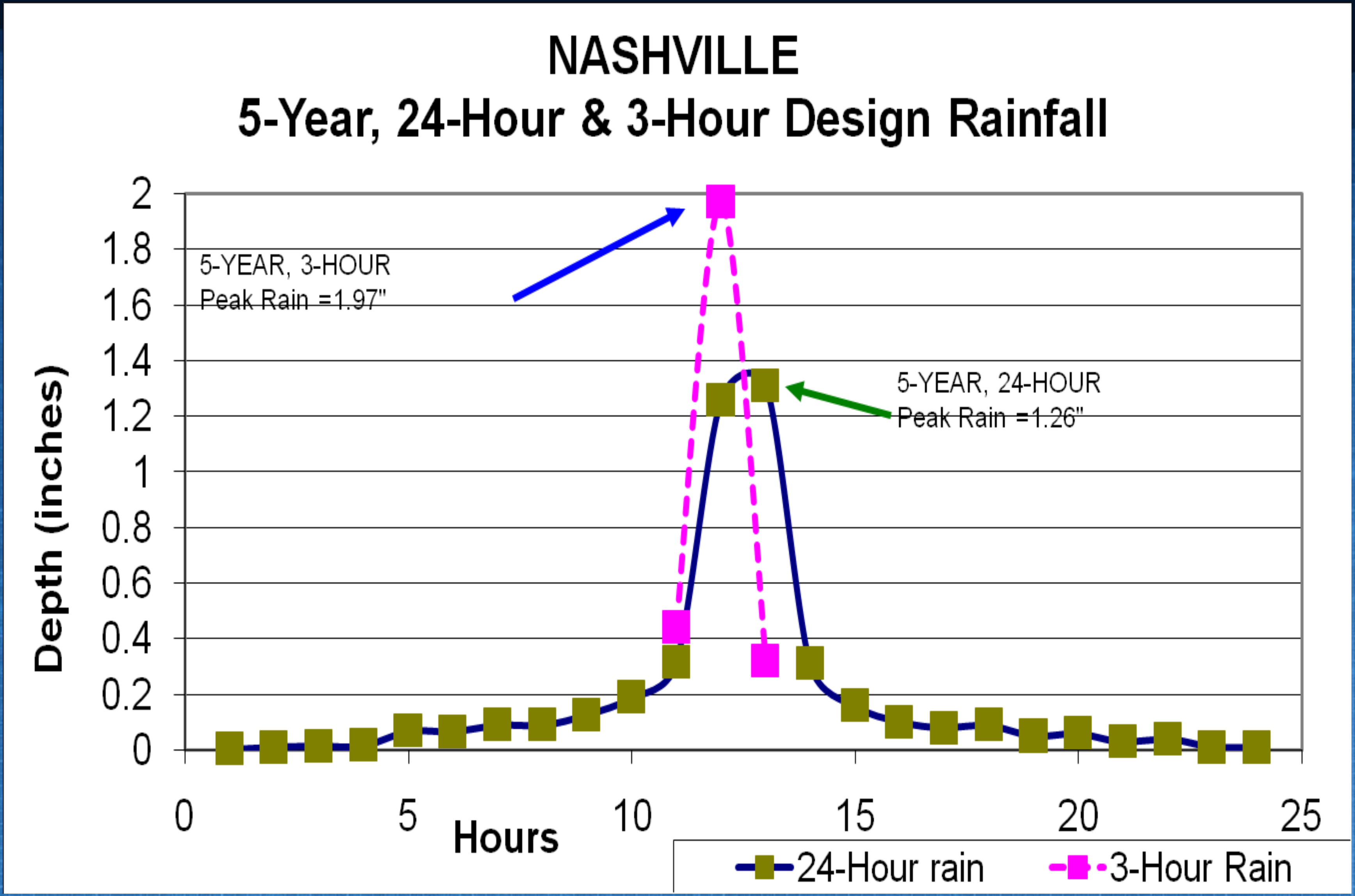
Summer ?

Or Winter ?

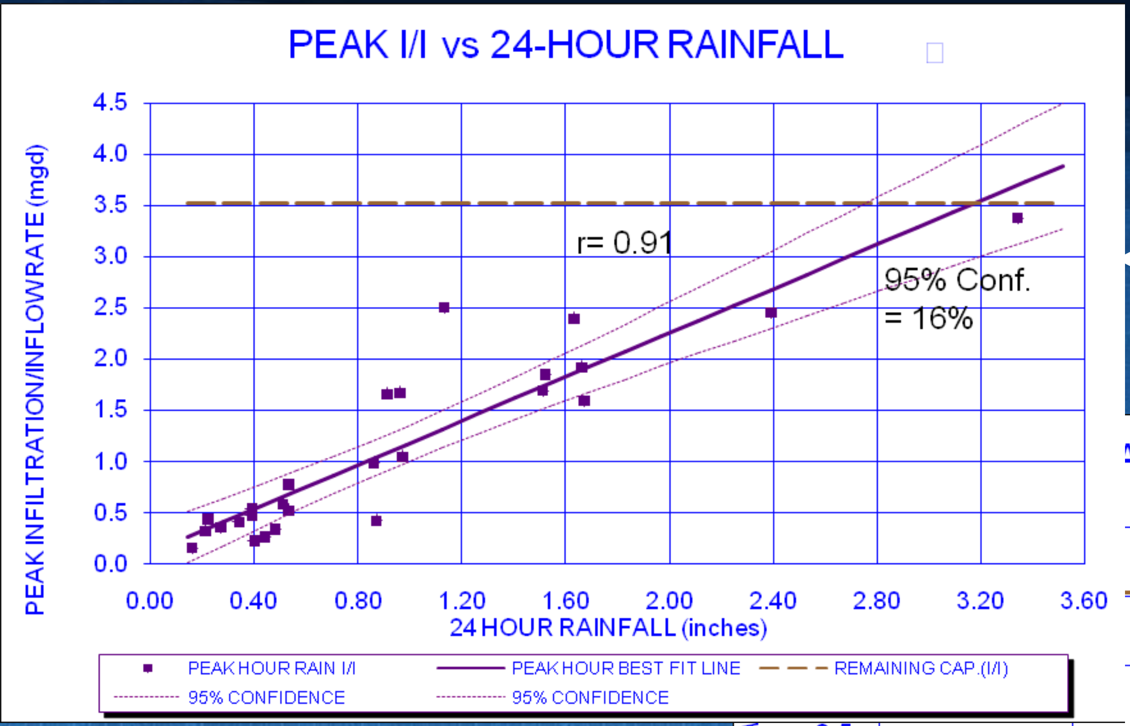
Typical Rainfall

Type II Rainfall* – Characterized by short-term, high intensity thunderstorms and also by long-duration frontal storms.

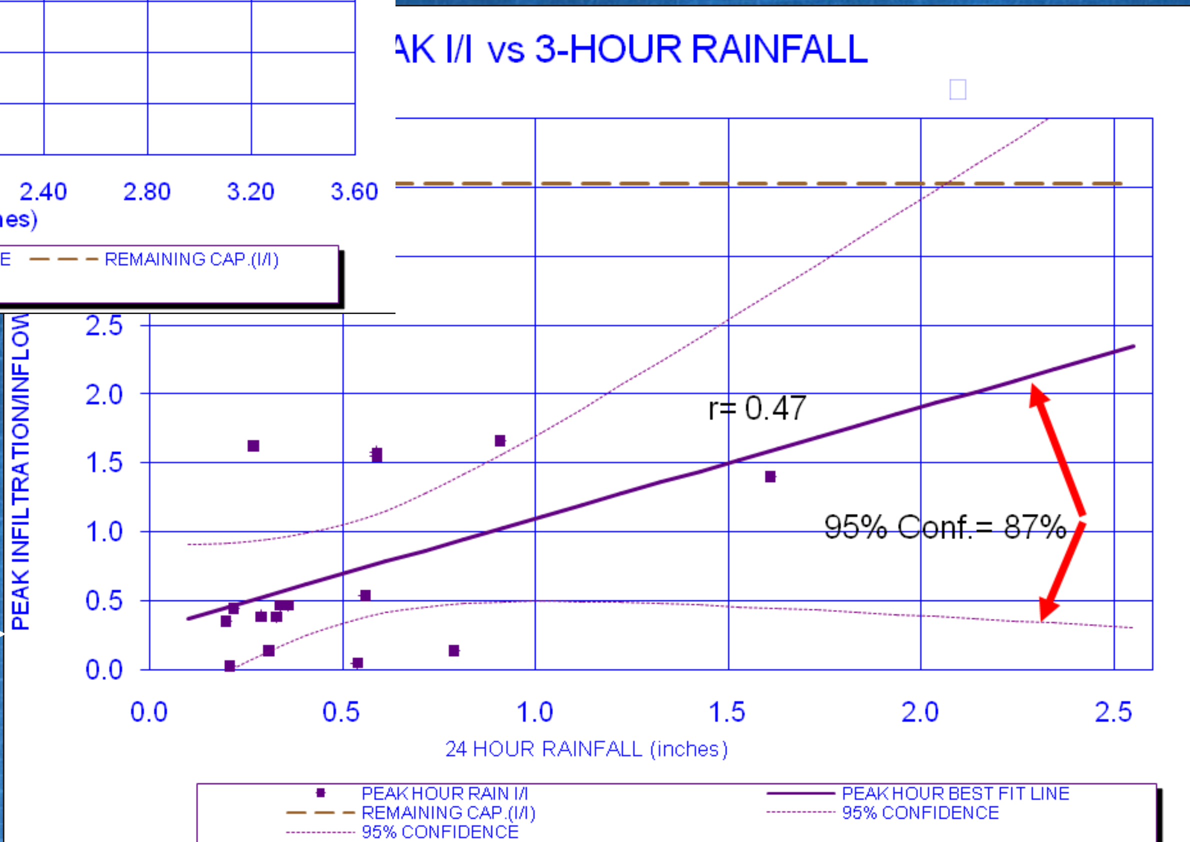
*USDA-SCS 1986


NASHVILLE
5-Year, 24-Hour & 3-Hour Design Rainfall
5-YEAR, 3-HOUR
Peak Rain =1.97"
5-YEAR, 24-HOUR
Peak Rain =1.26"
Depth (inches)
Hours
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
24-Hour rain
3-Hour Rain

2-Year Design Storm Peak: 24-Hr vs. 3-Hr



Peak hour I/I from 2-Yr, 24-Hr Storm is 3.89 mgd with good level of confidence



Peak hour I/I from 2-Yr, 3-Hr Storm is 2.35 mgd with poor level of confidence

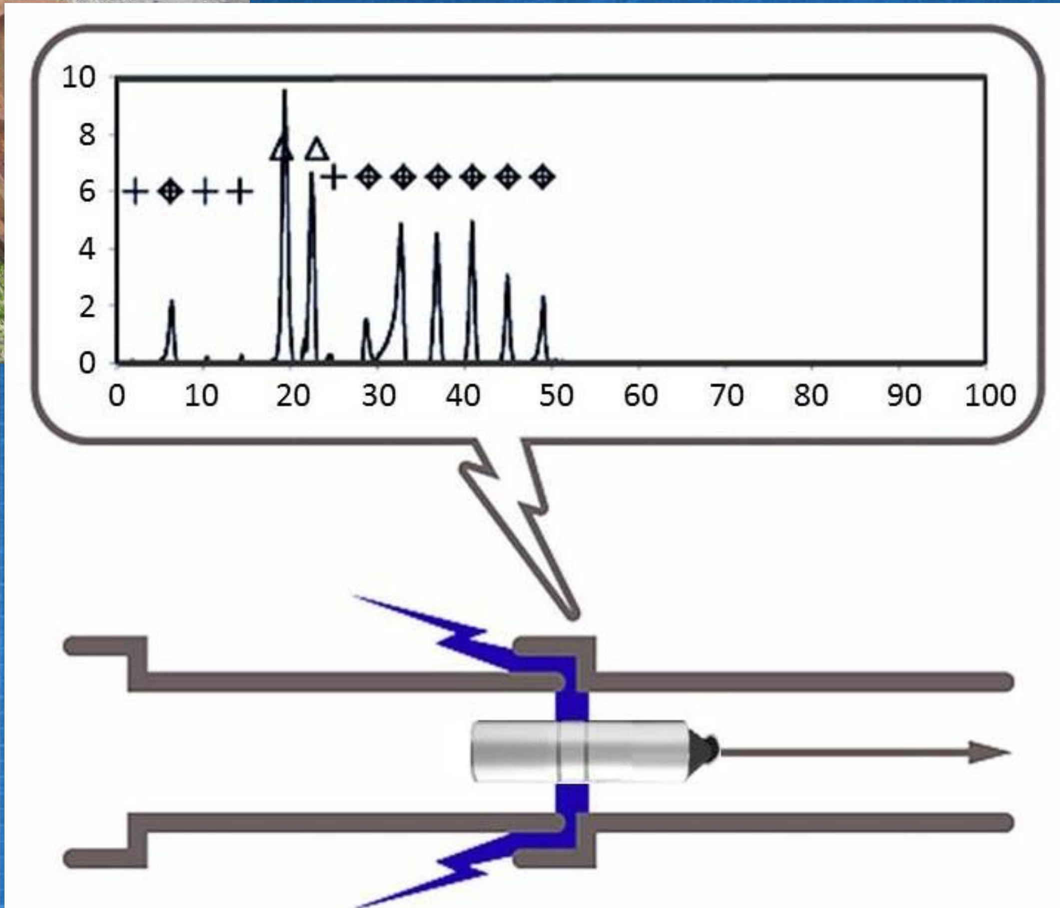
4 - LOCATE & IDENTIFY DEFECTS

- Televise target area system (may be concurrent with monitoring)
- Categorize defects with respect to I/I potential

4 - Locate & Identify Defects (Cont.)

- "Invisible" defects – electric field leak detection, segmental isolation
- Gross inflow (roof drains, etc.)

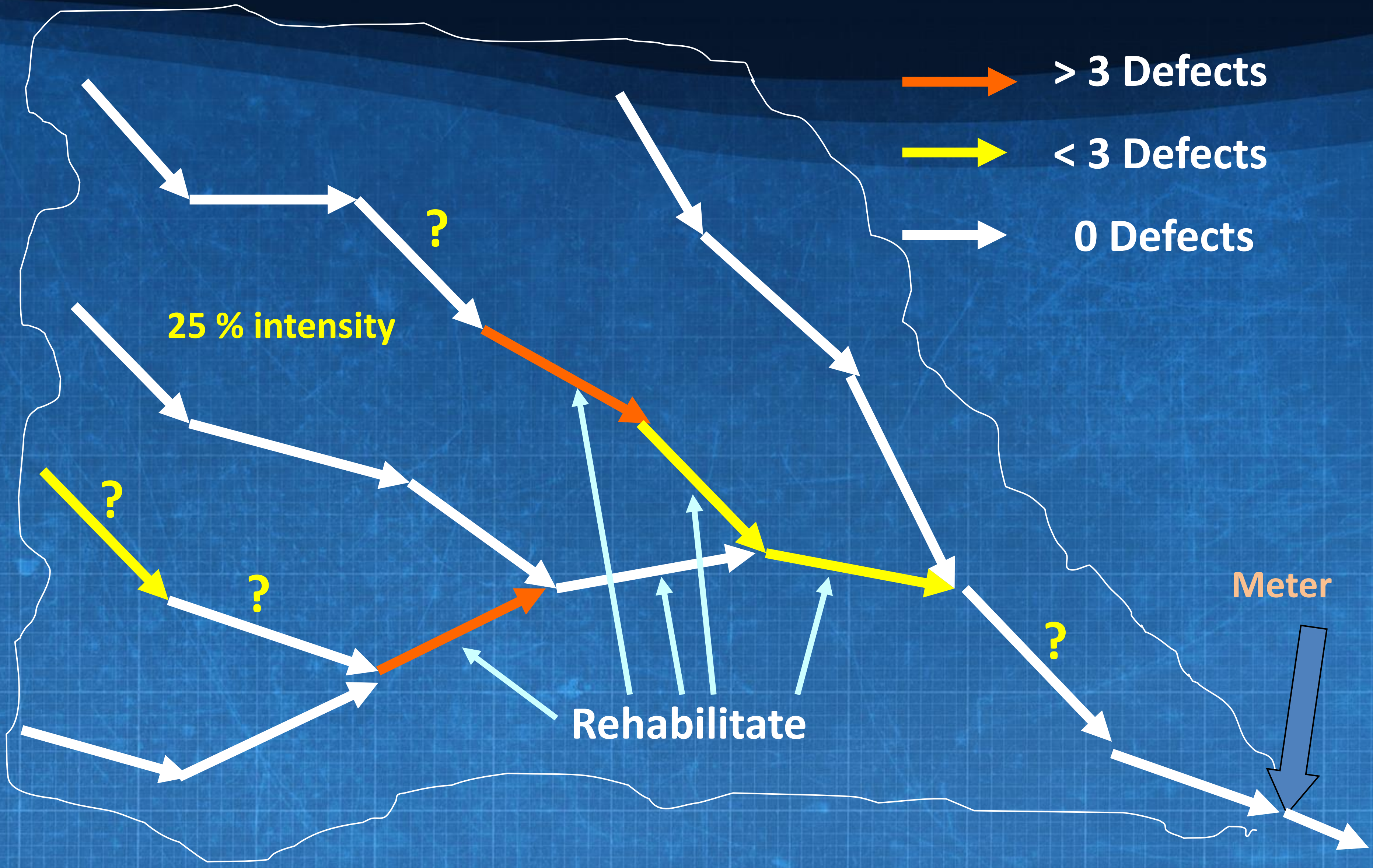
Electroscan



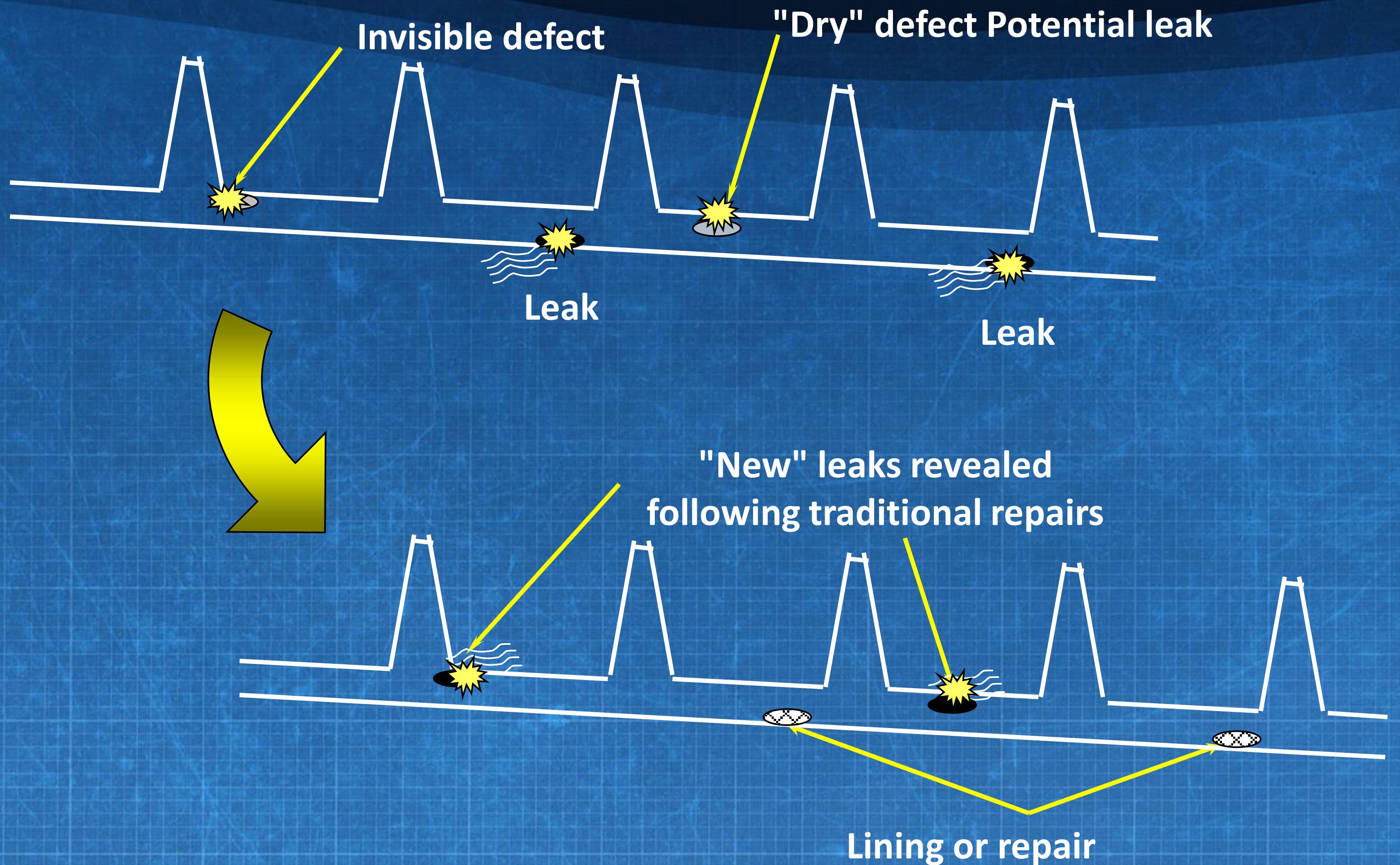
5 - Select Segments For Rehabilitation

- Categorize & color code lines
  - 3 or more major defects
  - 1–2 major defects
  - No major defects
- “3 or more” – renew!
- Check adjacent segments
- Renewal “intensity” – range of 15–20% (**or greater**) in first round

Connect The Dots



Sewer Rehab Strategy: Halt Migration!



6 - ESTIMATE COST-BENEFIT

- Compare renewal costs to: O & M costs ($1.73 – $1.87/ 1,000 gal)
- At least 50% I/I removal
- Costs:
  - Lining (8–10" cipp) ~ $43 / lf
  - Laterals ~ $2,500 ea. (1/ 200 lf)
  - Manholes ~ $1,000 –1,300 ea. (1/200 lf)
  - Engineering ~ 12% – 15% of total
  - Owner's expenses (admin, etc.)

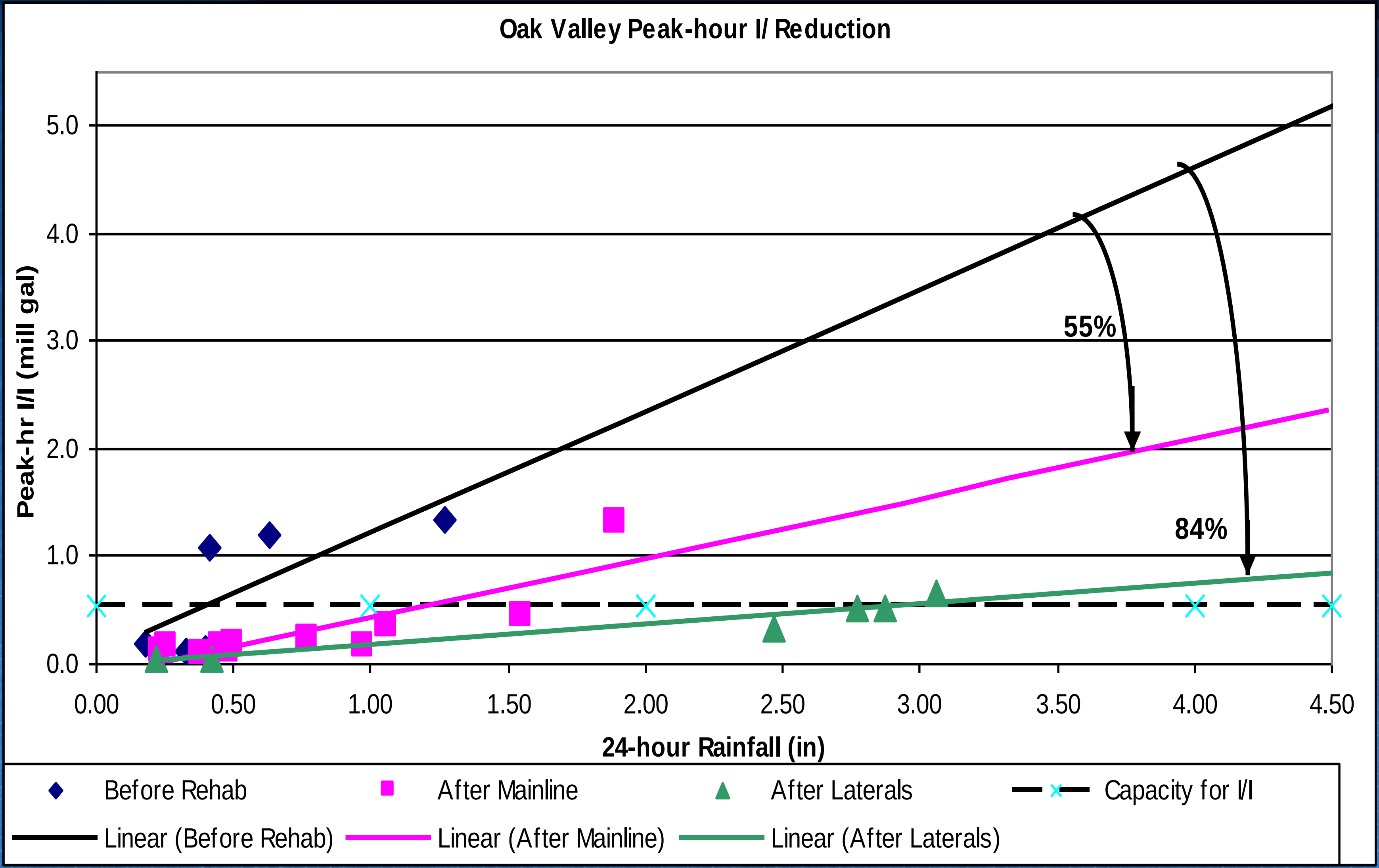
(Gross= ~$100 to $132/ft rehab)

7 - Design and Install Rehab

- Halt migration from outside pipe
- Halt migration (“tracking”) inside pipe
- Provide seal at manhole junction
- Renew service laterals

Over 10,000 service laterals rehabilitated in Nashville’s Program

Peak Hour I/I Reduction with Lateral Rehab



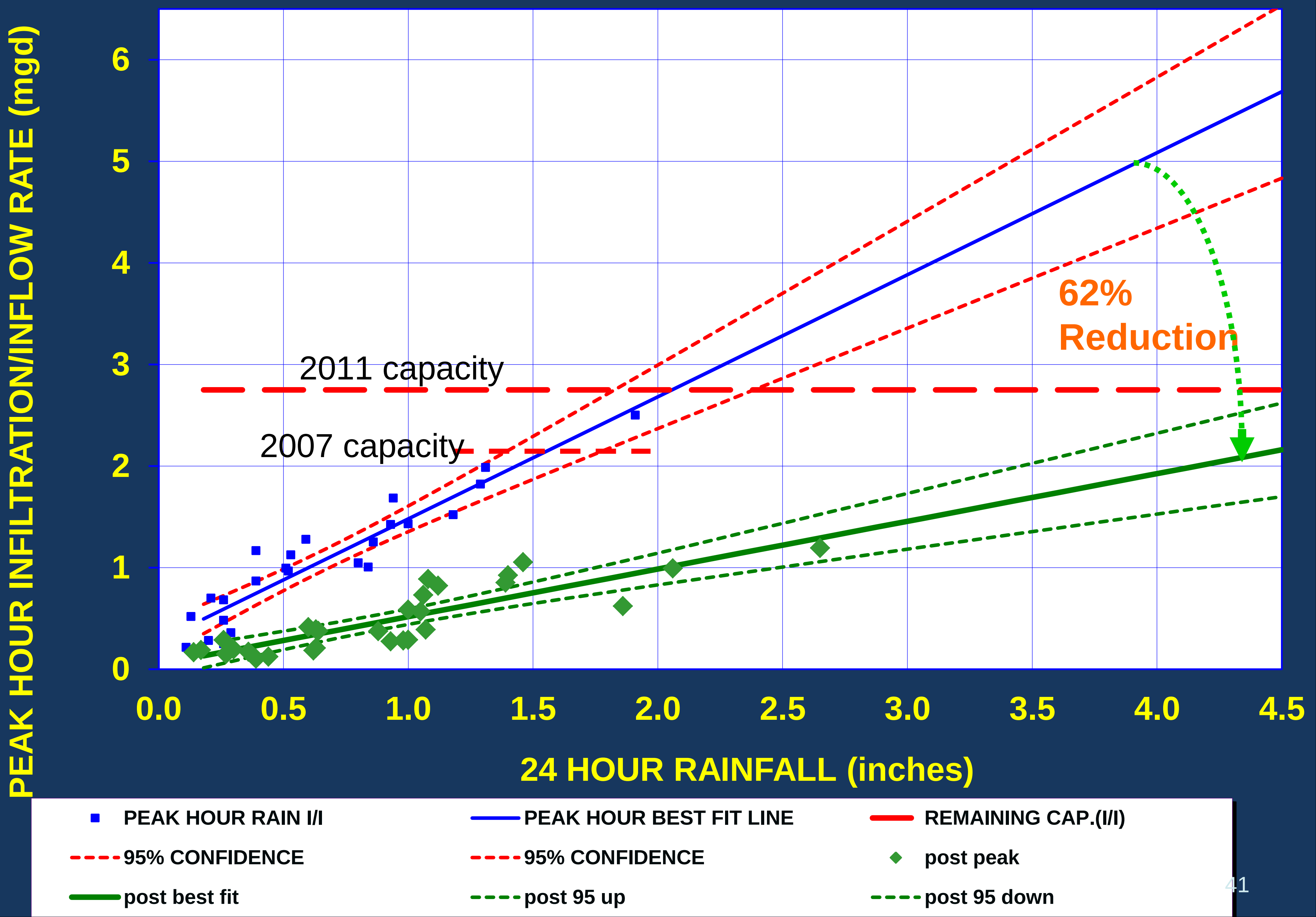
8 - Performance Testing

- Air-test sewer service connection!
  - Most vulnerable part
  - Not accepted until performance verified

9 - Follow-up Flow Monitoring

- Quantify I/I reduction
- Standardized I/I analysis
- TV during wet weather
- Rerun hydraulic model
- Determine if design goals met!

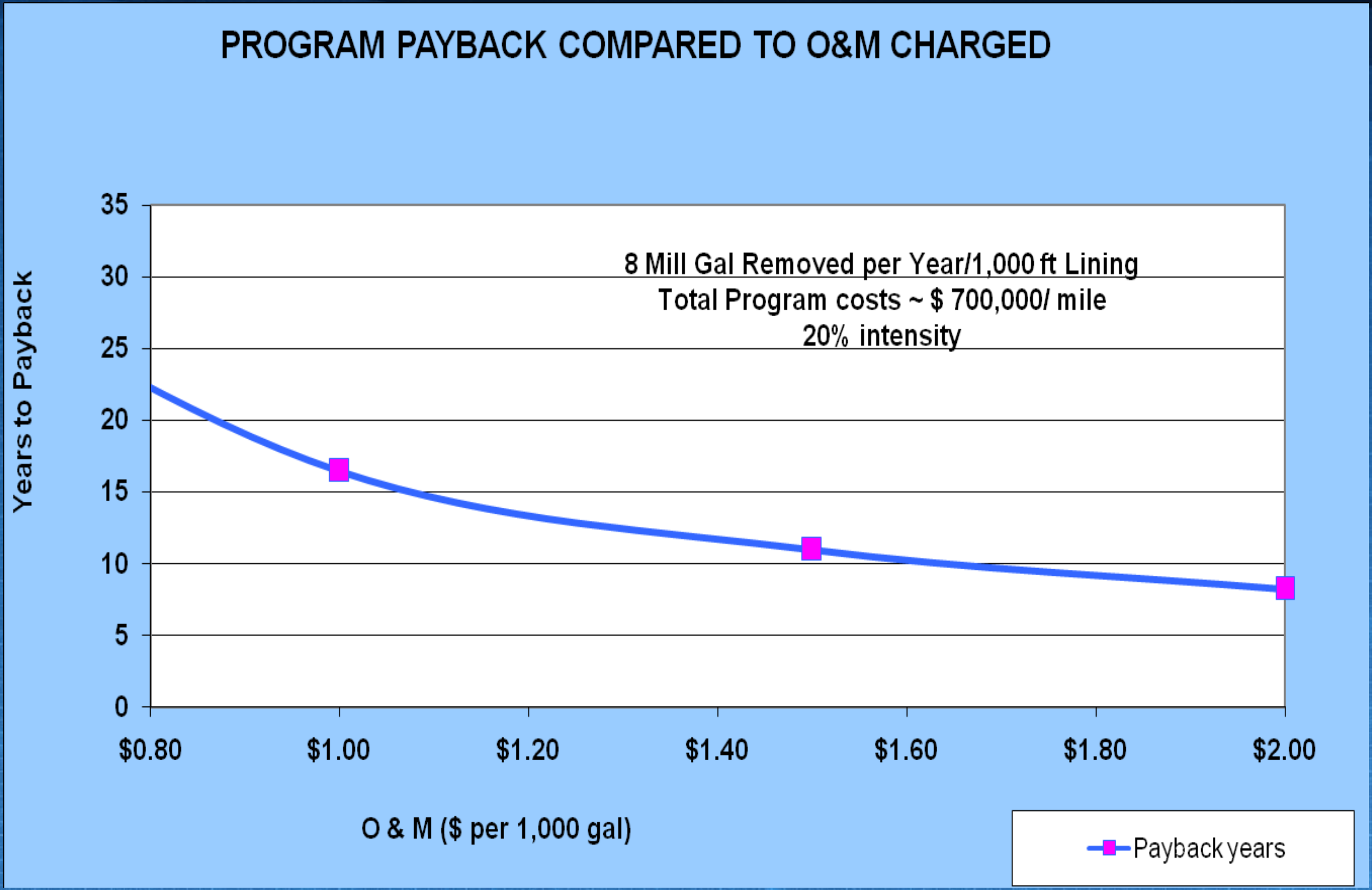
E-11 Before-After Peak-Hr I/I Reduction 2007- 2011



10 - CALCULATE O&M SAVINGS

- Possible 10-13 Year payback (on installation, design, investigation costs – TOTAL PROGRAM)
- Provides data for future program planning
- Accountability to community

- Brentwood is saving ~ $1.6 million/year by eliminating 851 million gallons of I/I annually – pays for the program in 13 years


PROGRAM PAYBACK COMPARED TO O&M CHARGED
8 Mill Gal Removed per Year/1,000 ft Lining
Total Program costs ~ $ 700,000/ mile
20% intensity
Years to Payback
35
30
25
20
15
10
5
0
$0.80
$1.00
$1.20
$1.40
$1.60
$1.80
$2.00
O & M ($ per 1,000 gal)
Payback years

Successful Rehab Factors

- Extensive flow monitoring
- Lateral renewal to easement
- “Targeting”– lining selected by observed defects, age, proximity, migration potential, surface water
- Performance (air) test line and lateral

Questions ?