Re-evaluation of Ohio Precipitation and Post-Construction Water Quality Volume (WQv)

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This Presentation

- Ohio EPA Post-Construction Criteria
- Volumetric Runoff Coefficient Evaluation
- Analysis of Ohio Precipitation Record
- Water Quality Capture Volume
- Recommendations

Ohio EPA NPDES Stormwater Permit

- Construction General Permit (CGP, April 2003 through April 2018)
  - Required capture and treatment (through extended detention or infiltration) of a Water Quality Volume (WQv) using structural BMPs.

$$WQv = C * P * A / 12$$

Where:

C = volumetric runoff coefficient

P = water quality event precipitation depth = 0.75 in

A = area draining to the BMP (acre)

NPDES Permit Post-construction Goals

- Address hydrologic impacts and increased pollutant loads resulting from land development.
  - BMPs "must address the anticipated impacts on the channel and floodplain morphology, hydrology and water quality."
  - "BMP(s) chosen must be able to detain storm water runoff for protection of the stream channels, stream erosion control, and improved water quality."

Sources: Ohio EPA. 2003. Authorization for Storm Water Discharges Associated with Construction Activity (Permit OHC000002); Ohio EPA. 2007. Post-Construction Q & A Document.

NPDES Permit Post-construction Metrics

(1) Hydrologic impacts and stream channel stability - ???

(2) Water quality impacts - Remove at least 80 percent of the average annual total suspended solids (TSS) load.

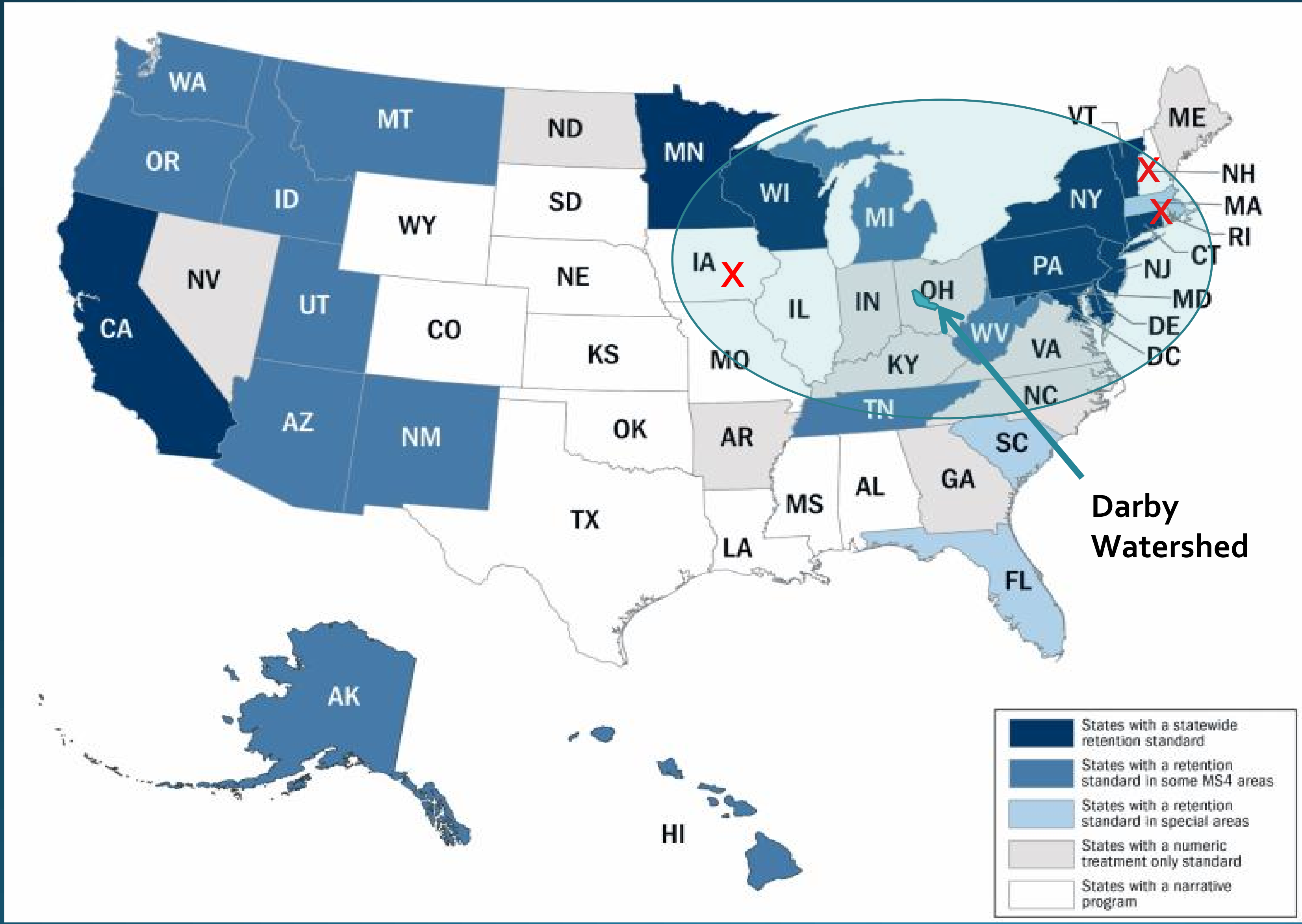
Sources: Ohio EPA. 2003. Authorization for Storm Water Discharges Associated with Construction Activity (Permit OHC000002); Ohio EPA. 2007. Post-Construction Q & A Document.

Post-construction Criteria (USEPA, 1993)

- By design or performance:
  a) After construction has been completed and the site is permanently stabilized, **reduce the average annual total suspended solid (TSS) loadings by 80 percent**. For the purposes of this measure, an 80 percent TSS reduction is to be determined on an average annual basis.
  b) Reduce the predevelopment loadings of TSS so that the average annual TSS loadings are no greater than pre-development loadings.
- To the extent practicable, **maintain post-development peak runoff rate and average volume at levels that are similar to pre-development levels**.

Source: US EPA. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters – Chapter 4: Management Measures for Urban Areas. EPA 840-B-92-002 (January 1993), Office of Water, U.S. Environmental Protection Agency, Washington, DC.

States with Retention Standards



Other RR Stds:
Iowa
New Hampshire
Rhode Island

Regionally 17 of 25 states (68%) have runoff reduction or groundwater recharge standards

Post-construction Evaluation Approach

Assumed the overall annual TSS pollutant load reduction can be estimated by the multiplication of:

(1) the percentage of the annual runoff volume that is captured and treated; and

(2) the TSS removal efficiency of the stormwater BMP.

Assumed several viable structural post-construction stormwater controls (wet extended detention basins, extended detention wetlands, bioretention, etc.) can achieve 90% TSS removal of the volume capture.

Post-construction Evaluation Approach

$$\text{Required Capture Volume} = \frac{\text{80\% reduction}}{\text{90\% treatment efficiency}}$$

Required Capture Volume = 89% =~ 90%

Water Quality Volume

$$WQv = Rv * P * A$$

Where:

Rv = volumetric runoff coefficient

P = water quality event precipitation depth

A = area draining to the BMP

Volumetric Runoff Coefficient

Volumetric Runoff Coefficient (2013 CGP)

(1)

Runoff Coefficients Based on the Type of Land Use

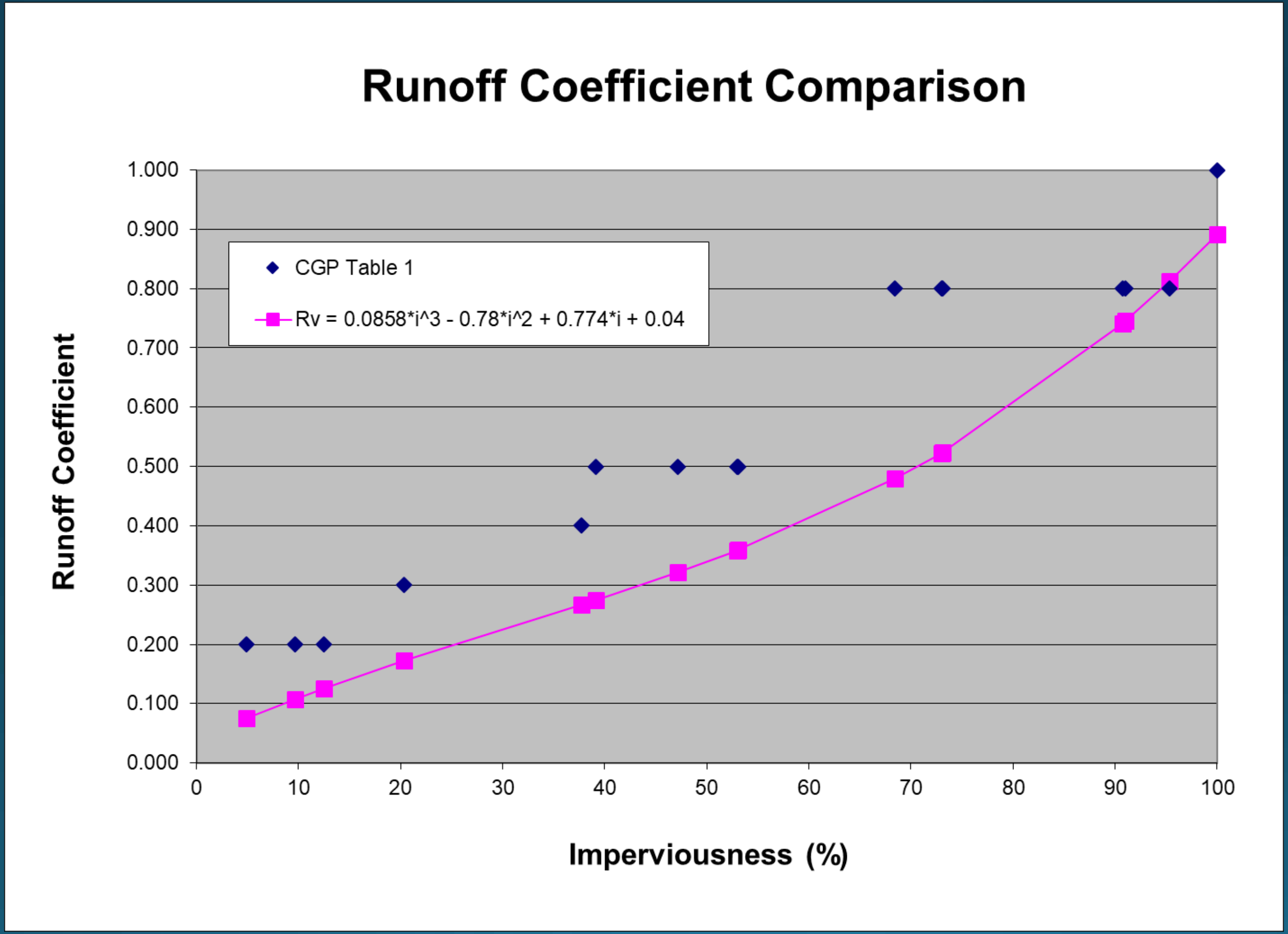
Land Use	Runoff Coefficient
Industrial & Commercial	0.8
High Density Residential (>8 dwellings/acre)	0.5
Medium Density Residential (4 to 8 dwellings/acre)	0.4
Low Density Residential (<4 dwellings/acre)	0.3
Open Space and Recreational Areas	0.2

(2)

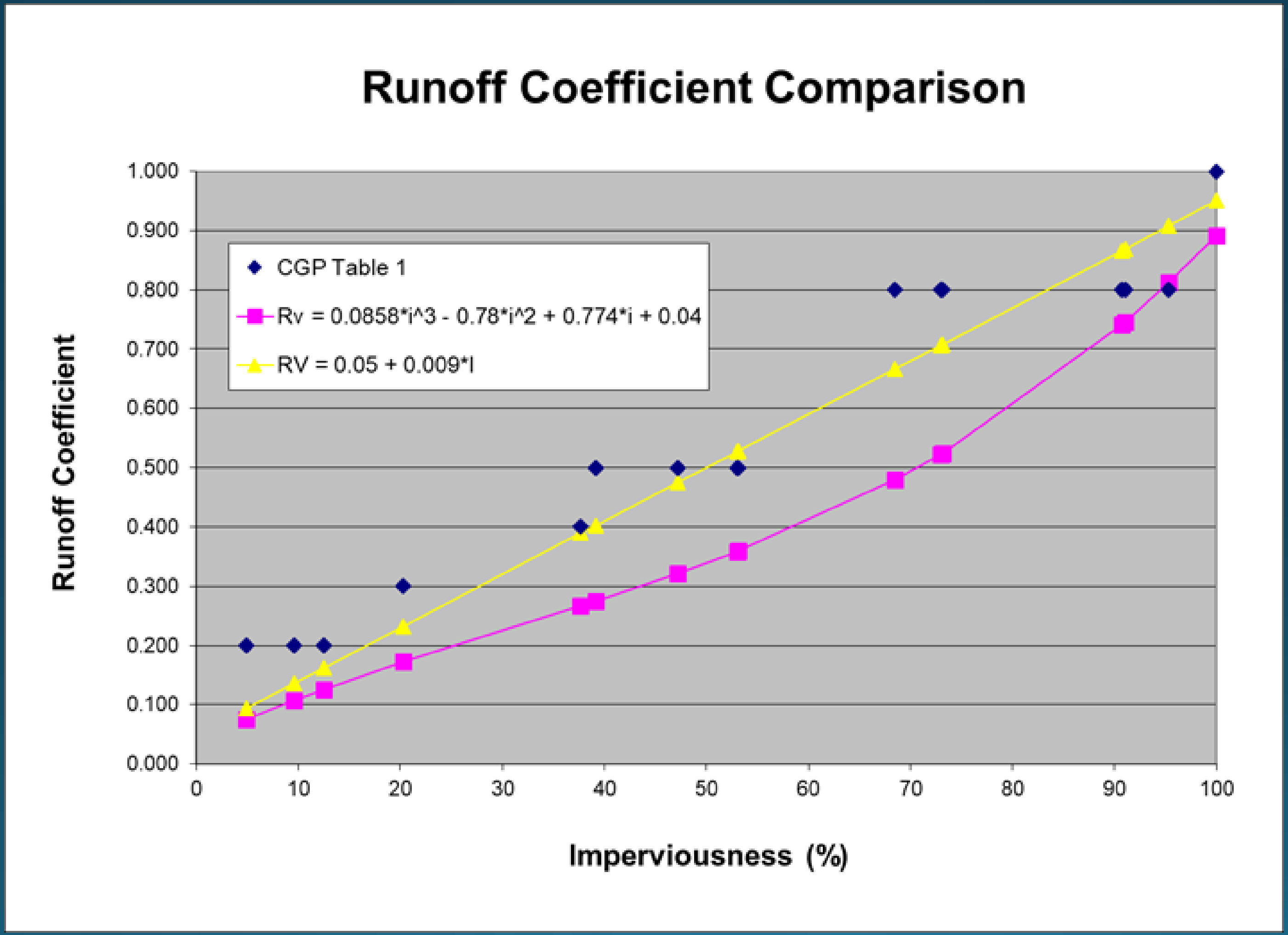
$$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$$

Source: Ohio EPA, 2003; 2013

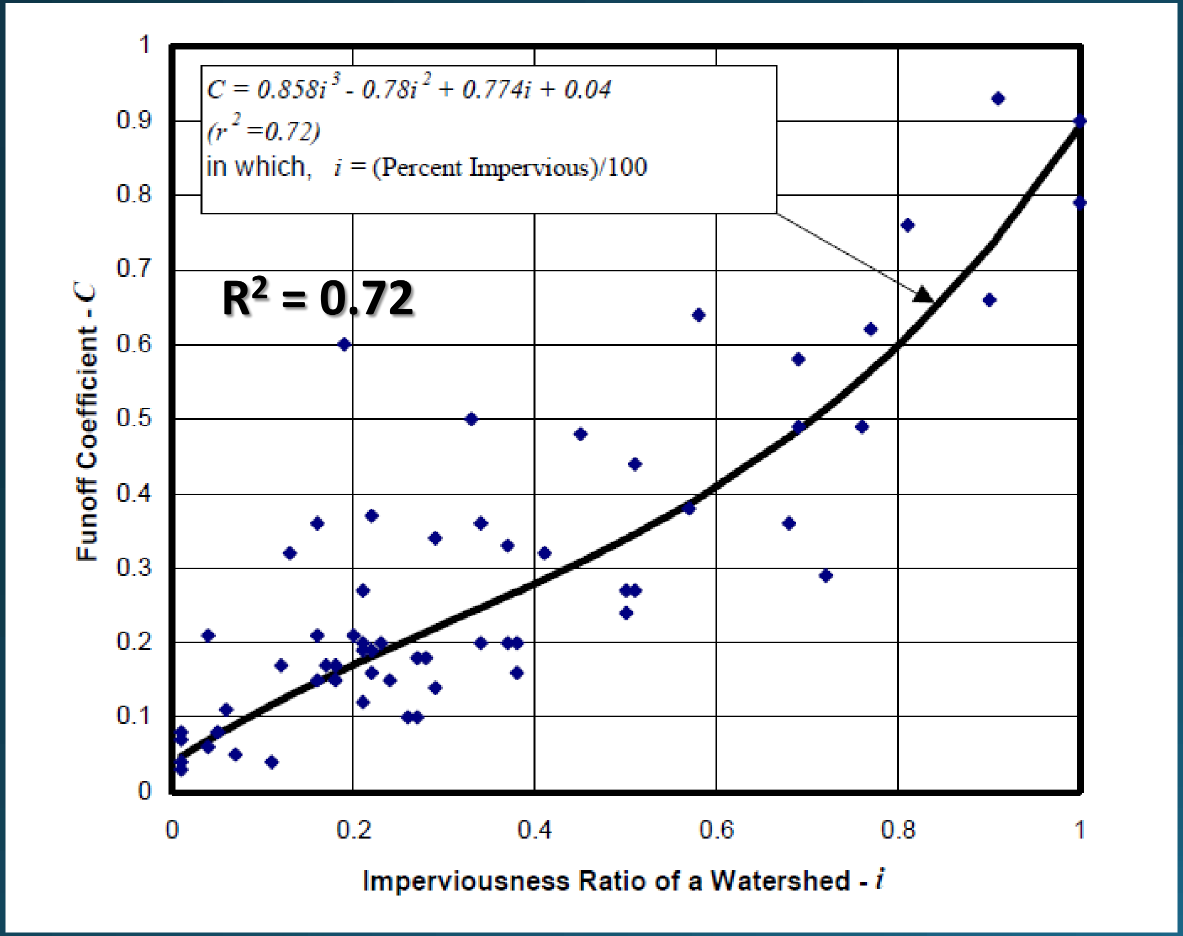
Volumetric Runoff Coefficient (2013 CGP)



Volumetric Runoff Coefficient (2013 CGP)



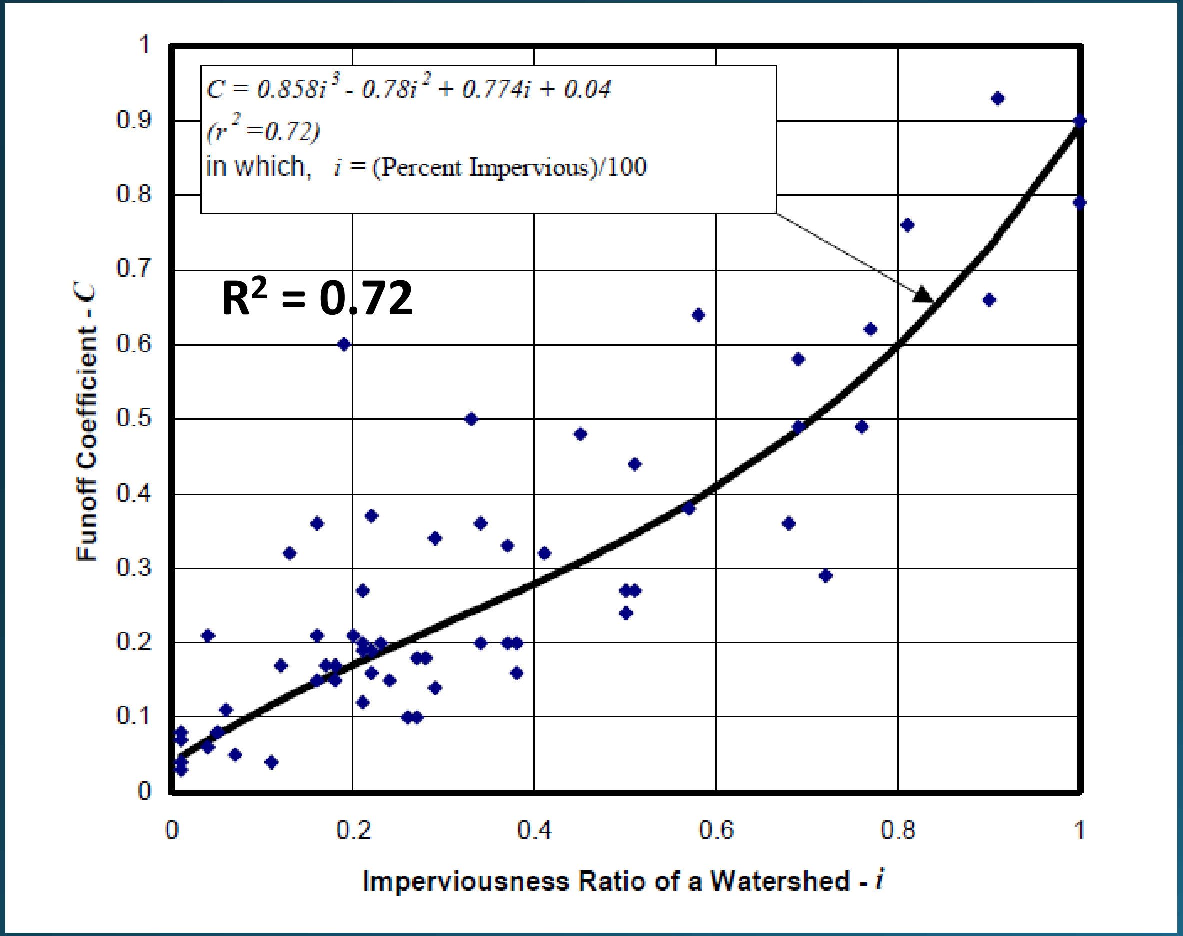
Volumetric Runoff Coefficient

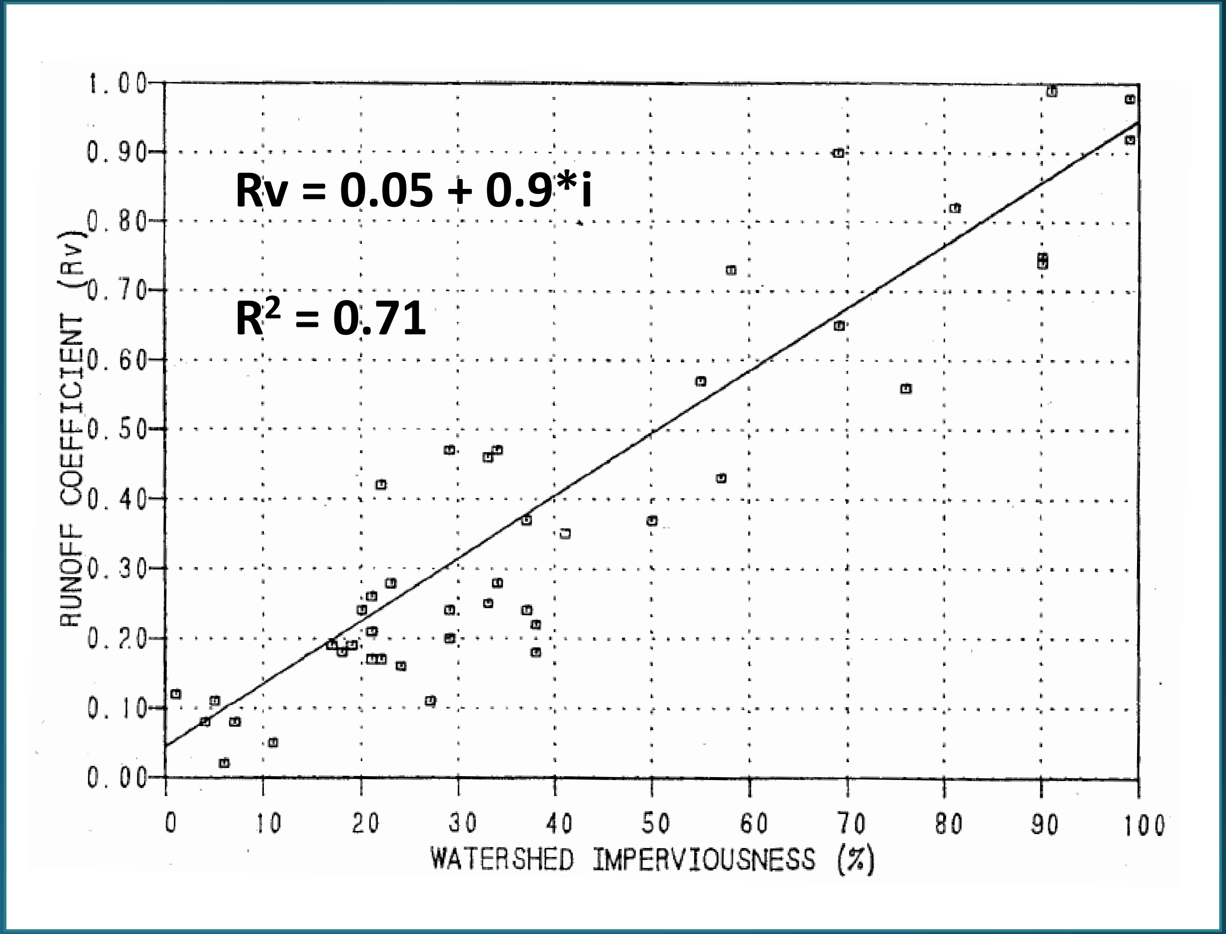


$$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$$

Source: Urbonas et al., 1989

Volumetric Runoff Coefficient





Source: Urbonas et al., 1989

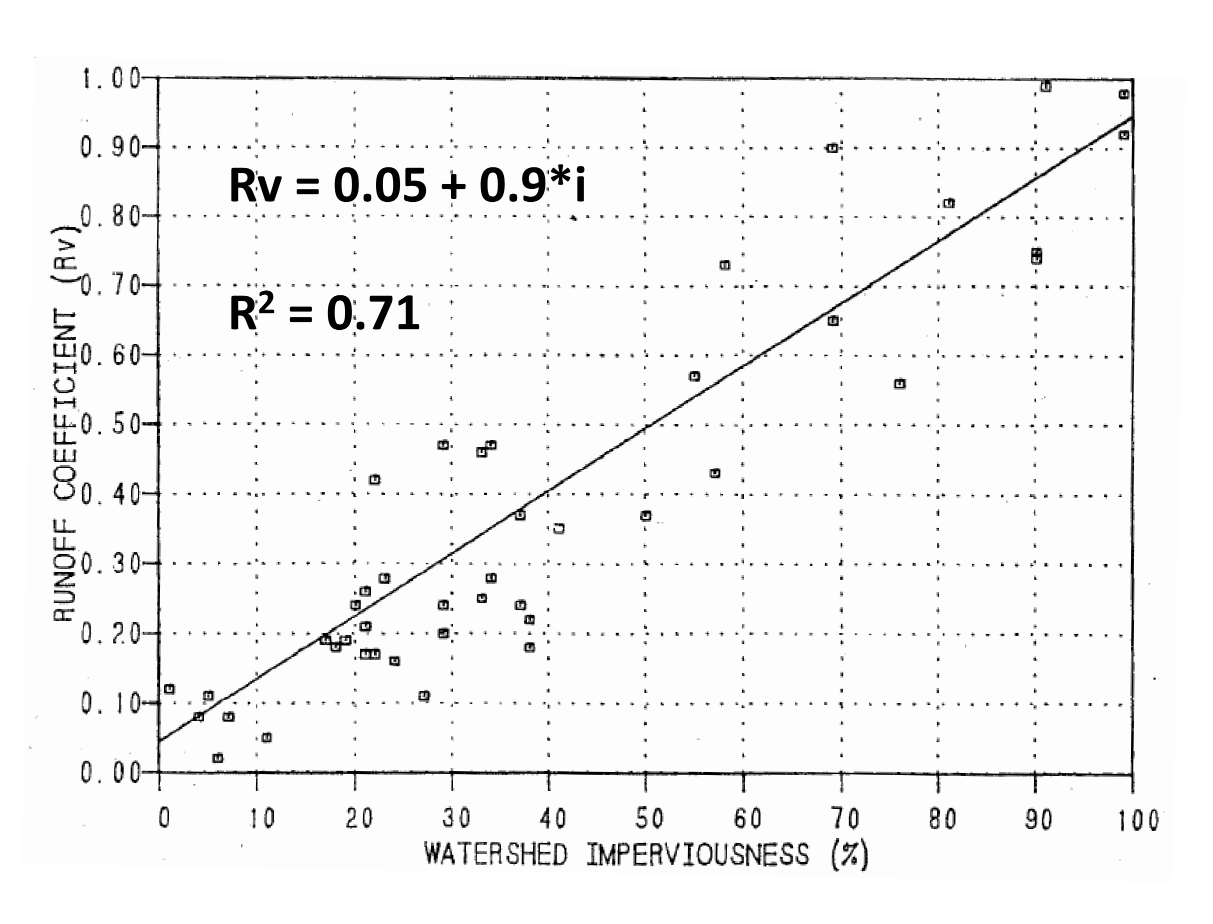
Source: Schueler, 1987

Volumetric Runoff Coefficient

$Rv = 0.05 + 0.9*i$

$Rv_{pervious} = 0.05$

$Rv_{impervious} = 0.95$



Source: Schueler, 1987

Rv Discussion

- The linear Rv equation correlates the data as well as the more complicated equation but is simpler to understand and use.
- The linear correlation lends itself to simple, flexible methods for both redevelopment site WQv accounting and Runoff Reduction Method accounting.

Recommendation

$$Rv = 0.05 + 0.9*i$$

$$Rv_{pervious} = 0.05$$

$$Rv_{impervious} = 0.95$$

Precipitation Depth-Frequency Analysis

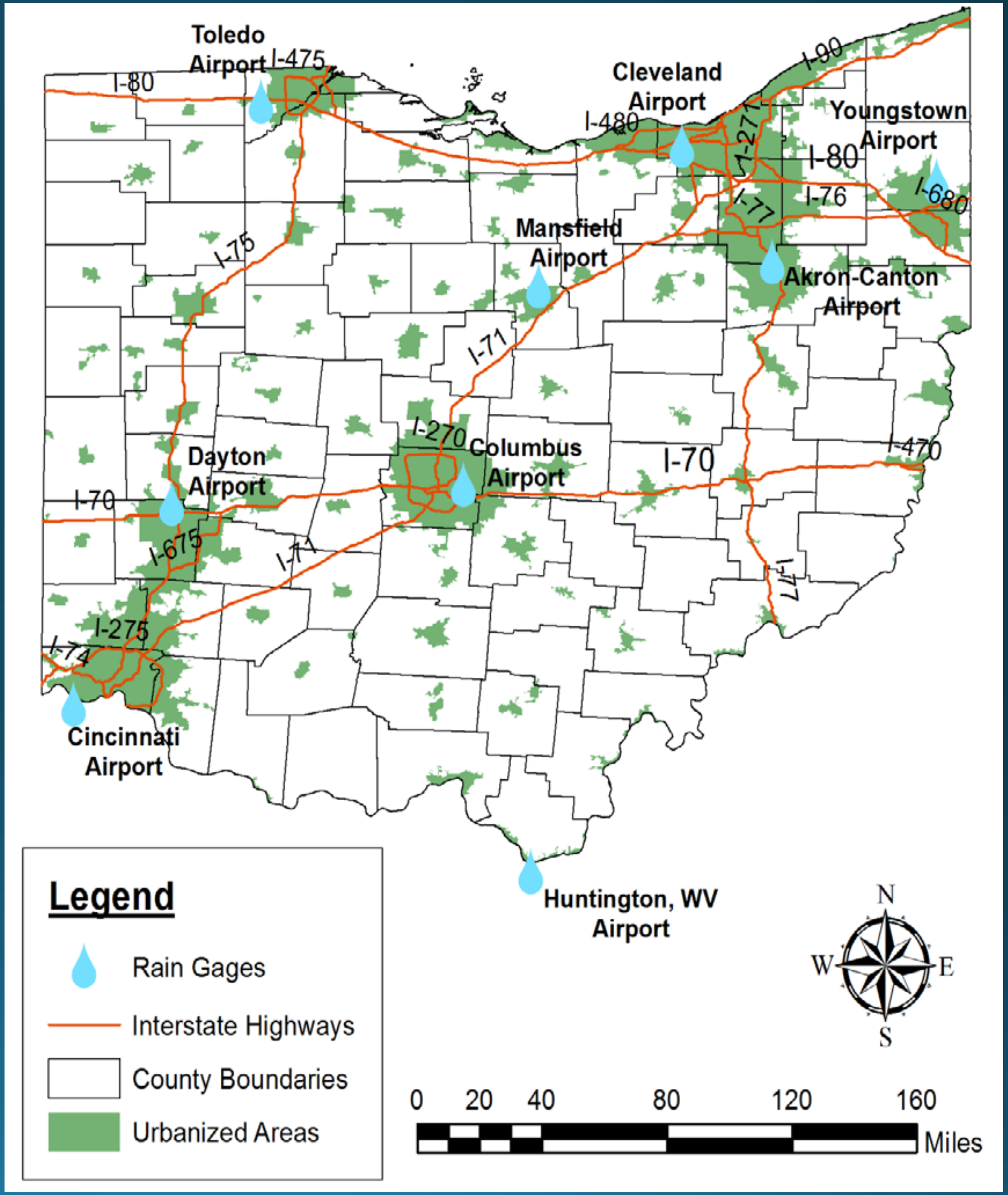
Precipitation Data Approach

- Target – analyze 15-20 historic precipitation data sets that represent the geographic and climatic diversity of Ohio.
- Data set criteria
  - a minimum 30-year period of record, preferably the most current 30 years;
  - a reasonable temporal scale (<=1-hour data collection time step);
  - 0.01-inch rain gage recording precision;
  - clean, quality data (few questionable or missing periods of record).
- Rainfall events < 0.10 inch removed (considered non-runoff producing).

Historic Precipitation Data Set Summary

Gage Location	Latitude	Longitude	Start Date	End Date	Years of Record	Average Annual Precip (in)	Average Annual Number of Events ≥ 0.1 in
Akron-Canton Airport	40.917	-81.433	8/1/1948	12/31/2013	65.5	36.8	73.1
Cincinnati Airport	39.067	-84.672	12/3/1950	12/31/2013	63.1	41.6	71.6
Cleveland Airport	41.406	-81.852	8/1/1948	12/31/2013	65.5	37.3	75.7
Columbus Airport	39.983	-82.867	8/5/1948	12/31/2013	65.4	38.3	72.3
Dayton Airport	39.906	-84.219	8/4/1948	12/31/2013	65.5	37.7	69.2
Huntington WV Airport	38.365	-82.555	1/1/1962	12/31/2013	52.0	41.9	75.3
Mansfield Airport	40.817	-82.517	12/1/1959	12/31/2013	54.1	39.7	73.6
Toledo Airport	41.587	-83.806	8/11/1948	12/31/2013	65.4	32.9	64.8
Youngstown Airport	41.255	-80.674	8/8/1948	12/31/2013	65.4	37.5	76.7
Mean					62.4	38.2	72.5

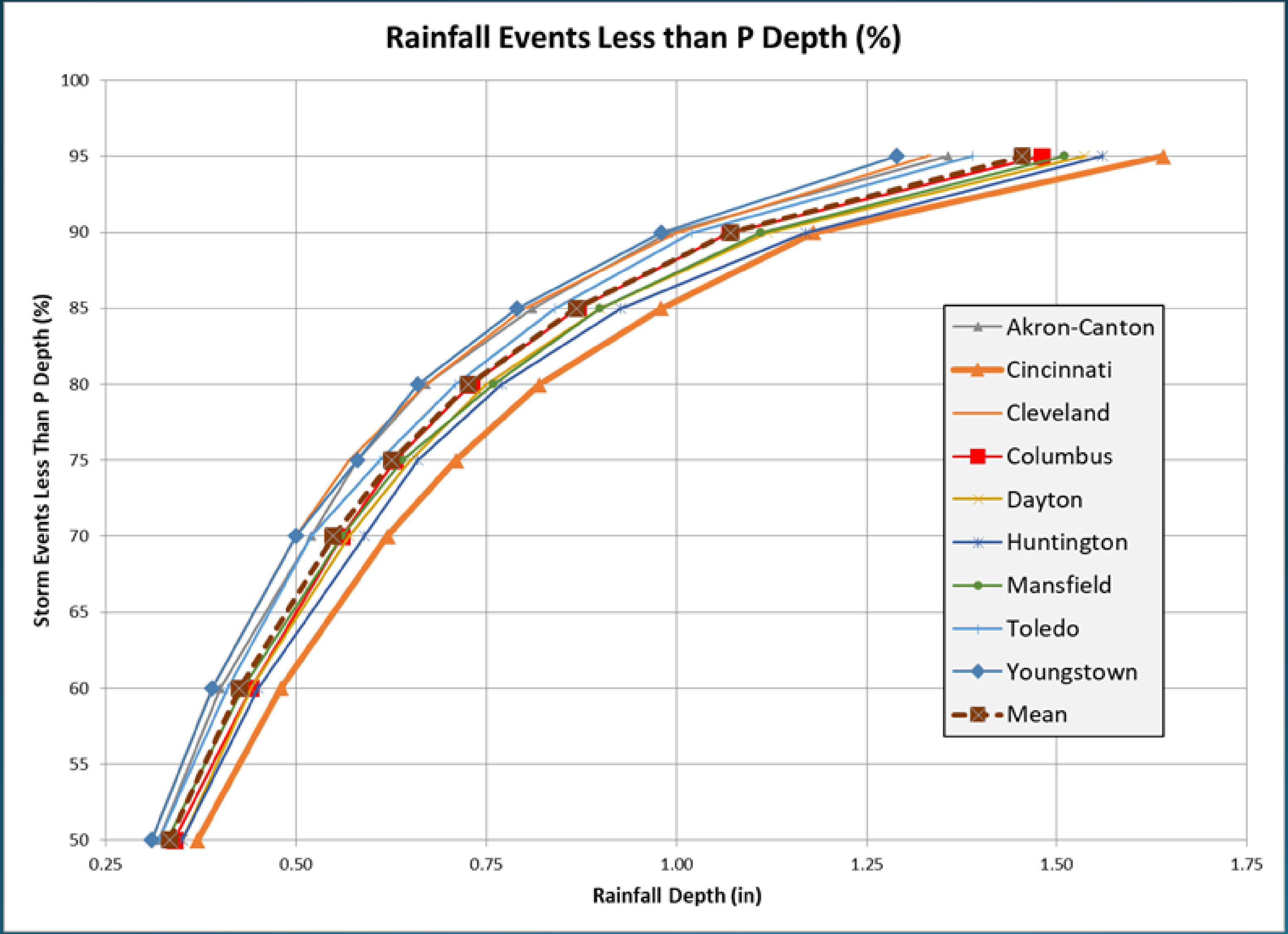
Historic Precipitation Data Sets



Precipitation Depth-Frequency Analysis

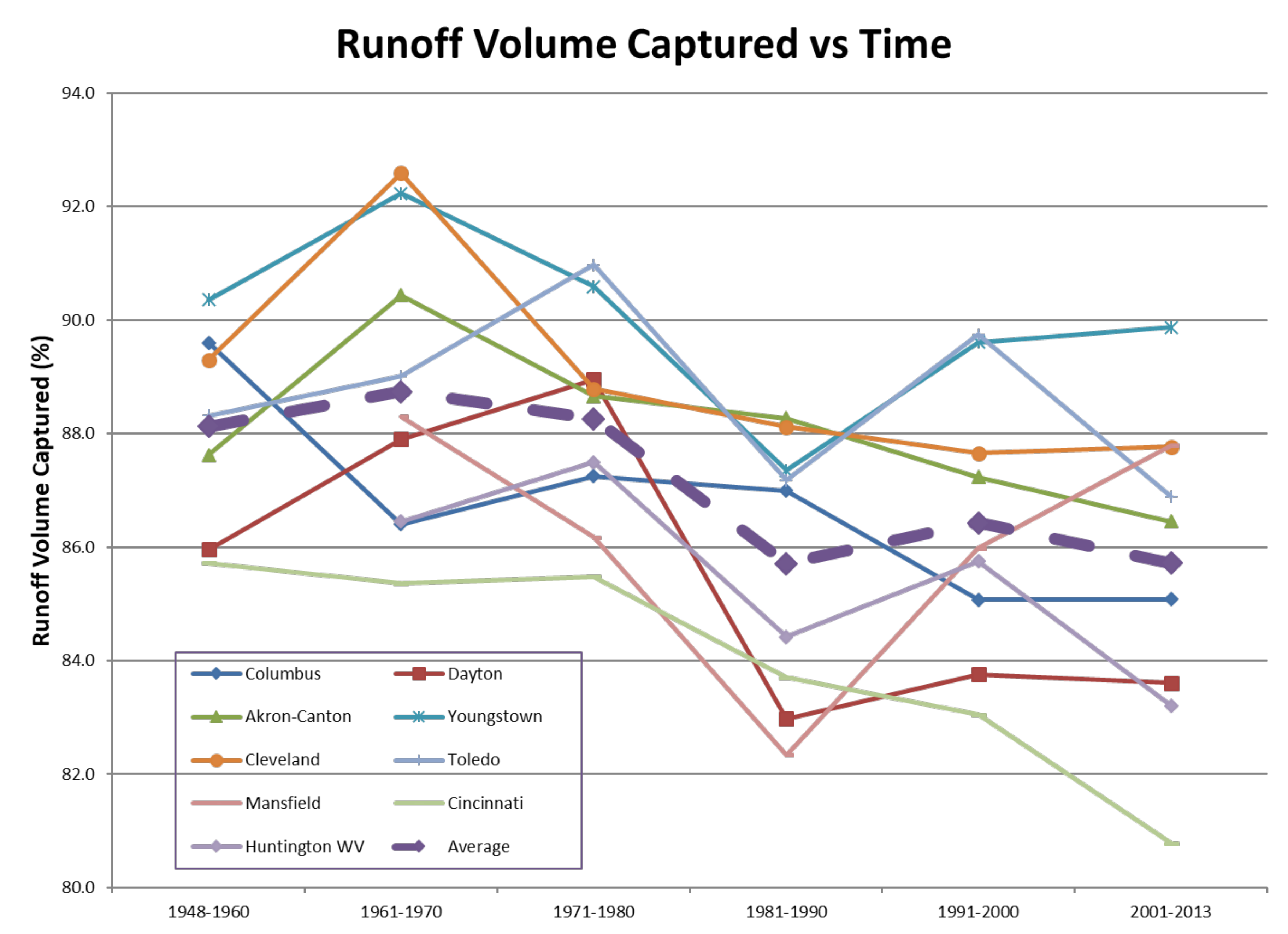
Gage Location	50th Percentile (in)	75th Percentile (in)	80th Percentile (in)	85th Percentile (in)	90th Percentile (in)	95th Percentile (in)
Akron-Canton Airport	0.32	0.58	0.67	0.81	**0.99**	1.36
Cincinnati Airport	0.37	0.71	0.82	0.98	**1.18**	1.64
Cleveland Airport	0.31	0.57	0.67	0.80	**1.00**	1.33
Columbus Airport	0.34	0.63	0.73	0.87	**1.07**	1.48
Dayton Airport	0.35	0.65	0.75	0.90	**1.12**	1.54
Huntington WV Airport	0.35	0.66	0.77	0.93	**1.17**	1.56
Mansfield Airport	0.33	0.64	0.76	0.90	**1.11**	1.51
Toledo Airport	0.32	0.61	0.71	0.84	**1.02**	1.39
Youngstown Airport	0.31	0.58	0.66	0.79	**0.98**	1.29
Mean	0.33	0.63	0.73	0.87	**1.07**	1.45

Precipitation Depth-Frequency Analysis



Runoff Capture Volume

- The runoff capture volume is a better predictor of water quality treatment than precipitation depth
  - For a given WQv, determined the percent annual runoff volume captured by a water quality BMP and <u>routed</u> through the WQv outlet
  - Each BMP sized for WQv = Rv * P * A
  - Capture volume determined using USEPA Storm Water Management Model (SWMM; v5.1.012)
  - Used Port Columbus Airport precipitation data (Aug 1948 – Dec 2013)



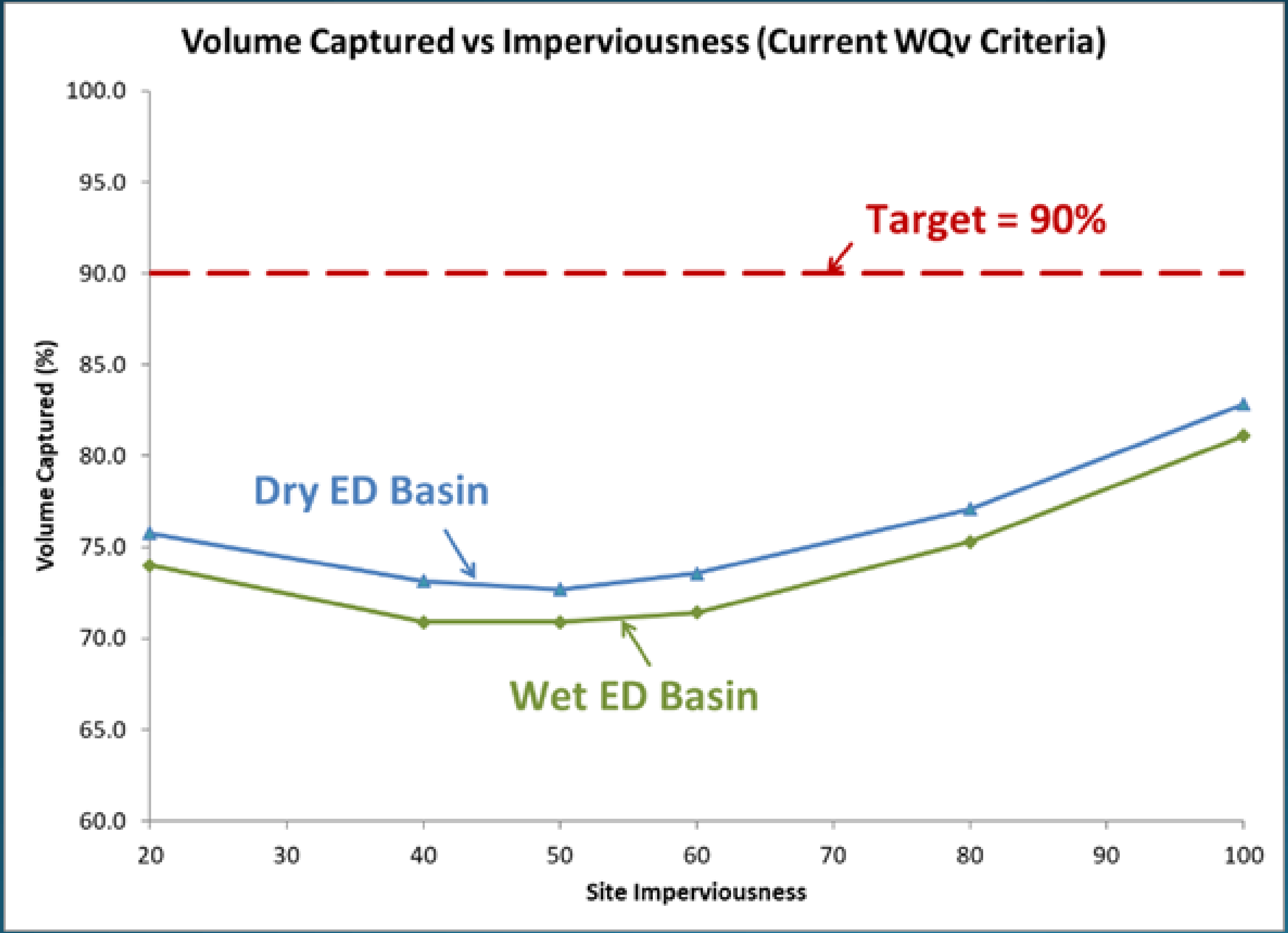
Runoff Volume Captured vs Time
Runoff Volume Captured (%)
94.0
92.0
90.0
88.0
86.0
84.0
82.0
80.0
1948-1960
1961-1970
1971-1980
1981-1990
1991-2000
2001-2013
Columbus
Dayton
Akron-Canton
Youngstown
Cleveland
Toledo
Mansfield
Cincinnati
Huntington WV
Average

Runoff Capture Volume (2013 CGP)

(1) Estimating runoff capture volume using 2013 CGP criteria

- BMPs - wet and dry extended detention basins
- Each BMP sized for WQv = Rv * P * A
- $Rv = C = 0.858i^3 – 0.78i^2 + 0.774i + 0.04$
- P = 0.75”

Runoff Capture Volume (2013 CGP)



Runoff Capture Volume (2013 CGP)

Imperviousness (%)	Average Annual Runoff Capture Volume %	Estimated TSS Reduction (Assuming BMP Effectiveness = 90%) %
20	74.0	66.6
40	70.9	63.8
50	70.9	63.8
60	71.4	64.3
80	75.3	67.8
100	81.1	73.0
Goal	90.0	80.0

90% Runoff Capture Volume

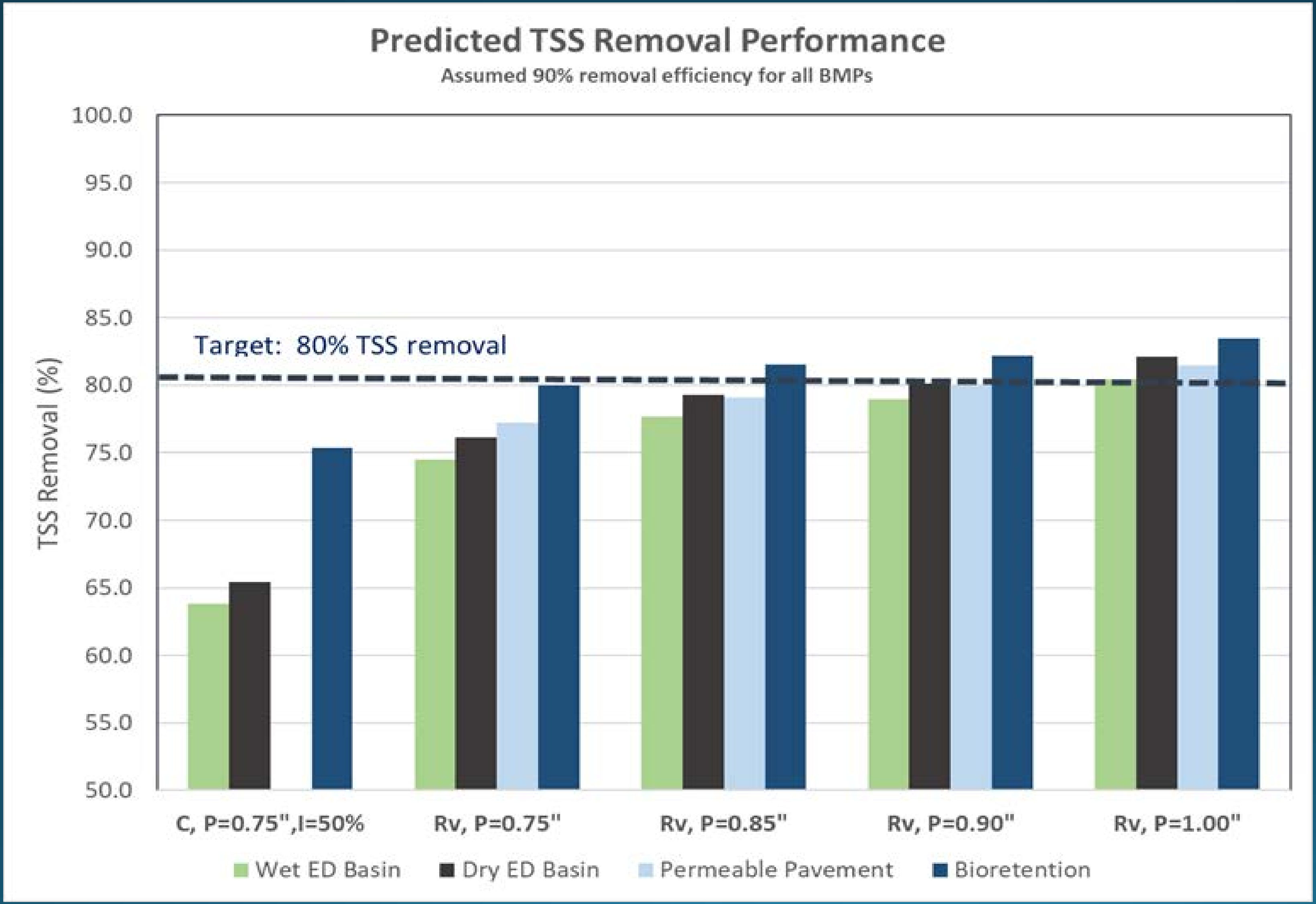
(2) Estimating WQv precipitation depth necessary to capture 90% of annual runoff volume

- BMPs - wet and dry extended detention basins, bioretention, permeable pavement
- Each BMP sized for WQv = Rv * P * A
- Rv = 0.05 + 0.9*i
- P = 0.75, 0.85, 0.90, 1.0 inch

90% Runoff Capture Volume

WQv P Depth (in)	Dry ED Basin %	Wet ED Basin (EDv=0.75*WQv) %	Permeable Pavement %	Bioretention %
0.75	84.6	82.8	85.8	88.9
0.85	88.1	86.3	87.9	90.6
0.90	89.0	87.7	88.9	91.3
1.00	91.2	89.4	90.5	92.7

Predicted TSS Removal Performance



WQv Analysis Recommendations

- Utilize $Rv = 0.05 + 0.9*i$
- Increase the WQv precipitation depth (P_{WQv}) to 0.90 inches

State Post-construction Criteria – P_{WQv} Depth

P_{WQv} Depth (in)	States
0.75	KY (80% annual capture volume target)
0.80	NY*
0.90	MD*, OH
1.00	CT, MA, MD*, MI*, NH, RI, TN, WV, VT, IN, NC*
1.10	MN
1.20	NY*
1.25	IA, NJ
1.50	NC*

Source: US EPA. 2016. Summary of State Post Construction Stormwater Standards. Office of Water, U.S. Environmental Protection Agency, Washington, DC.

Questions:

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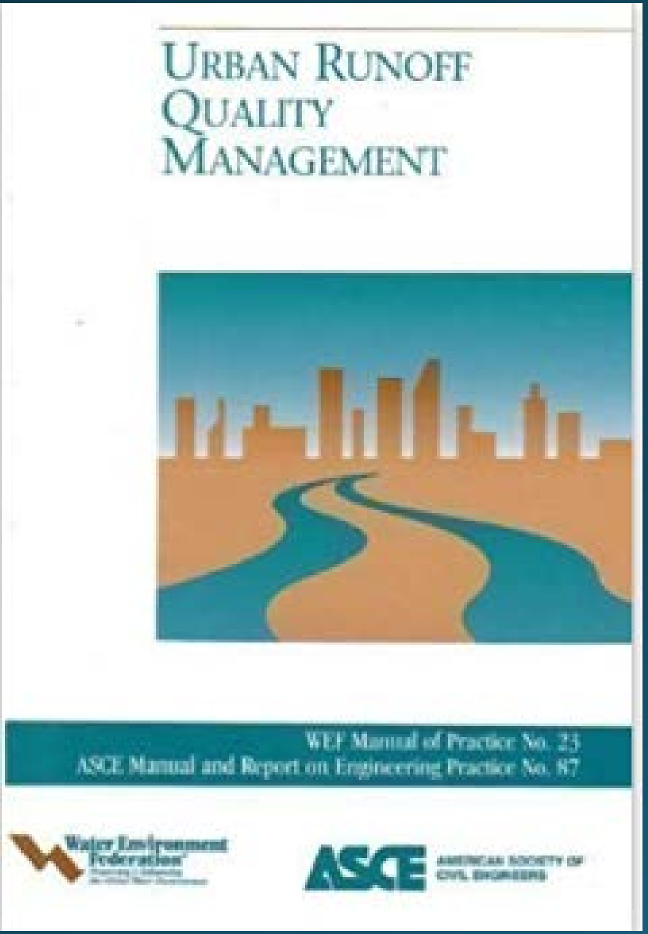
Maximized Detention Volume (WEF, 1998)



Wet ED Basin

Mean P Depth (inches)	24-hr Drain Time Multiplier	Maximized Detention Volume (85% capture) (wshed-inches)
0.47	1.582	0.74
0.50	1.582	**0.79**
0.53	1.582	0.84

Dry ED Basin

Mean P Depth (inches)	48-hr Drain Time Multiplier	Maximized Detention Volume (85% capture) (wshed-inches)
0.47	1.963	0.92
0.50	1.963	**0.98**
0.53	1.963	1.04

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