

Effects of BMP and Retention Sizing

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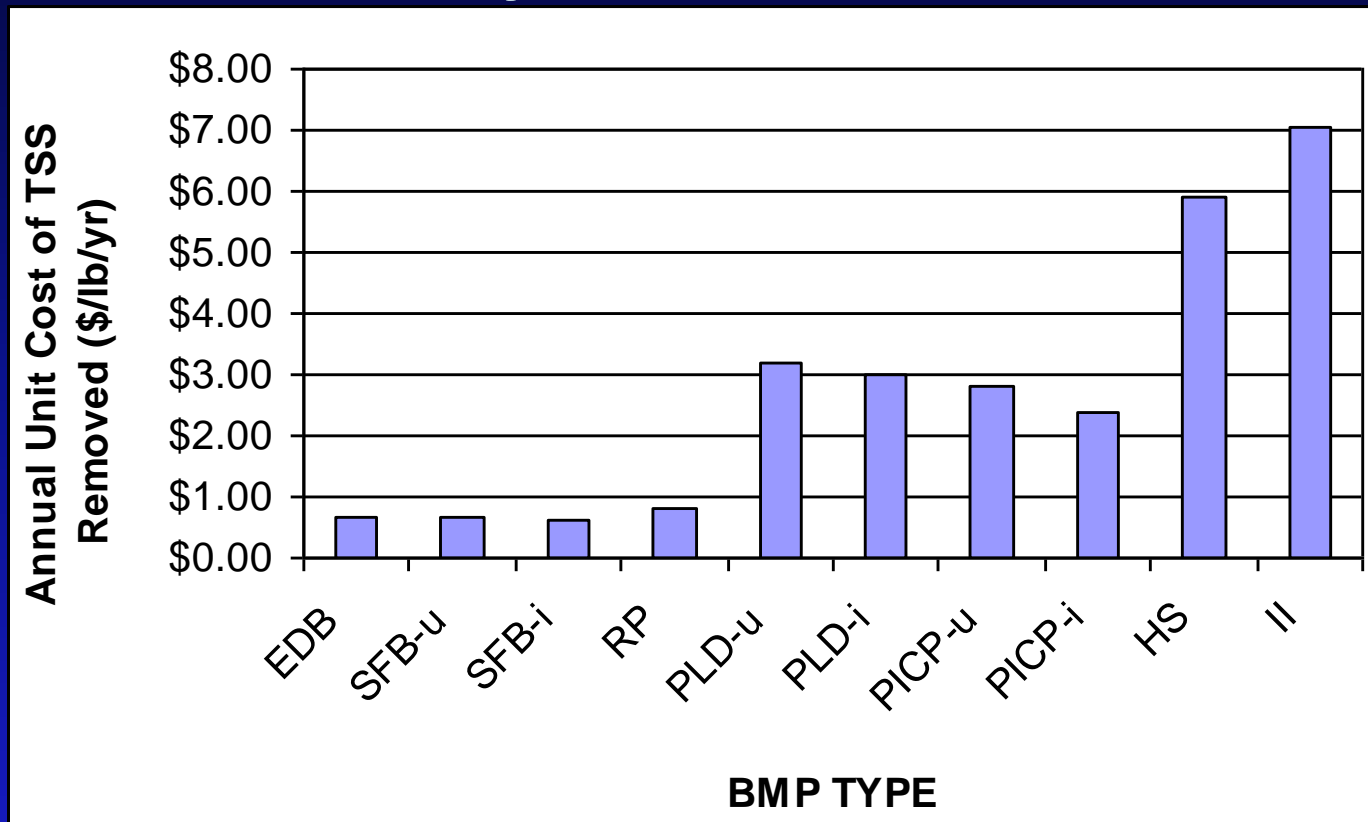
NAFSMA Stormwater Focus Workshop

October 30, 2011

Last Year I Presented Whole Life Effectiveness Analysis for Denver.

Analysis for Denver.

Example below shows TSS load removed in \$/lb/yr for several BMPs



**Differences in Net Present Costs
50-year Project Life,
Account for Inflation.**

1-Sq.Mi. Mixed Land Use Watershed

Rain Gardens: \$32,514,000

Extended Det. Basins: \$5,973,000

**Using RGs (i.e., retention) only approach is
5 times more expensive than using EDBs**

Today I will discuss another
dimension of stormwater
management:

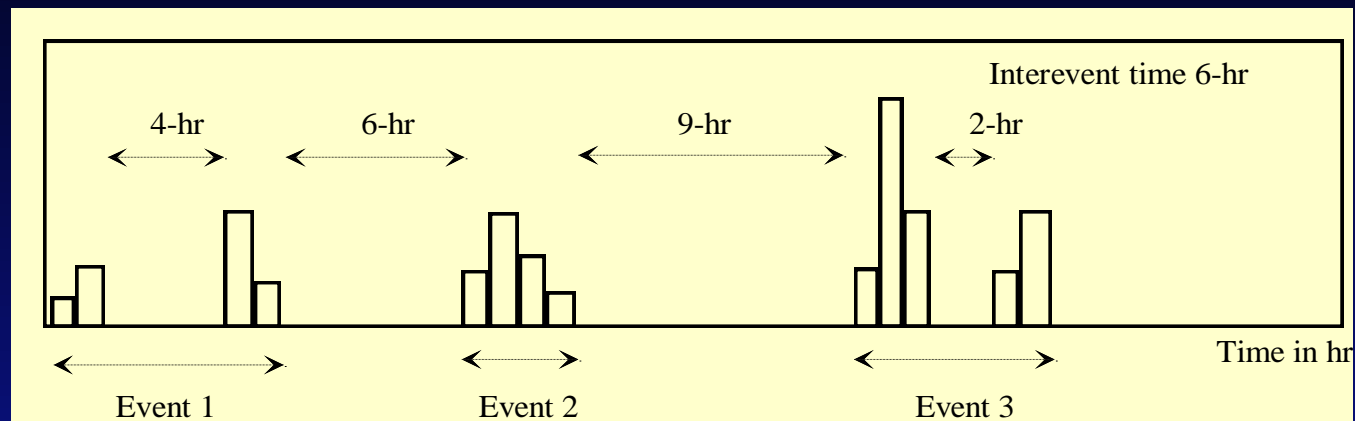
Sizing of BMPS

Cost is Proportional to

BMP Size

Need to look at
Counting Storms Captured
VS
Counting Runoff Volumes
Captured?

Identifying Individual Storms

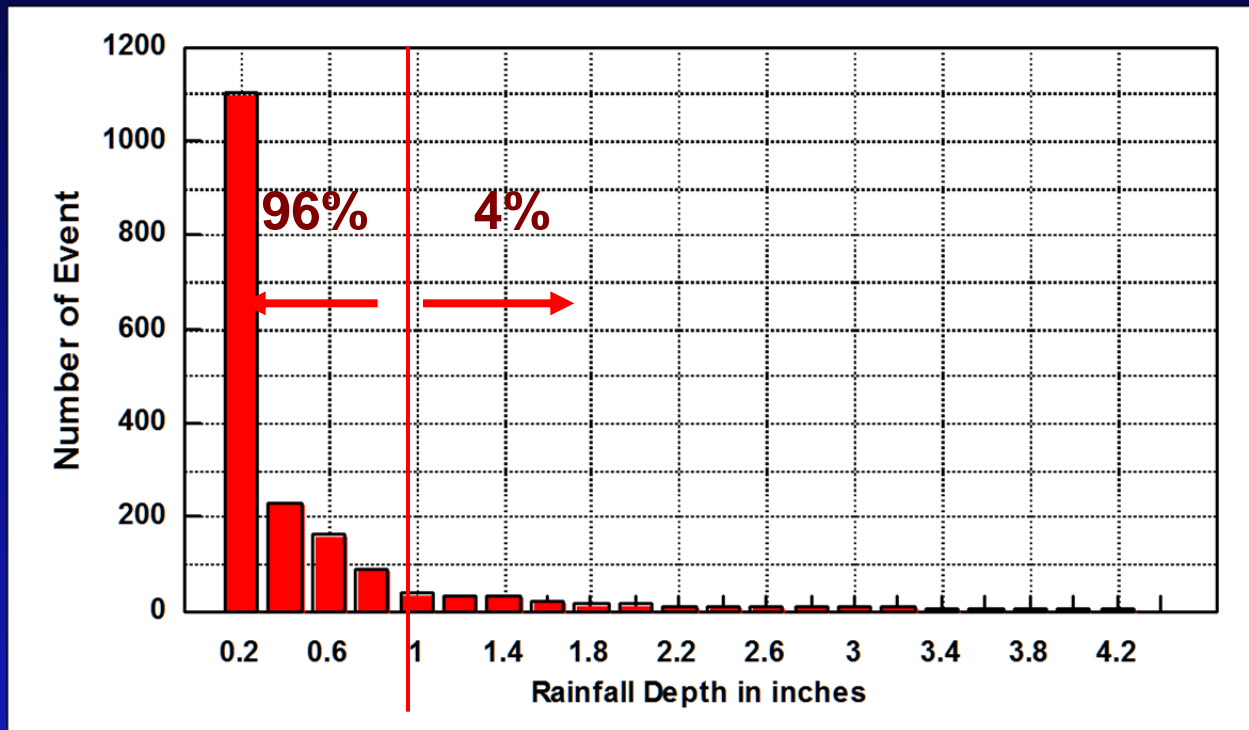


- Time-of-Separation or “Inter-Event Time”
 - Can be used to define the dry period between end of rainfall in one storm and start of a new one
 - Eugene Driscoll In 1980 recommended use of 6-hours to define a new storm event.
 - He based this on statistical **analysis for EPA** of NWS raingage data at may sites in Unites States

Example:

Denver Statistics (Guo and Urbonas 1989)

- (a) average storm depth = 0.41 inch (40 year record of rainfall)
- (b) average inter-event time = 110 hours
- (c) 96% of **Runoff-Producing** rainfall events < 1-hr 2-yr depth 0.93"



This pattern is very typical for most sites in USA

Precipitation data is available from
National Climatological Data Center (NCDC)

These data need screening for errors and
format differences

- Consider excluding from analysis seasons that would not have direct rainfall/runoff relationships, such as the winter seasons

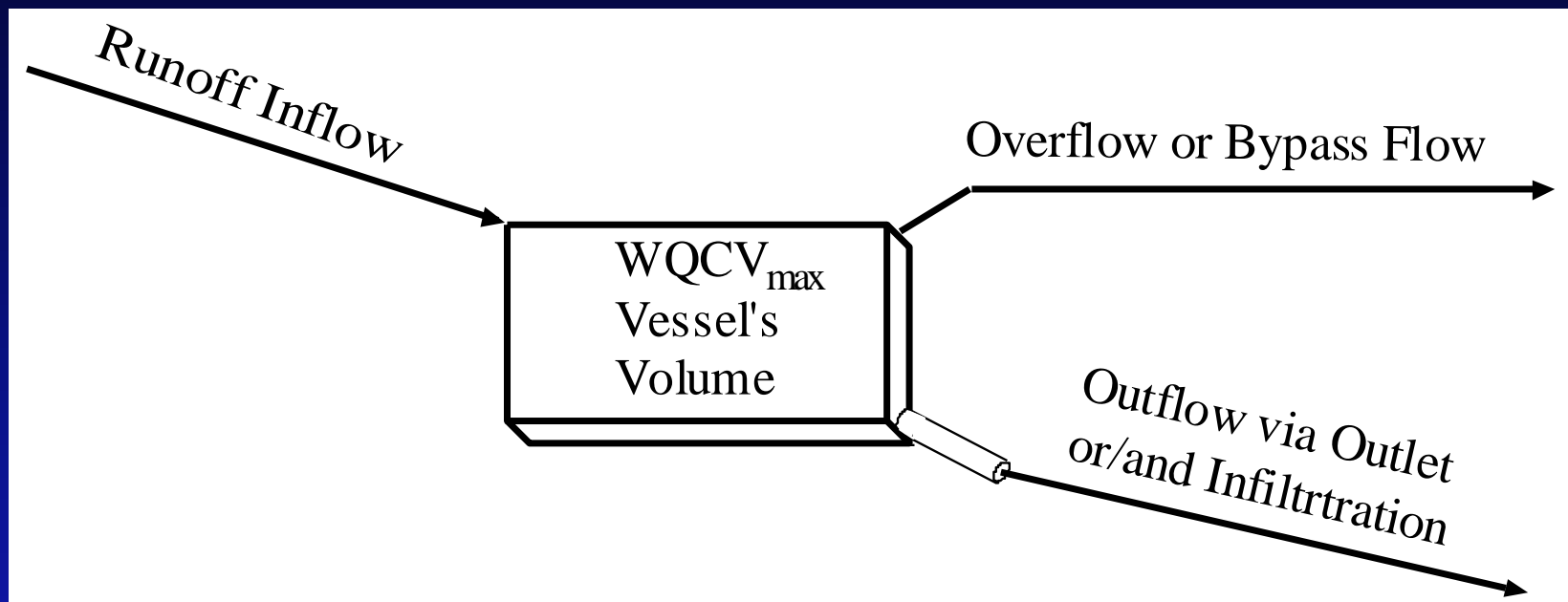
Storm Screening

- Identify individual storms using inter-event time (separation time)
- Filter out very small storms that do not produce runoff (i.e., < 0.08 or 0.1)
 - Need to address runoff to be addressed, not rainfall

Use Continuous Simulations to find Water Quality Capture Volumes (WQCV)

1. Need to use continuous filtered rainfall data set
2. Develop a continuous record of surface runoff volumes
3. Process this runoff data through a series of increasing WQCV vessels based on time it takes to drain a brim-full vessel. (i.e., discharge rate)
4. Array the findings to find % of runoff volume and % of runoff events captured to find maximized WQCV
5. Screen out large-outlier events (e.g., > 99.5%)
6. Describe statistics of % captured vs. size of WQCV.

ROUTING RUNOFF THROUGH THE WQCV VESSEL



Note: The discharge rate is equal to $(WQCV_{max}/\text{Drain Time})$

Counting WQCV Overflows (2)

The ***Runoff Volume Capture Ratio (R_v)*** is defined as:

$$R_v = 1.0 - (P_{to}/P_{tr})$$

in which,

P_{to} = cumulative overflow volume of runoff (in. or mm),

P_{tr} = total volume of runoff in period of record (in. or mm).

The ***Event Capture Ratio (R_n)*** is define the as:

$$R_n = 1.0 - (N_{to}/N_s)$$

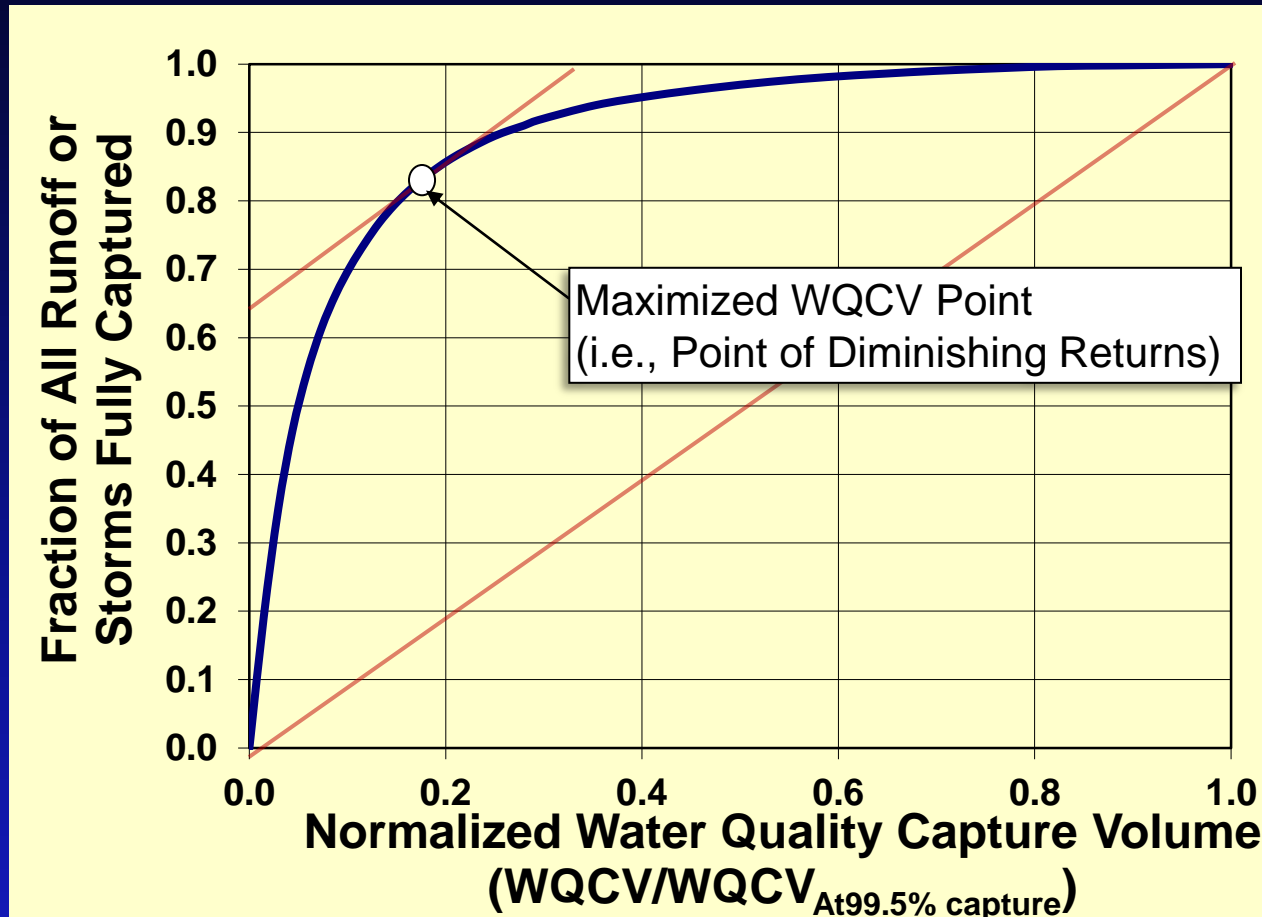
in which,

R_n = runoff event capture ratio,

N_{to} = total number of storms with runoff exceeding $WQCV_{max}$

N_s = total number of storm runoff events in period of record.

Finding the Point of Diminishing Returns



We looked at BMP/Retention Sizing Needs at Several Cities in USA

Assumed that a full BMP/Retention basin will empty out in 12 hours to prevent public nuisance.

Used a newly developed continuous
Runoff and Water Quality Capture model

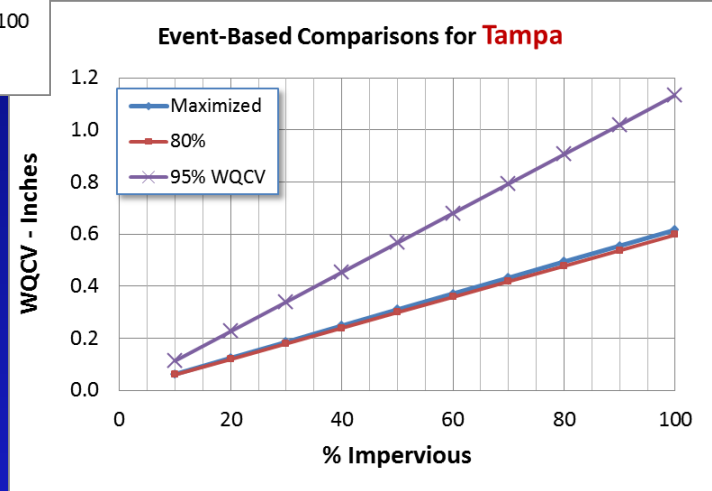
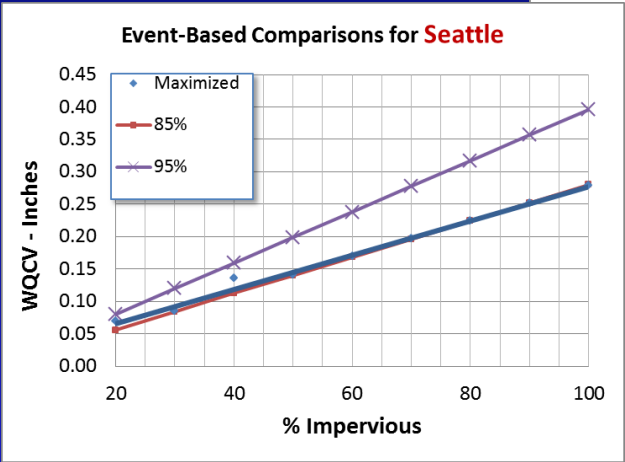
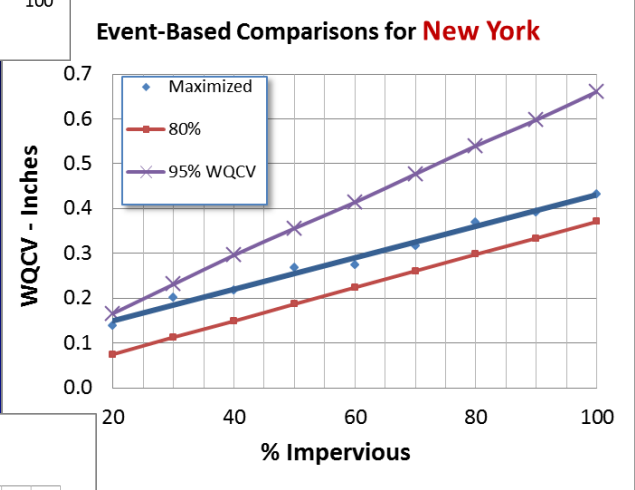
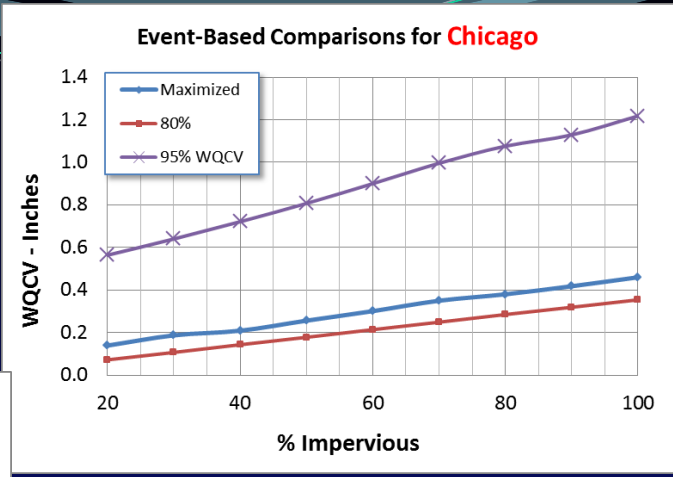
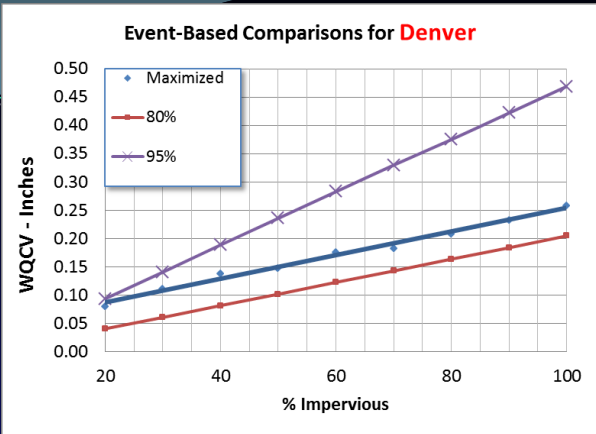
WQ-COSM

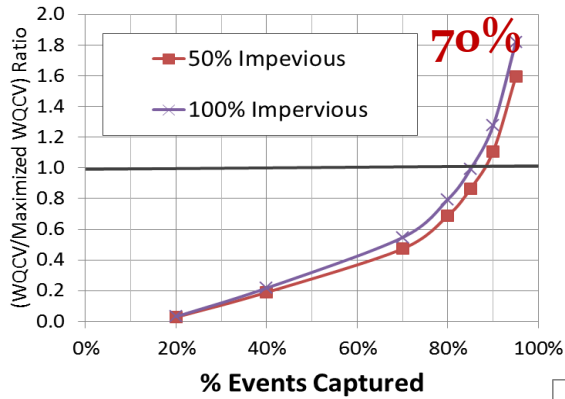
To analyze BMP and Retention
Sizing in USA

- **Water Quality Capture Optimization and Statistics Model (WQ-COSM):**
 - Available as freeware from UWRI & UDFCD
 - Uses NOAA's NCDC comma separated 15-minute and 1-hour rainfall data
 - Calculates WQCV for any site in USA
 - Develops statistical information on local rainfall

Findings that Emerge:

- Sizing needs vary greatly across United States
- Receiving Water need also vary greatly
- A single capture/retention standard fails to recognize these variability's
- There is a need to screen out large outlier (flood and drainage problem producing) storms from analysis when looking for appropriate WQCV.
 - Suggest WQCVs > 99.5 percentile capture be excluded.
- **There is a point of diminishing returns** (i.e., Maximized Point).
 - Increased capture sizing beyond that quickly diminish in effectiveness in the number of events or runoff volumes captured.

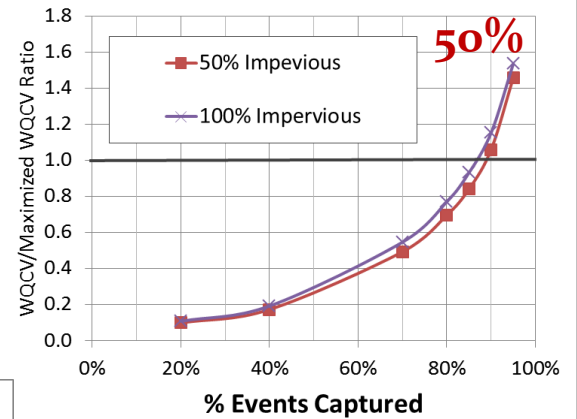




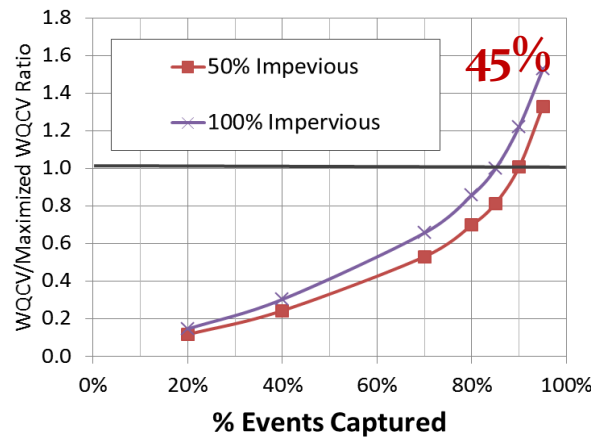
Denver

Ratios of WQCV/Max. WQCV

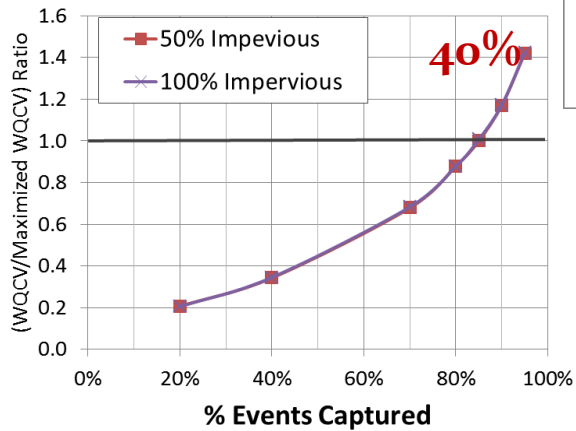
95% Capture Penalty



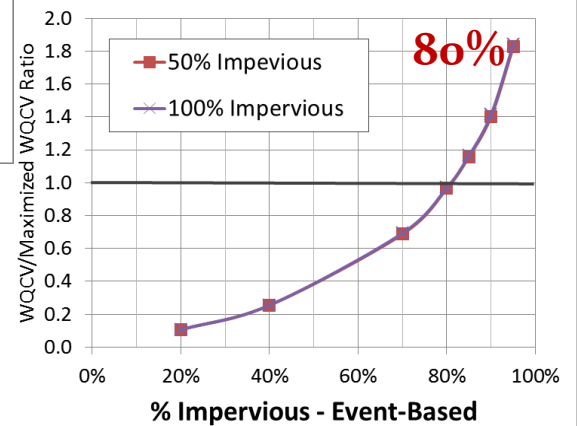
Chicago



New York



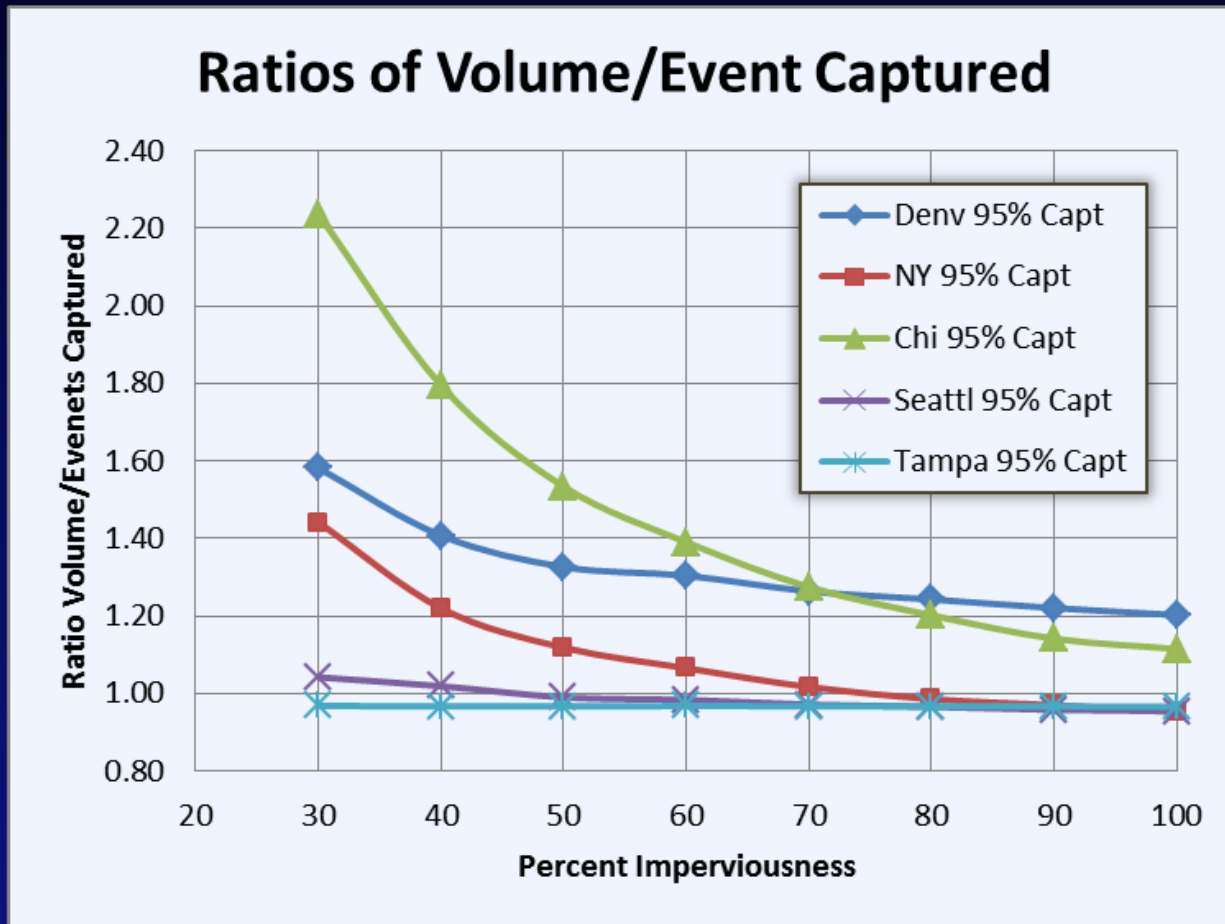
Seattle



Tampa

Volumes vs. Events Captured

Ratios Vary Across the Country



%
Penalty
to use
volumes
vs.
events
captured

Compound Penalties

- Volume vs. Events Captured and 95% vs. Maximized Captured Compound
- Ratios of oversizing needed at 60% imperviousness:
 - CHICAGO 2.1
 - DENVER 3.2
 - NEW YORK 1.5
 - SEATTLE 1.4
 - TAMPA 1.75

Observations/Recommendations

When designing a stormwater quality control facility system, need to balance:

- runoff capture capabilities against
- effectiveness in protecting receiving waters and
- life-cycle facility costs, including
 - construction,
 - maintenance, and
 - eventual rehabilitation.

Observations/Recommendations

A *Water Quality Capture Volume* is an integral part of all BMPs, including retention facilities.

Recommend using:

- Maximized/Optimized capture volume as basis for sizing and design
- Events Captured as basis for sizing **instead of** Volumes Capture for protection of streams and rivers
 - Streams also respond more to numbers of runoff events, not only runoff volumes
 - *Volumes Capture* may be more appropriate for lake and estuary protection
- Screen out large, flood-producing outlier events, from sizing analysis

Observations/Recommendations

There is great diversity across United States in how WQCV responds to local precipitation

Also, there is great diversity throughout USA in the receiving water protection needs:

Estuaries

Lakes,

Arroyos

Gulches

Streams

Rivers

Wetlands

One Size does not fit all



Thank You!!!

QUESTIONS?