5TH ANNUAL CONFERENCE, APRIL 8, 2008
INTEGRATING WATER RESOURCES MANAGEMENT

Analysis of Long Term Rainfall to Develop Stormwater Quality Design Criteria

Dan Nason, National Engineering Manager

Objective

- To present a method to determine a design flow rate for flow-based stormwater BMPs using the annualized Water Quality Volume (WQ_V) for drainage areas (typically less than 10 acres)
  - Volumetric criteria is expressed as a percentage of the total annual volume of runoff rather than a single volume or the peak flow rate of a storm event
  - Volumetric criteria is interpreted to a flow rate called the Water Quality Flow (WQ_F)
  - Analysis is based on a continuous hydrologic simulation model rather than a single storm event

Traditional Practices

- Volume-Based Approach (**Water Quality Volume**) or **Peak Flow Design**
- Based on a single storm event selected from the analysis of historical rainfall data
- Typically applied to ponds, wetlands and infiltration systems
- However, often applied generically to all stormwater BMPs where no other design guidance exists

Water Quality Volume

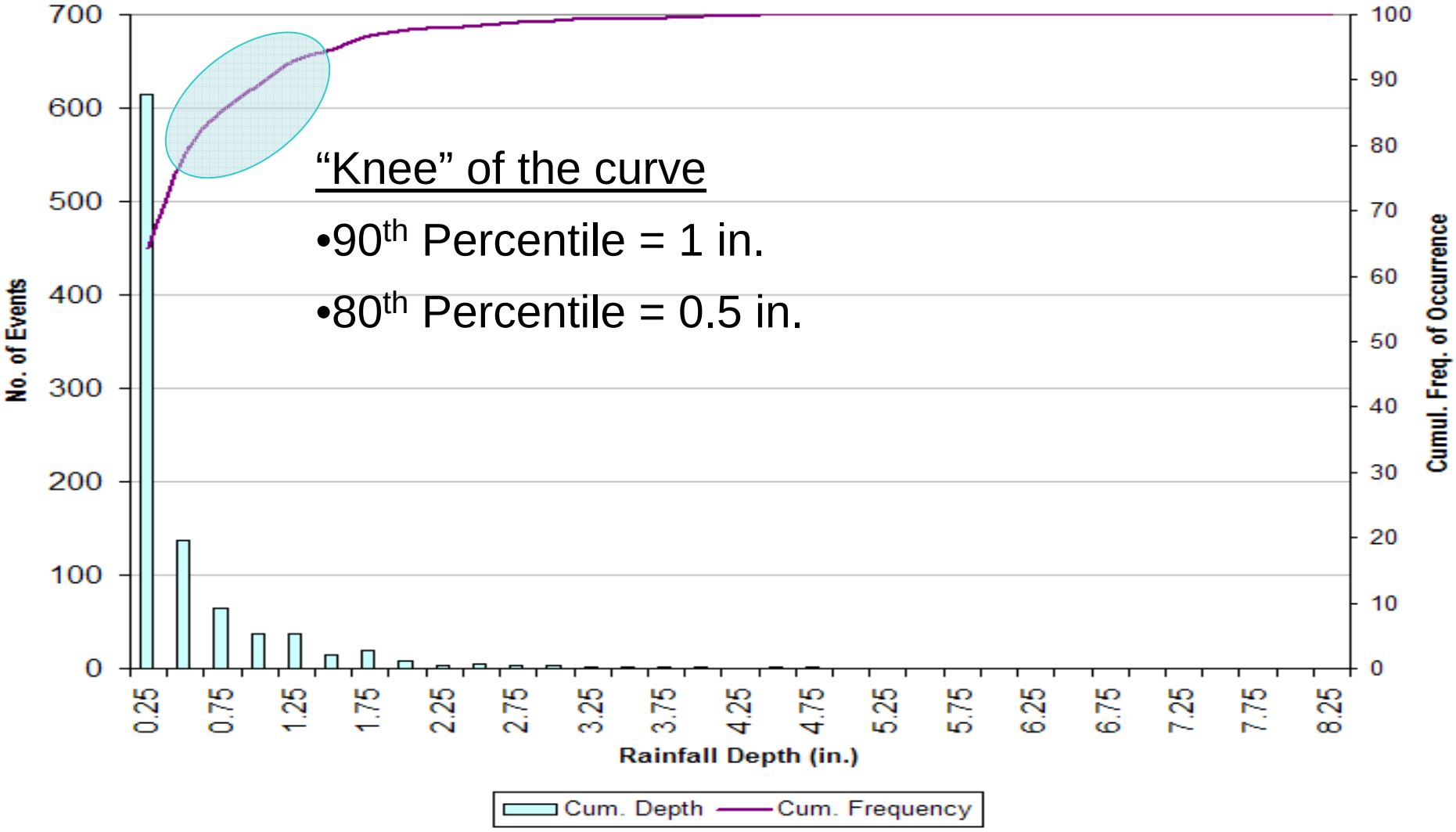
What is Water Quality Volume (WQ_V)?

- Minimum volume of runoff required to achieve a desired water quality outcome (expressed as a minimum depth)
- Ranges from 0.5 in. to 1.5 in. of rainfall depth
- Represents the most frequent cumulative annual volume of runoff captured
  - Objective is to treat the 80th to 90th percentile of the annual runoff volume
  - Determined from long-term analysis of historical rainfall
- Wet ponds, wetlands, infiltration systems, bio-filters, sand filters, etc.

How is WQ_V Established?

- ASCE and WEF
  - ASCE Manual and Report on Engineering Practice No. 87
  - WEF Manual of Practice No. 23
- USEPA Stormwater Management Practice Design Guide, Volume 1, General Considerations
- Analysis of long term historical rainfall data
- Relationship of cumulative annual volume capture versus rainfall depth
- "Knee of the Curve"

Rainfall Frequency Analysis

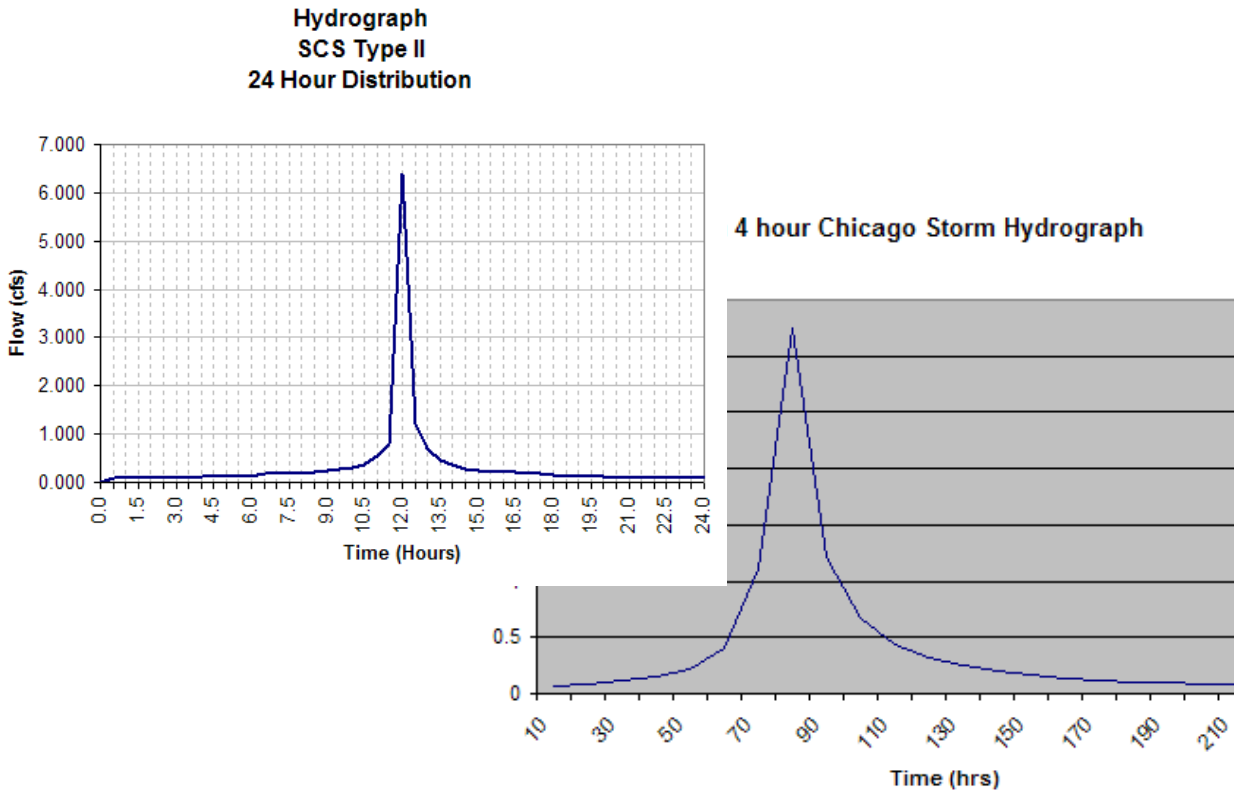


"Knee" of the curve

- 90th Percentile = 1 in.
- 80th Percentile = 0.5 in.

Peak Flow Design Storm

- Based on a portion, or the peak, of a single storm event expressed as either a rainfall depth, intensity or synthetic storm distribution



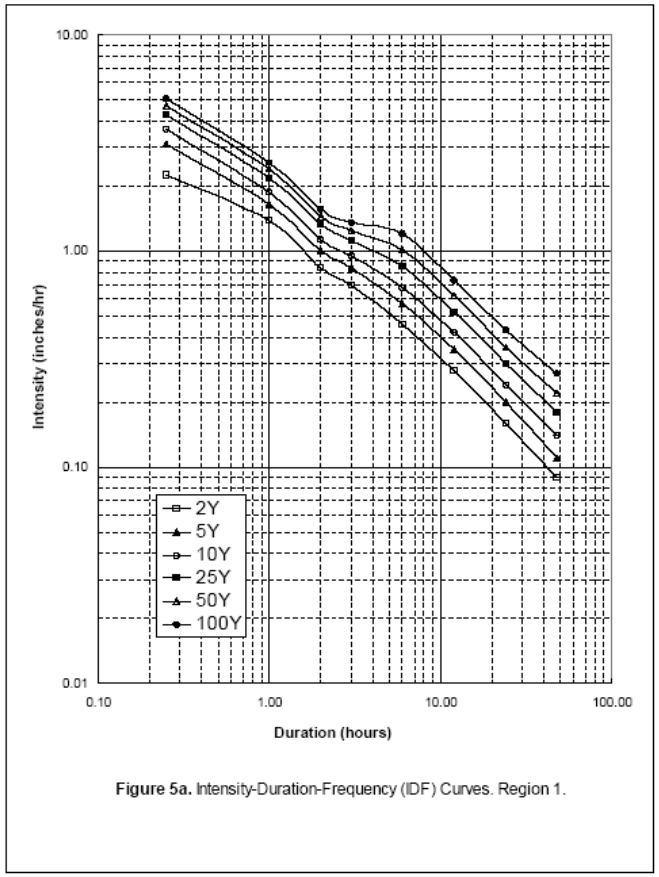


Figure 5a. Intensity-Duration-Frequency (IDF) Curves. Region 1.

Typical Characteristics of BMPs Designed for a Water Quality Volume

- Requires a large storage volume
  - i.e., 0.5 inch (12.7 mm) depth, 2.47 acres (1 ha) site requires 166 cy (127 m^3) volume of storage
  - i.e., 1.0 inch (24.3 mm) depth, 2.47 acres (1 ha) site requires 332 cy (254 m^3) volume of storage
- Drawdown time ranges from 12 hours to 24 hours
- Typical applied to large drainage areas

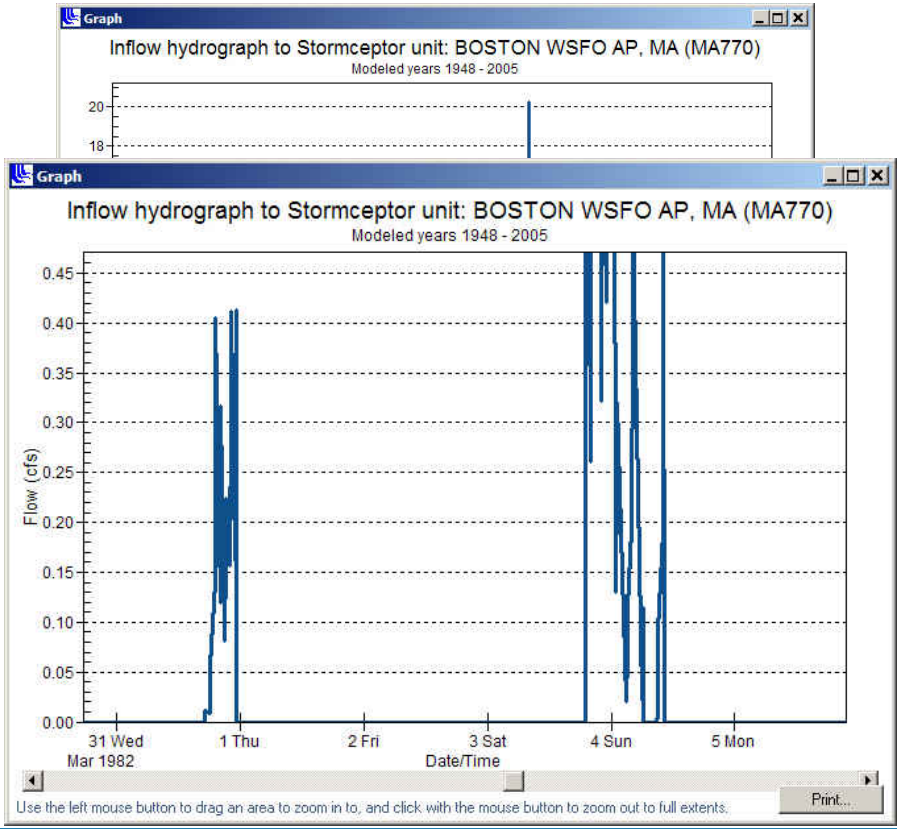
Water Quality Flow (WQ_F)

What is Water Quality Flow (WQ_F)?

- A defined minimum treatment flow rate required to achieve a desired water quality outcome
- Expresses water quality volume as a flow rate based on the percentage of the **cumulative average annual** volume of runoff captured
- "knee of the curve"
- Applied to manufactured treatment systems which treat the WQ_F and divert the excess
- Analysis of continuous local historical rainfall

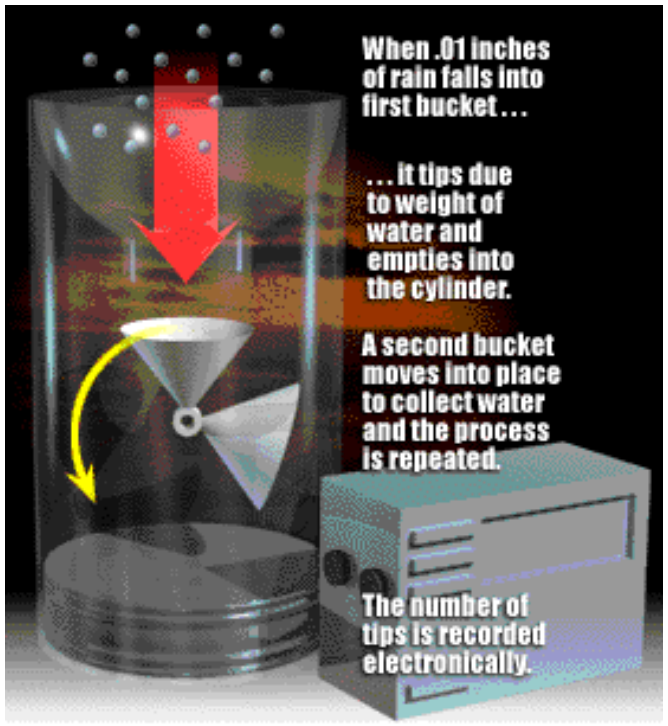
Methodology

- Analysis of continuous long-term historical rainfall data
  - USEPA SWMM
    - PCSWMM.net
    - XPSWMM
    - WinSLAMM, etc.
- Define boundary conditions
  - What is a rainfall event?
  - Volume of Runoff
- Create a continuous hydrograph



Long-Term Historical Rainfall Data

- Local Rainfall Station/Rain Gauge (Boston Logan A/P)
- Record of Rainfall (1948 – 2005)
- Rainfall depth measured in 60 minute time steps
- National Climactic Data Center (NCDC) Format
- Each tip is equivalent to 0.01 inch (0.25 mm) of rainfall depth accumulation



Boundary Conditions

- Define a rainfall event
  - 2-hour inter-event period
- Calculation of Long Term Volume of Runoff
  - USEPA SWMM Version 4.3
  - Sub-catchment characteristics indicative to stable commercial and industrial land uses
  - Define a drainage area

Summary of Rainfall Events

Boston Logan AP

- 9,245 rainfall events (1948 to 2005)
- 84% of rainfall events were 0.5 inch or less

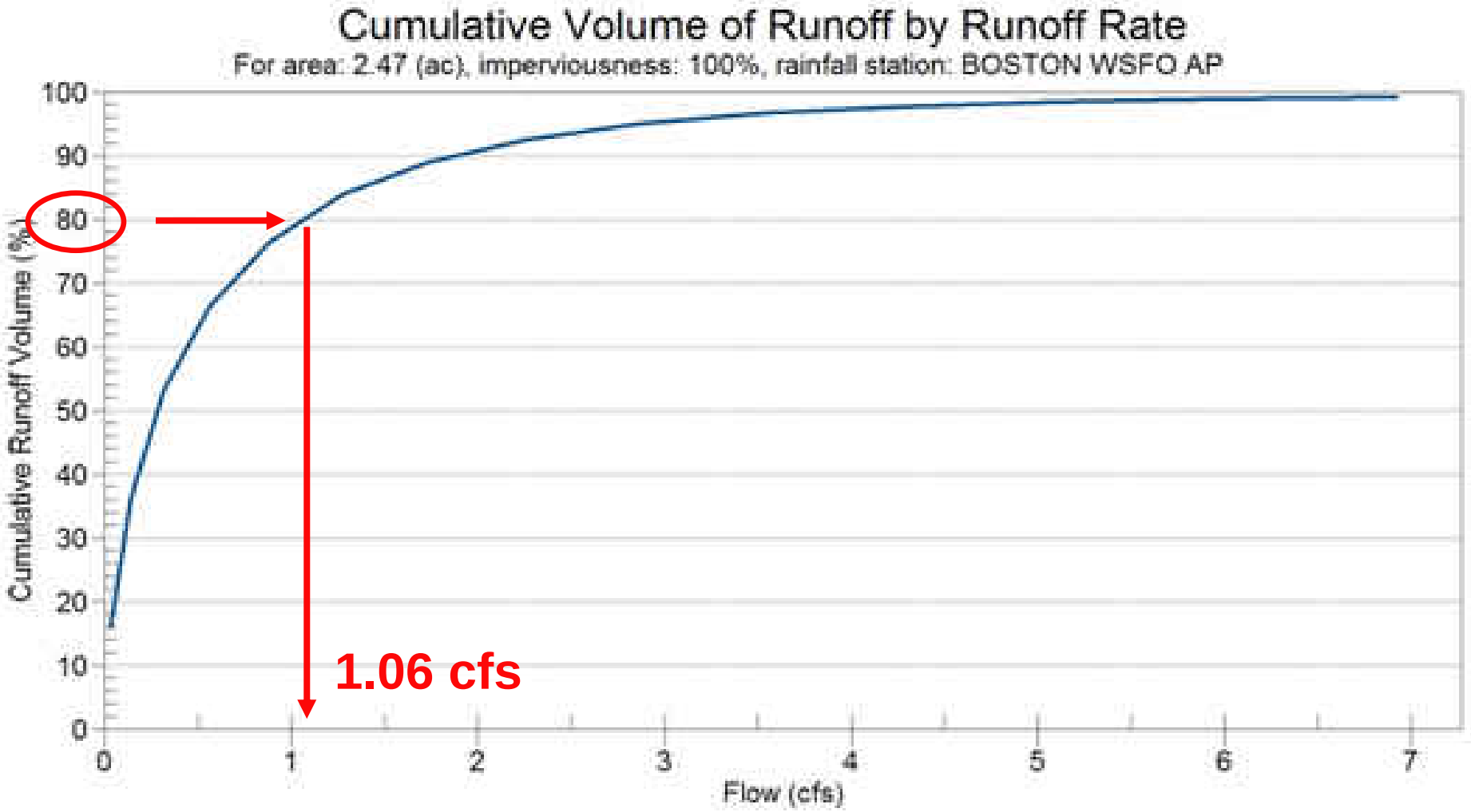
Rainfall Depth	No. of Events	Percentage of Total Events
in.		%
0.25	6728	72.8
0.50	1052	11.4
0.75	541	5.9
1.00	323	3.5
1.25	192	2.1
1.50	128	1.4
1.75	89	1.0
2.00	52	0.6
2.25	48	0.5
2.50	29	0.3
2.75	14	0.2
3.00	16	0.2
3.25	4	0.0
3.50	5	0.1
3.75	4	0.0
4.00	2	0.0
4.25	4	0.0
4.50	2	0.0
4.75	1	0.0
5.00	4	0.0
5.25	1	0.0
5.50	0	0.0
5.75	3	0.0
6.00	0	0.0

Long-Term Volume of Runoff Treated

Runoff Rate	Runoff Volume	Volume Overflowed	Cumulative Runoff Volume
cfs	ft³	ft³	%
0.035	3252910	17100654	16.0
0.141	7371430	12971370	36.2
0.318	10825373	9516321	53.2
0.565	13514218	6826716	66.4
0.883	15540345	4799891	76.4
1.271	17035680	3305587	83.8
1.73	18092490	2247328	88.9
2.26	18824312	1516438	92.5
2.86	19318590	1021700	95.0
3.531	19647292	693624	96.6
4.273	19865834	474638	97.7
5.085	20014840	325844	98.4
5.968	20113845	226754	98.9
6.922	20182806	157852	99.2
7.945	20233532	107096	99.5
9.041	20271202	69431	99.7
10.206	20296048	44564	99.8
11.442	20310732	29913	99.9
12.749	20321632	19300	99.9
14.126	20330280	10362	99.9
15.574	20336170	4471	100.0
17.092	20338210	2432	100.0
18.681	20339636	1001	100.0
20.341	20340642	0	100.0
22.072	20340642	0	100.0
23.873	20340642	0	100.0
25.744	20340642	0	100.0
27.687	20340642	0	100.0
29.7	20340642	0	100.0
31.783	20340642	0	100.0

1.06 → 16 M cf ← 80%

Cumulative Volume vs. Flow Curve



Characteristics of BMPs Designed by the Annualized Approach

- Drainage areas (typically < 10 acres)
  - Follows ‘source treatment’ philosophy
- Storage volumes from 60 cf (1.7 m^3) - 2225 cf (63 m^3)
- Uses a high flow diversion system (internal or external) to prevent re-suspension
- Treatment flow rates are low (0.32 cfs to 5 cfs)
- Detention times are small (< 7 minutes)

*The **traditional approach** to sizing water quality volume, based on a single event, **is not practical** based on the aforementioned characteristics*

Features of the Annualized Approach

- Water quality volume is expressed as a percentage of the cumulative volume of runoff treated
- Uses each event in long term historical rainfall data – not a single storm event
- Approach meets the intent of traditional water quality volume standards
- Approach provides a practical and realistic means of regulating the design of stormwater BMPs for drainage areas less than 10 acres

Conclusion: The Annual Approach for WQ_V

- Like traditional methods, historical rainfall data is used to select the optimum design point (the “knee” of the curve)
- WQV is expressed as a percentage of the annual runoff capture
- Provides a realistic means to design water quality devices

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Thank You…

Dan Nason
National Engineering Manager
Imbrium Systems Corp.
100 Grove Street
Worcester, MA 01605
t: 508.792.1190
f: 508.792.1193
e: dnason@imbriumsystems.com