VILLANOVA UNIVERSITY
COLLEGE OF ENGINEERING

VILLANOVA URBAN
STORMWATER PARTNERSHIP

Moving towards Dynamic Crediting for Adaptive Stormwater Control Measures

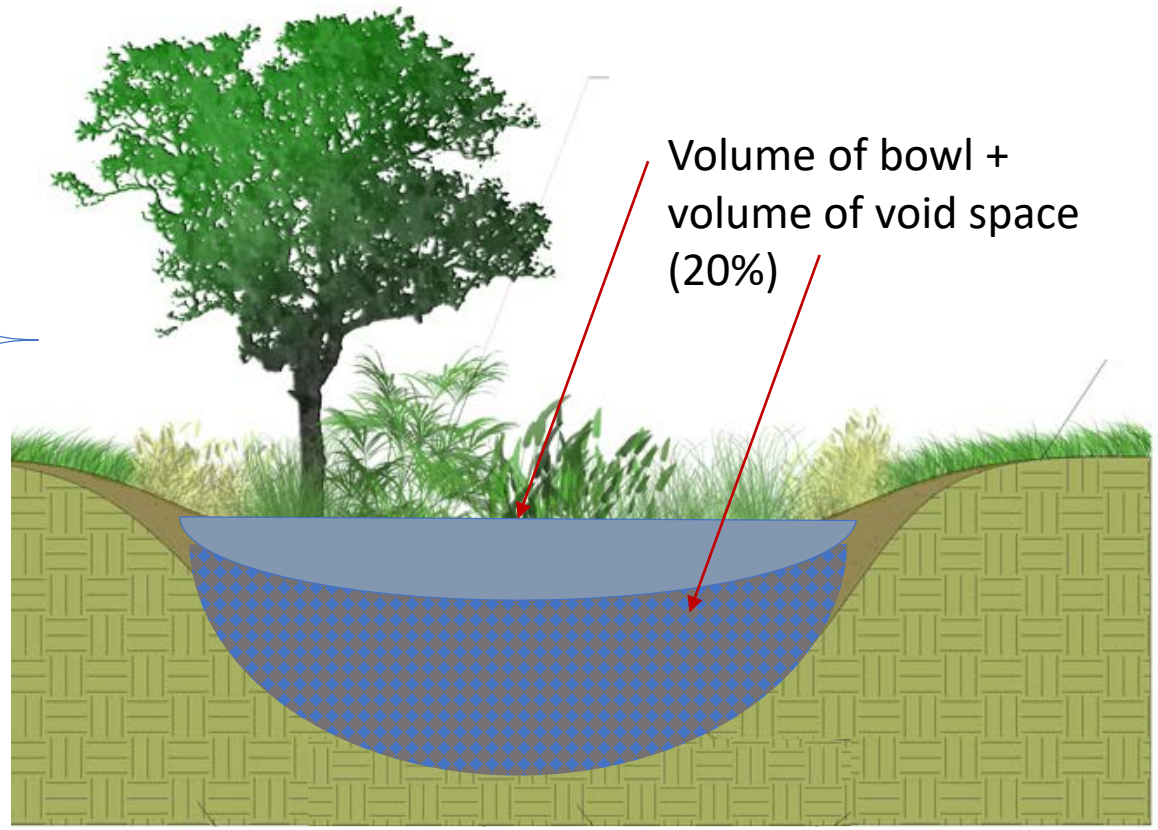
Villanova Stormwater Symposium 2019

Amanda Jean Hess, PhD EIT
OptiRTC, Inc
Villanova University

Opti

Outline

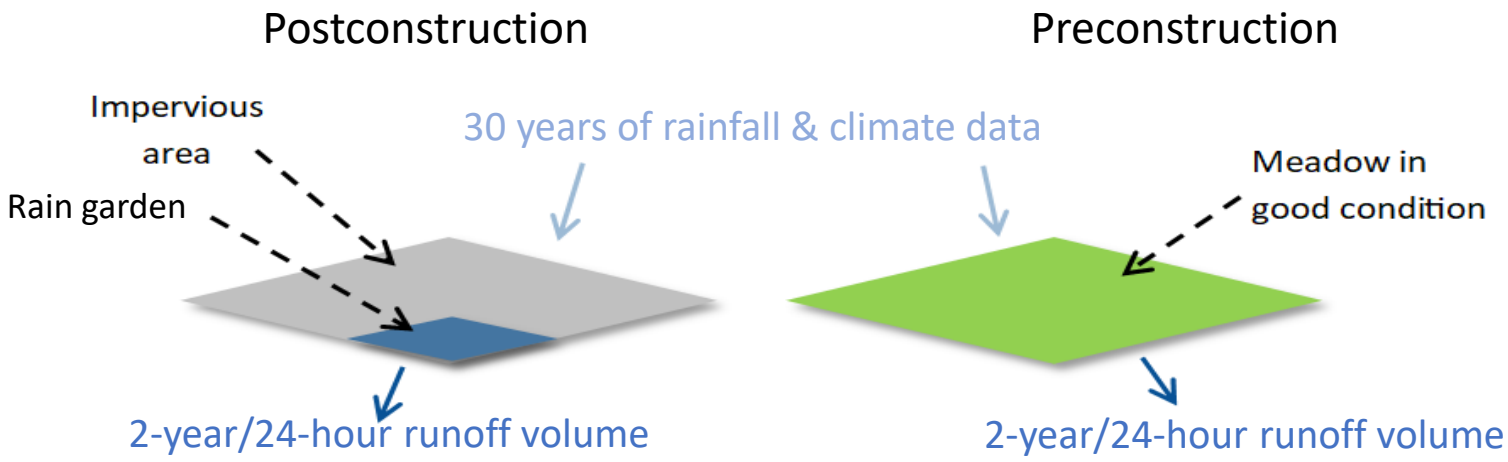
- Goal: to discuss how credit a dynamic Stormwater Control Measure (SCM) in the current regulatory environment
- In PA, the difference in the 2-year/24-hour storm from pre- to post-construction conditions:
  - Volume
  - Geomorphologic concerns
- Example site in Philadelphia (rain garden):
  - Infiltration
  - Evapotranspiration
- Two real sites (ponds):
  - Dynamic outlet controls (i.e., CMAC logic applied)
- How are other states crediting CMAC designs?

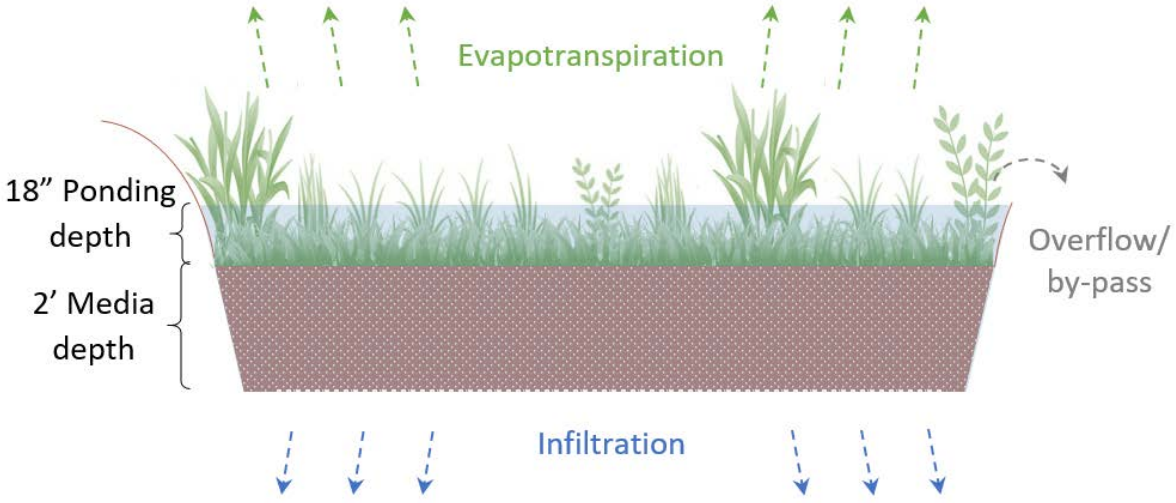


Statically sized stormwater controls

Example site in Philadelphia

- Rain Garden
- 30 years from the Philadelphia international airport
- Green & Ampt equation
- Obtain 2-year/24-hour runoff volumes





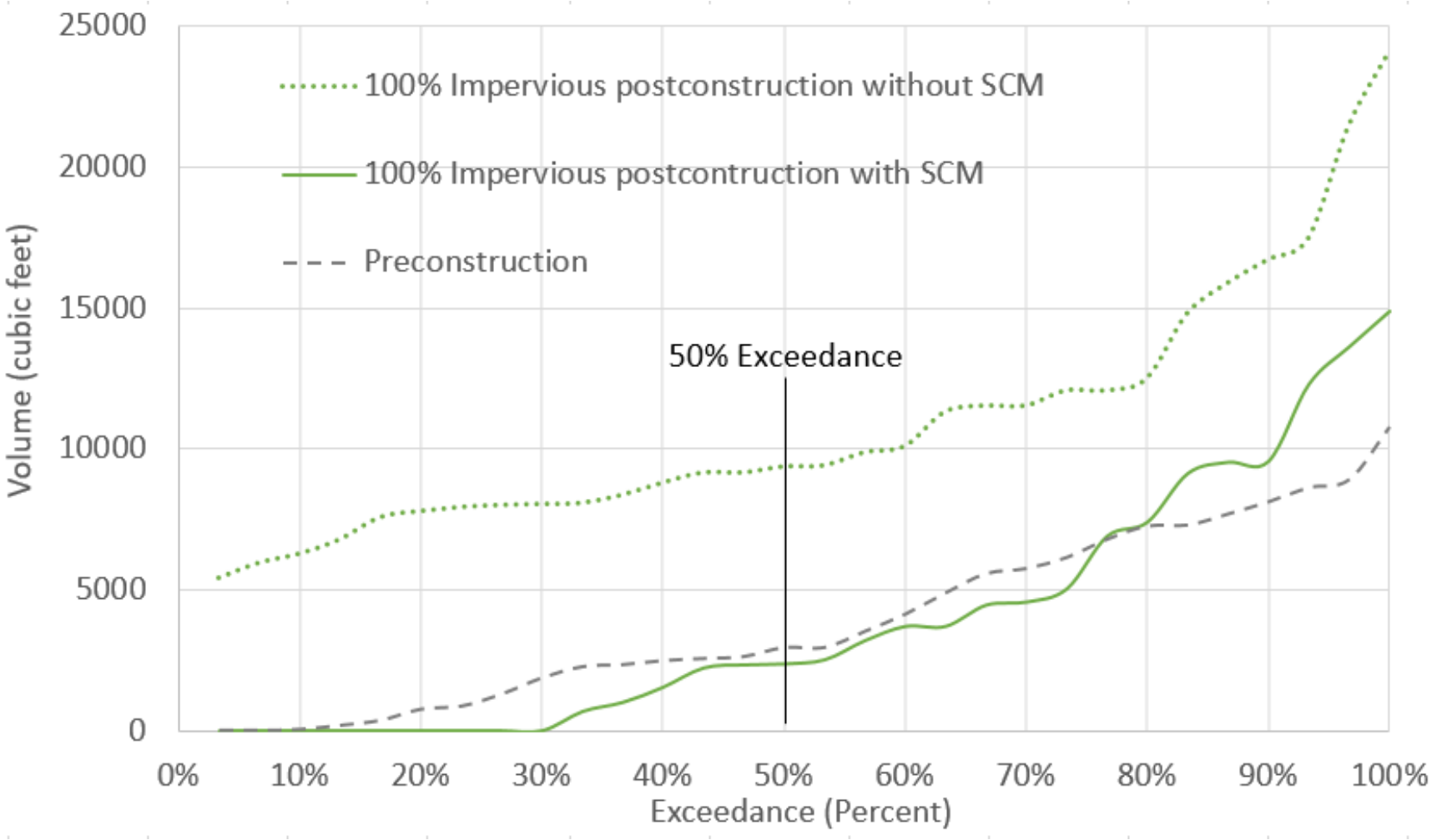
Description	Postconstruction (impervious)	Preconstruction (pervious meadow)
Slope	2%	10%
Depression storage value	0.05	0.20
Manning's n-value	0.01	0.20

Saturated hydraulic conductivity: 0.2 in/h
Soil suction: 5 psi

Example site in Philadelphia – Runoff Volume

Percent exceedance (ranking) vs. runoff volume

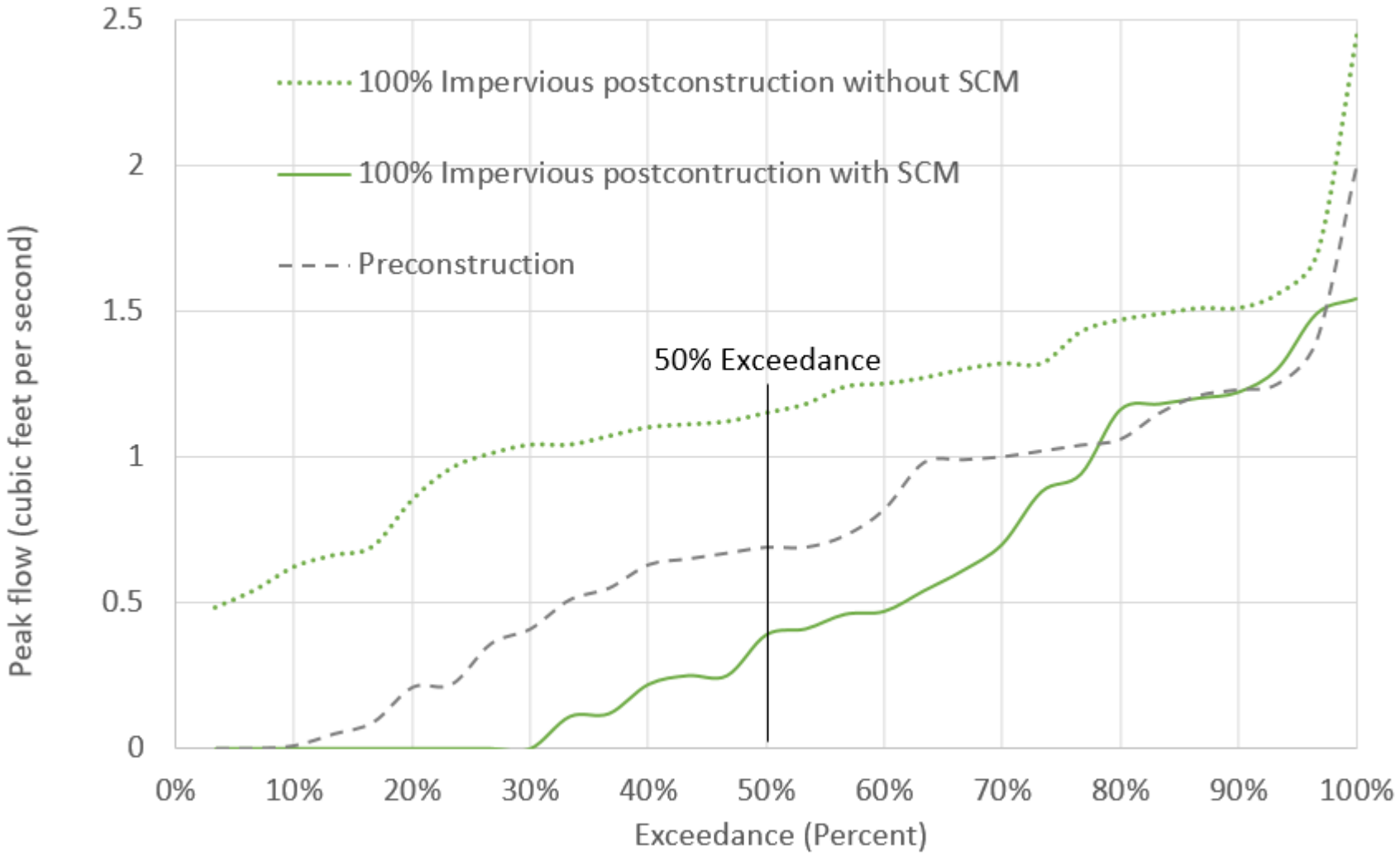
- 2 year storm = ½ % chance of exceedance in one year (i.e., 50%)
- Took largest daily runoff volume for every year (i.e., annual exceedance probability)



Example site in Philadelphia – Runoff Rate

Percent exceedance (ranking) vs. runoff rate

- 2 year storm = ½ % chance of exceedance in one year (i.e., 50%)
- Took largest daily runoff volume for every year (i.e., annual exceedance probability)



Example site in Philadelphia

- Let's look at more infiltration rates

HSG	Range (NEH 2007, Table 7-2)	Scenario Name	Selected Saturated Hydraulic Conductivity Rate (in/hr)	Selected Soil Suction (psi)
A	Greater than 1.42 in/hr	A	1.5	1.9
B	Between 1.42 and 0.57 in/hr	B	0.6	3.5
C	Between 0.57 and 0.06 in/hr	C1	0.32	5
		C2	0.2	5
		C3	0.1	6
D	Less than 0.06 in/hr	D	0.03	8

Example site in Philadelphia

- Let's look at more infiltration rates
- Already focused on this one

HSG	Range (NEH 2007, Table 7-2)	Scenario Name	Selected Saturated Hydraulic Conductivity Rate (in/hr)	Selected Soil Suction (psi)
A	Greater than 1.42 in/hr	A	1.5	1.9
B	Between 1.42 and 0.57 in/hr	B	0.6	3.5
C	Between 0.57 and 0.06 in/hr	C1	0.32	5
		C2	0.2	5
		C3	0.1	6
D	Less than 0.06 in/hr	D	0.03	8

Example site in Philadelphia

- Let's look at more infiltration rates
- Already focused on this one

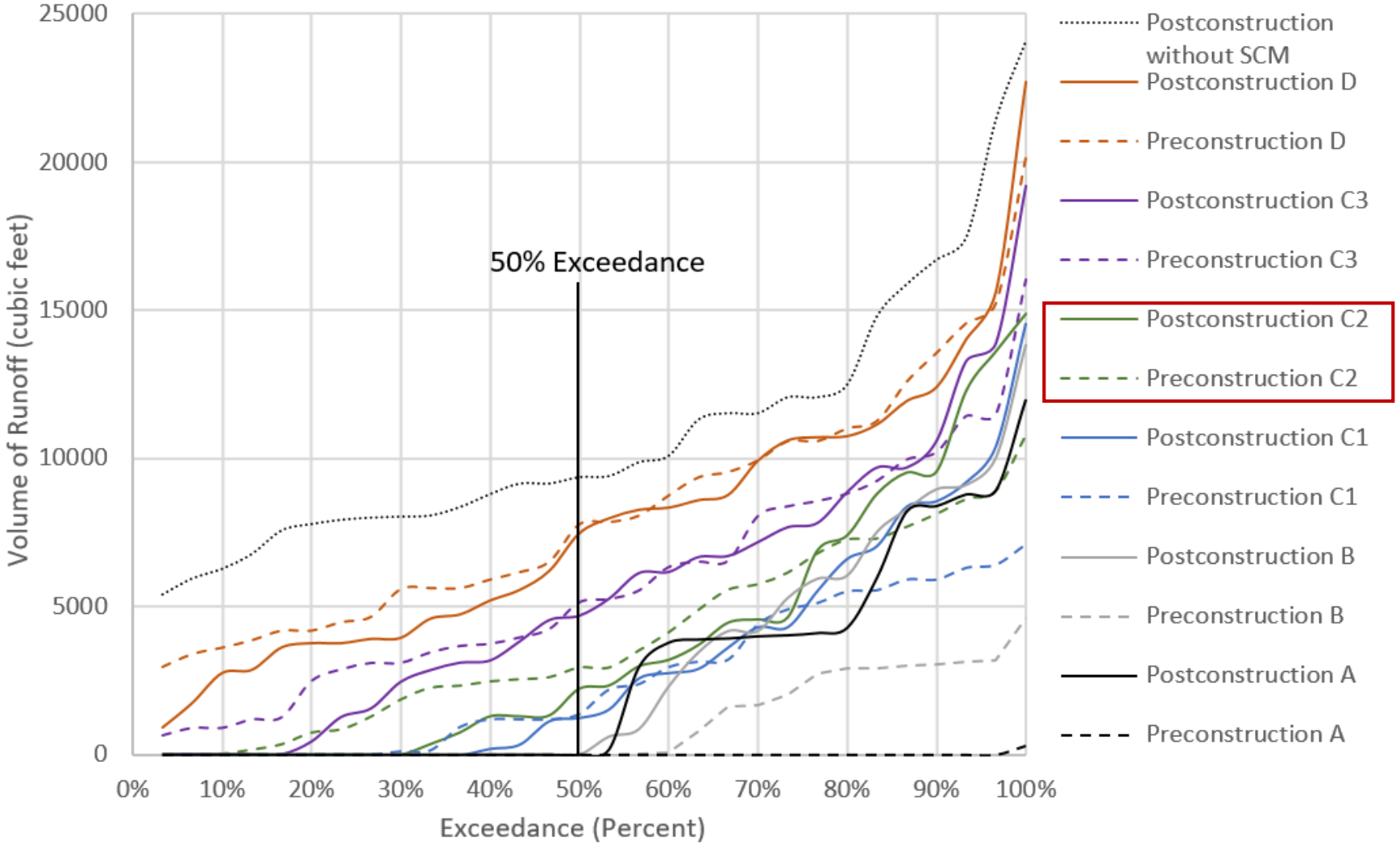
HSG	Range (NEH 2007, Table 7-2)	Scenario Name	Selected Saturated Hydraulic Conductivity Rate (in/hr)	Selected Soil Suction (psi)
A	Greater than 1.42 in/hr	A	1.5	1.9
B	Between 1.42 and 0.57 in/hr	B	0.6	3.5
C	Between 0.57 and 0.06 in/hr	C1	0.32	5
		C2	0.2	5
		C3	0.1	6
D	Less than 0.06 in/hr	D	0.03	8

HSG C soil was broken down into 3 different infiltration

Example site in Philadelphia – Runoff Volume

Percent exceedance (ranking) vs. runoff volume

- Same as before

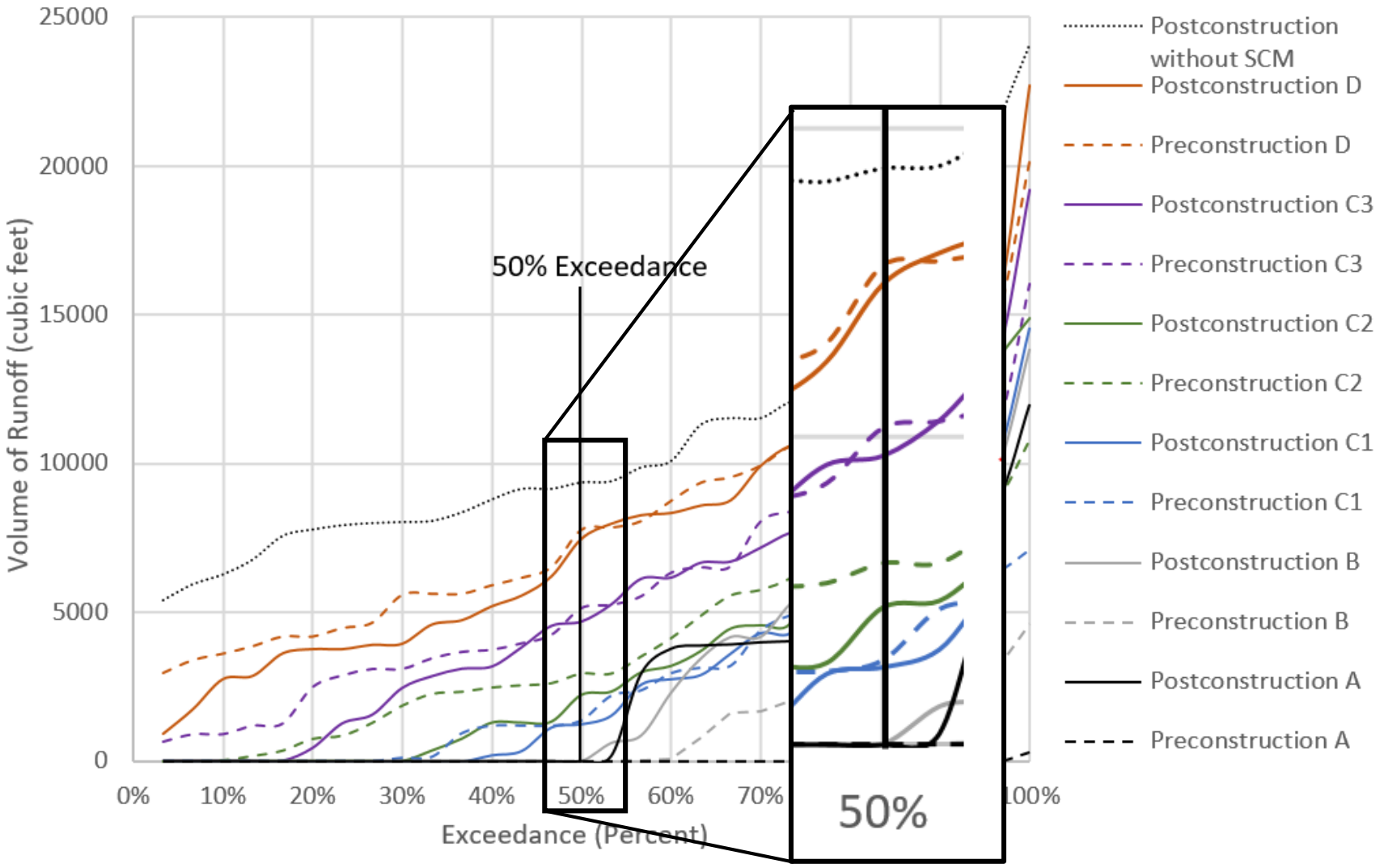


Example site in Philadelphia – Runoff Volume

Percent exceedance (ranking) vs. runoff volume

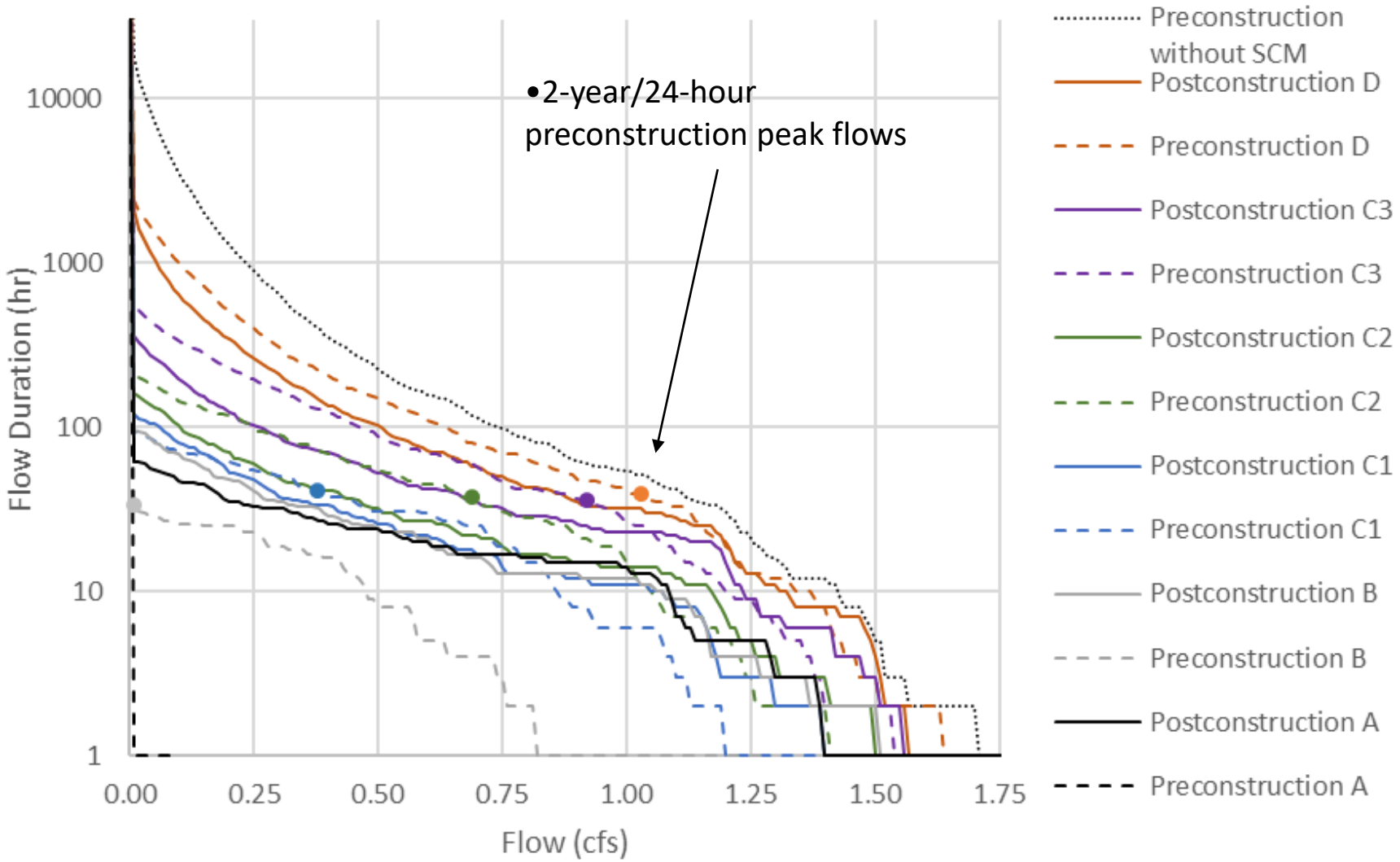
- Same as before

Scenario	2-yr/24-hr volume		Difference (cf)
	Pre (cf)	Post (cf)	
A	0	0	0
B	0	0	0
C1	1368	1260	-108
C2	2952	2232	-720
C3	5148	4680	-468
D	7776	7488	-288



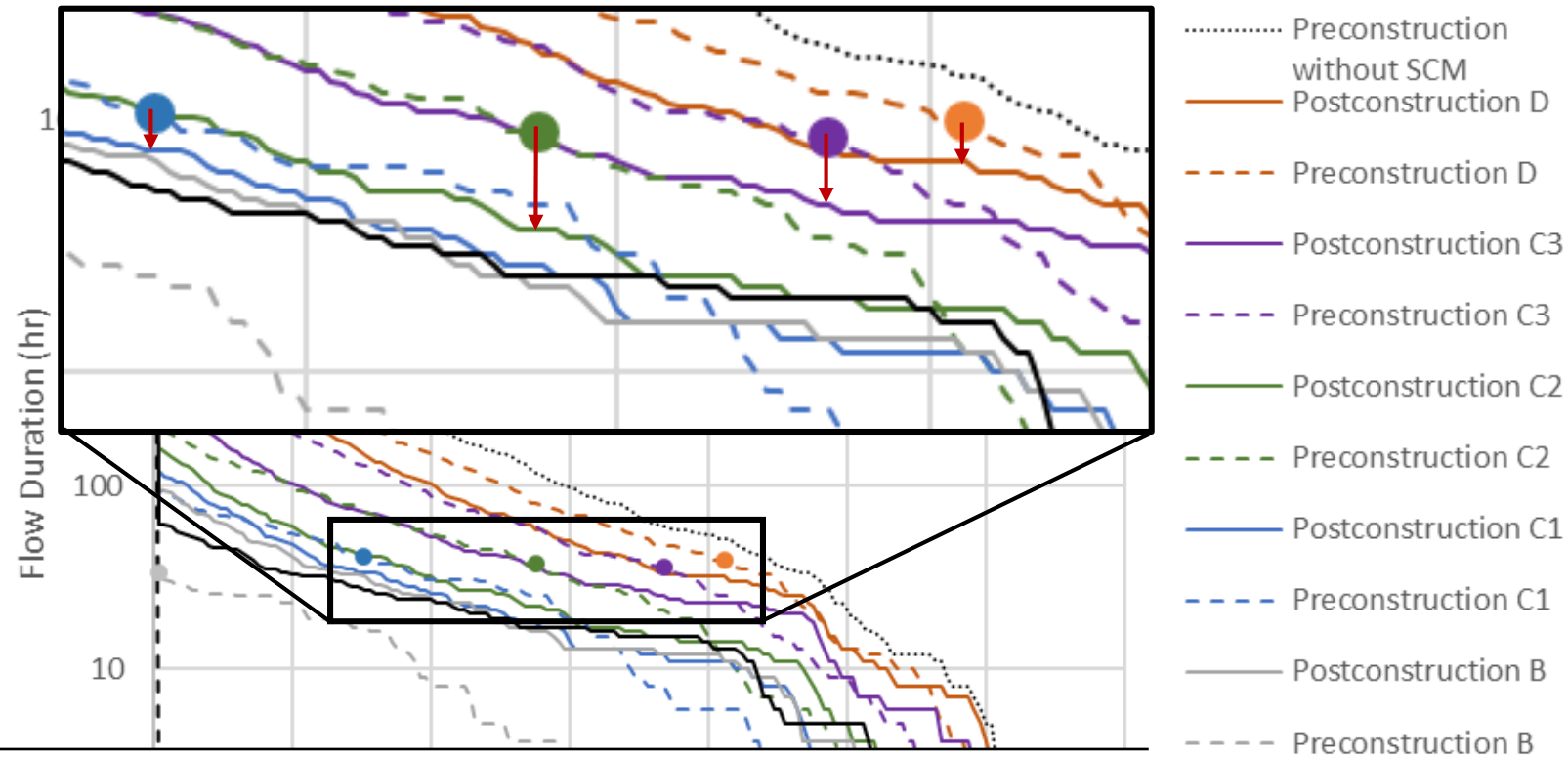
Example site in Philadelphia – Flow Duration

- Number of hours for each flow rate leaving the SCM
- Important for geomorphological concerns
  - 2-year/24-hr preconstruction peak flow is not exceeded in postconstruction
  - Duration of all flows <2-year/24-hr peak
  - All C & D reduced
  - A&B flowrate insignificant



Example site in Philadelphia – Flow Duration

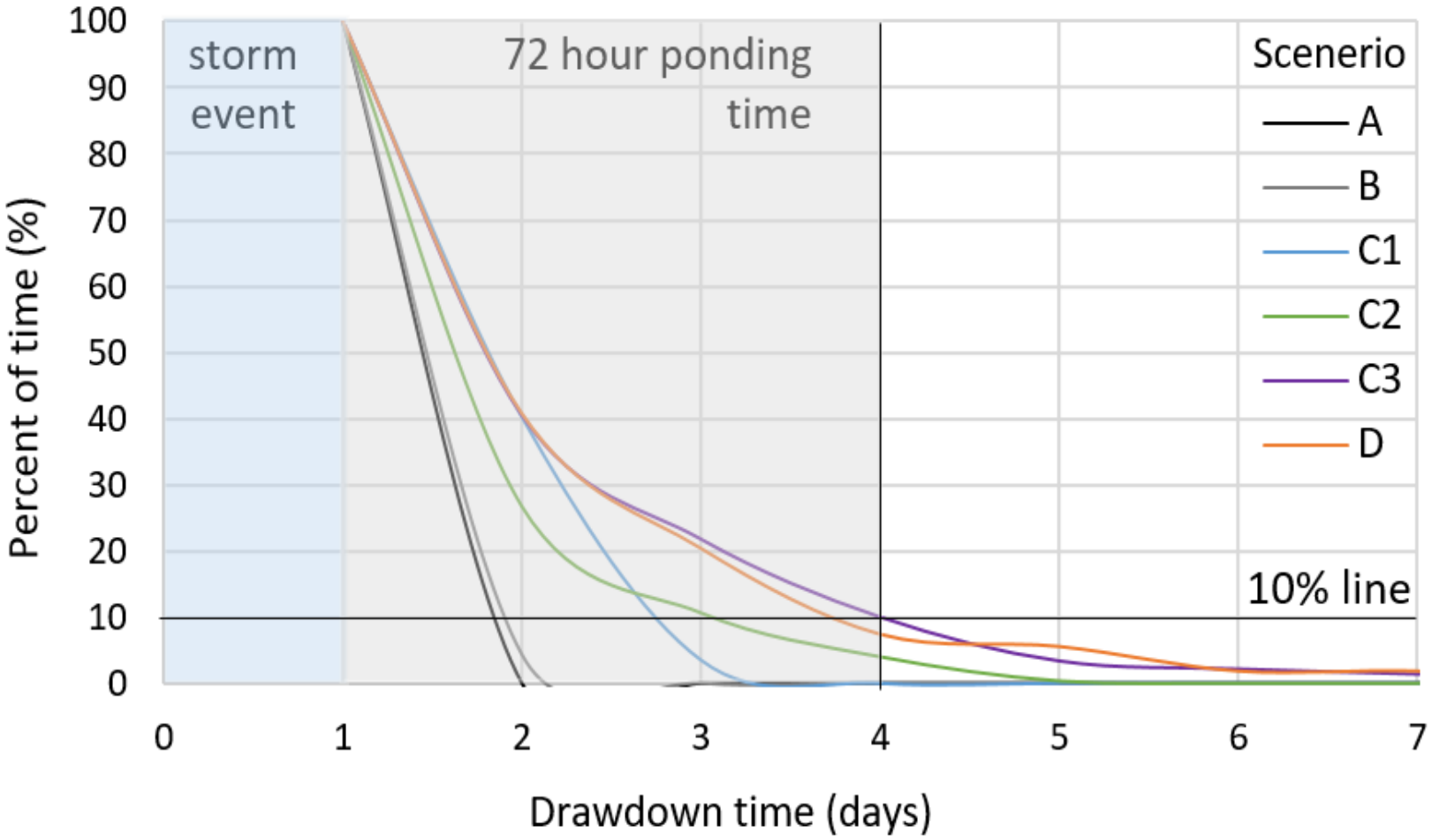
- Flow-duration curves for 30 years
- Number of hours that flow rate was produced
- 2-year/24-hr preconstruction peak flow is not exceeded in postconstruction
- Duration of all flows <2-year/24-hr peak
  - C1,2,3 & D reduced
  - A&B flowrate insignificant



Scenario	Duration of 2-yr/24-hr peak flow Pre (hrs)	Post (hrs)	Difference (hrs)
C1	41	34	- 7
C2	37	22	-15
C3	36	25	-11
D	39	32	- 7

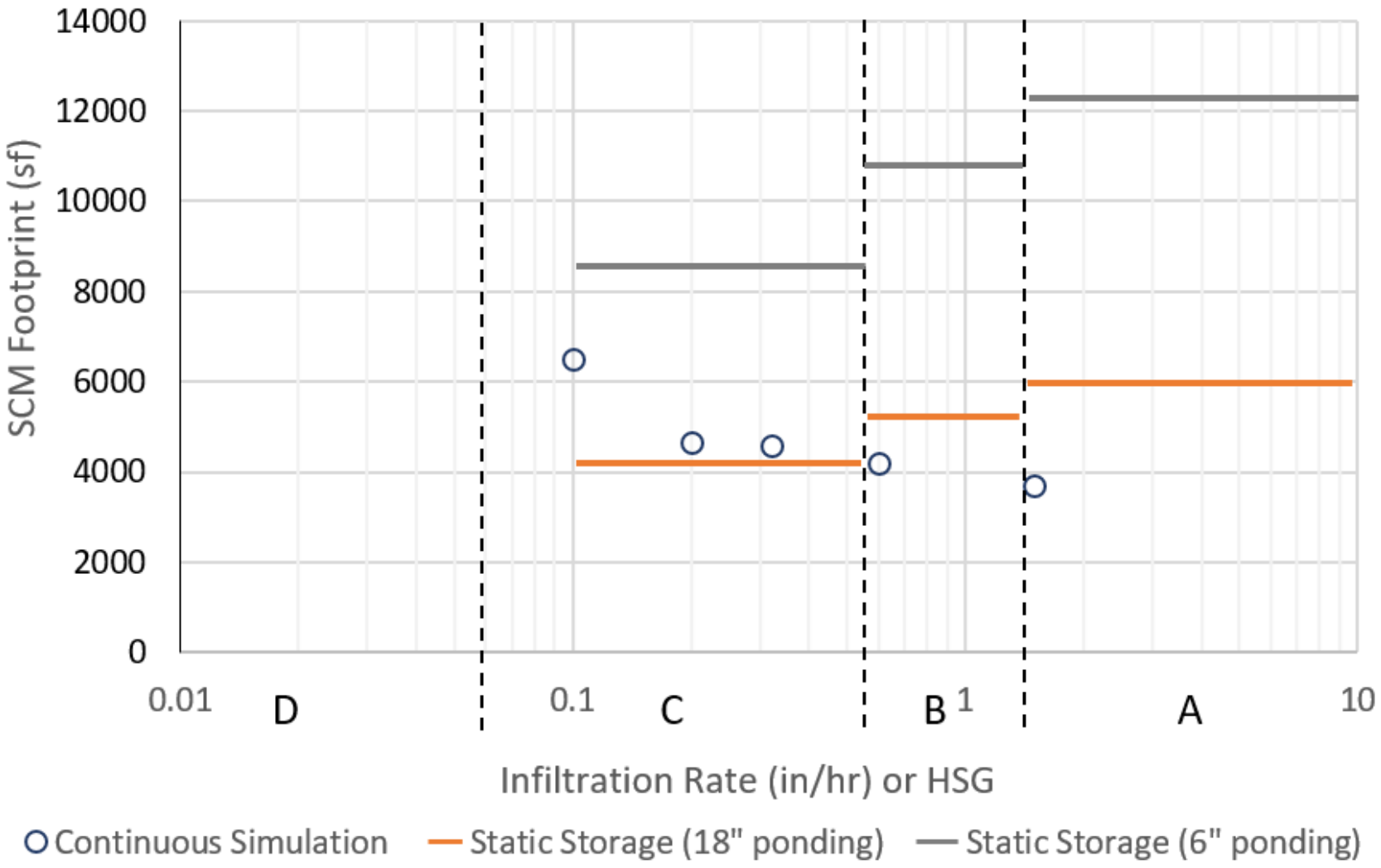
Example site in Philadelphia – Ponding

- SCM sizing primarily based on 2-year/24-hour storm
- Also considered meeting a 72 hour ponding time
  - 90% of the time ponding is under 72 hours
  - Only needed to adjust footprints for C3 and D soils

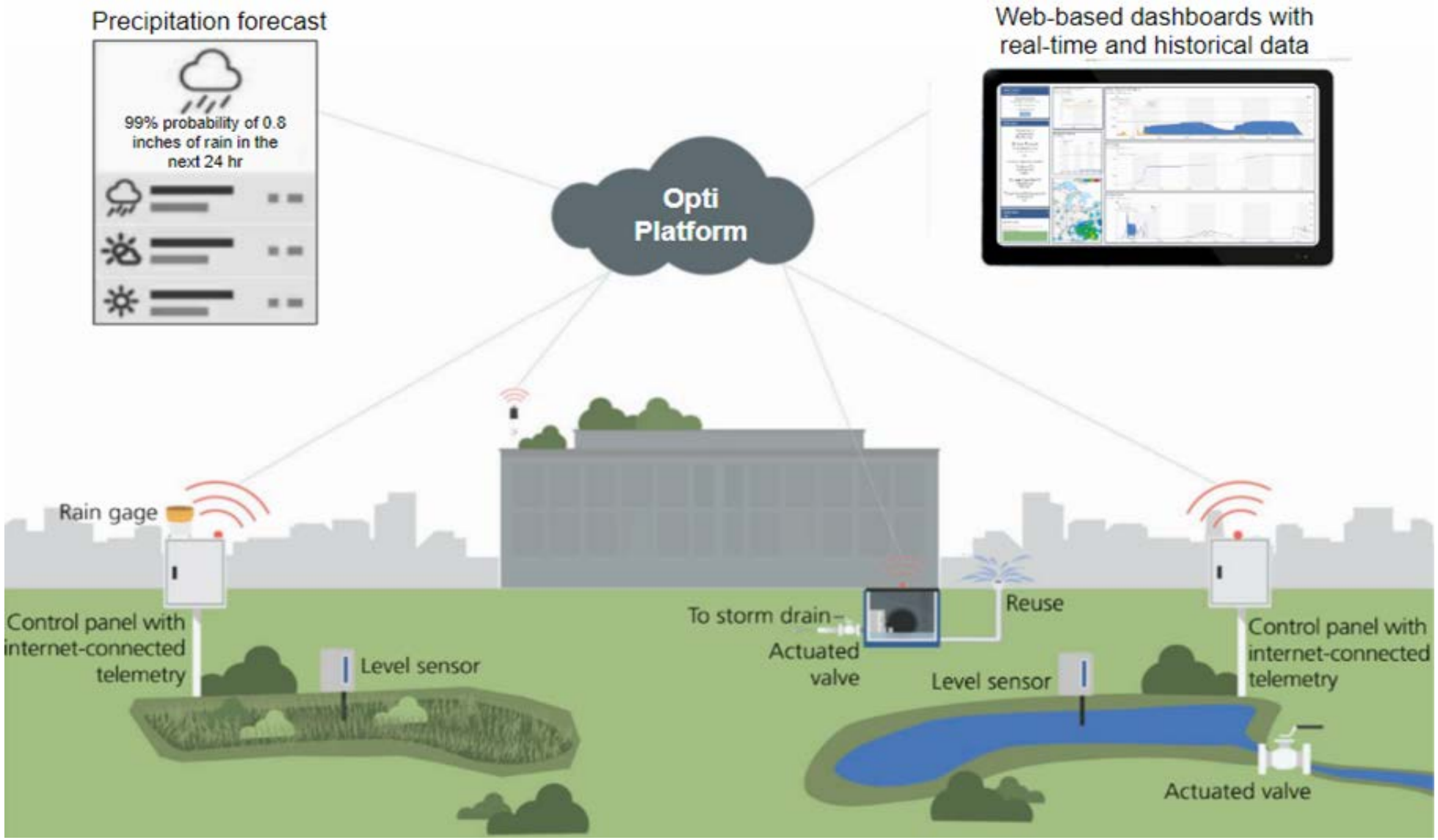


Continuous Approach – Comparison to Static

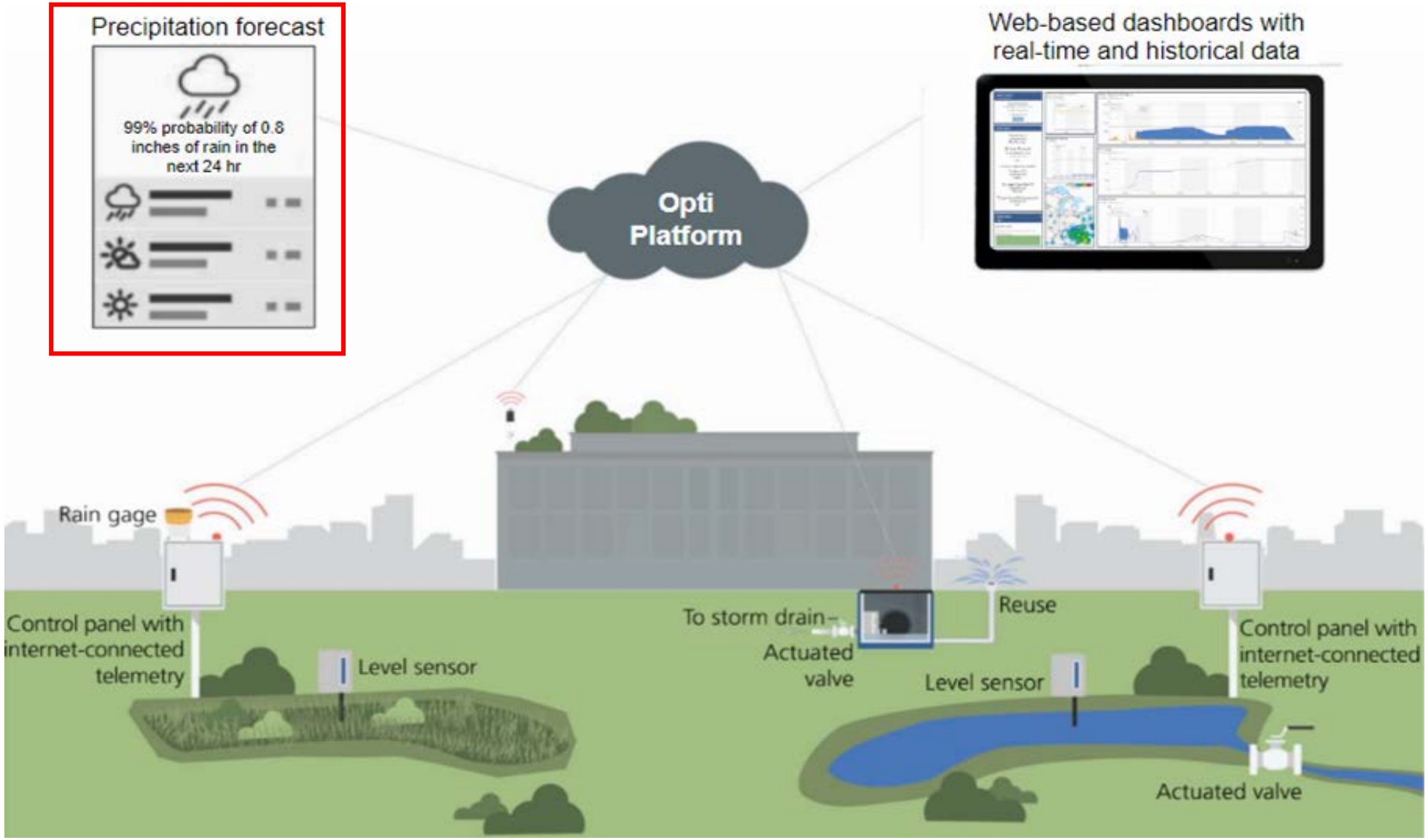
- Footprint SCM size compared to Continuous Simulation approach vs. static design storm approach sizing
- Static Storage
  - Used CN & NOAA rainfall depth
  - PA DEP Manual currently allows for 6” ponding depth
  - Modeled with 18” depth



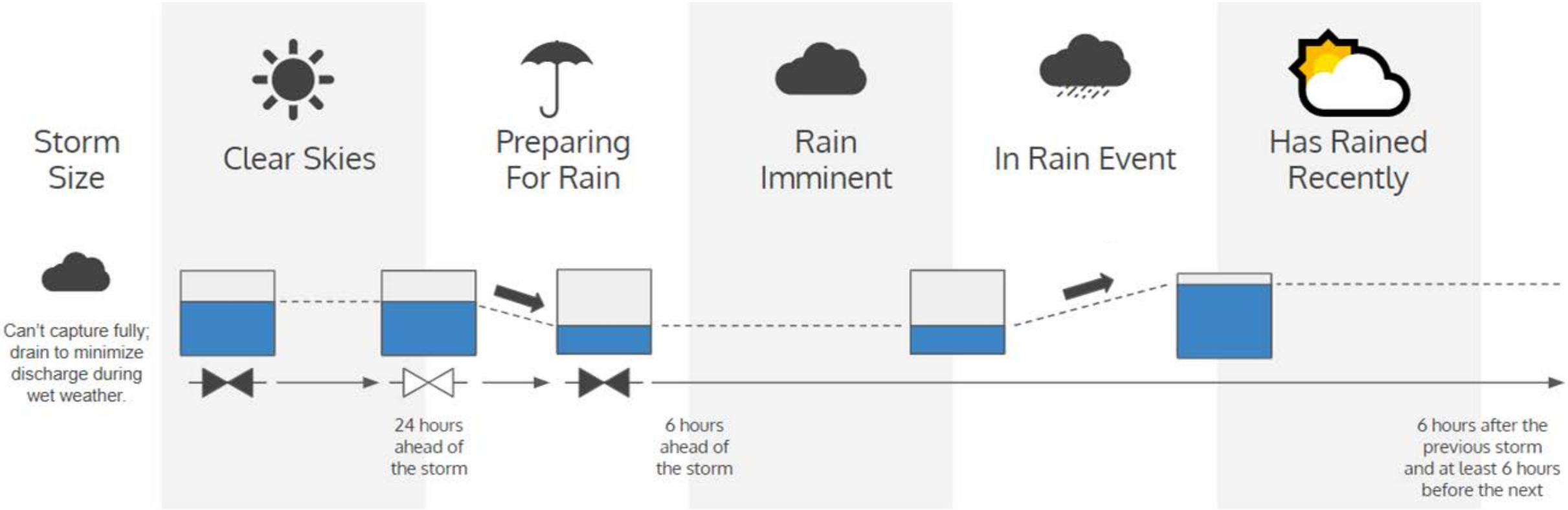
Continuous Monitoring and Adaptive Control (CMAC)



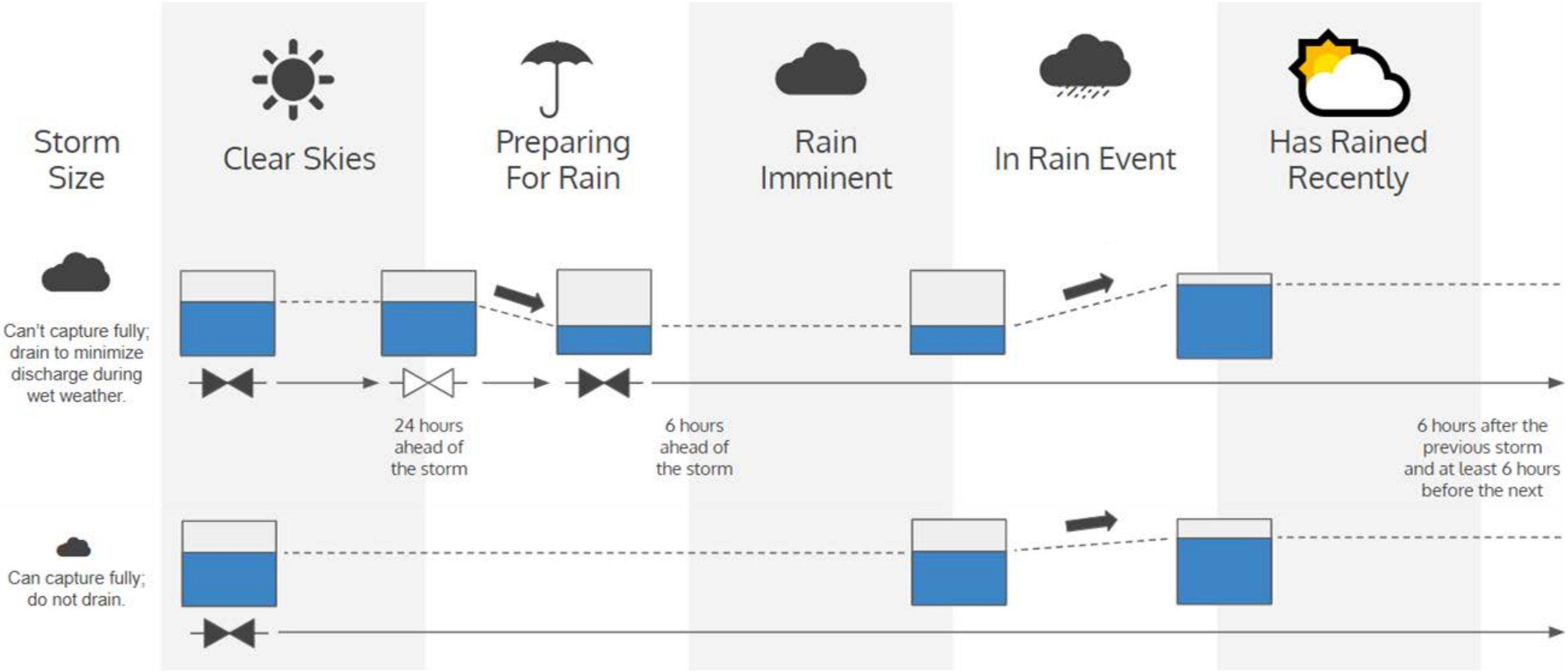
Continuous Monitoring and Adaptive Control (CMAC)



CMAC Example logic

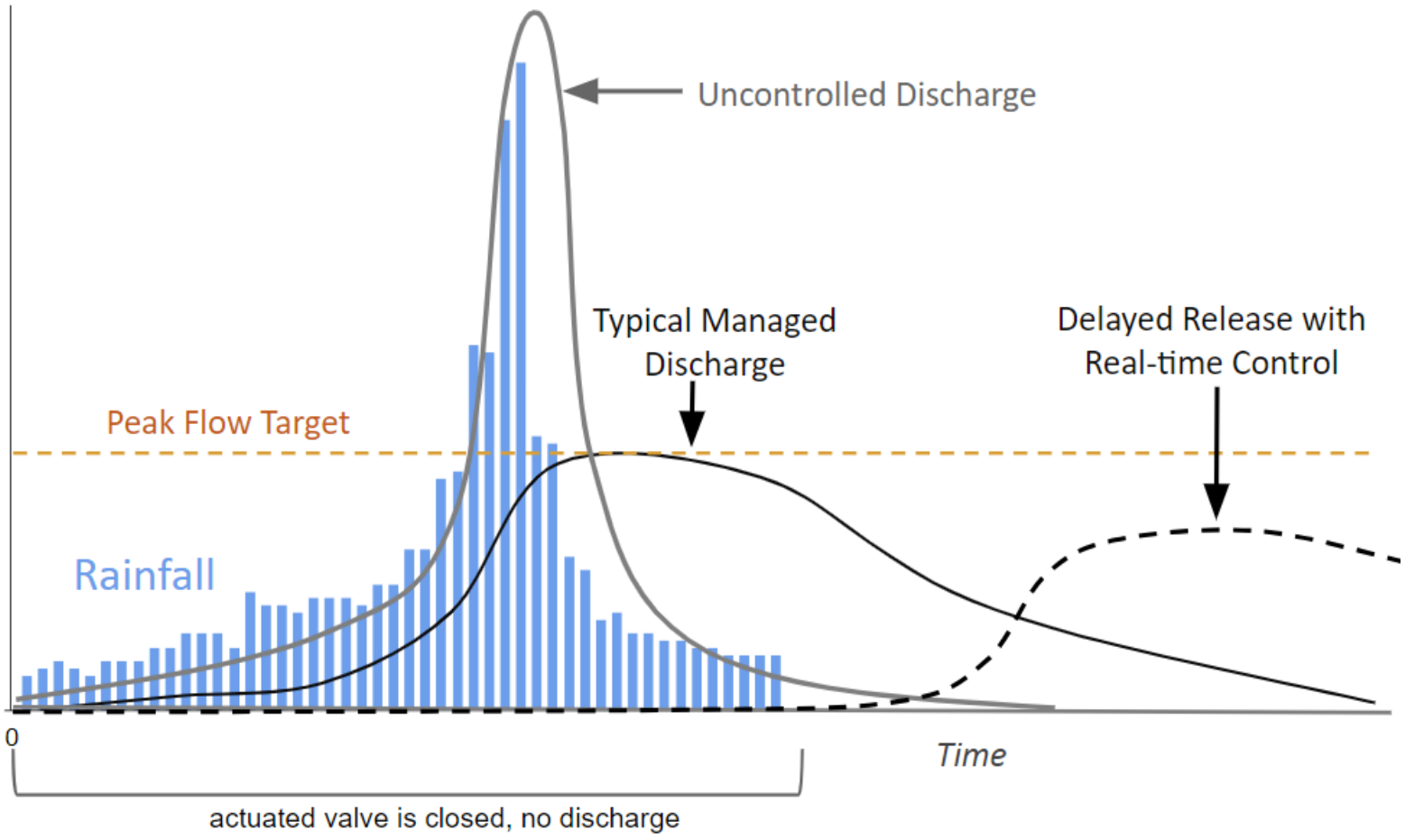


CMAC Example logic



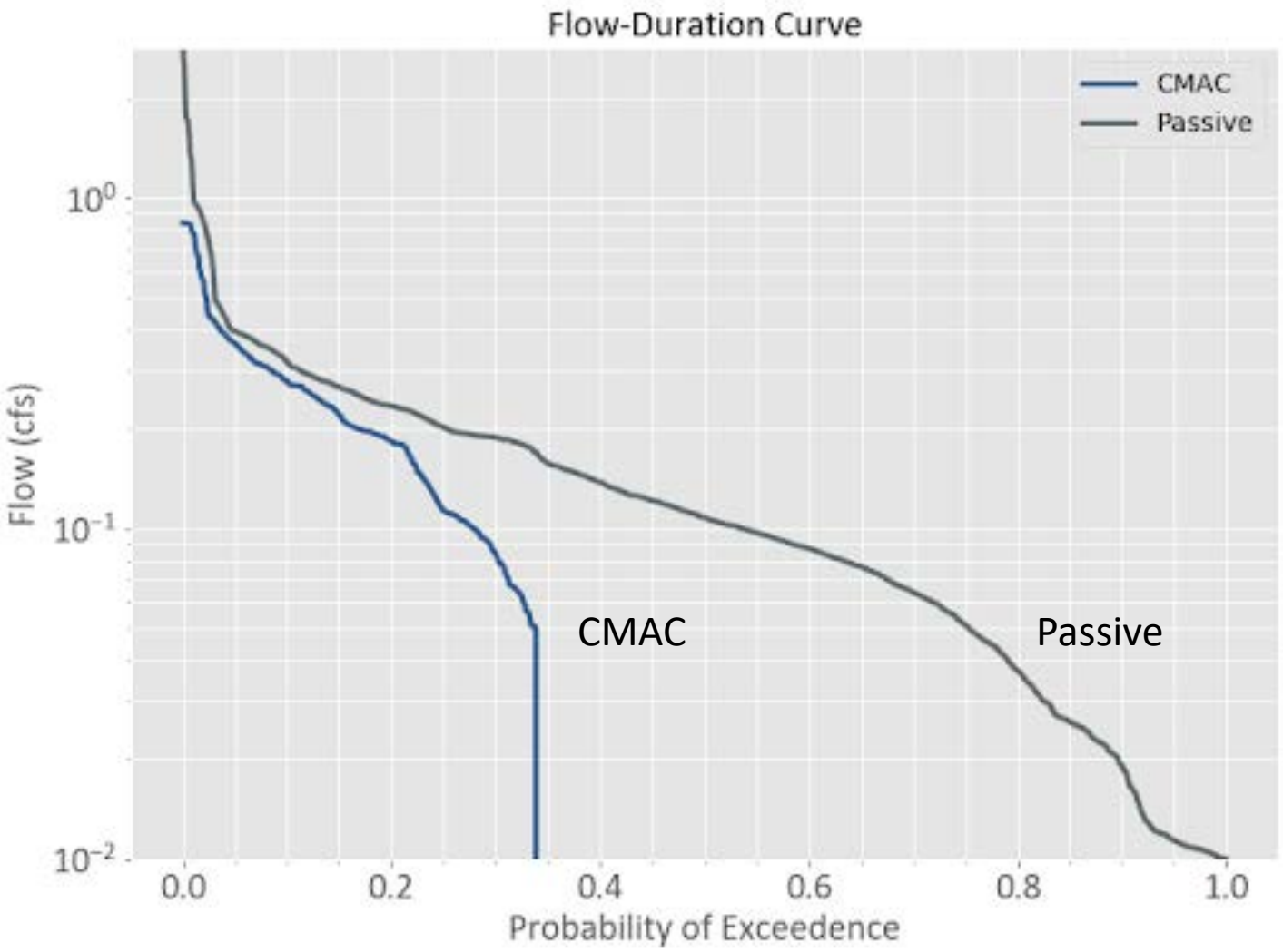
CMAC Example Performance

- Delayed release of real time controlled (CMAC) systems leads to:
  - Reduction in wet weather flows
  - Flow duration curve augmentation
  - Longer settling times



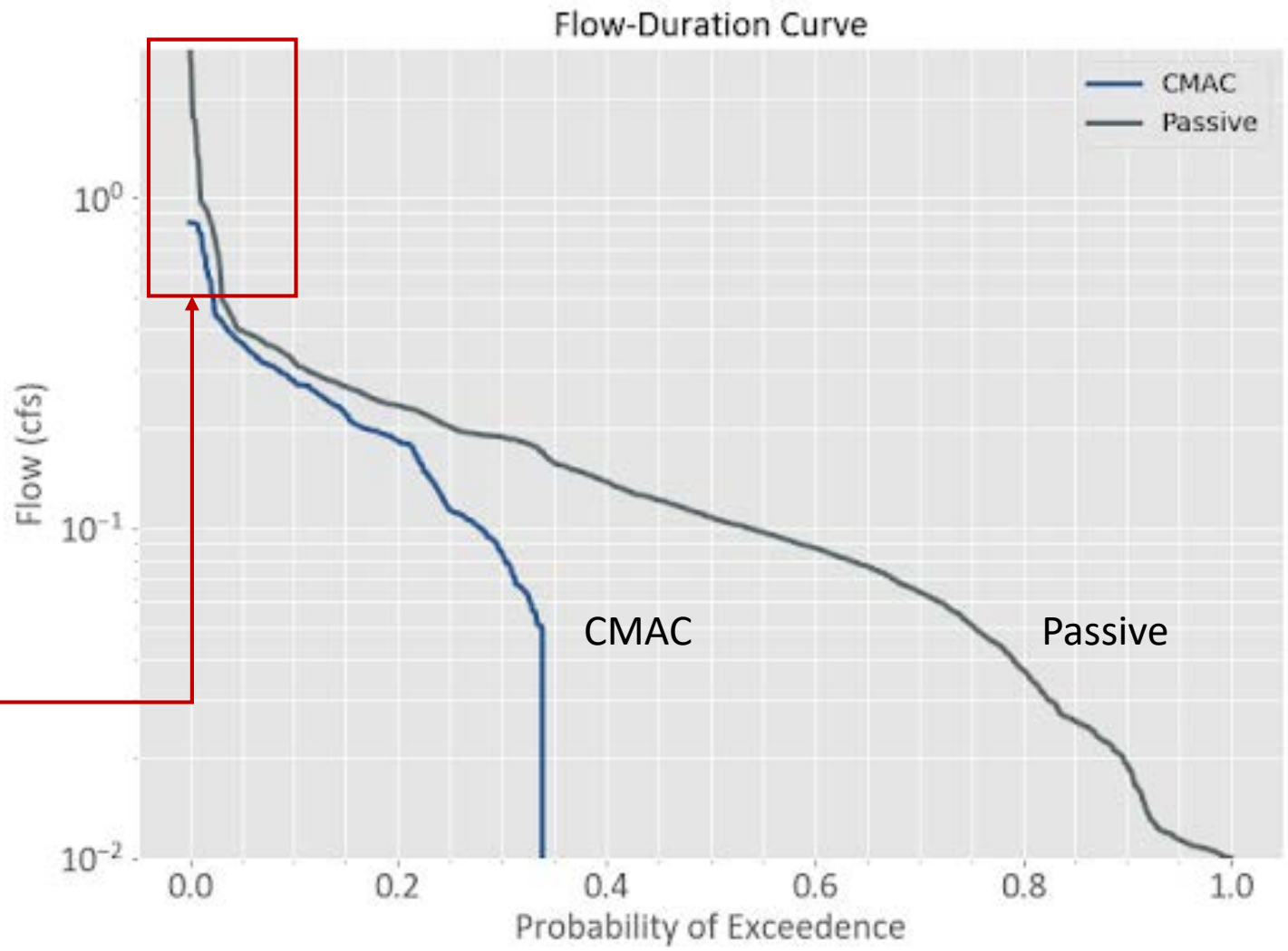
CMAC Site 1

- Real flow duration curves from wet pond with CMAC
- Probability of exceedance (normalized to duration)
- Passive vs active regimes (not preconstruction)
  - Maximum flow rate reduced
  - Lower flows do not enter the downstream system as often



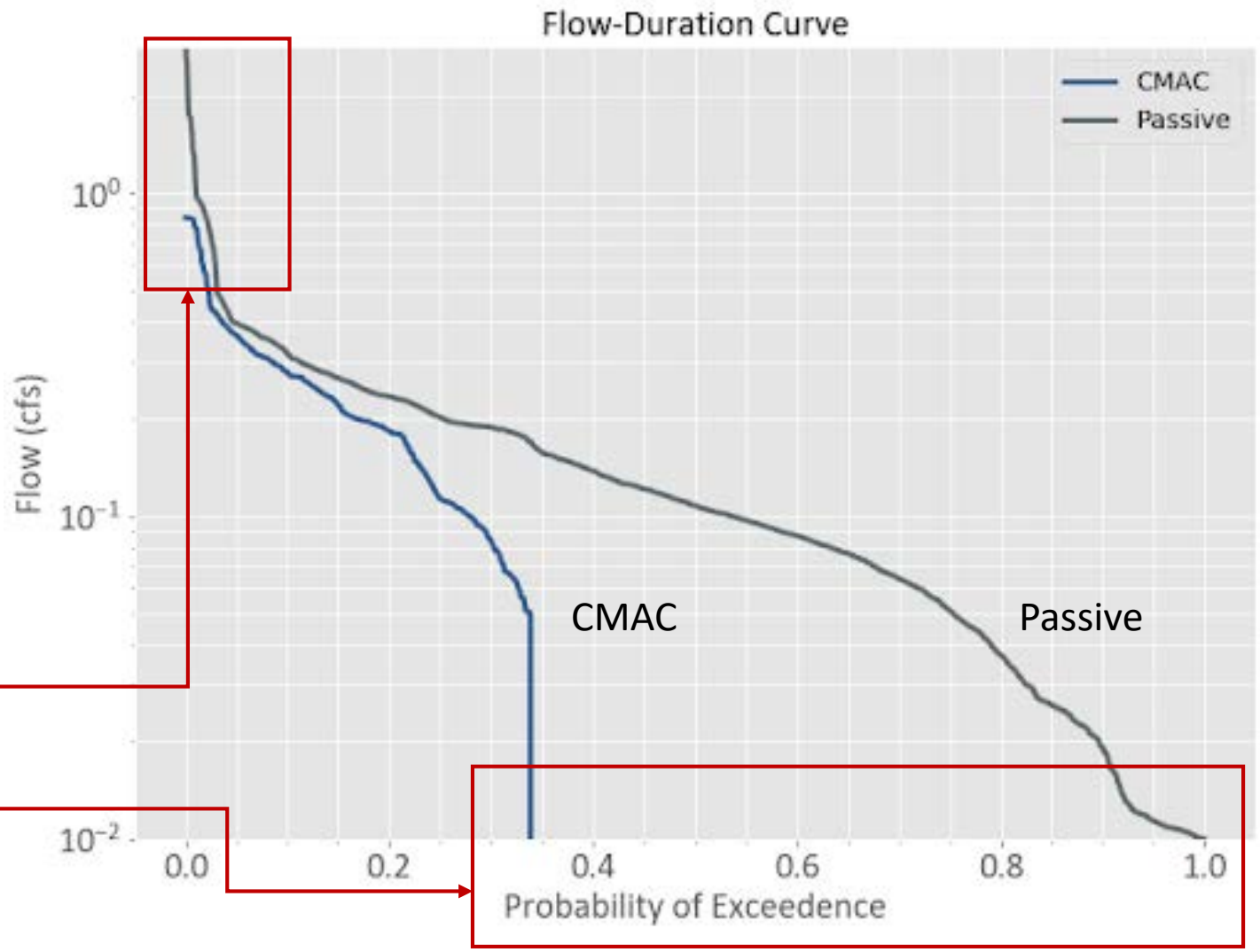
CMAC Site 1

- Real flow duration curves from wet pond with CMAC
- Probability of exceedance (normalized to duration)
- Passive vs active regimes (not preconstruction)
  - Maximum flow rate reduced
  - Lower flows do not enter the downstream system as often



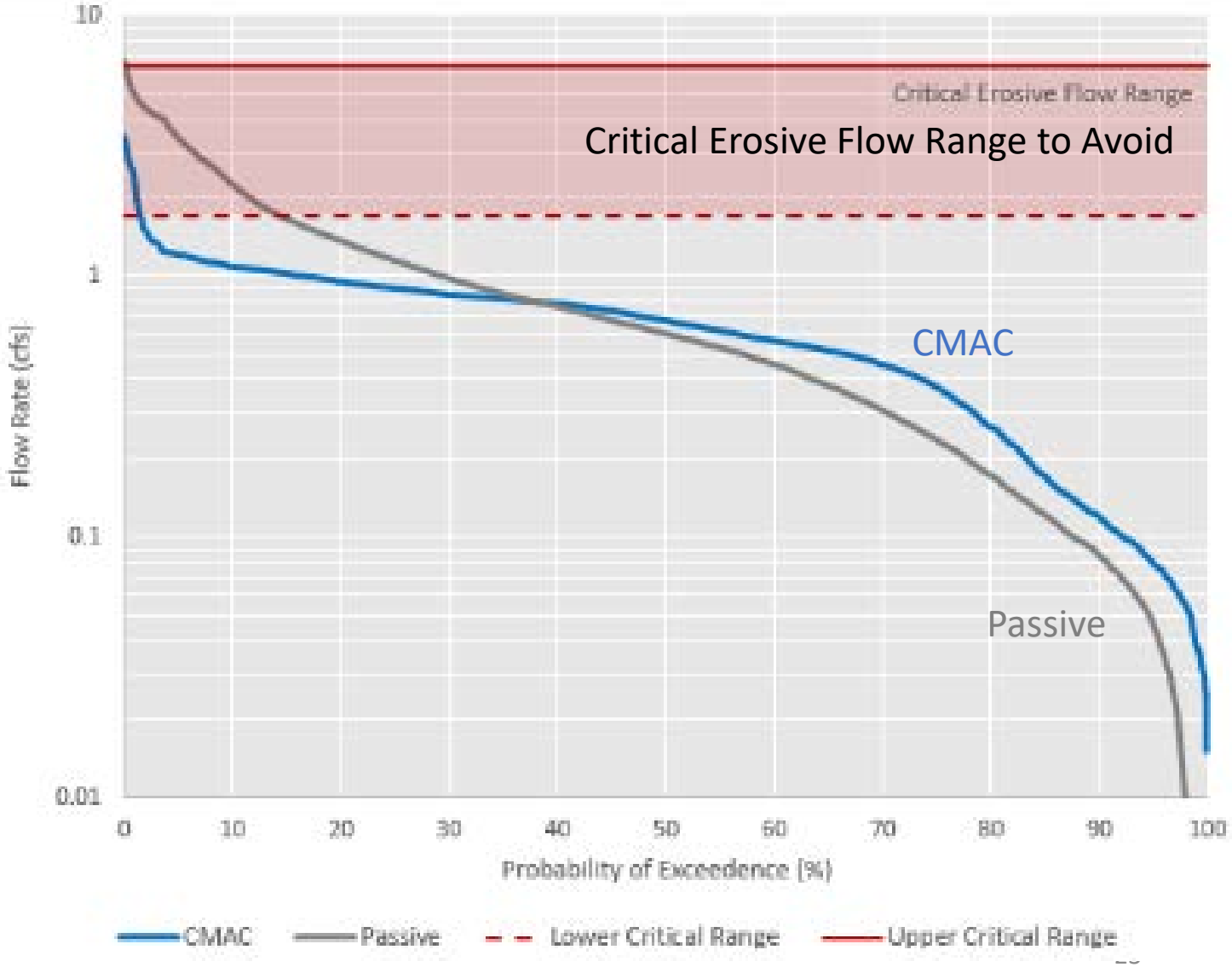
CMAC Site 1

- Real flow duration curves from wet pond with CMAC
- Probability of exceedance (normalized to duration)
- Passive vs active regimes (not preconstruction)
  - Maximum flow rate reduced
  - Lower flows do not enter the downstream system as often



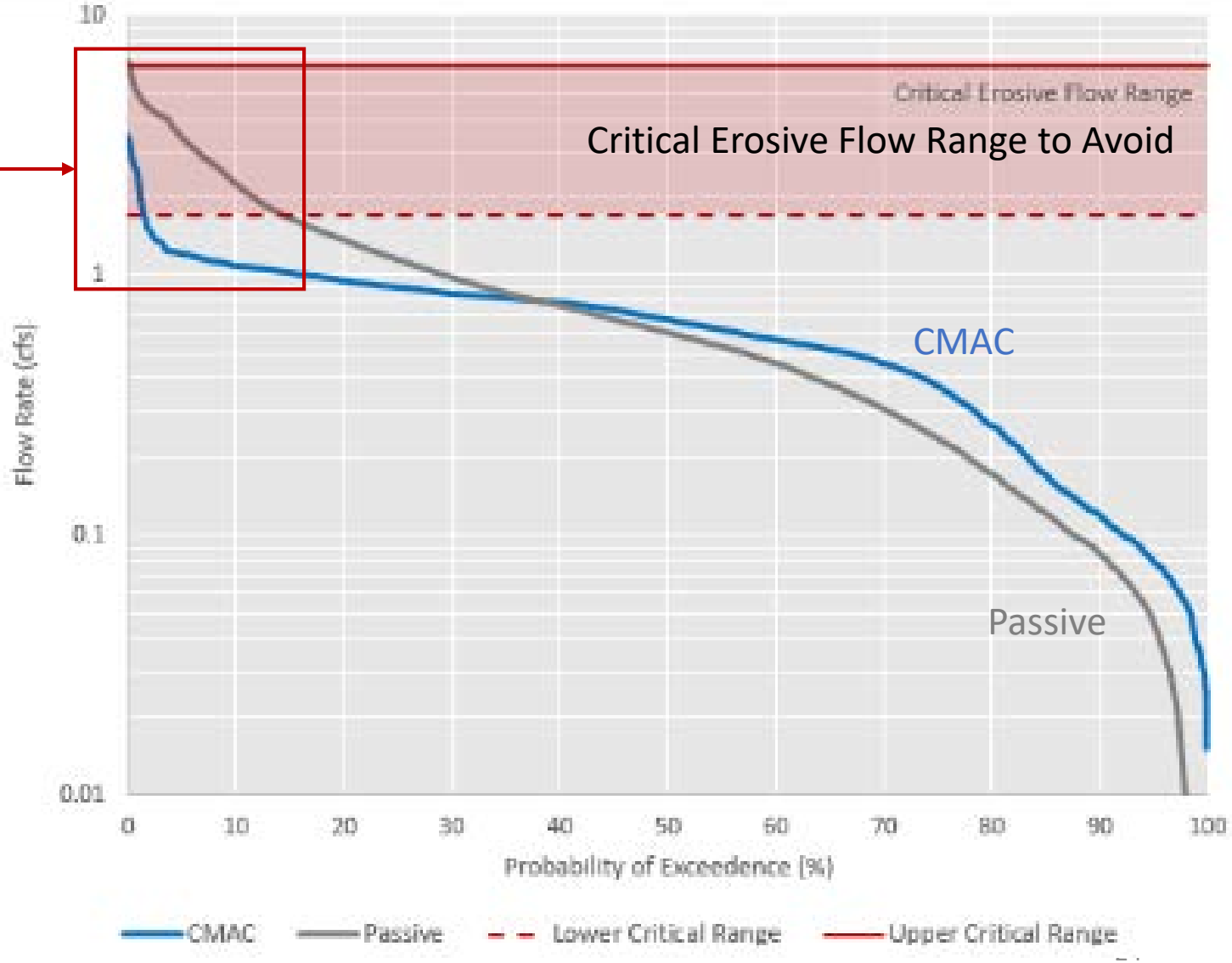
CMAC Site 2

- Real flow duration curves from an in stream wet pond with CMAC
- Desired:
  - Reduction of high flows for detention
  - Increase in baseflow for the frogs



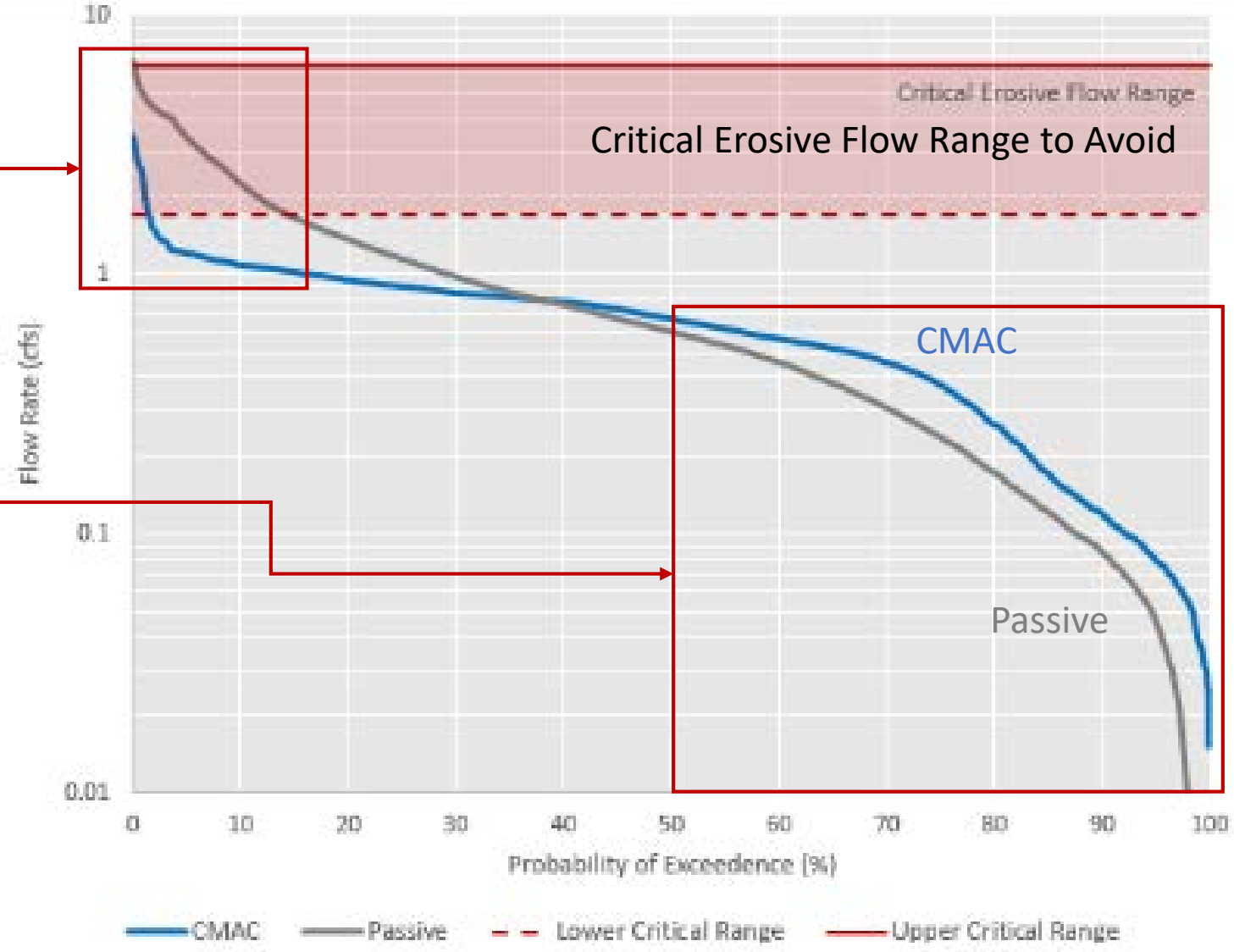
CMAC Site 2

- Real flow duration curves from an in stream wet pond with CMAC
- Desired:
  - Reduction of high flows for detention
  - Increase in baseflow for the frogs

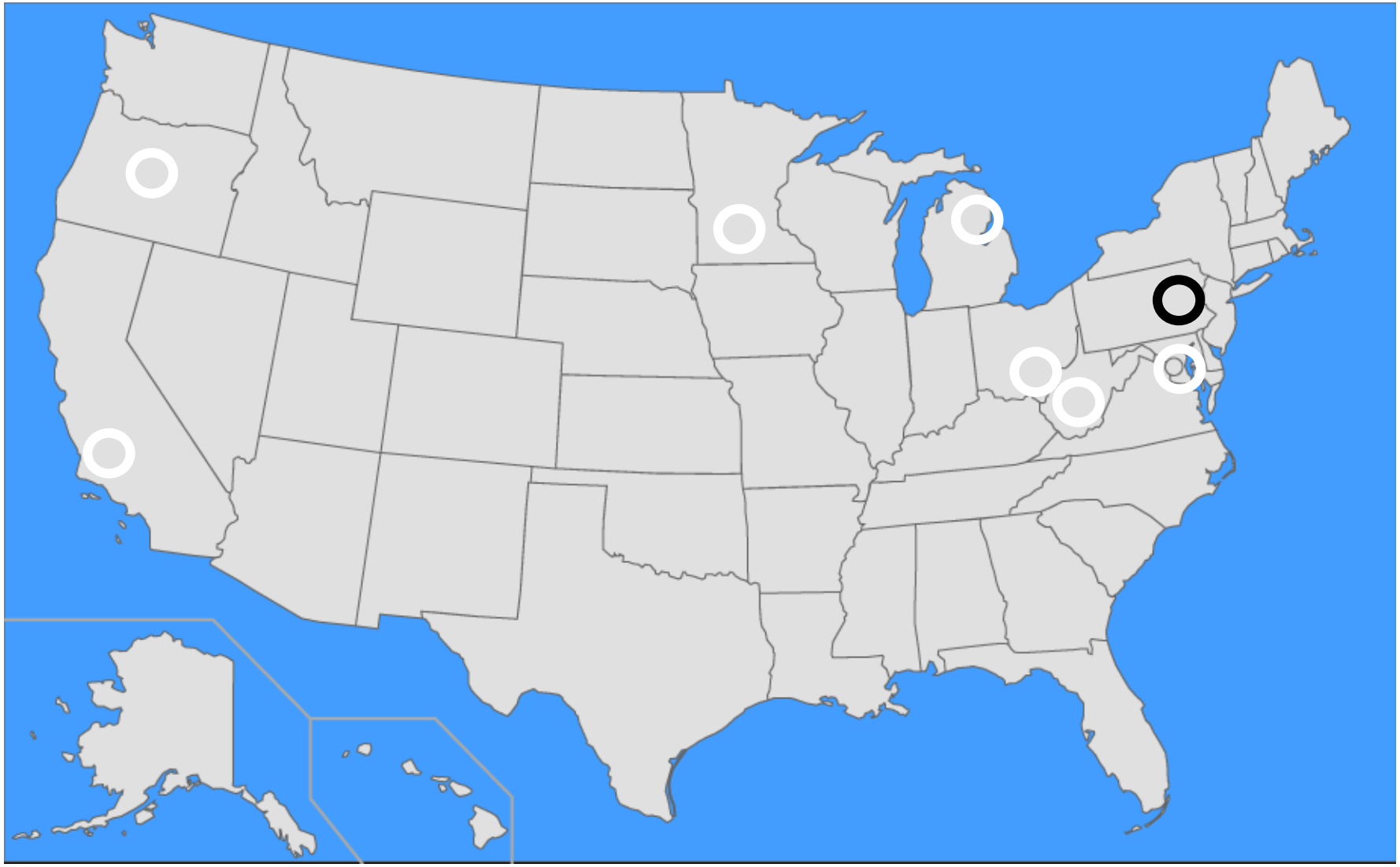


CMAC Site 2

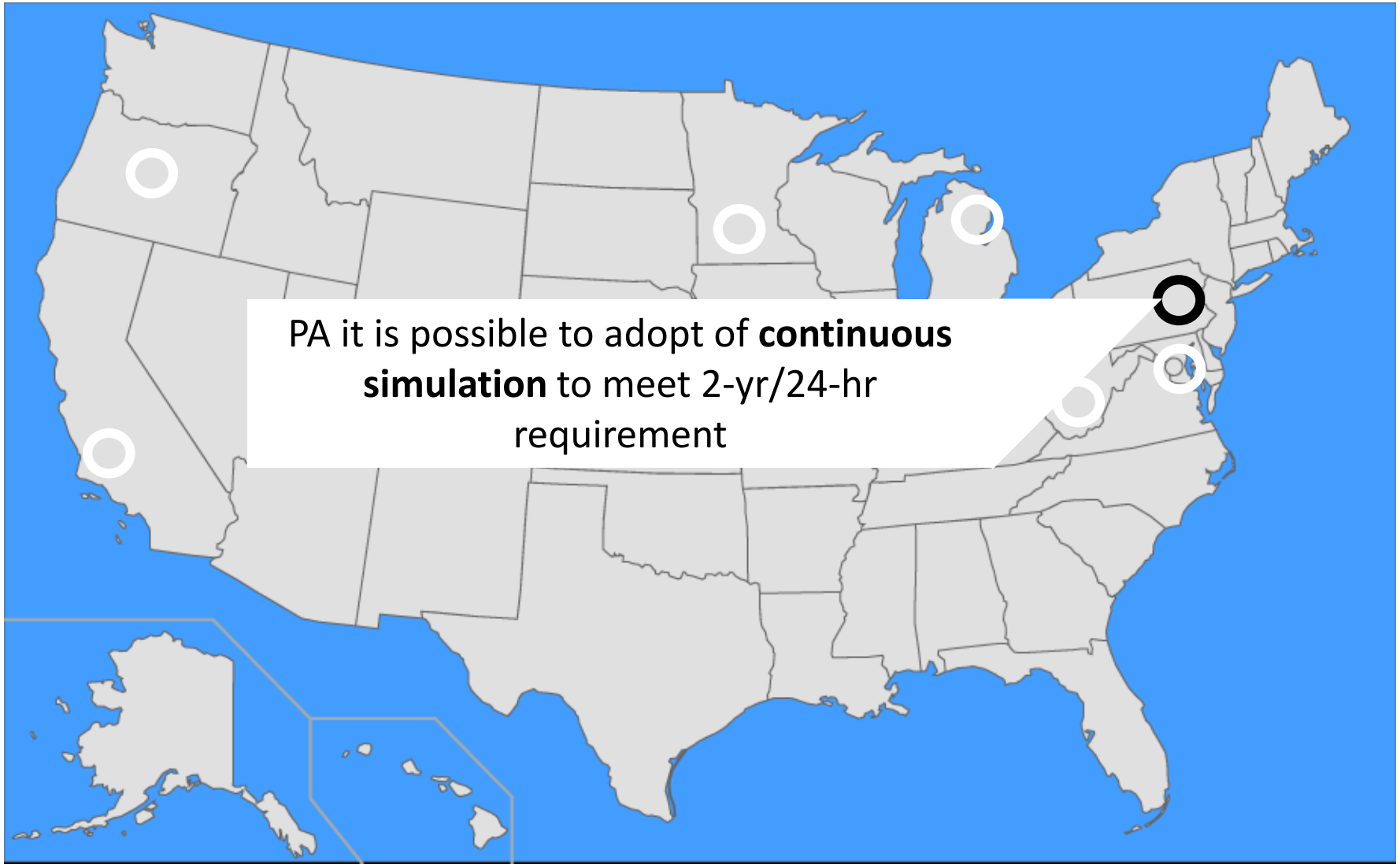
- Real flow duration curves from an in stream wet pond with CMAC
- Desired:
  - Reduction of high flows for detention
  - Increase in baseflow for the frogs



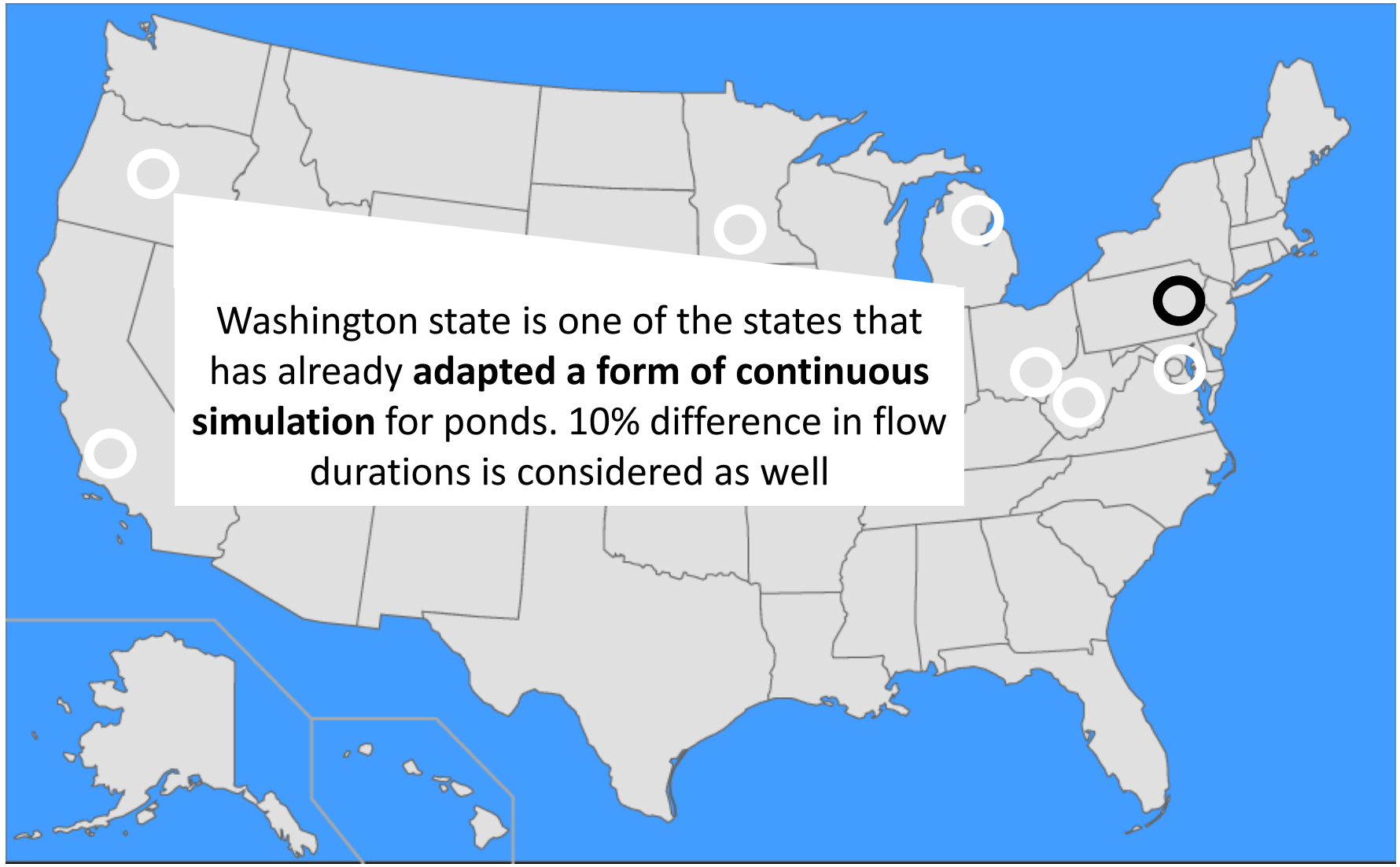
How dynamic are other states?



How dynamic are other states? – Flow Perspective

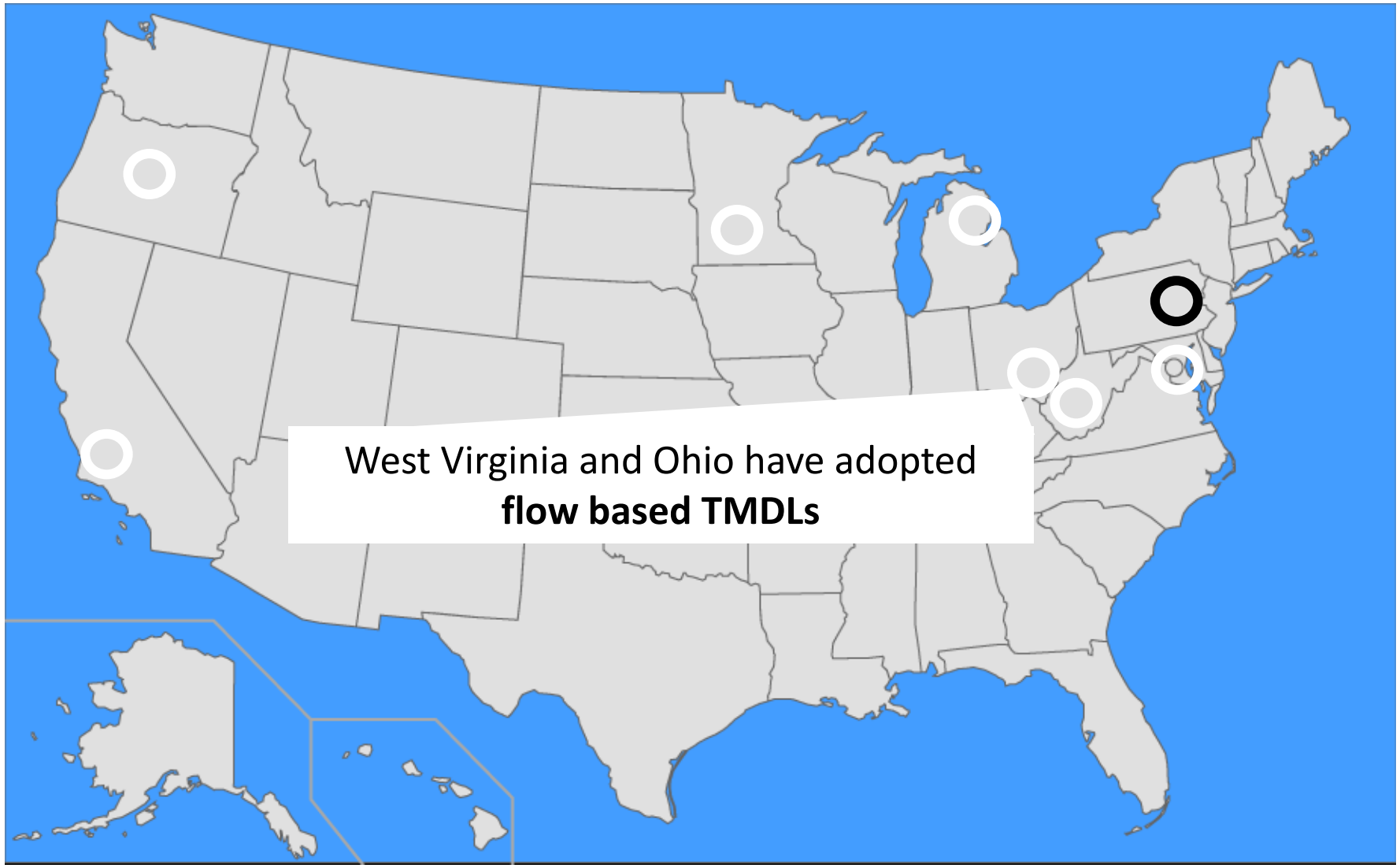


How dynamic are other states? – Flow Perspective

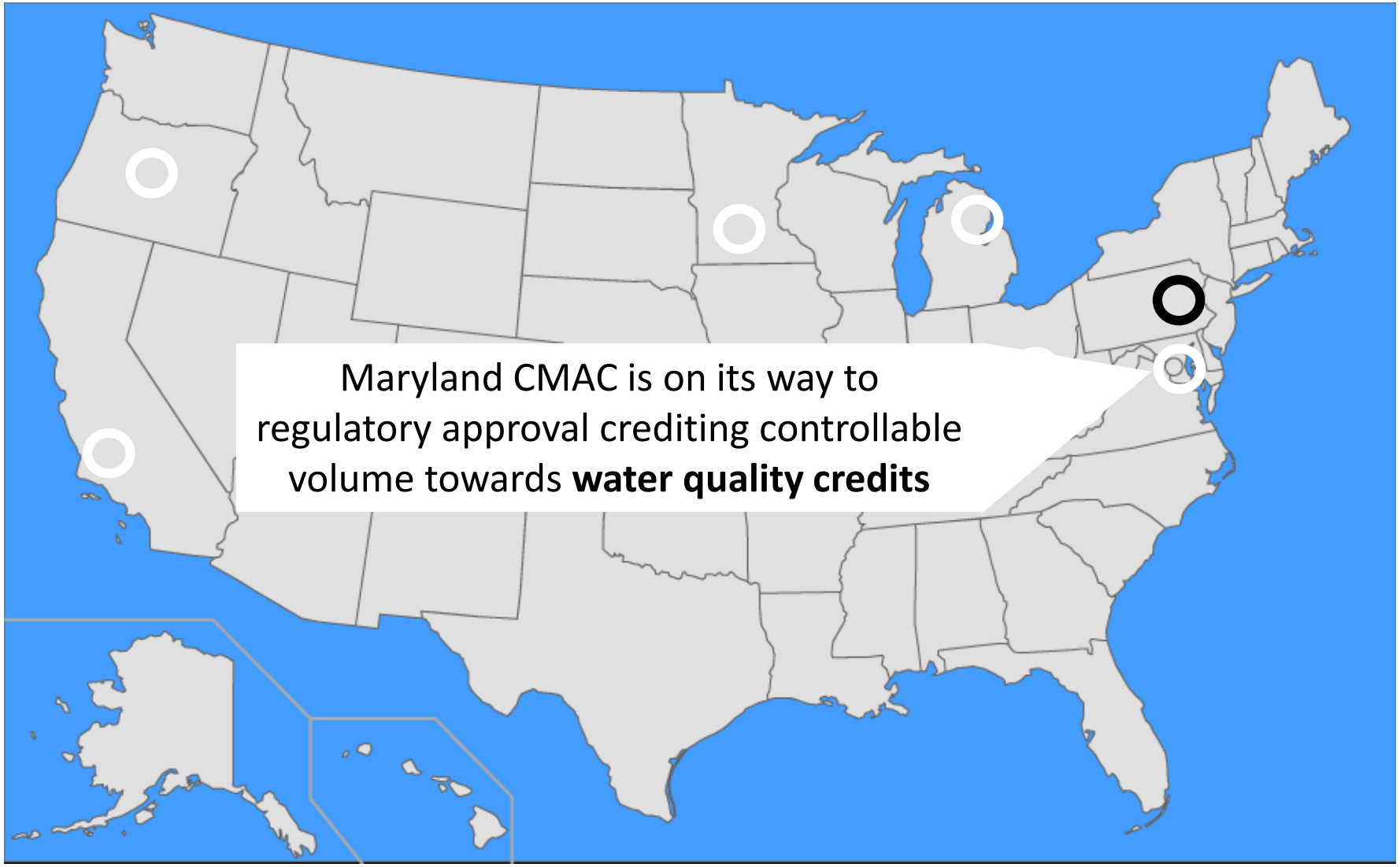


Washington state is one of the states that has already **adapted a form of continuous simulation** for ponds. 10% difference in flow durations is considered as well

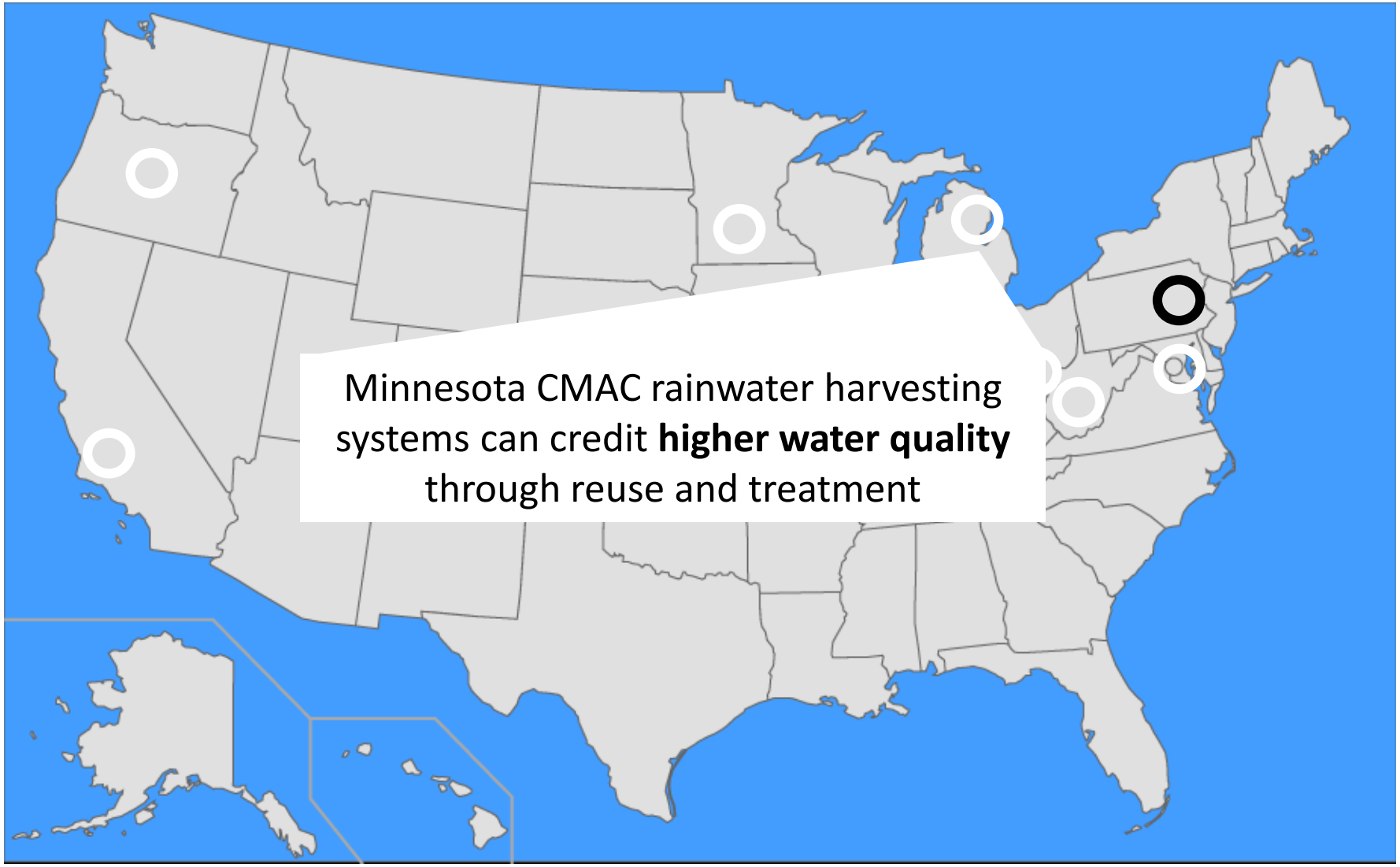
How dynamic are other states? – Flow Perspective



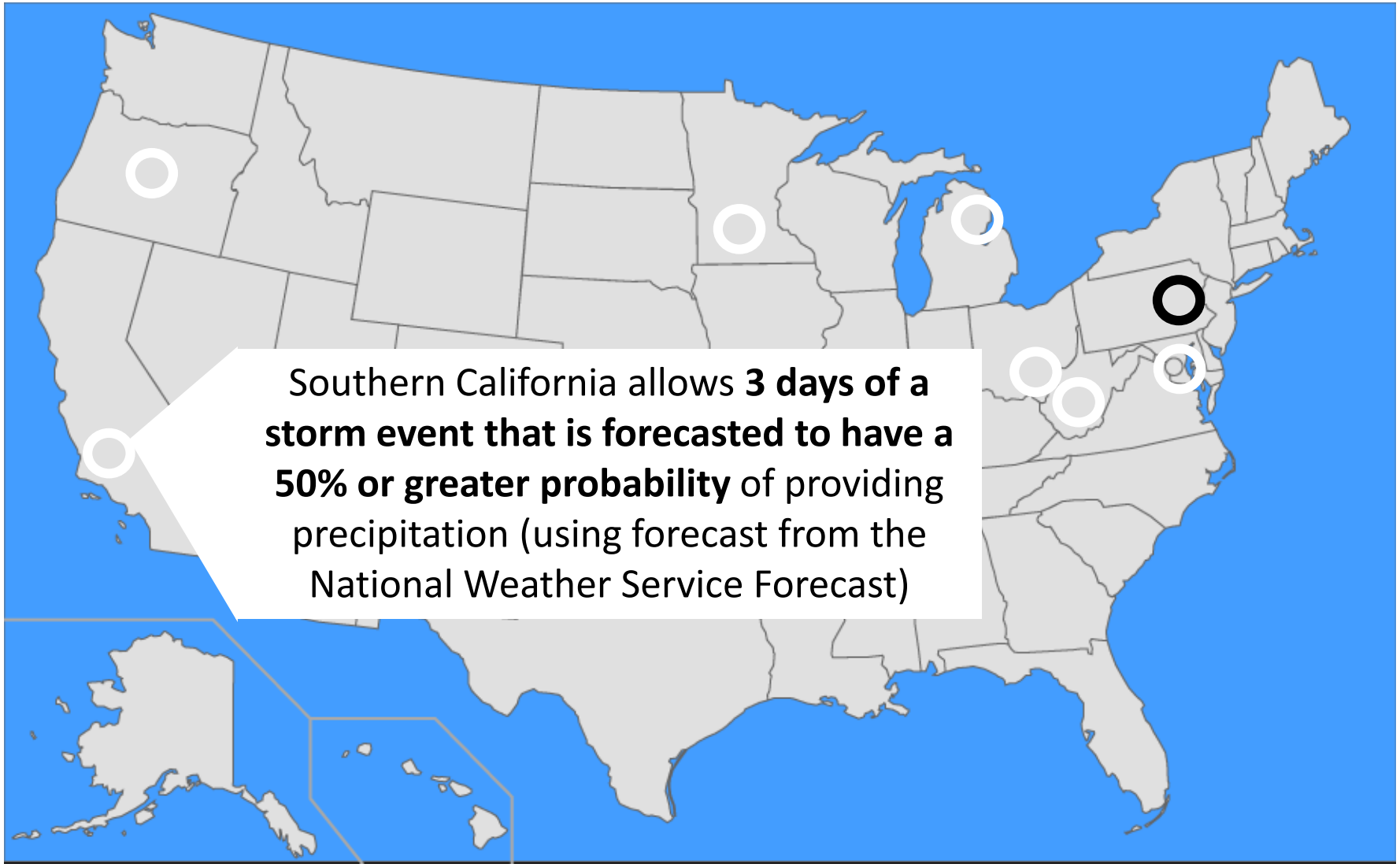
How dynamic are other states? – Quality Perspective



How dynamic are other states? – Quality Perspective



How dynamic are other states? – RWH Perspective



How dynamic are other states? – RWH Perspective

Summary

- Dynamic loss mechanism and flow control mechanisms provide multiple benefits that are not fully realized in the current regulatory environment
  - Infiltration & ET based systems can be sized to be more resilience in face of climate change
  - Dynamic outlet controls can provide system with a more ideal flow regime
- Generally, forward movement seems to be in this direction

VILLANOVA UNIVERSITY
COLLEGE OF ENGINEERING

VILLANOVA URBAN
STORMWATER PARTNERSHIP

Questions?

Amanda Jean Hess, PhD EIT
OptiRTC, Inc (Ahess@optirtc.com)
Villanova University (Amanda.hess@villanova.edu)

Opti