A Proposal for Statewide Knee-of-the-Curve BMP Sizing Criteria

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Overview

- Background
- Existing Methods
- Differences between and within Methods
- Comparisons of Sizing Results
- Proposal for New Knee-of-the-Curve Approach

Background: Different Sizing Methods

- Volume Based Sizing
  - Design storm (85^{th} percentile, 24-hour)
  - Percent capture (80%)
  - SCS curve number
  - 4% of catchment area
- Flow Based Sizing
  - 0.2 in/hr rain intensity
  - 2 x (85^{th} percentile hourly rainfall intensity)

Background:
Different Method Applications

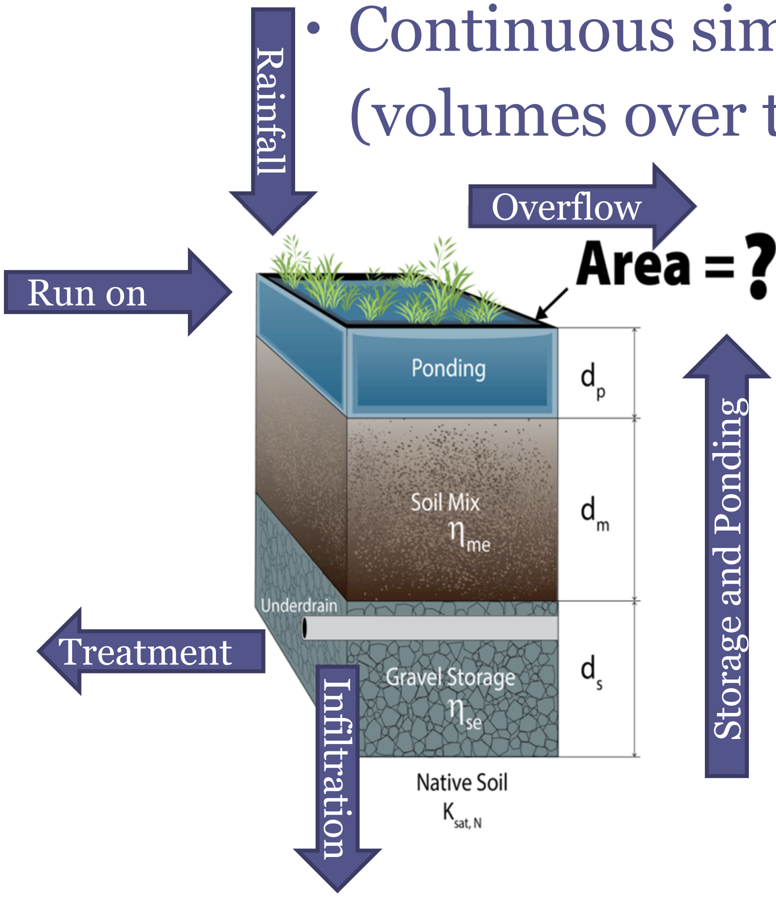
- Post-Construction BMPs Permit Methods
  - Phase II
    - Use volume or flow methods
  - Caltrans
    - Use 85th percentile design storm
  - CGP
    - Use SCS curve number

Background: Different Questions

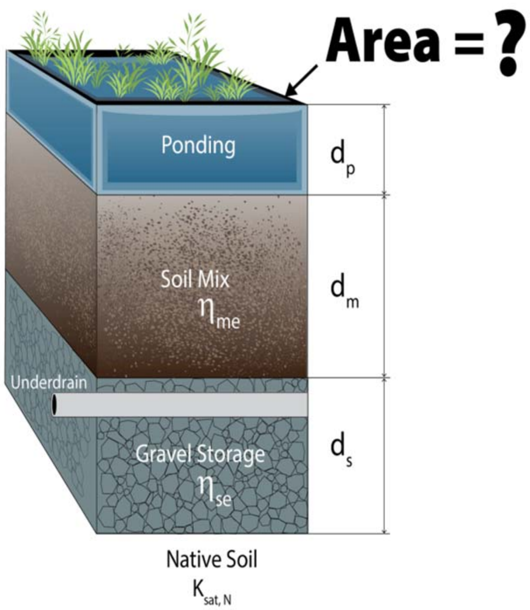
- Why so many methods?
- Why different statewide methods?
- How do the sizing results compare?
  - Hang around to find out!
  - Example: Percent Capture vs Design Storm

Existing Methods: Percent Capture vs Design Storm

- Percent Capture
  - Continuous simulation (volumes over time)

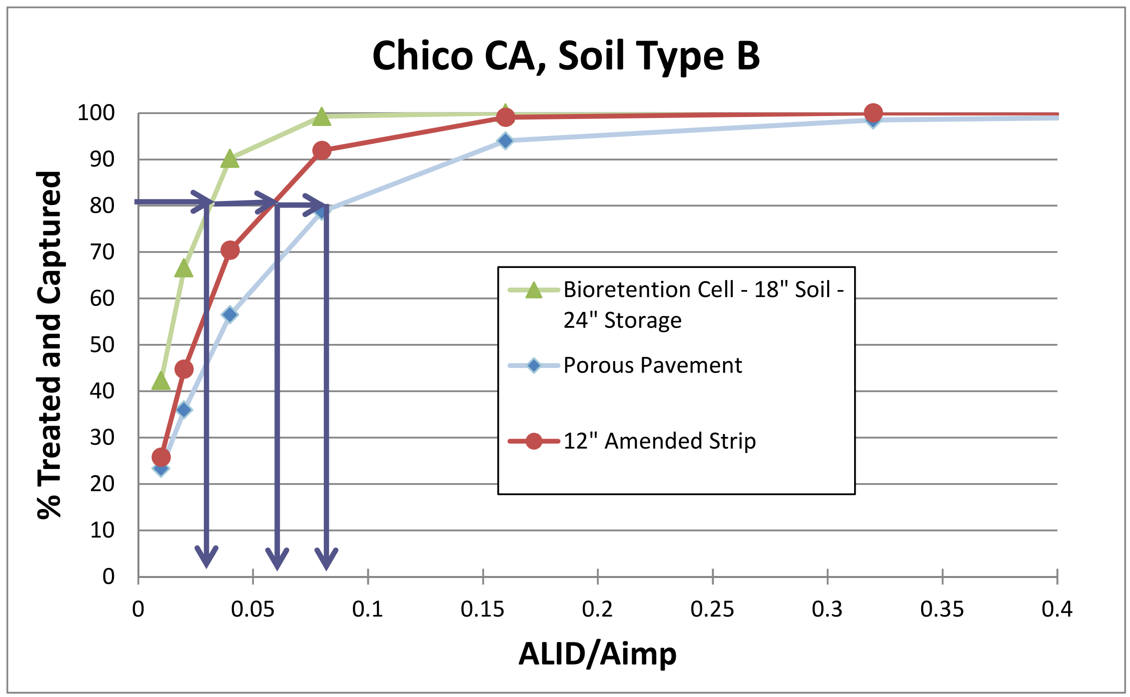


- Design Storm
  - Storage volume (one point in time)

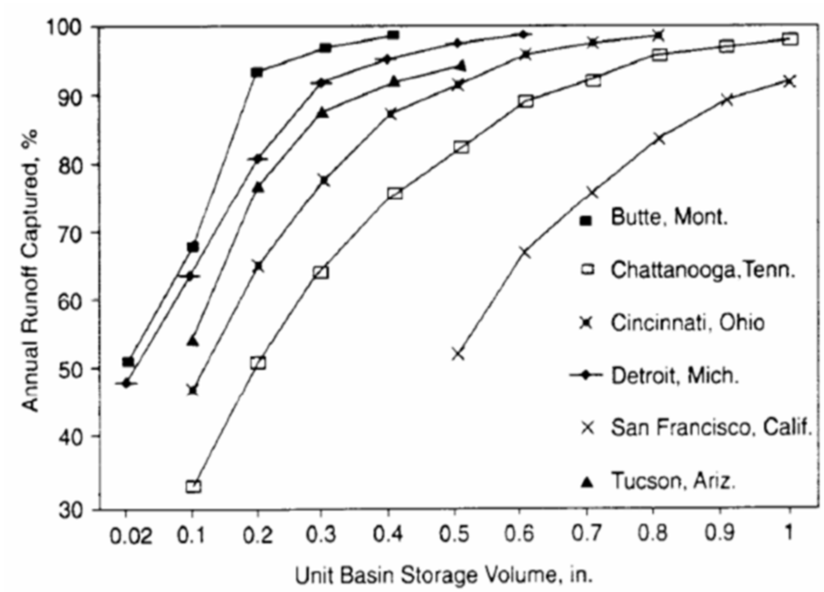


Existing Methods: Percent Capture

- Integrated Water Balance
  - Calculate % capture: $\frac{\sum Volume\ retained}{\sum volume\ entering\ BMP}$
  - Develop design curves for multiple scenarios
    - Historic rainfall
    - BMP characteristics
    - Underlying soils
  - Lookup % capture
  - Read off area



Existing Methods: Why 80% Capture?



- Roesner et al., 1991
  - 6 detention basins in US
  - Volume capture vs BMP size
    - Size indicates cost
    - Point of diminishing returns (knee-of-the-curve)
    - Optimized storage volume
  - Knee-of-the-curve capture ranged 80 - 90%

Source: Storm Water Best Management Practices Design Guide (EPA, 2004)

- Standard Urban Stormwater Mitigation Plans, 2000
  - Adopt 80% (the low end)

Source: Response to Comments on Draft PCRs (Central Coast Water Board, 2013)

Existing Methods: Why 80% Capture?

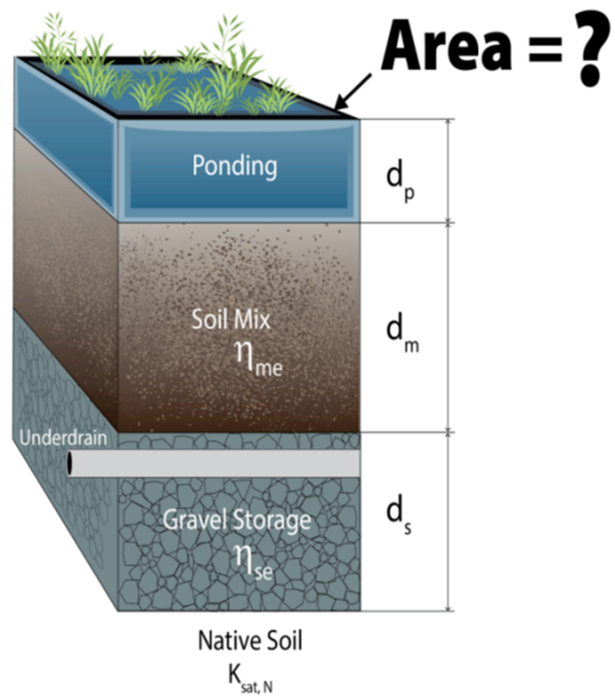
- Guo and Urbanos 1996
  - 7 US locations
  - Volume and event captures ranged 82 - 88%
- CASQA Handbook 2003
  - Use local requirement for % capture
  - If not specified, use knee-of-the-curve (typ. 75-85%)

Source: CASQA New Development and Redevelopment BMP Handbook

- Caltrans Basin Sizer
  - Dozens of California locations
  - Knee-of-curve ranged 70-95%

Existing Methods: Design Storm

- Algebraic Water Balance
  - BMP Storage = Run on + BMP Rainfall
  - $d_s * \eta_s * A_{BMP} = RF_{ds} * (C * A_{catchment} + A_{BMP})$
  - Solve for A_{BMP}



Existing Methods:
Why 85th Percentile Design Storm?

- Not sure
- CA Rainfall Analysis?
  - 80% capture size = 85th percentile design storm size

Differences between Methods

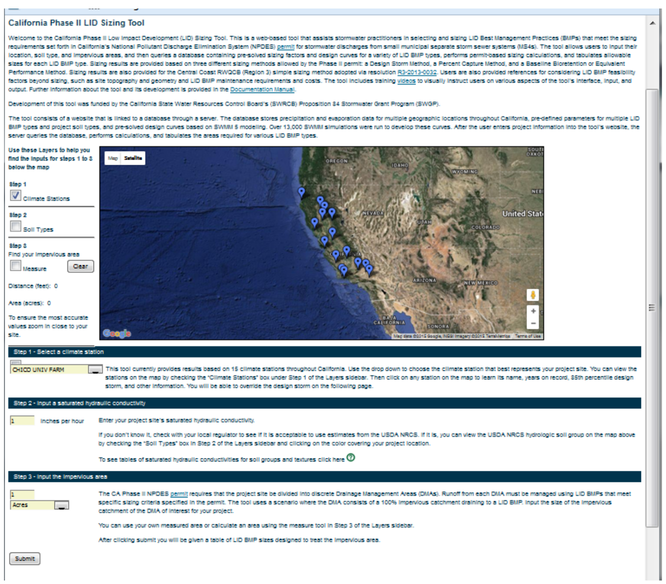
- Different Mathematics
  - Static vs dynamic
    - Design storm: volume at one point in time
    - Percent capture: volume throughout time
- 80% Capture based on 1 BMP, 6 US Locations
  - Not representative of CA climate variations
  - Not representative of LID BMPs (treat and retain)
    - Single discharge mechanism vs. multiple mechanisms
    - Size not the only indicator of cost

Differences within Methods

- Different Models
  - Green Ampt vs Horton
  - Orifice sizing (stage-storage-discharge)
  - Rainfall to runoff conversion
    - Runoff coefficient
    - Initial abstraction
    - Curve number
- For Example
  - CA LID Sizing Tool vs EPA Stormwater Calculator
    - SWMM vs SWMM
    - Up to 4% differences
  - CA LID Sizing Tool vs SAHM
    - SWMM vs HSPF
    - Up to 24% differences
    - Difference due to stage-storage-discharge relationships

Comparison of Sizing Results: CA Phase II LID Sizing Tool

- Inputs
  - Location
  - K_{sat}
  - Catchment area



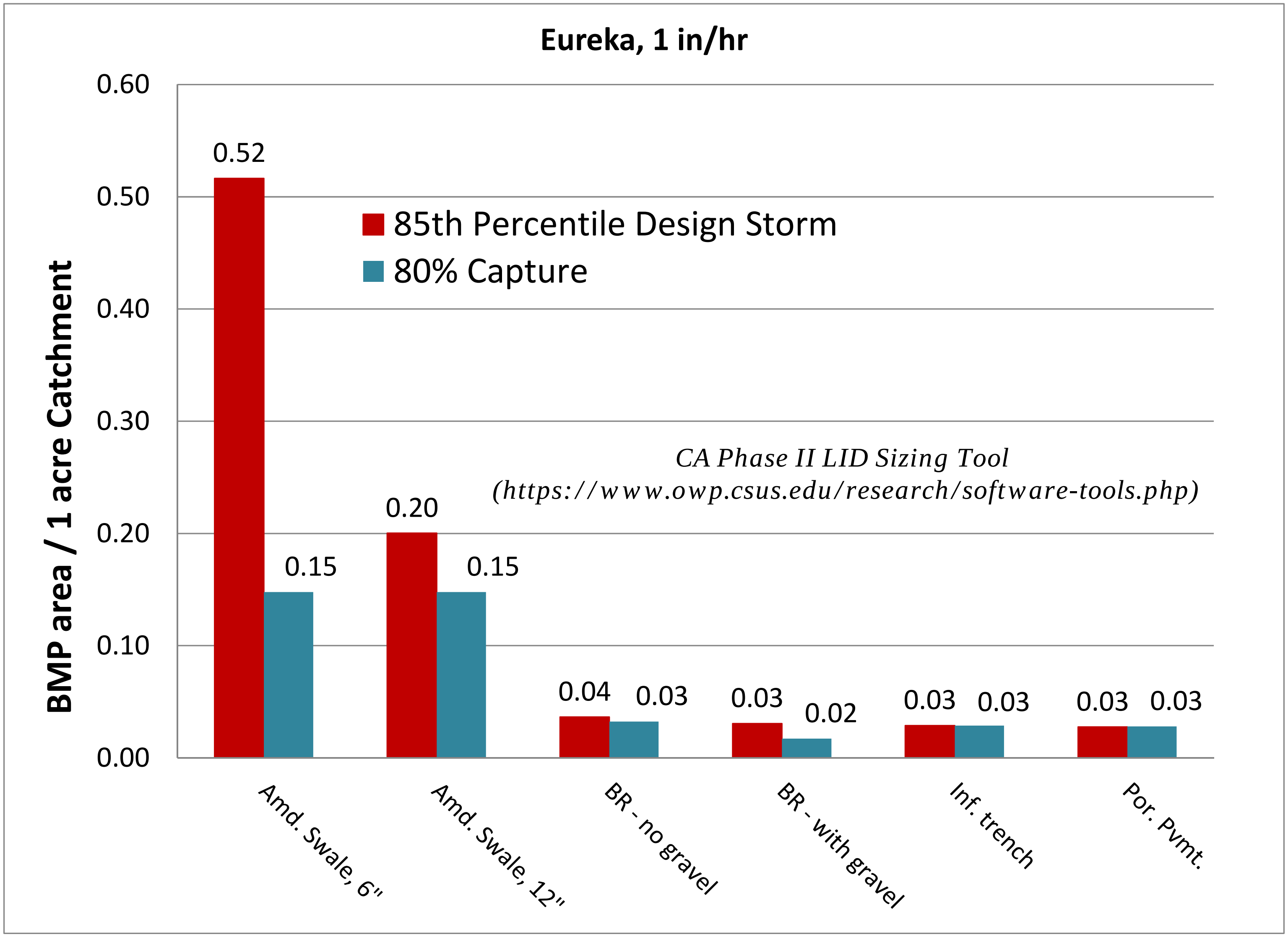
- Output: BMP Sizes
  - Multiple BMPs
    - Bioretention
    - Biostrips & bioswales
    - Porous pavement
    - Infiltration trenches, galleries, etc.
  - Multiple Sizing Methods
    - 85^{th} percentile, 24-hr design storm
    - 80% capture
    - 4% equivalent
    - Central Coast simple method

http://www.owp.csus.edu/LIDTool/Start.aspx

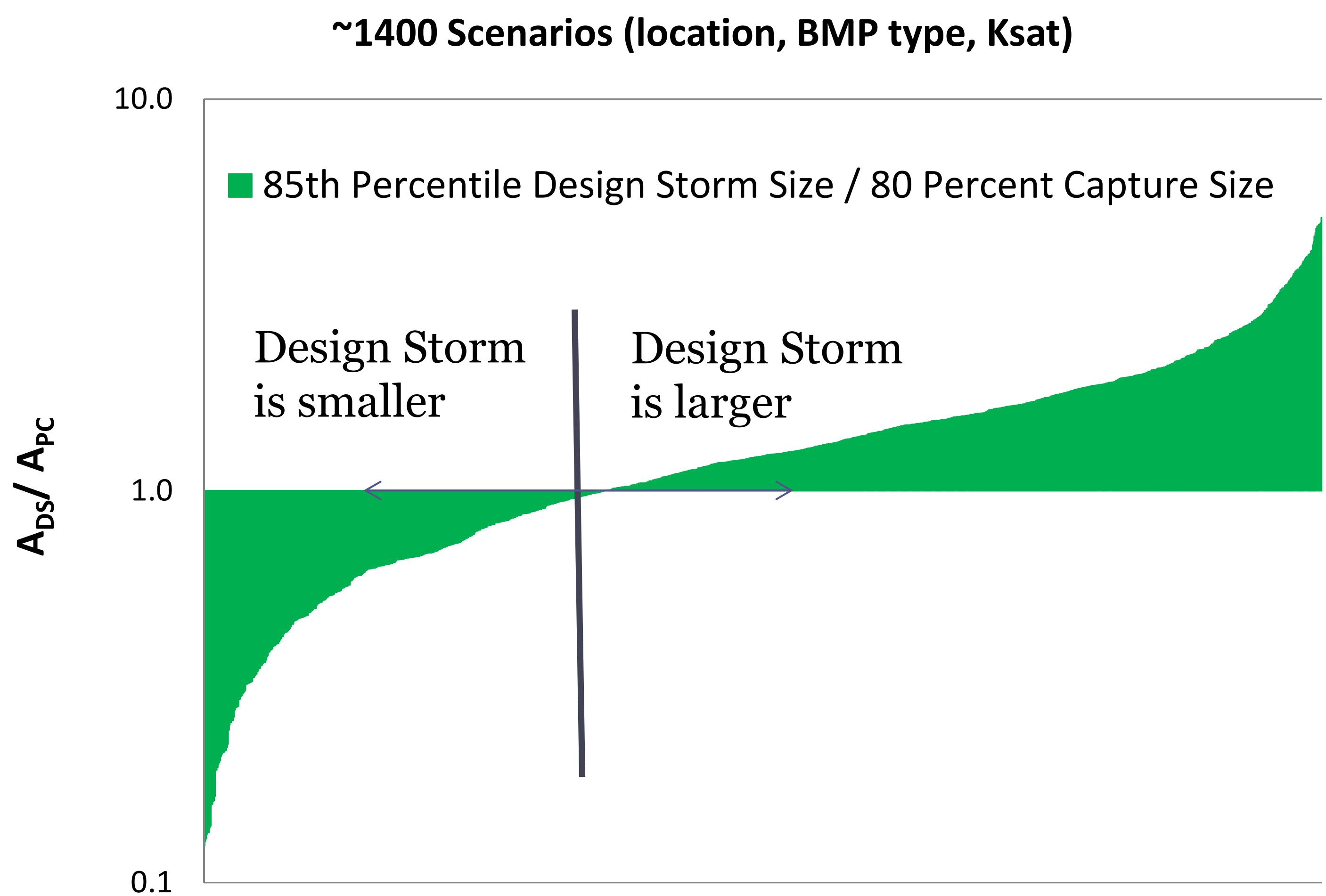
Comparison of Sizing Results:

Storm Water Treatment Measures				
LID BMP Types	Permit Compliant LID BMP Areas (acres)			
	Design Storm 0.8 inches[1, 8]	Percent Capture[2]	Baseline Bioretention or Equivalent Performance[3]	Central Coast Simple Method 0.8 inches[4, 8]
Bioretention Cell - 18" Soil - 12" Gravel Storage	0.048	0.018	0.040	0.210
Bioretention Cell - 18" Soil - 24" Gravel Storage	0.038	0.018	0.040	0.094
Bioretention Cell - 18" Soil - 36" Gravel Storage	0.031	0.018	0.039	0.060
Bioretention Cell - 24" Soil - 12" Gravel Storage	0.043	0.018	0.039	0.210
Bioretention Cell - 24" Soil - 24" Gravel Storage	0.034	0.017	0.039	0.094
Bioretention Cell - 24" Soil - 36" Gravel Storage	0.029	0.017	0.039	0.060
Bioretention Cell - Soil Depth Varies[5] - No Gravel Storage	0.045	0.033	0.075	0.045
Infiltration Basin - Vegetated	0.015	0.016	0.037	0.015
Infiltration Gallery	0.012	0.016	0.037	0.012
Infiltration Trench	0.035	0.029	0.069	0.035
Overland Flow no amendment	N/A	0.100	0.300	N/A
Porous Pavement	0.034	0.028	0.068	0.034
Strip, Amended 6"	0.710	0.068	0.160	0.710
Strip, Amended 12"	0.250	0.057	0.140	0.250
Strip, Amended 18"	0.160	0.048	0.130	0.160
Swale, Amended 6"[6]	0.710	0.150	0.480	0.710
Swale, Amended 12"[6]	0.250	0.150	0.480	0.250

Comparison of Sizing Results



Comparison of Sizing Results



Source: CA Phase II LID Sizing Tool (https://www.owp.csus.edu/research/software-tools.php)

Are We Making a Difference?

- Regarding Stormwater Management and BMP Implementation, Intent is there
  - Simplified, uniform procedures
  - Multiple benefits
    - Improve receiving water quality
    - Stormwater as a resource
- Perhaps design standards need to catch up
  - More systematic approaches
  - Better understanding of design standards
  - Updated design standards for LID BMPs being implemented in CA

Proposal for New Knee-of-the-Curve

- Calculate design curves for LID BMPs
  - Determine true knee-of-the curve capture
  - Determine corresponding design storm size
- Redefine cost/practicality indicator
  - Replace size with materials
  - Replace size with water quality benefit measurement
- Monitor performance
  - Compare actual performance to intended design
  - Compare performance among design approaches

What do you think/know?

- Is there a need for new design curves (and storms)?
  - CA specific locations
  - LID BMP characteristics
  - New "diminishing returns'" indicator
- How can we gather design/performance information to get meaningful data?
- Are we making a difference?
- Where ***DID*** the 85th percentile design storm come from?!

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