



Using Stormwater as a Resource

Presented by:

Aspect Consulting, LLC

J. Scott Kindred, PE



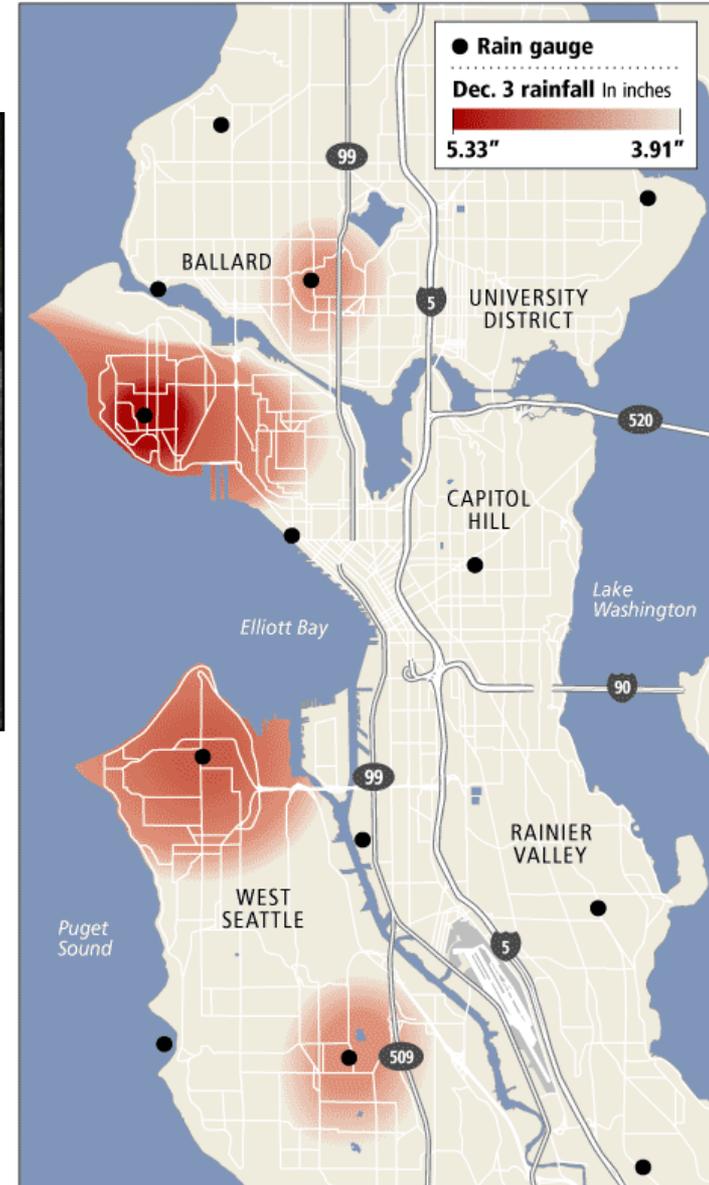
West Seattle - Dec. 3, 2007



Photos from:
www.WestSeattleBlog.com

RAINFALL ACROSS THE CITY

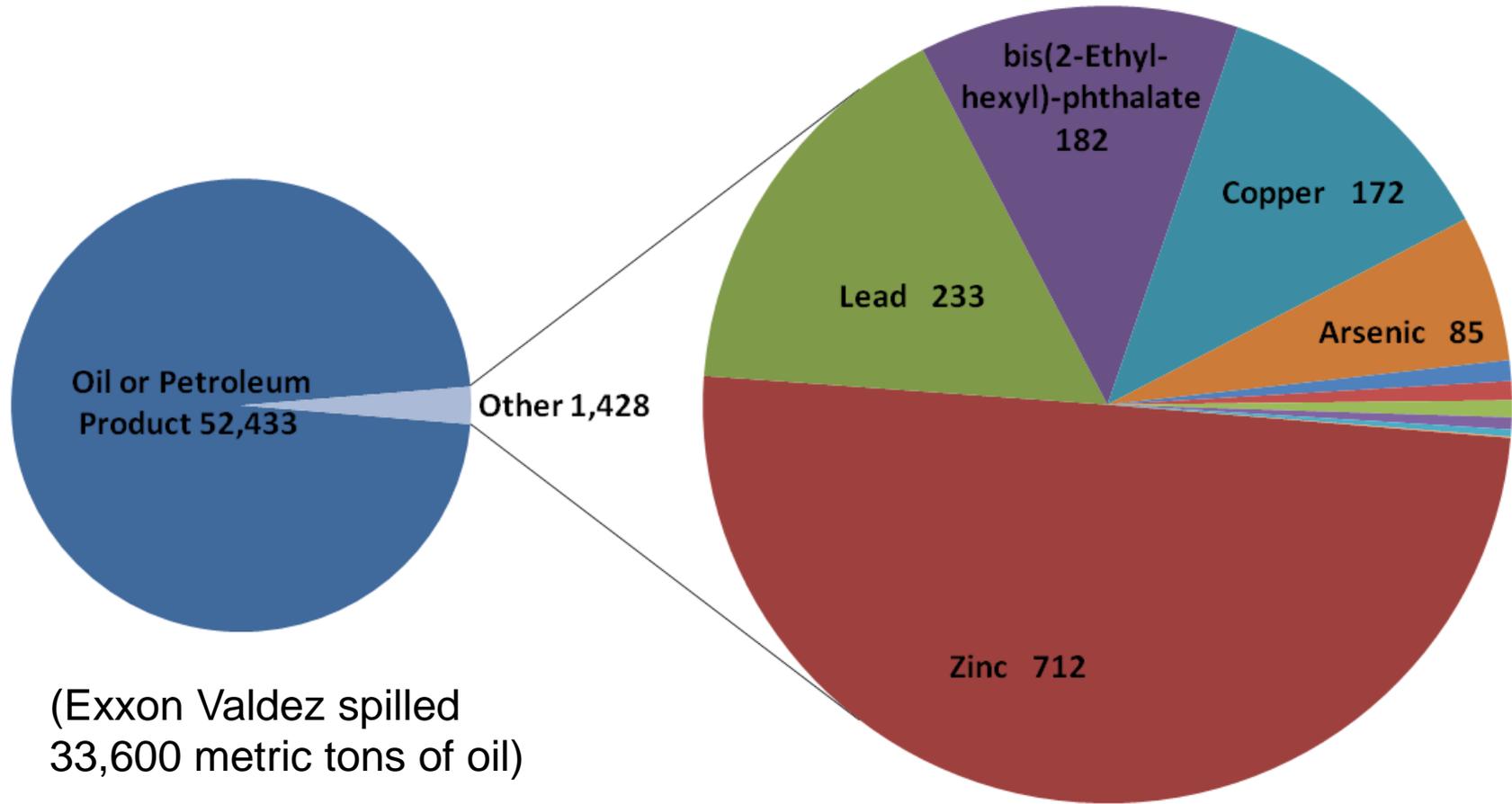
Precipitation measured by rain gauges throughout the city during the Dec. 3 storm.



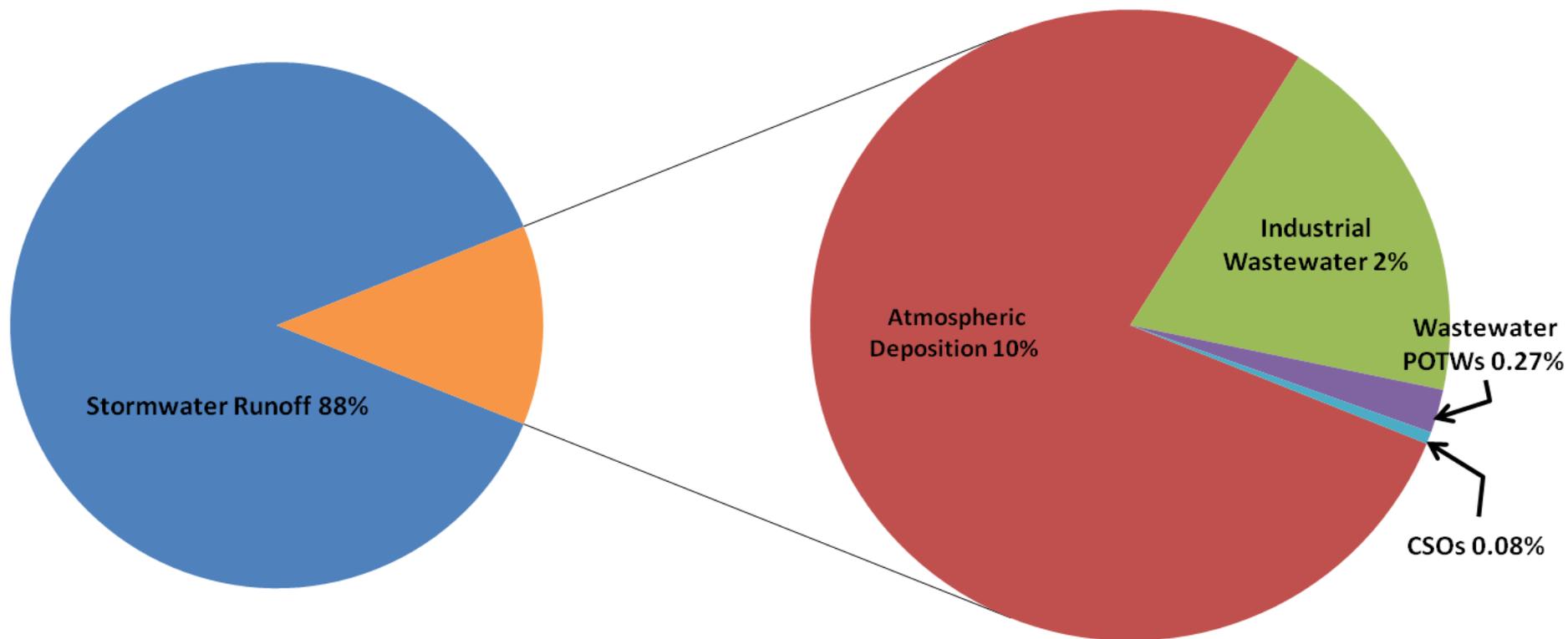
Source: Seattle Public Utilities

SEATTLE P-I

Toxic Chemical Loading to Puget Sound (metric tons)



Sources of Non-Petroleum Toxics Loading to Puget Sound



Phase 1: Initial Estimate of Toxic Chemical Loadings to Puget Sound, Hart Crowser, et. al., 2007, and Phase 2: Improved Estimates of Toxic Chemical Loadings to Puget Sound from Surface Runoff and Roadways, EnviroVision et al., 2008

Combined sewer outfalls (CSO)

- CSOs discharge between 495 MG and 1.7 BG per year to Puget Sound
- ~100 MG from Seattle CSOs

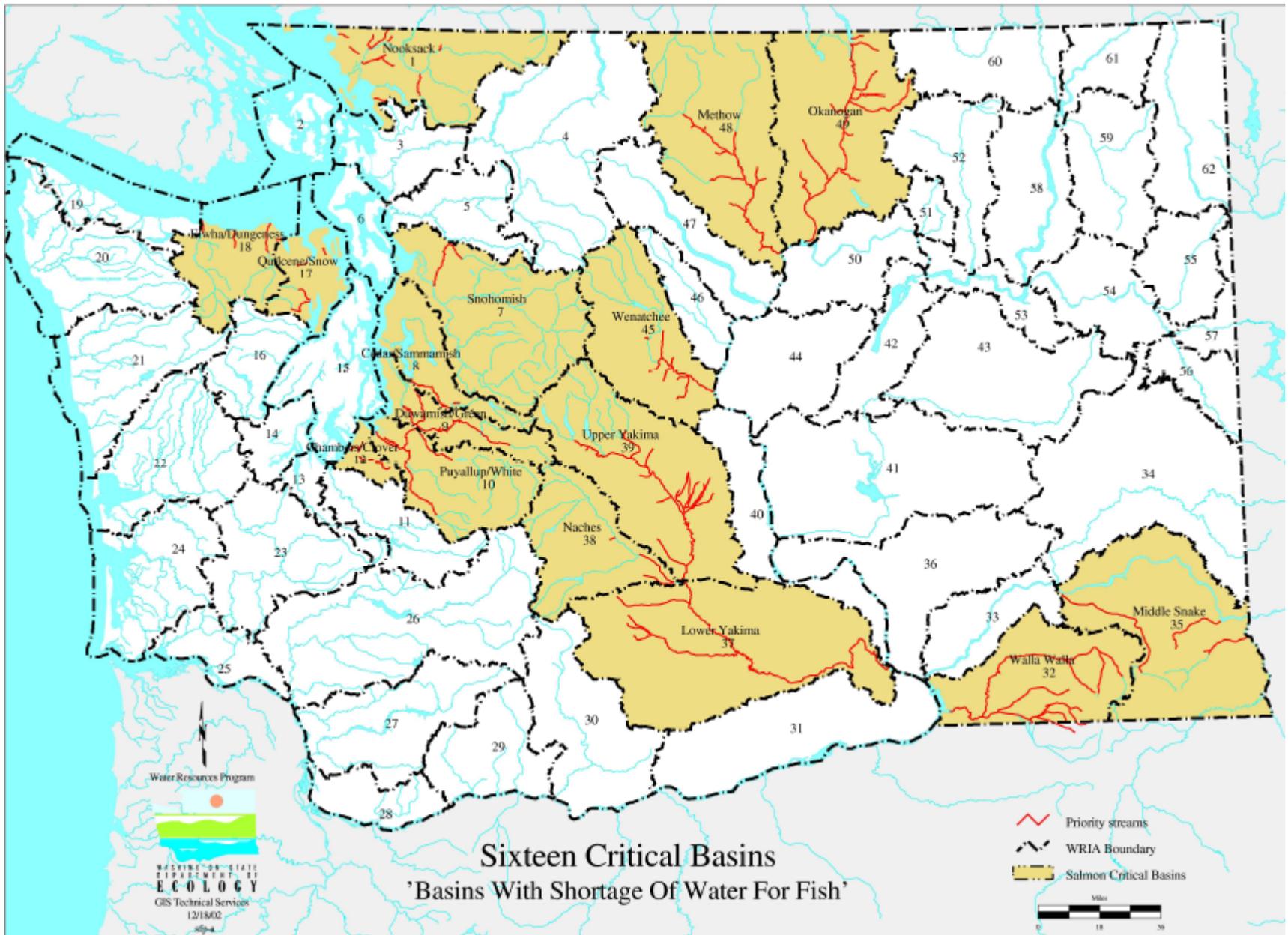


King County Combined Sewer Overflow (CSO) Locations

- King County CSO
- City of Seattle CSO
- CSO Treatment Plant/Facility
- Wastewater Treatment Plant
- Park



File Name: 0808CSOmap.ai wgab



Sixteen Critical Basins
 'Basins With Shortage Of Water For Fish'

Summary of Stormwater-Related Issues

- High peak flows (flooding)
- Toxics loading to surface water
- CSO discharge
- Declining groundwater levels and baseflow



Traditional detention solutions help with flooding and CSO discharge, however...

...pollutants still discharge to surface water

...no help for groundwater recharge and summer baseflow

...expensive

Low Impact Development (LID) / Green Stormwater Infrastructure (GSI) Solutions

- Leaving natural green belts / wetlands in place
- “Absorbent” landscaping / tree planting
- Rain gardens, green roofs, and other natural detention/treatment systems
- Pervious pavement
- “Engineered” infiltration following treatment
- Rainwater harvesting with cisterns

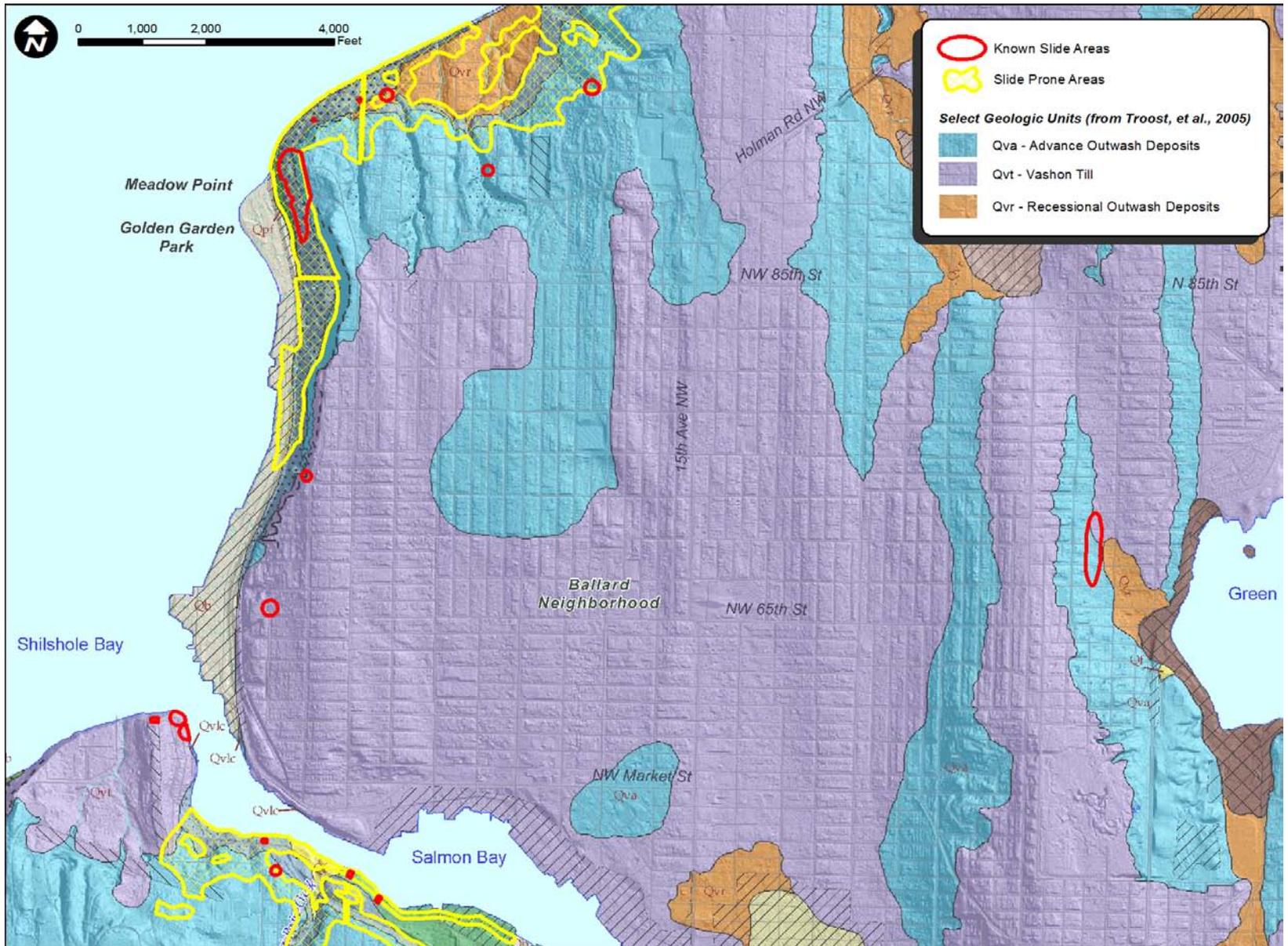


“Engineered” Infiltration

- Shallow or deep infiltration based on subsurface conditions
- Designed using measured infiltration rates
- May require mounding analysis
- Evaluate potential impact on steep slopes and other sensitive areas



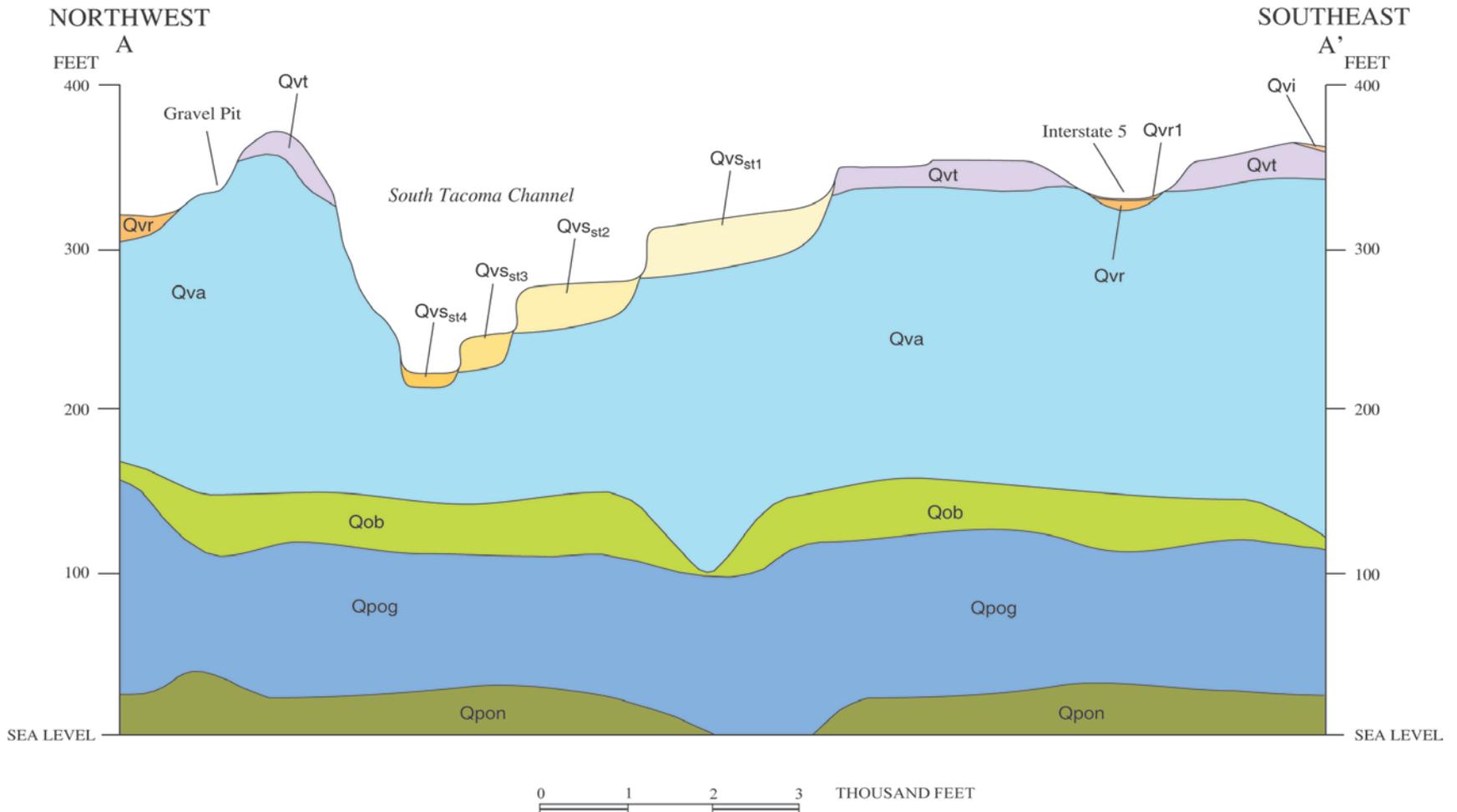
Ballard Geologic Map

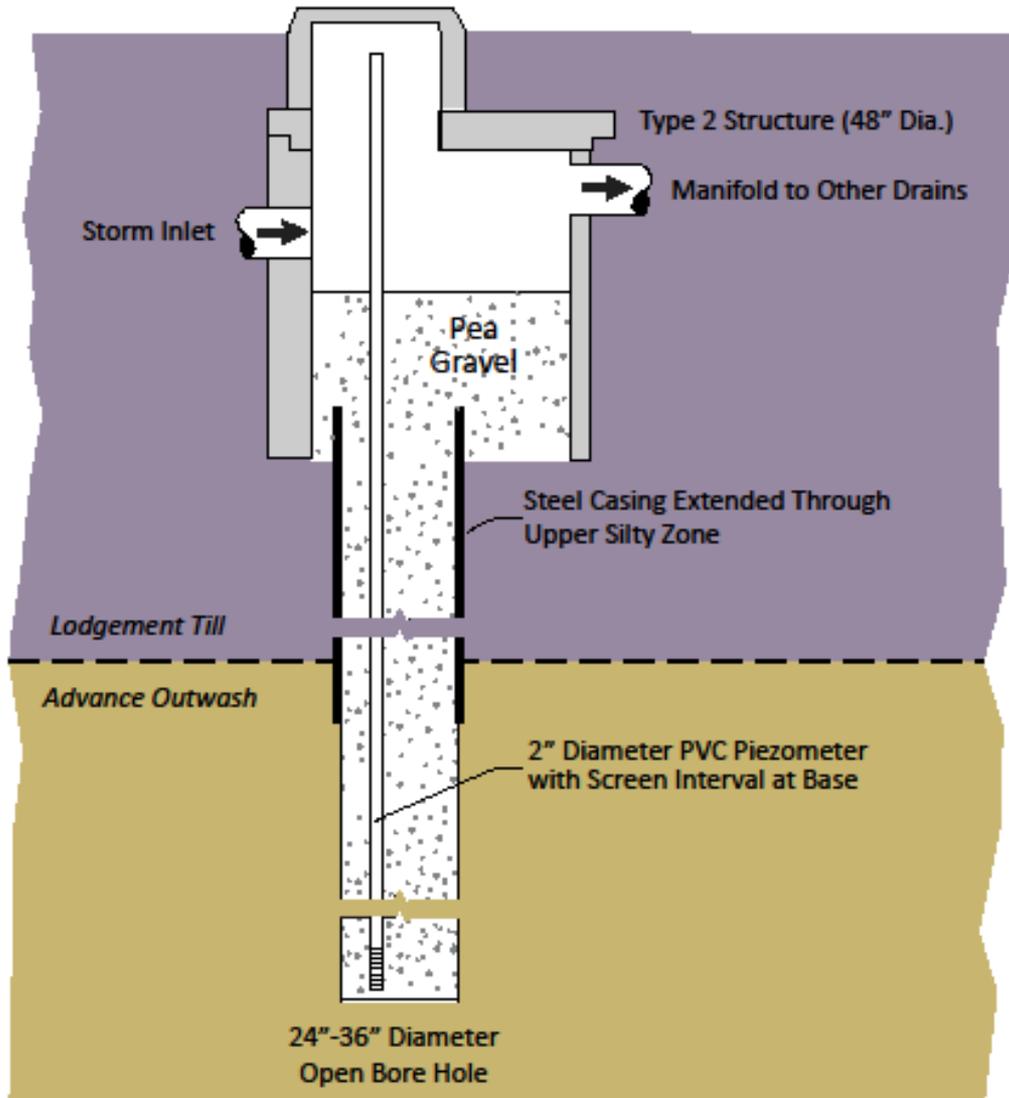


Infiltration often Feasible Beneath Till

SCHEMATIC CROSS SECTION OF THE SOUTH TACOMA CHANNEL

[View looking northeast; vertical exaggeration X20]

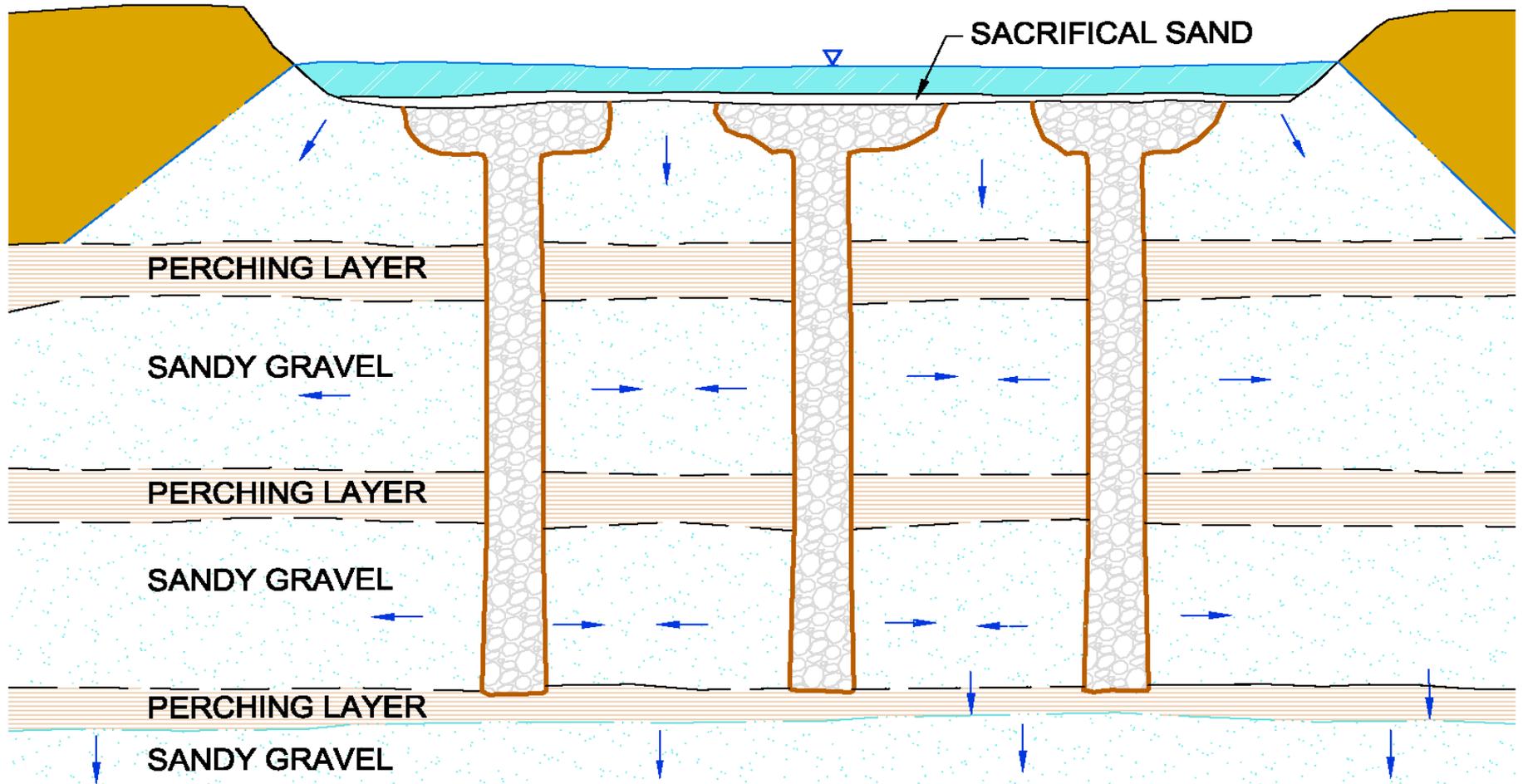




Stand-Alone Drilled Drain Completion Detail

- Typically 2-3 ft in diameter
- Backfilled with Pea Gravel
- Type 2 Structure
- Piezometer
- May include surface casing

Deep Drains beneath Ponds/Rain Gardens



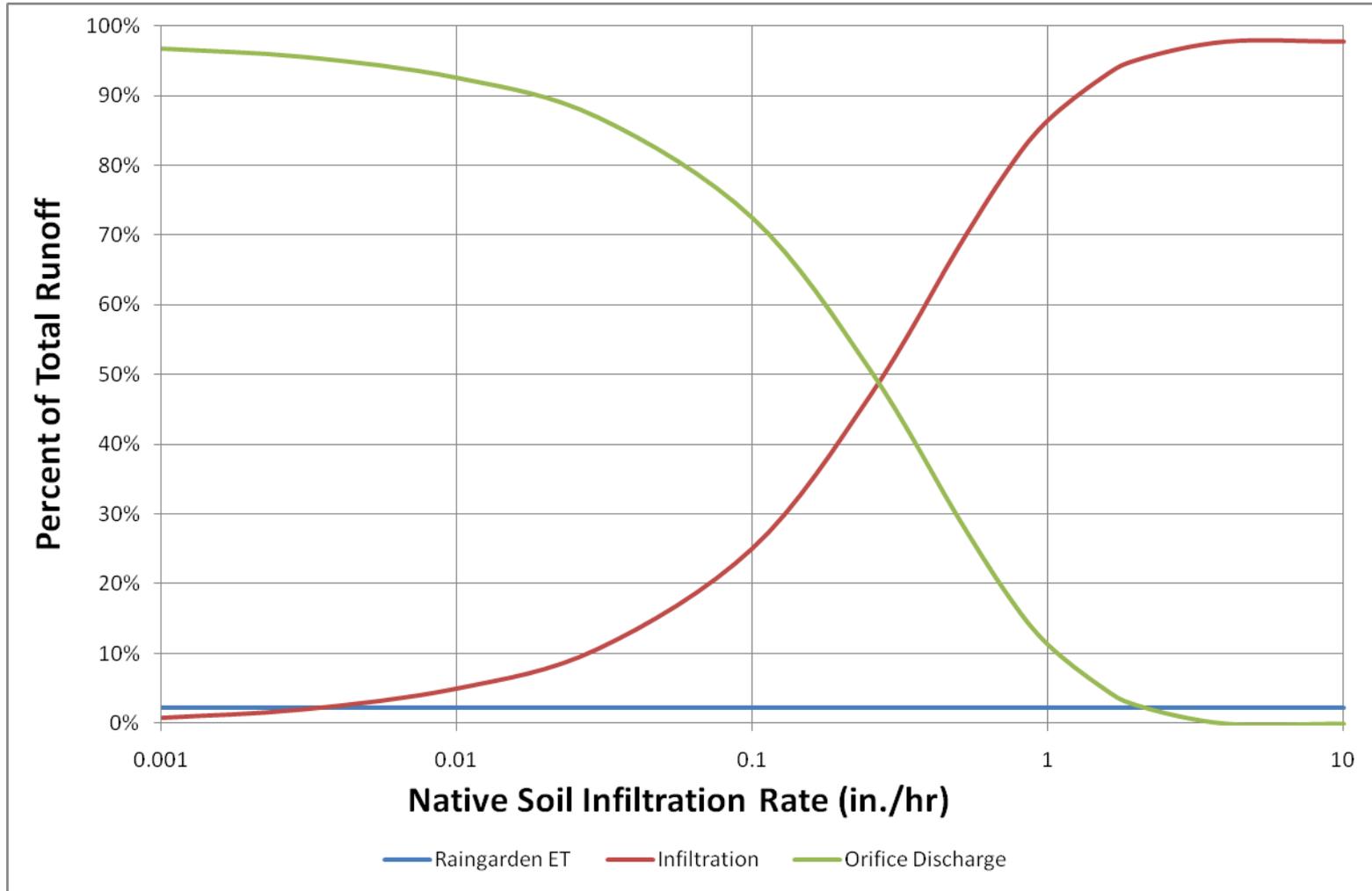
Rain Garden with Infiltration

Spreadsheet Model Assumptions:

- Runoff from street: 40,000 sf
- Rain garden: 10 ft by 120 ft
- Rain garden biofiltration soils: 4 in./hr (50 gpm)
- 16,800 gal of storage in rain garden and underdrain
- 1.5 inch orifice drains underdrain

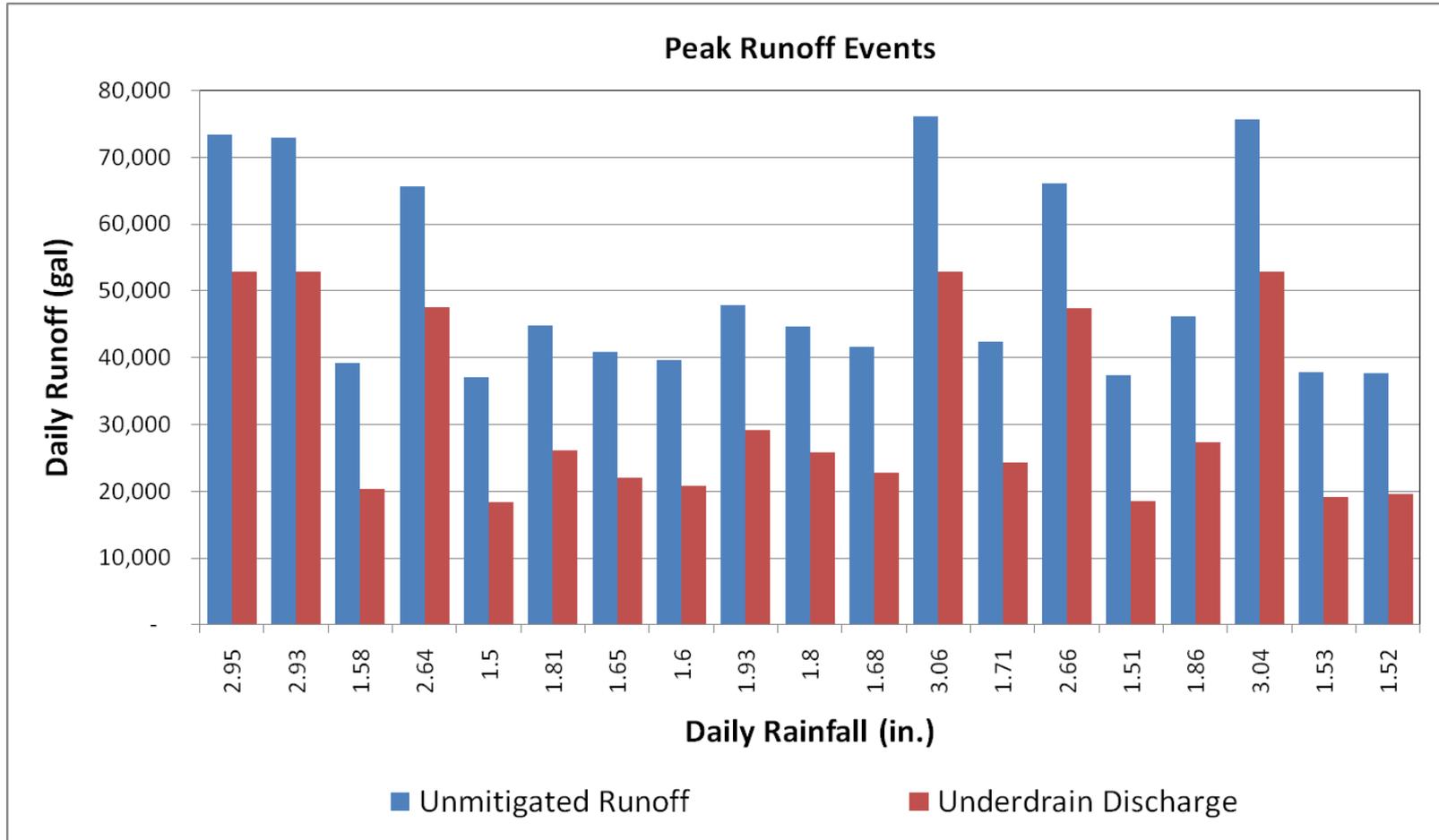


Annual Distribution of Total Runoff with No Deep Infiltration Drain

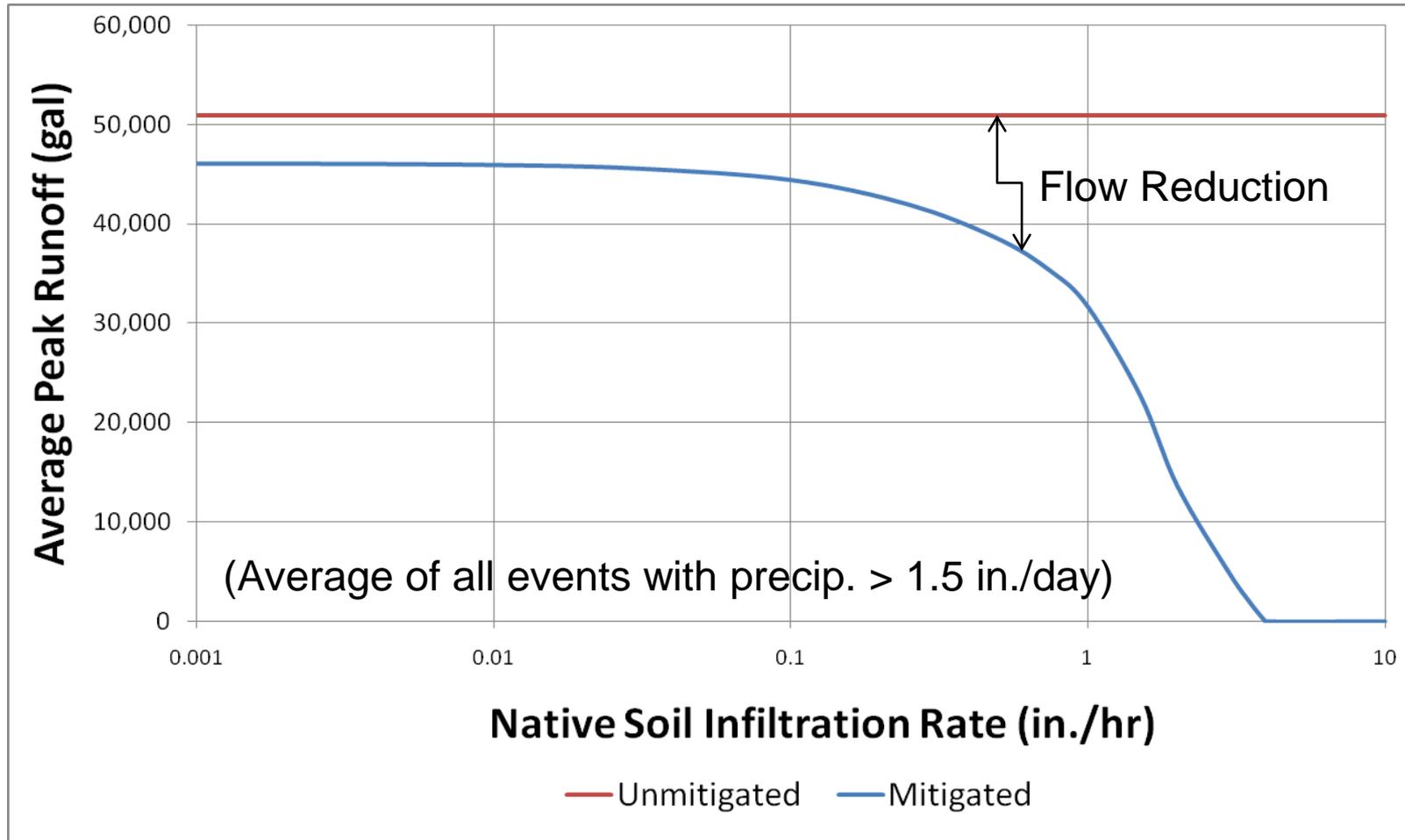


Conclusion: 90% of total runoff infiltrates when native soil infiltrates 1 in./hr

But, Peak Discharge Still Substantial at 1 in./hr



Average Peak Runoff as a Function of Native Soil Infiltration Rate



Conclusion: Peak flow discharge decreases dramatically when native soil infiltration rate > 1 in./hr.

Cost

- Approximate cost of \$90K per raingarden (no infiltration drain)
 - Design, testing, and permitting (\$25K)
 - Demo street/sidewalk and excavate 180 cy (\$10K)
 - Place 150 cy of material at \$100/yd (\$15K)
 - Plant and water 500 plants at \$20/plant (\$15K)
 - Repair/modify street and drainage (\$25K)
- Daily flow reduction ranges from 5K to 50K gallons (depending on native soil infiltration rate)



Deep Infiltration Drain Can Substantially Improve Infiltration at a Glacial Till Site

- Same raingarden on glacial till (infiltration rate ~ 0.001 in./hr)
- Infiltration drain with capacity of 50 gpm will infiltrate 100% of runoff
- Suitable for any site with low permeability soils over unsaturated permeable soils
- Generally not suitable in areas with shallow groundwater
- Generally not suitable near slide prone slopes

Deep Drain Costs and Benefits

- Requires hydrogeologic assessment ~\$10K
- Depending on thickness of low permeability soil, cost of drain between \$1,000 (dug) and ~\$20,000 (drilled and cased)
- Rain garden with deep drain provides ~50,000 gal of control volume

Cost per gallon of control volume <\$2.6 per gallon!

Raingarden Cost per Gallon of Control Volume

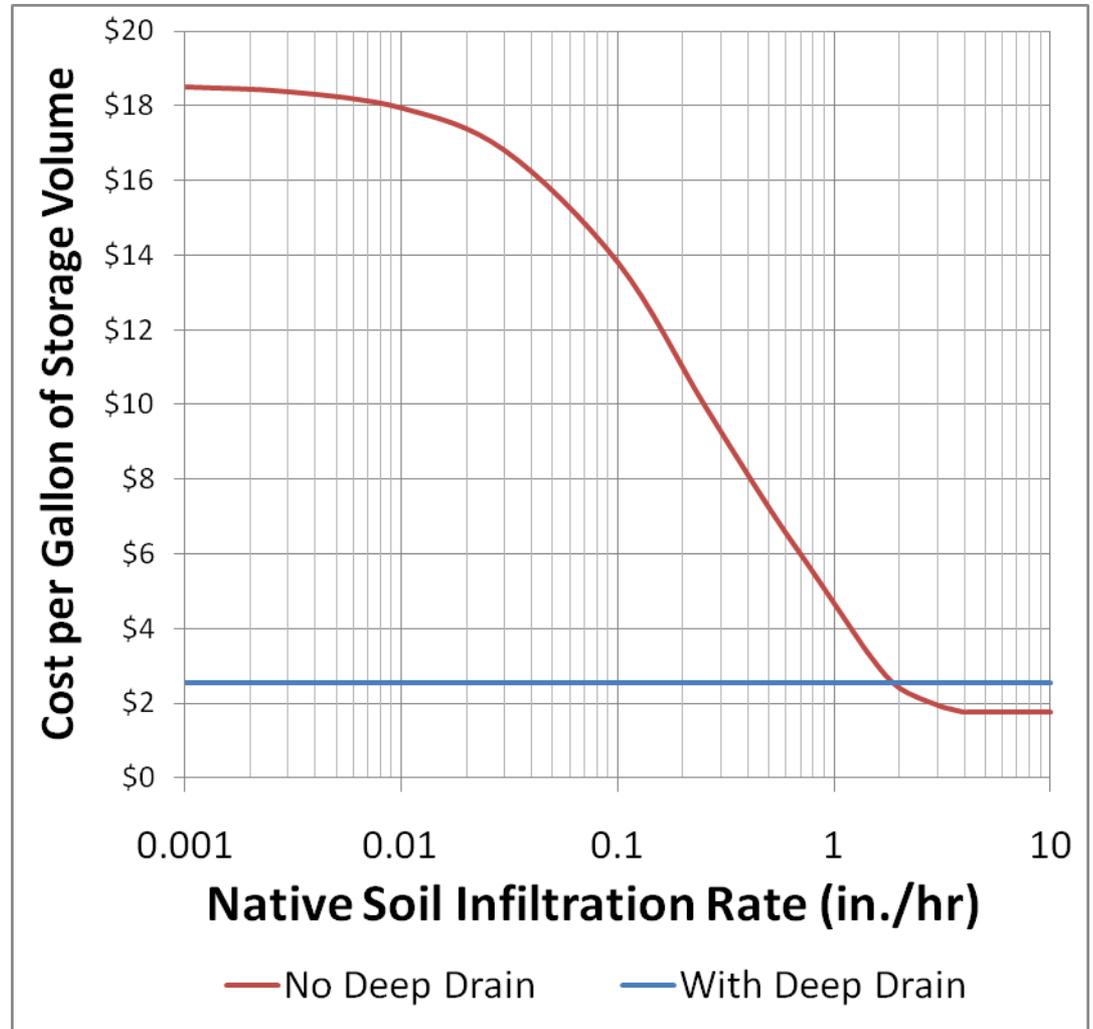
Cost Assumptions:

Rain garden - \$90K

Deep Drain - \$30K

Conclusion:

Deep drains are cost effective when native soil infiltration rate < 2 in./hr.



Rainwater Harvesting

- Roof runoff fills cistern
- Provides irrigation water during summer months
- With filtering can be used to flush toilets (probably only feasible for new construction)
- With additional treatment (carbon filtration and UV radiation) can be used for potable water
- Orifice discharge during winter provides detention



1,550 Gallon Cistern



Two 550 Gallon Cisterns



Photo by EarthSystemsNW

Under Deck Storage (1,500 gallons)



Photos by EarthSystemsNW



Water Fence (720 gallons)



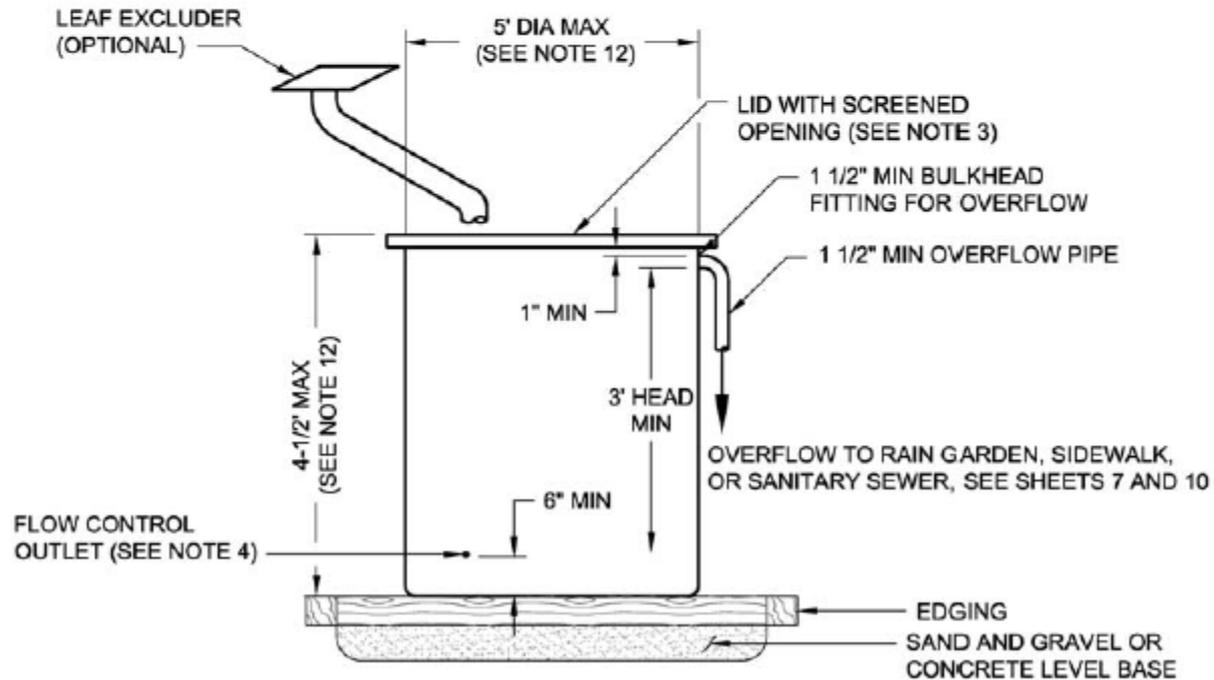
Photos by EarthSystemsNW





RainWise Detail Sheet 9

Downspouts to Cistern 1

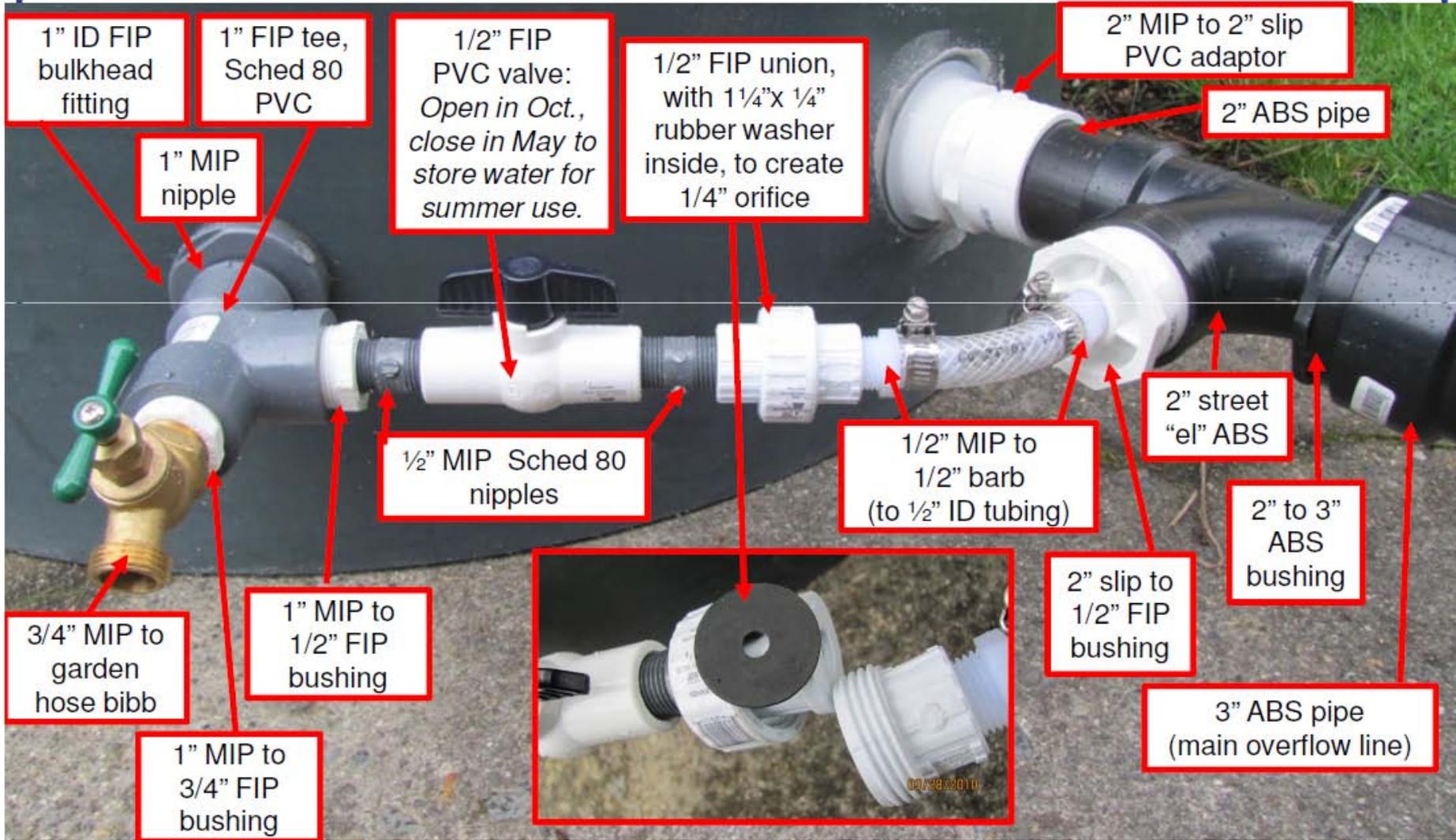


CISTERN WITH EXTERNAL OVERFLOW PIPE



RainWise Detail Sheet 12

Low-flow 1/4" orifice drain into main overflow example design, using easily available fittings

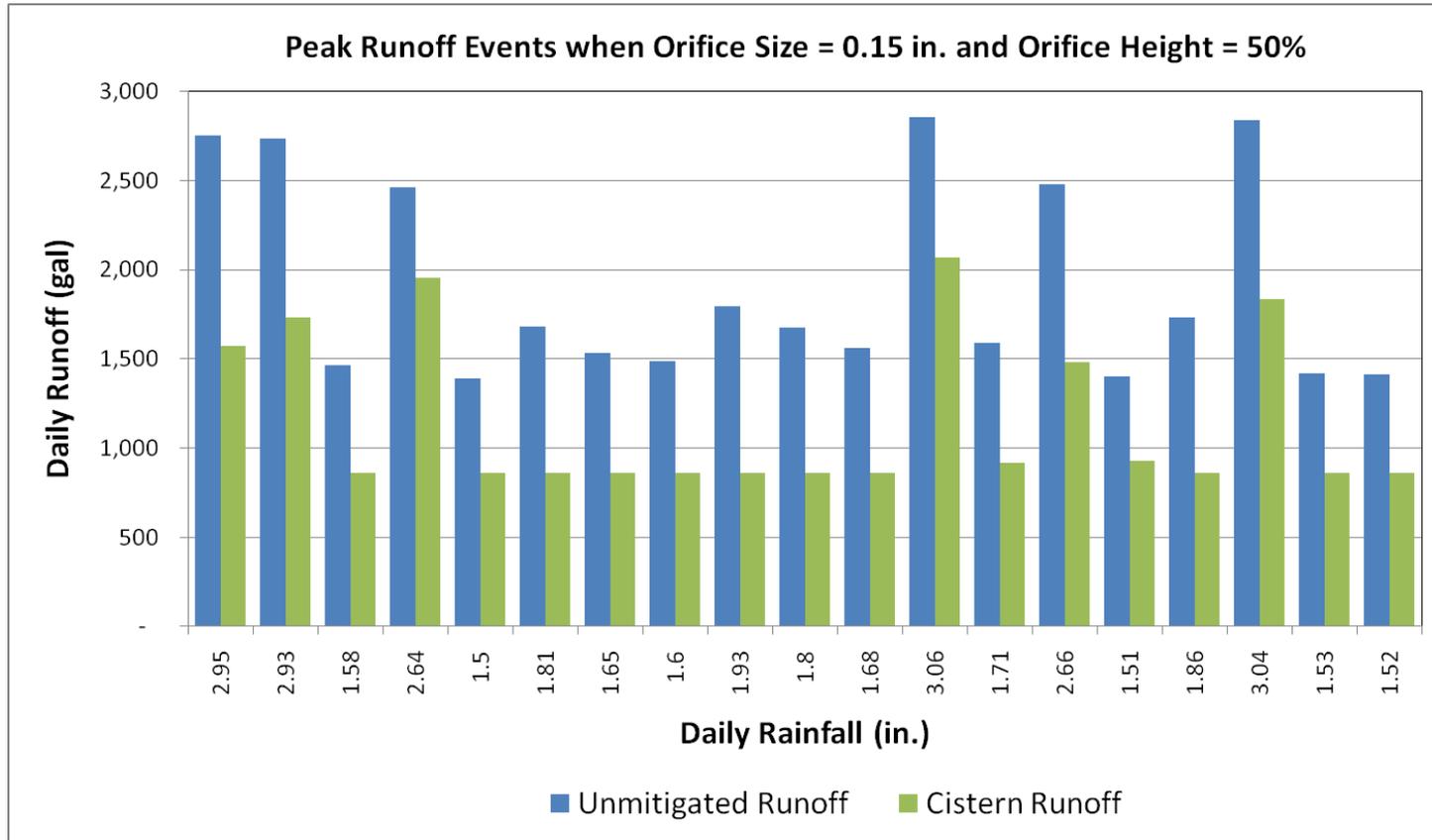


Developed Spreadsheet Model to Simulate Performance

- Used daily rainfall data from 1990-2001
- Annual rainfall ranged from 29 inches (1993) to 51 inches (1996)
- 19 events over 1.5 in./day
- Orifice open between Oct-April
- Orifice can discharge to sewer or rain garden with infiltration

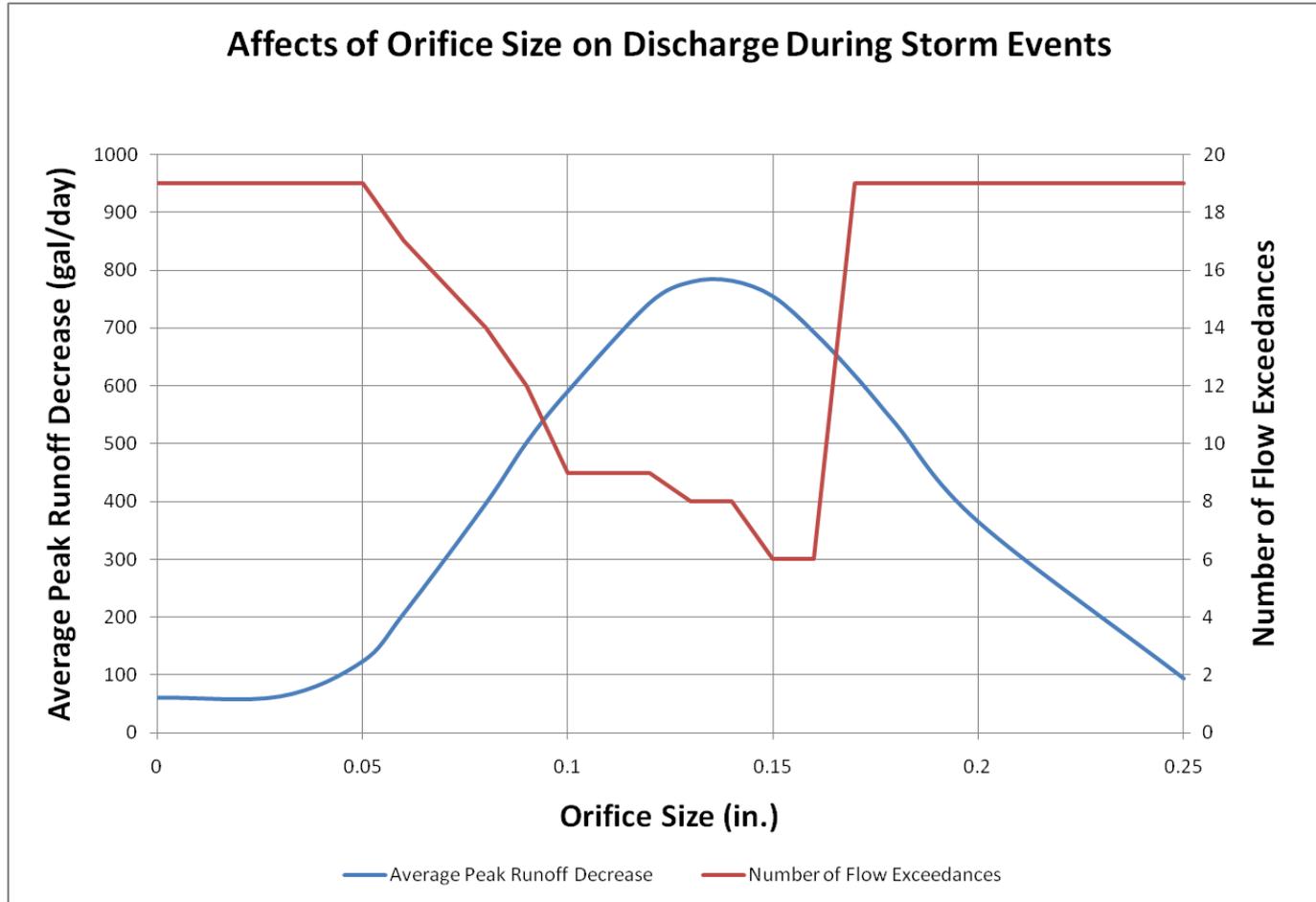
| Assumptions | |
|-------------------|---------------|
| Roof Area | 1500 sf |
| Tank Diameter | 6 ft |
| Tank Height | 9.5 ft |
| Storage | 2008 gal |
| Indoor Water Use | 145 gal/day |
| Irrigated Area | 1,000 sf |
| Orifice Height | 50% |
| Orifice Diameter | 0.15 in. |
| Orifice Area | 0.018 sq. in. |
| Oct-Dec Watering | 0.00 in./wk |
| Jun/Sep Watering | 0.50 in./wk |
| July/Aug Watering | 1.00 in./wk |
| Oct-Dec Evap. | 0.02 in./day |
| Jun/Sep Evap. | 0.05 in./day |
| July/Aug Evap. | 0.10 in./day |

Orifice Discharge and Irrigation Only



- 6 runoff events > 1,000 gallons
- Average daily peak runoff reduced 750 gallons
- Total runoff reduced 14%
- Use of city water reduced 6%

Effects of Orifice Size on Discharge



- Irrigation only
- Flow criteria = 1,000 gallons/day
- Orifice height = 4.75 ft (50%)

With Permeable Soils, Rain Garden can Infiltrate all Roof Runoff

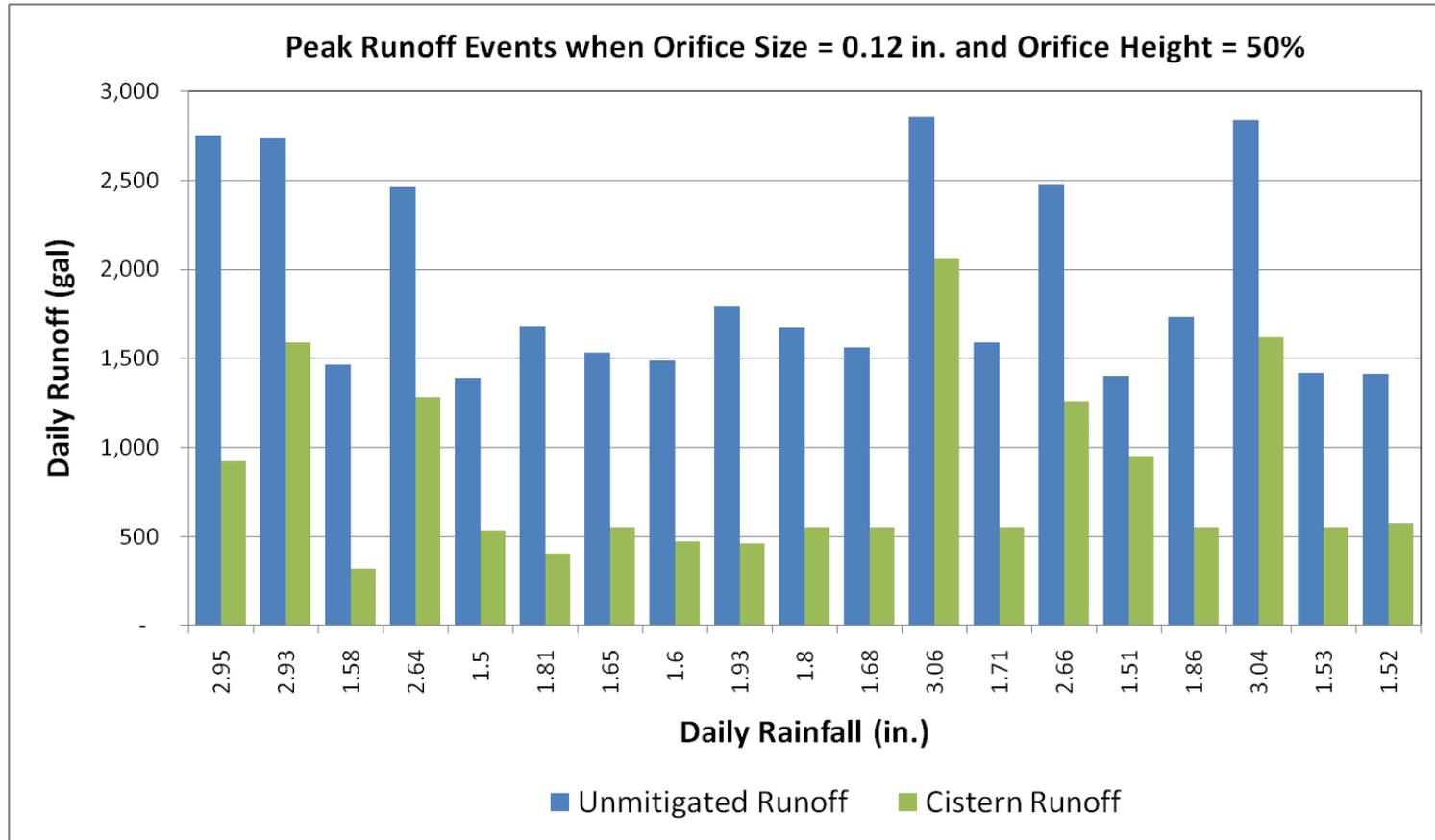
- Maximum runoff of 2,000 gpd (1.4 gpm)
- 10 ft x 10 ft Rain Garden
- Requires infiltration rate > 1.4 in./hour

2,000 Gallon Cistern for Potable Water



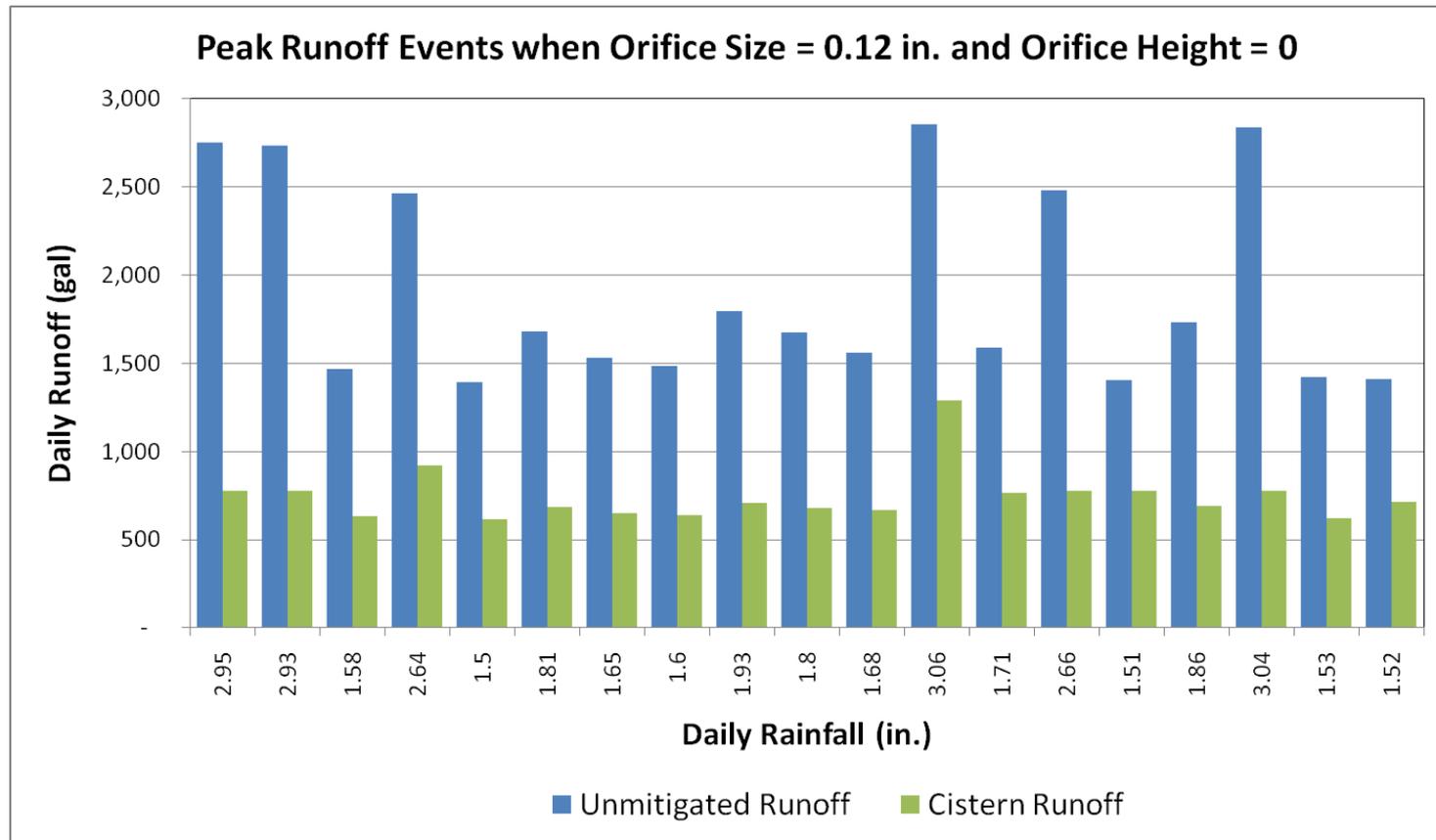
Photo by EarthSystemsNW

Orifice Discharge, Irrigation, and Potable Water



- 5 runoff events > 1,000 gallons
- Average daily peak runoff reduced 1,080 gallons
- Total runoff reduced 79%
- Use of city water reduced 48%

Operate to Minimize Peak Runoff Events



- 1 runoff event > 1,000 gallons
- Average daily peak runoff reduced 1,160 gallons
- Total runoff reduced 55%
- Use of city water reduced 33%

Cost per Gallon of Daily Flow Control

- Irrigation use only
 - $\$5,000 / 1,080 \text{ gal} = \$4.6 \text{ per gal flow control}$
 - Water savings = \$24/yr
- Irrigation and Potable Use
 - $\$15,000 / 1,160 \text{ gal} = \$12.9 \text{ per gal flow control}$
 - Water savings = \$108/yr

Summary

- Deep infiltration can significantly reduce peak flow discharge and total runoff in areas with shallow impermeable soils
- Cisterns equipped with orifices can significantly reduce peak flows
- Irrigation use can reduce total runoff by ~14% and city water use by ~6%
- Irrigation and potable use can reduce total runoff by 79% and city water use of 48%

More Information

J. Scott Kindred, PE
Associate Water Resources Engineer
skindred@aspectconsulting.com
206.838.6589



Bainbridge Island – Mount Vernon – Seattle - Wenatchee

