Practical Considerations for Stormwater Harvesting and Use

Eric Strecker, P.E.
Geosyntec Consultants

Effectiveness of Stormwater BMPs

- Function of:
  - Runoff Patterns
  - Pollutant types and forms
  - Storage Volume/Treatment Rate
  - Hydraulics of recovering storage
    - Deeper infiltration
    - Evapotranspiration
    - Harvest and use (irrigation/toilet flushing)
    - Draw-down/discharge rate
  - Treatment Process for released flows
    - Physical/Biochemical (settling/adsorption filtering, etc.)
  - Operations and Maintenance

Factors Affecting Stormwater Management in Southern (and most of) California

- Weather:
  - Precipitation events arrive in clusters
    - High pressure ridge down, then series of storm until ridge re-established
    - High pressure ridge up – no or very little precipitation for long periods
  - Most rainfall/runoff occurs in December/January/February/March
- Results:
  - Makes harvest and use via irrigation difficult at best
  - Evaporation loss opportunities are limited as well
  - If Infiltration rates slow, then infiltration value is limited

Pelican Hills Resort – A Low-Impact Approach in Southern California

Eric Strecker
Geosyntec Consultants

Sat Tamaribuchi
The Irvine Company

Project Overview

Client Specified Desired Project Water Quality and Hydrology Goals

- No changes in pre/post in hydrology
  - No increase in runoff volume
  - No increase in infiltration
- Show an improvement in water quality
- No irrigation runoff
- Eliminate all runoff to Morning Canyon
- Project area drains to ASBS

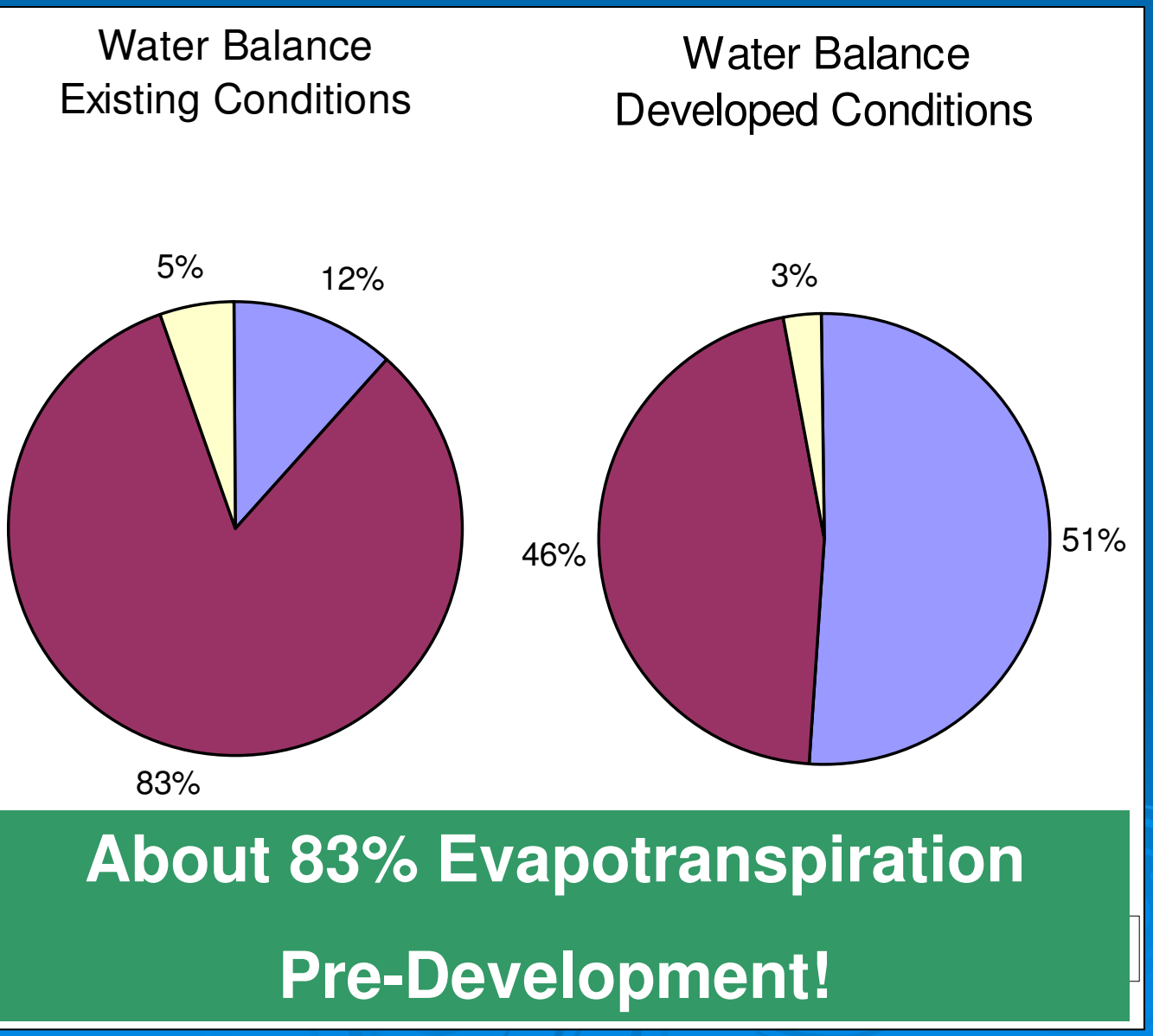
No Change in Hydrology!
(Surface or sub-surface)

- Manage the “ET” Sponge

- Necessitated a detailed analysis of precipitation,
  - runoff,
  - shallow soaking and drying, and
  - deeper infiltration

  to ascertain what conditions to match

Pre- and Post-Hydrology No BMPs
Water Balance -SWMM Model 40+ year record



About 83% Evapotranspiration

Pre-Development!

Evaluated “Standard” LID Approach

- How much of the site would we have to have in biofiltration areas to meet goals?

  With:

  - Various depths of amended, moisture holding soils and
  - Limited but some infiltration.

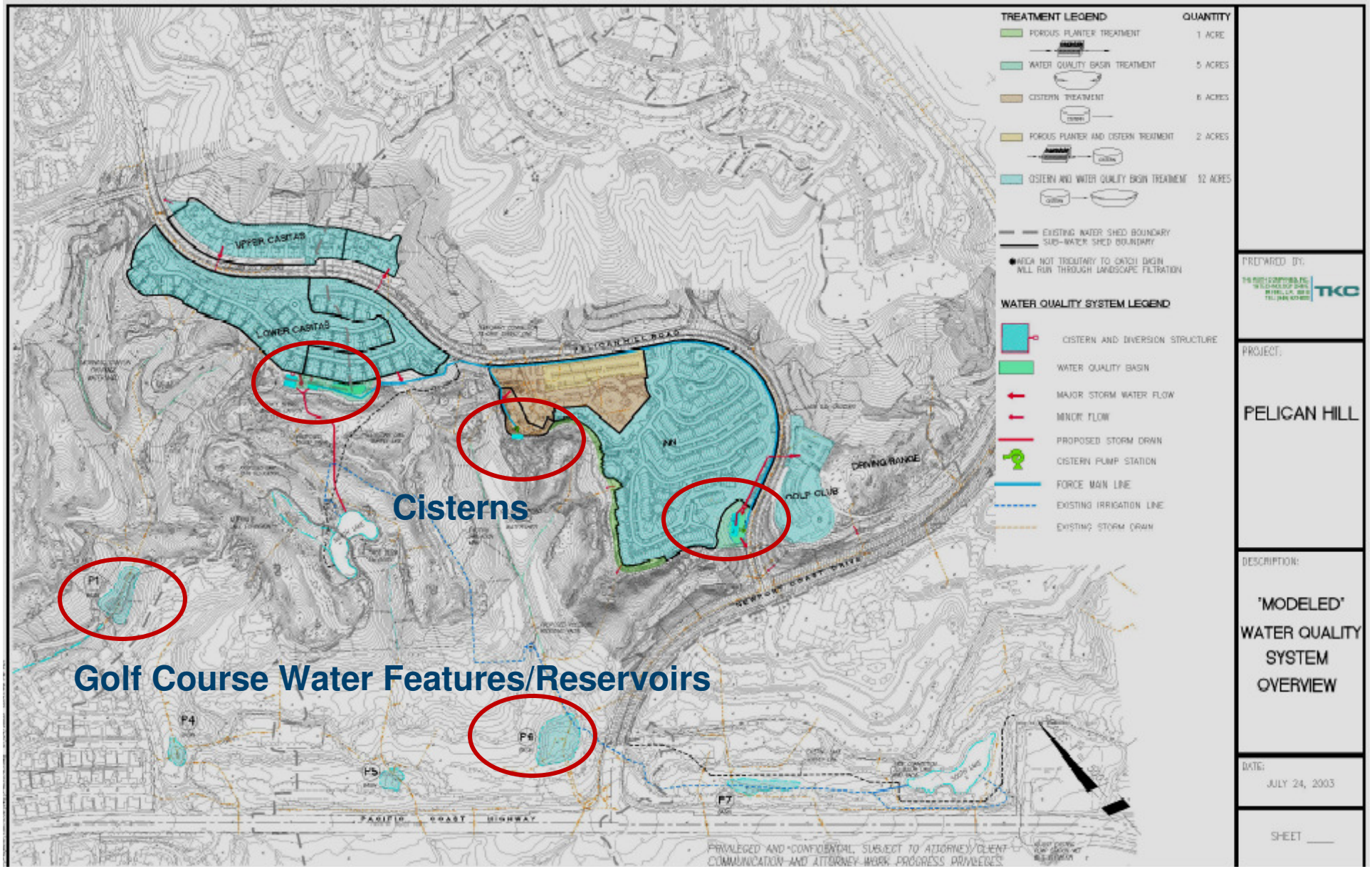
Modeling Assumptions

- Biofiltration systems were modeled for a range of design depths (the resulting volume from a depth of water over the impervious area of the sub-basin).
  - SWMM Model used
  - 40+ year simulation of hourly rainfall
  - Tracked infiltration, evapotranspiration, and surface discharge
- Result = about 30% of the site in 4 ft thick engineered soils biofiltration systems
- Not acceptable behaviour = Plan B Cisterns

What to do with the water?

Golf Course

Pelican Hills Development

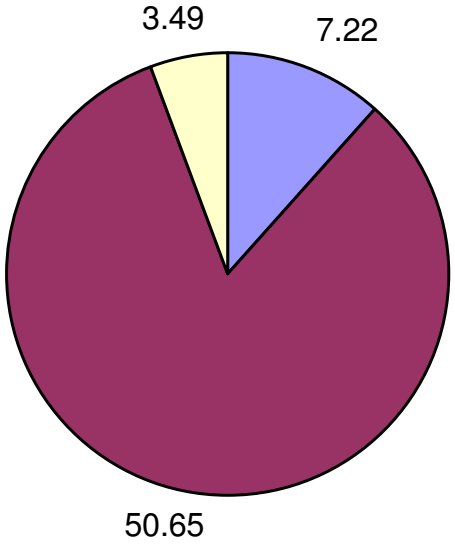


Cisterns

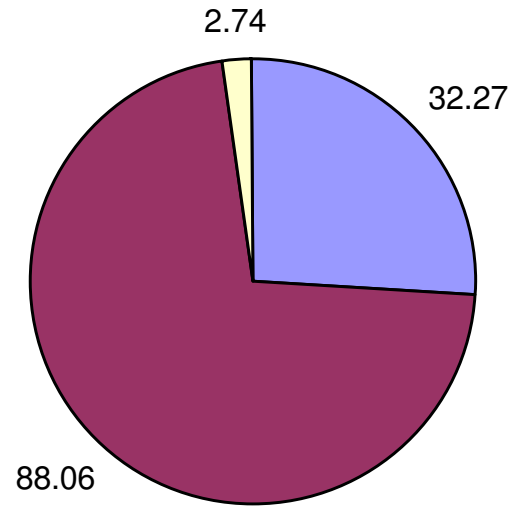
Golf Course Water Features/Reservoirs

Water Balance for All Years Modeled

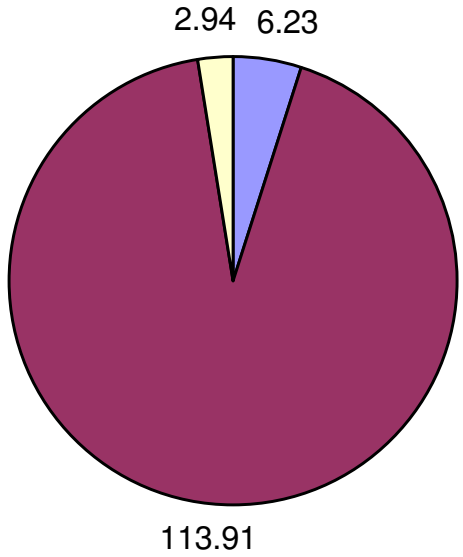
Water Balance
Existing Conditions



Water Balance
Developed Conditions



Water Balance
w/ 10 Day Cisterns & Reservoirs



Runoff Evap & Trans Groundwater

Acre-Feet/per year

Tanks Under Construction and Post

600,000 gallon cistern

Summary

- Water balance would be maintained for the project area with the planned 1.26 inch design depth cisterns and other runoff reducing BMPs.
- Water Quality was enhanced over existing conditions

Summary (cont.)

- Standard LID type controls may not be able to truly match pre-development surface hydrology, unless infiltration volumes are much higher than natural and/or a very large portion of the site is available for LID
- Captured runoff replaced about 20 percent of average annual reclaimed water use – no potable water demand reduction
- We need to improve guidance on LID Hydrology using appropriate hydrologic methods to look at surface and groundwater hydrology

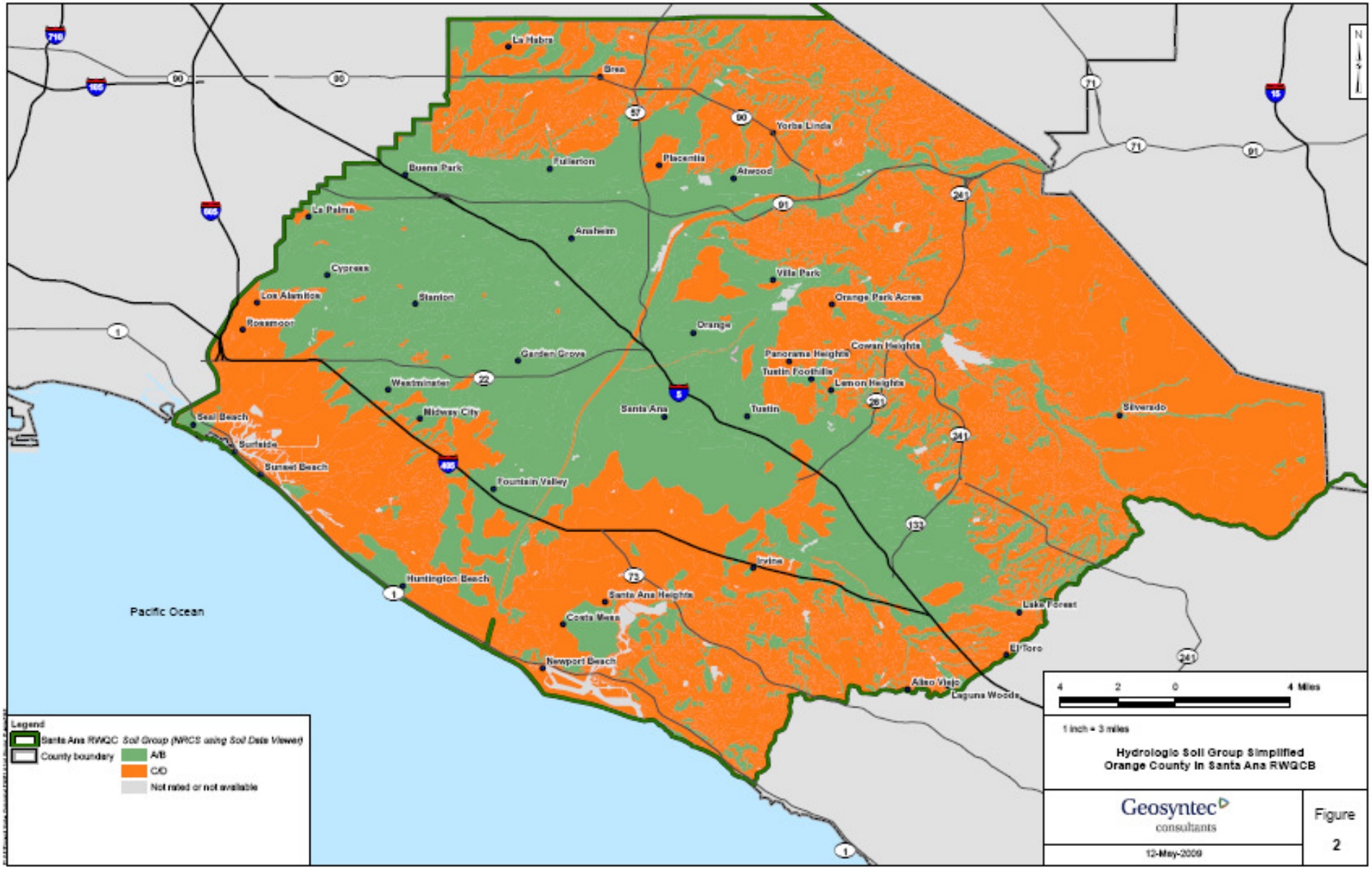
Retain on site - Choices

- Infiltrate
- Evapotranspirate
- Harvest and Use

Infiltration

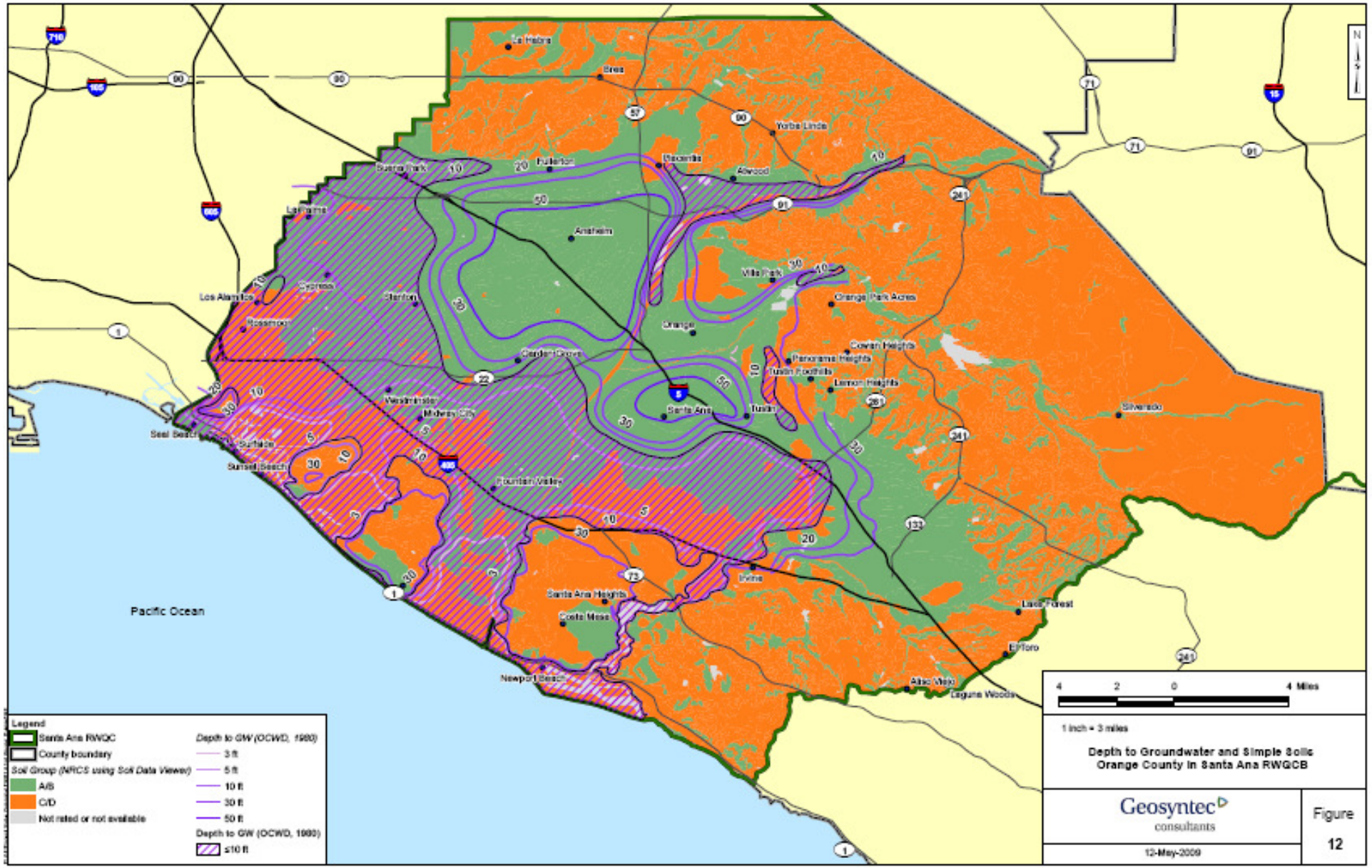
- Can you do it?
- Should you do it?
- If you do, do it carefully.

North Orange County
(Green areas are A+B Soils)

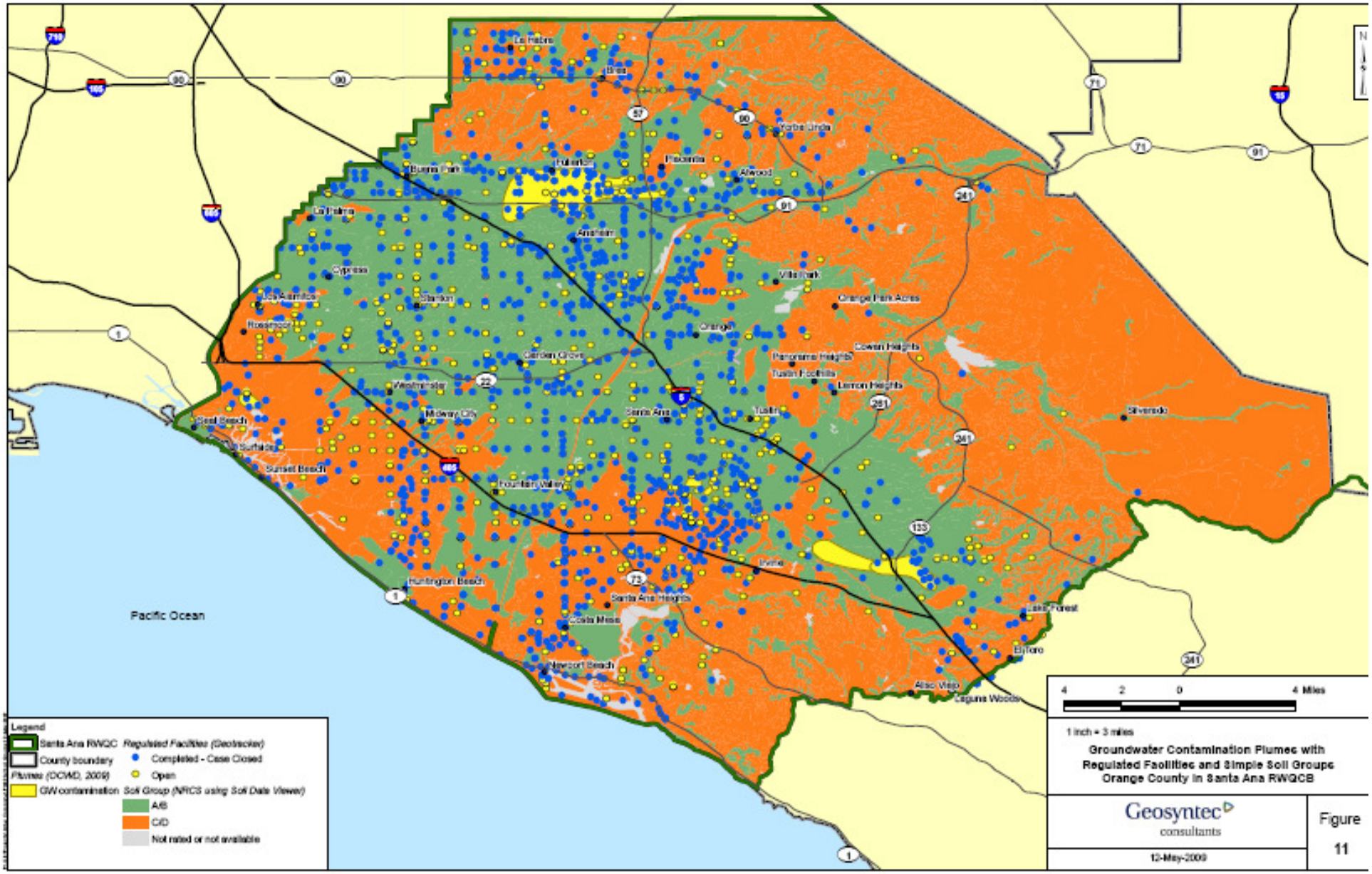


North Orange County

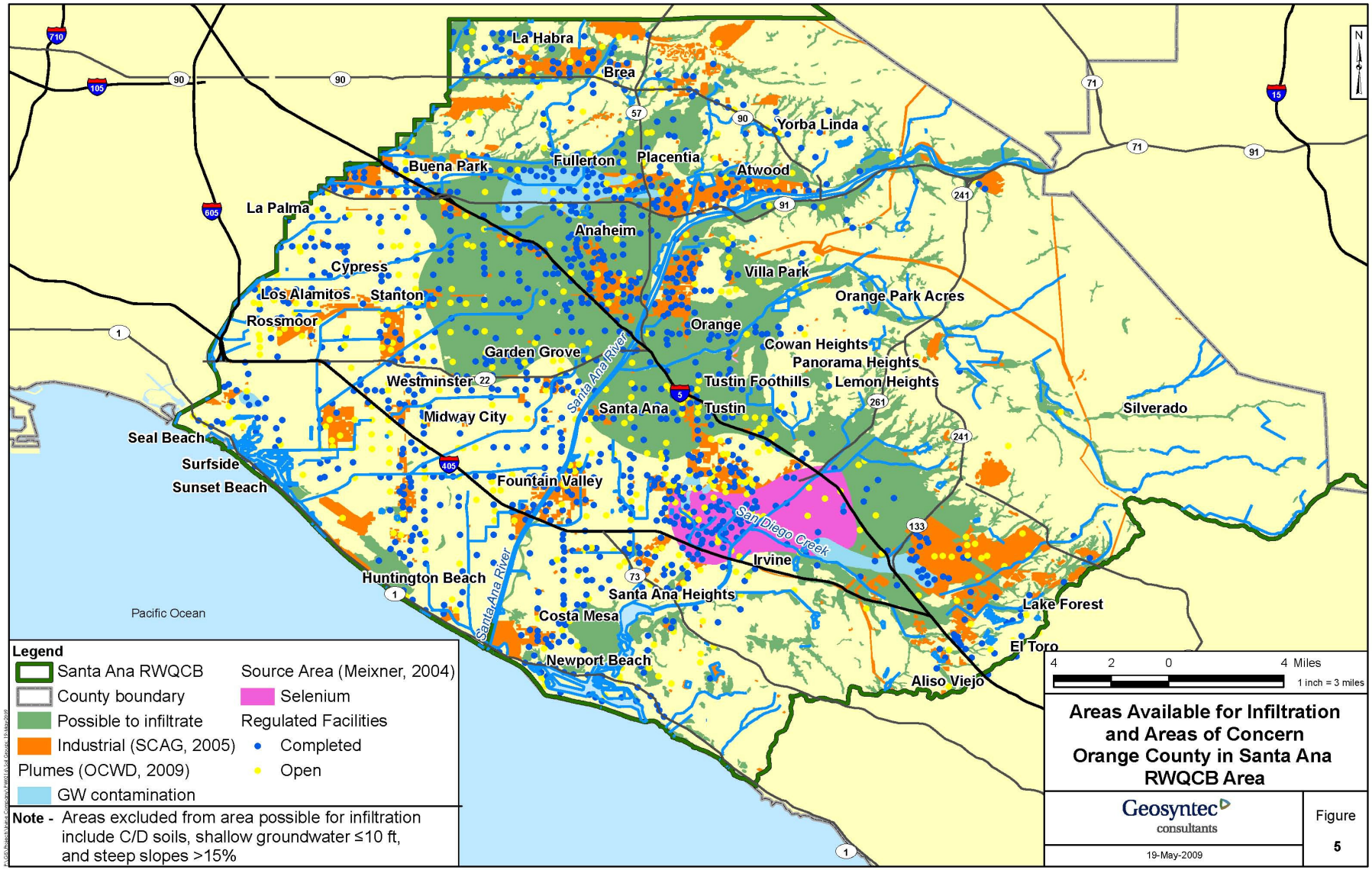
(Green areas -A+B Soils + Hatched 10 feet or less Depth to GW)

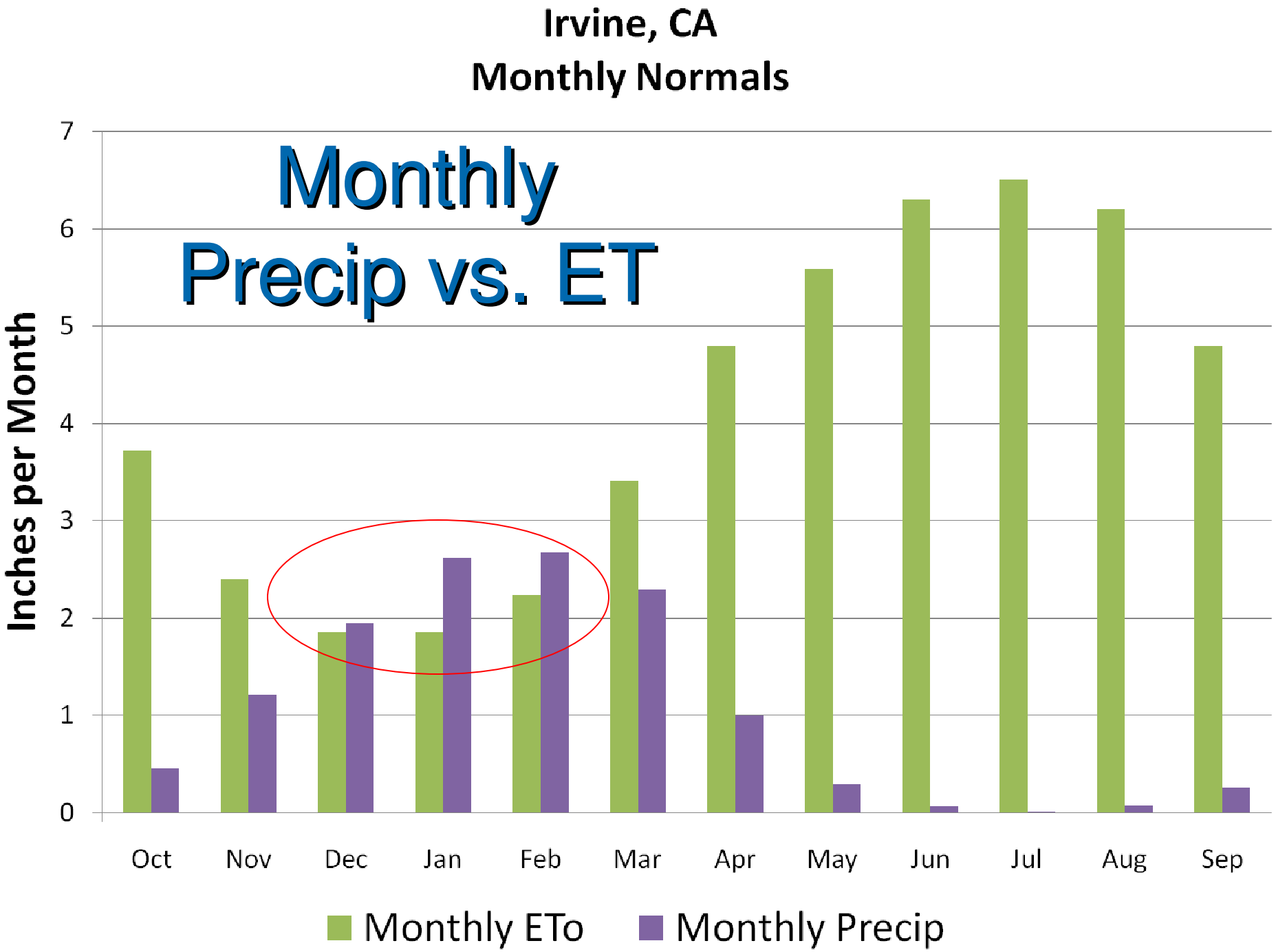


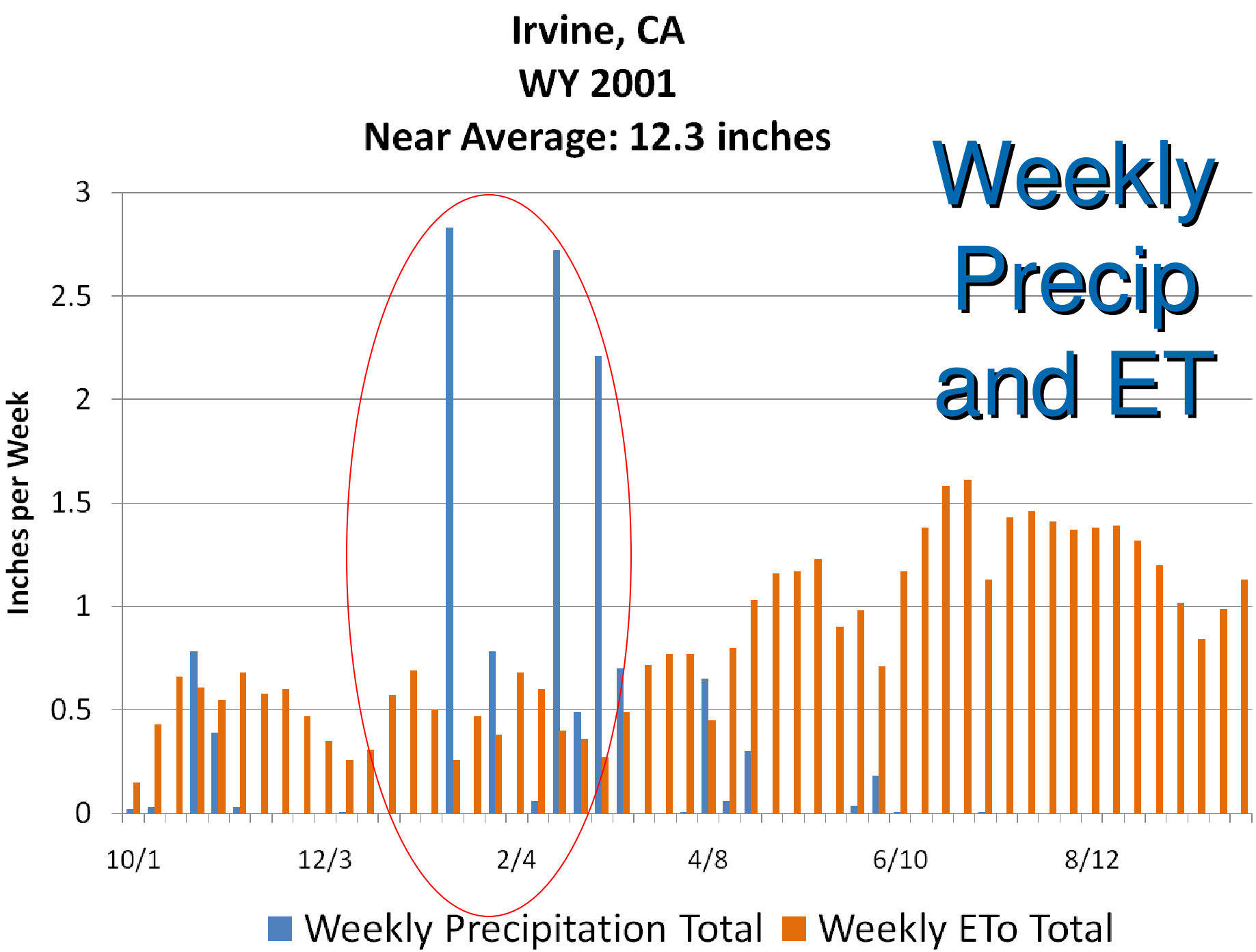
North Orange County
(Green A+B Soils + Contaminated Sites/Plumes)



Contaminated Soils/Plumes, Depth to GW + A/B + Steep Slopes

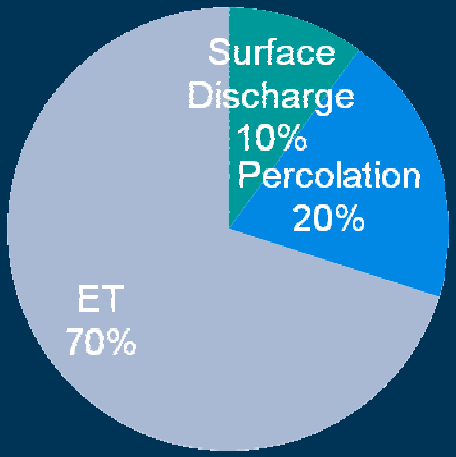



Irvine, CA
Monthly Normals
Monthly
Precip vs. ET
Inches per Month
7
6
5
4
3
2
1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Monthly ETo
Monthly Precip


Irvine, CA
WY 2001
Near Average: 12.3 inches
Weekly Precip and ET
Inches per Week
3
2.5
2
1.5
1
0.5
0
10/1
12/3
2/4
4/8
6/10
8/12
Weekly Precipitation Total
Weekly ETo Total

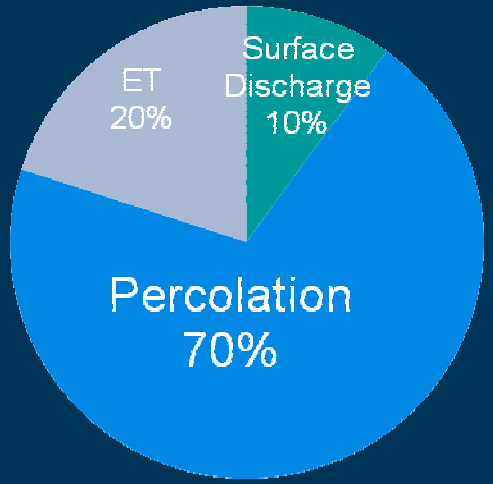
General Water Balance Impacts

Natural Conditions - Semi-Arid Climates

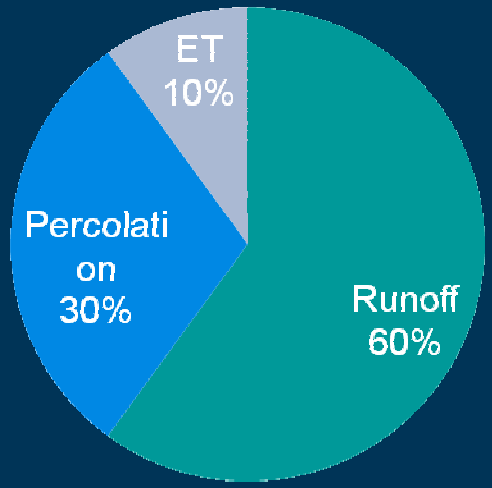


ET fraction estimated as 83-97% in Southern California Chaparral.[1]

Example Developed with LID (no underdrains)



Example Developed with LID (with underdrains)



[1] Ng and Miller (1980) *Soil Moisture Relations in the Southern California Chaparral.* Ecology, Vol. 61, No. 1. (Feb., 1980), pp. 98-107

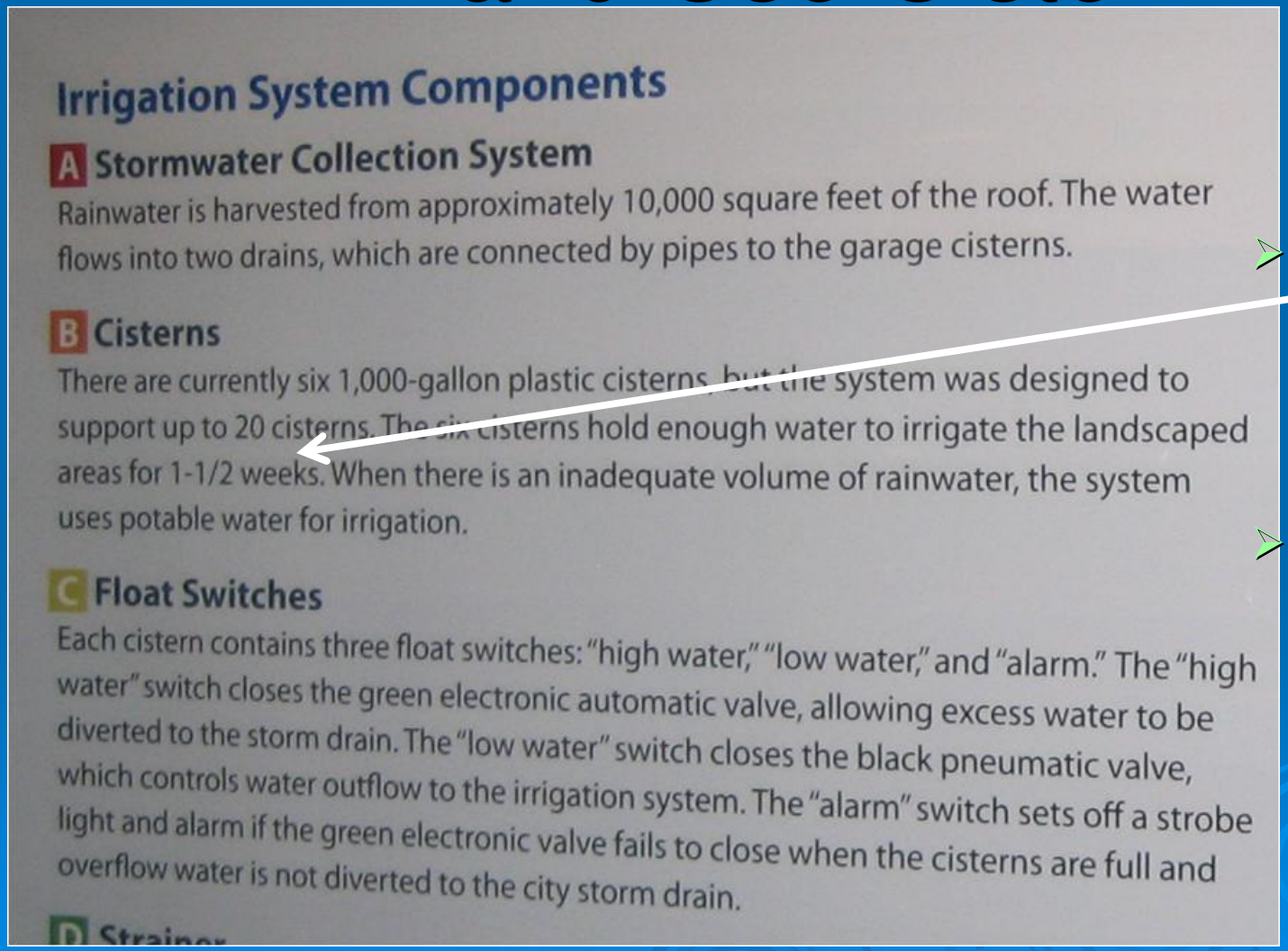
Harvest and Use (re-use)

- Key factors for success of harvest and use:
  - Having a use for the water: irrigation, toilet flushing, process water
  - Being able to use the water: Code issues/human health
  - Being able to use the water fast enough to recover storage (due to back-to-back storm events) so that subsequent storms are captured and overall capture meets goals
  - Replacing reclaimed?

EPA Headquarters'- Harvest and Use Cistern

- Visited on April 28th, 2009 (about 80 degrees that day)
- Cisterns were empty as flows were being bypassed due to lack of irrigation demand

EPA Headquarters'- Harvest and Use Cistern



Irrigation System Components

A Stormwater Collection System

Rainwater is harvested from approximately 10,000 square feet of the roof. The water flows into two drains, which are connected by pipes to the garage cisterns.

B Cisterns

There are currently six 1,000-gallon plastic cisterns, but the system was designed to support up to 20 cisterns. The six cisterns hold enough water to irrigate the landscaped areas for 1-1/2 weeks. When there is an inadequate volume of rainwater, the system uses potable water for irrigation.

C Float Switches

Each cistern contains three float switches: "high water," "low water," and "alarm." The "high water" switch closes the green electronic automatic valve, allowing excess water to be diverted to the storm drain. The "low water" switch closes the black pneumatic valve, which controls water outflow to the irrigation system. The "alarm" switch sets off a strobe light and alarm if the green electronic valve fails to close when the cisterns are full and overflow water is not diverted to the city storm drain.

D Strainer

- 6 Tanks store about 1" of rainfall from roof
- About 9 to 10 days to drain the tanks when full
- Likely that significant amount of runoff bypasses the tank when tanks on-line

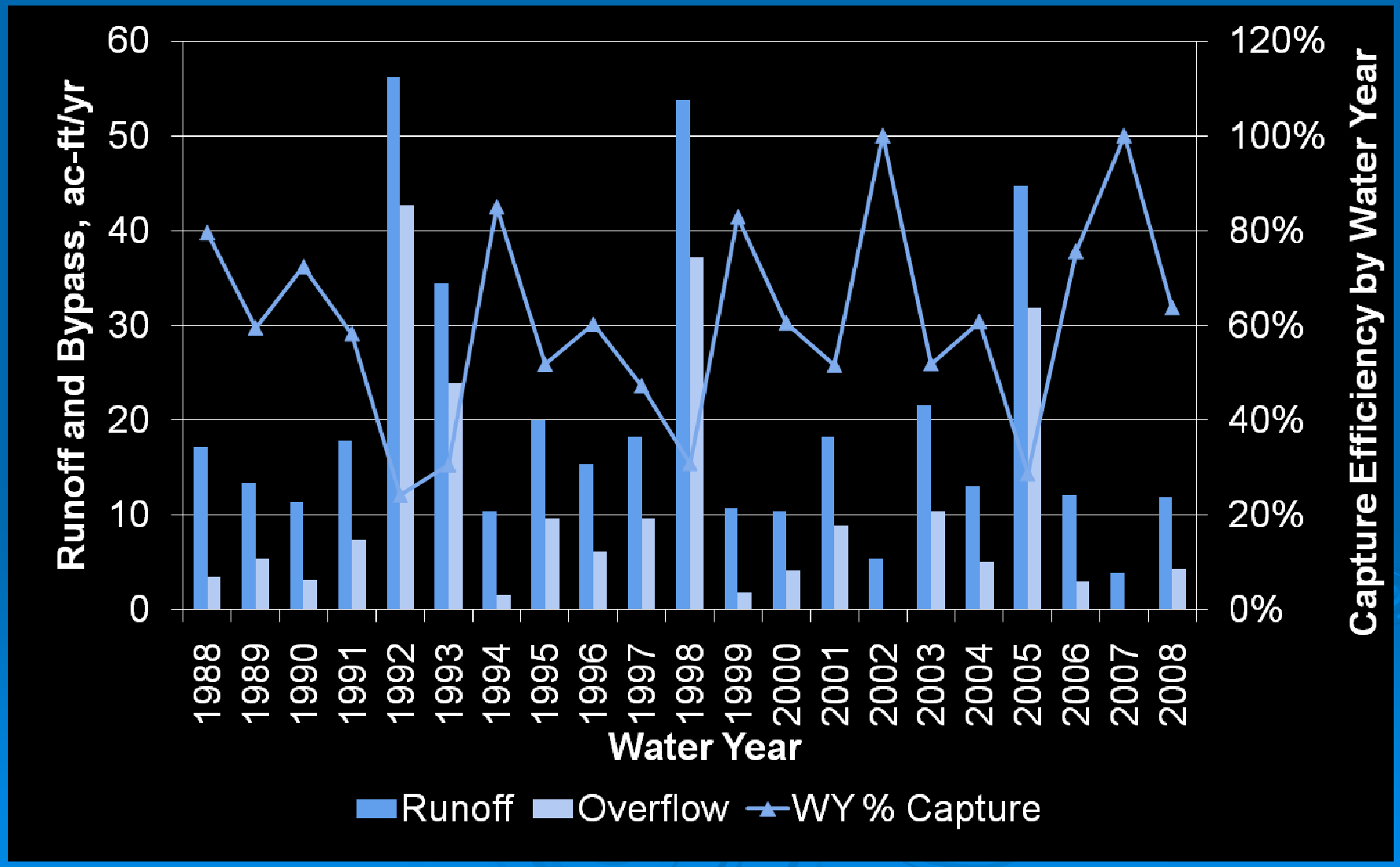
Example Cistern Scenario & Modeling Inputs

- 100 ac Residential Catchment @ 60% impervious
- Tank sized to DAMP (0.8” storm) = 1.3 MG
- Indoor non-potable demand (Toilet Flushing) = 65 gpd/du, assumed 4.5 du/ac
- Outdoor ET demand = monthly average ETo x assumed 30 ac of irrigated area (irrigation always on regardless of rainfall)
- Rainfall and Eto data from Irvine CIMIS station (WY 1988-2008), ETo simulated as monthly averages (not normals)

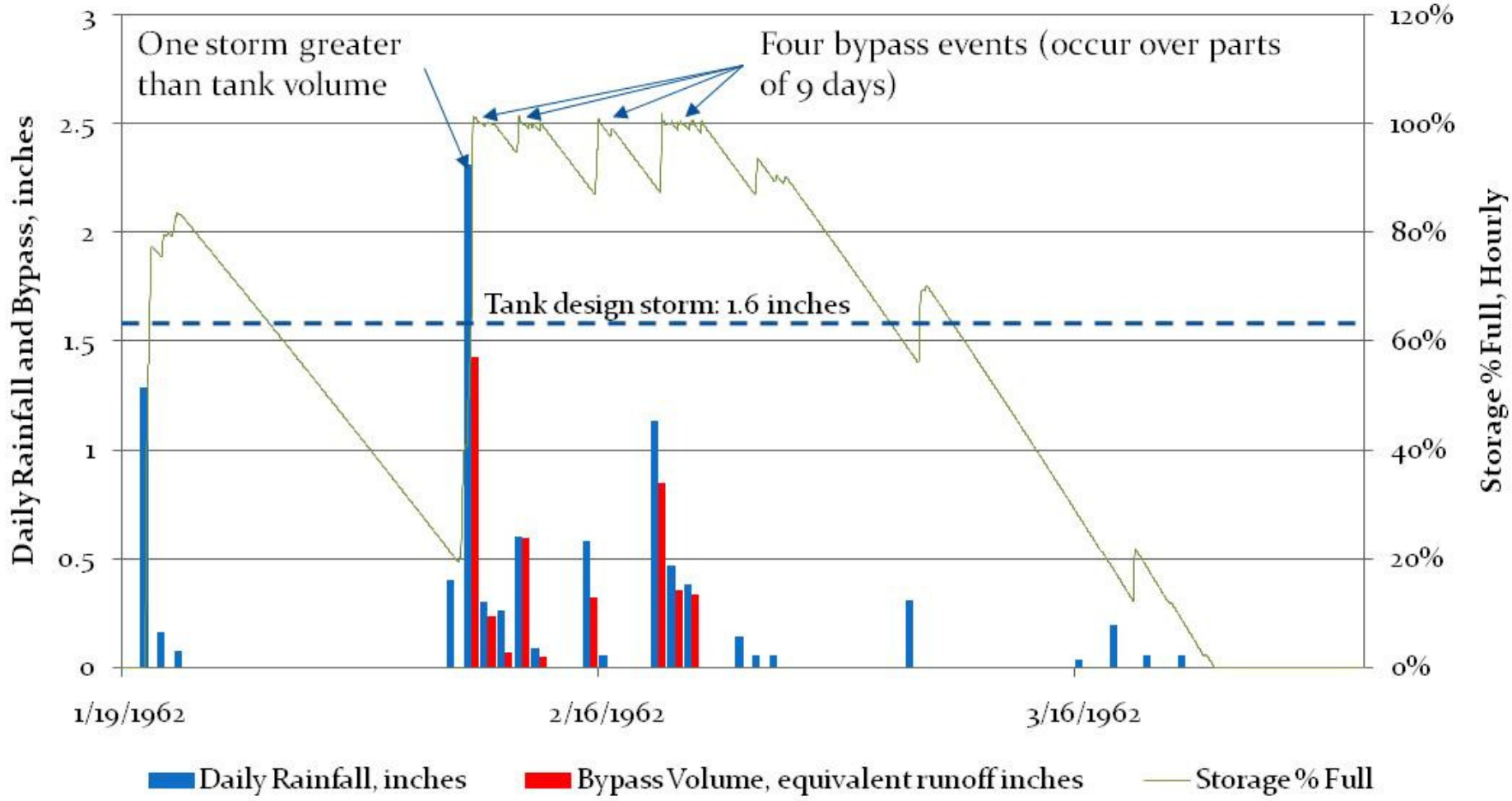
Modeling Results

- Overall capture efficiency = 48%
- Capture efficiency for individual water years ranges from less than 30% to 100%
- Potable water demand reduction – about 3 to 4%
- Doubling tank size (to 1.6 inches = 2.6 million gallons up capture to about 58% and potable demand reduction of about 7 to 8%
- Following charts illustrate temporal patterns of tank storage conditions and bypass conditions

Individual Water Year Performance



Capture and Reuse - Effect of Sequential Storms (100 acre residential development with Cistern = 1.6 inches of runoff -2.6 Million Gallons and use for irrigation and toilet flushing

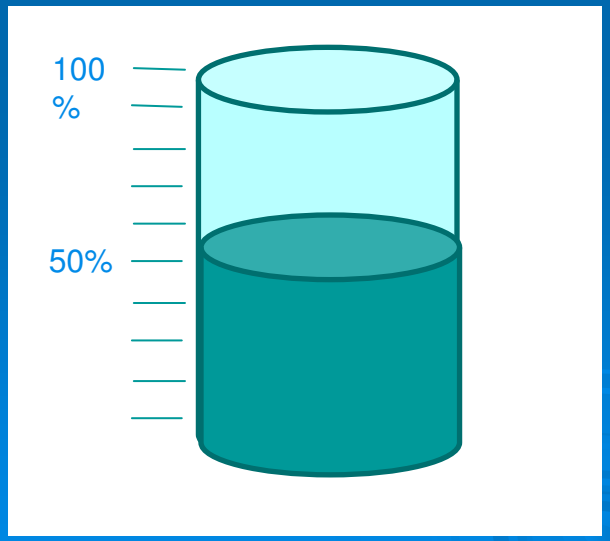


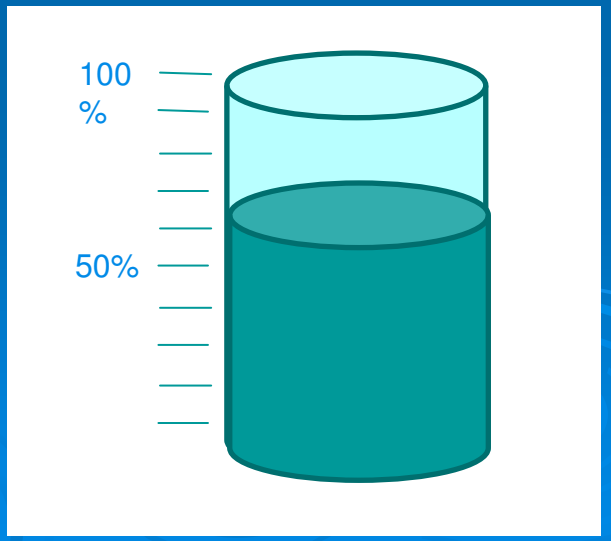
Tank volume = 1.6 inch design storm (2x DAMP);
Reuse demand = residential toilet flushing + irrigation of 30% of watershed at monthly avg ETo continuously (before, during and after rainfall)

Pollutant Loading/Concentration Example

- Example 100-acre residential development with 0.8 inch (OC DAMP size) Cistern and use for irrigation and toilet flushing
- Results – Bioretention with underdrains showed better TSS loading reductions

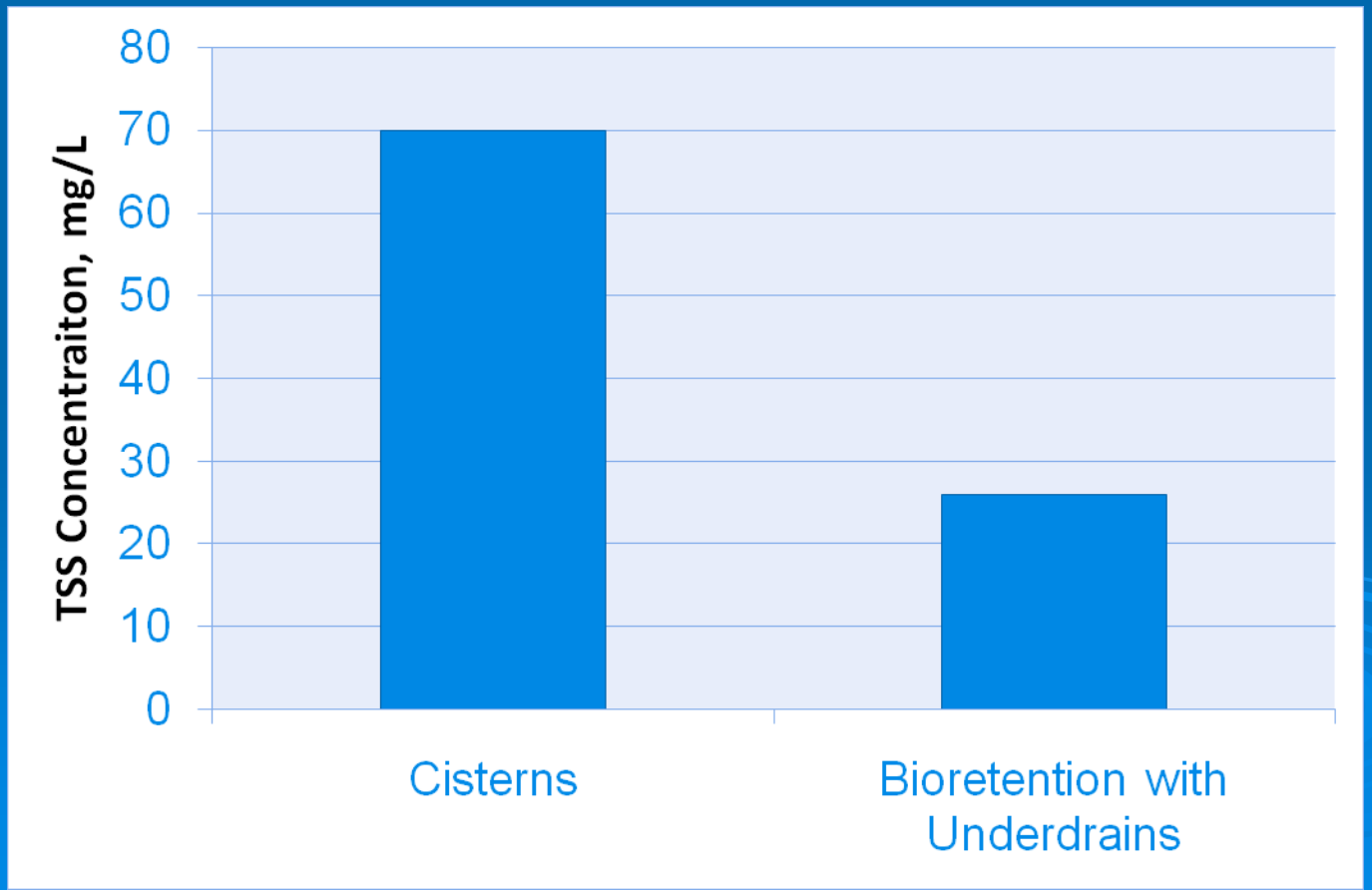
Cisterns and Re-Use: **55%** Bioretention with Underdrains: **63%**





Pollutant Loading/Concentration Example

Results – Biotention with underdrains had lower average concentrations



Stormwater Capture/Harvest and Use

- Must drain tank relatively fast (similar to Extended Detention/Infiltration System Drawdown rates)
- Irrigation uses are limited:
  - Seasonal issues
  - “Zeroscaping” encouragement/requirements
  - Competition with reclaimed water
- Toilet flushing possible with high enough densities (TUTIA – Toilet Users To Impervious Area Ratio)
  - Competition with reclaimed water
  - Low flush toilets?
- Combine with Grey Water Systems?
  - Positives of using infrastructure better

Rainwater harvesting and Reuse Systems

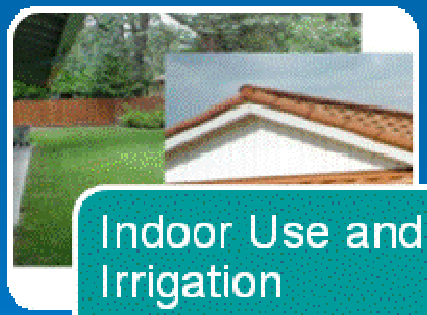
Impervious Area
- Roof tops
- Driveways
- Streets

Stormwater Conveyance and Pretreatment
- Pipes
- Filters

Storage
- Cistern
- Storage Basin
- Underground Vault

Treatment
- UV treatment
- Filtration

Pumping and Piping
- Pipes back to house (purple)



Indoor Use and Irrigation
- Toilet flushing
- Yard and Garden irrigation

Sustainability? Carbon Footprint?

Summary/Recommendations

- Infiltration is not broadly feasible, effective and/or desirable (maximize where appropriate- i.e. Central Valley, Inland Empire)
- Harvest and use of runoff due to runoff patterns and ET potential has limited applications where it can be effective (should be considered for where it is effective- i.e. Pelican Hills Resort)
- There needs to be more technical vetting of retain on site and stormwater harvest/use before these approaches are made mandatory or otherwise pursued