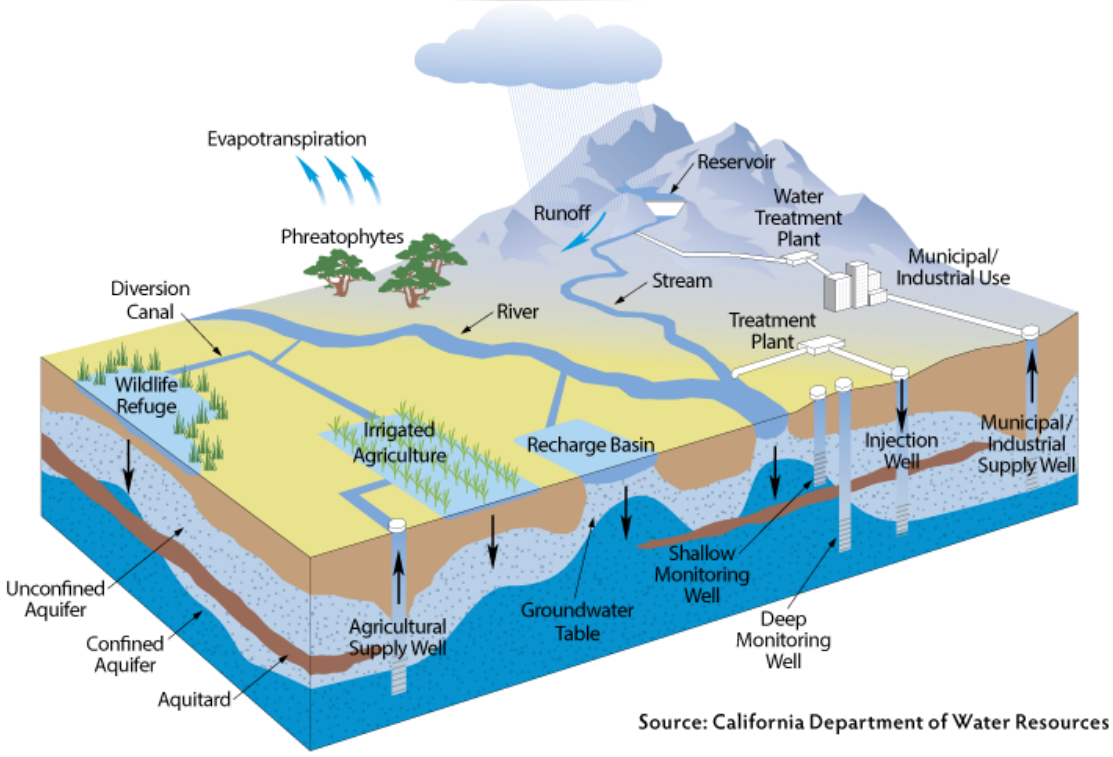
USING DEEP INFILTRATION AND DRYWELLS FOR GROUNDWATER RECHARGE



Source: California Department of Water Resources

Presenter

James Mayer, M. ASCE

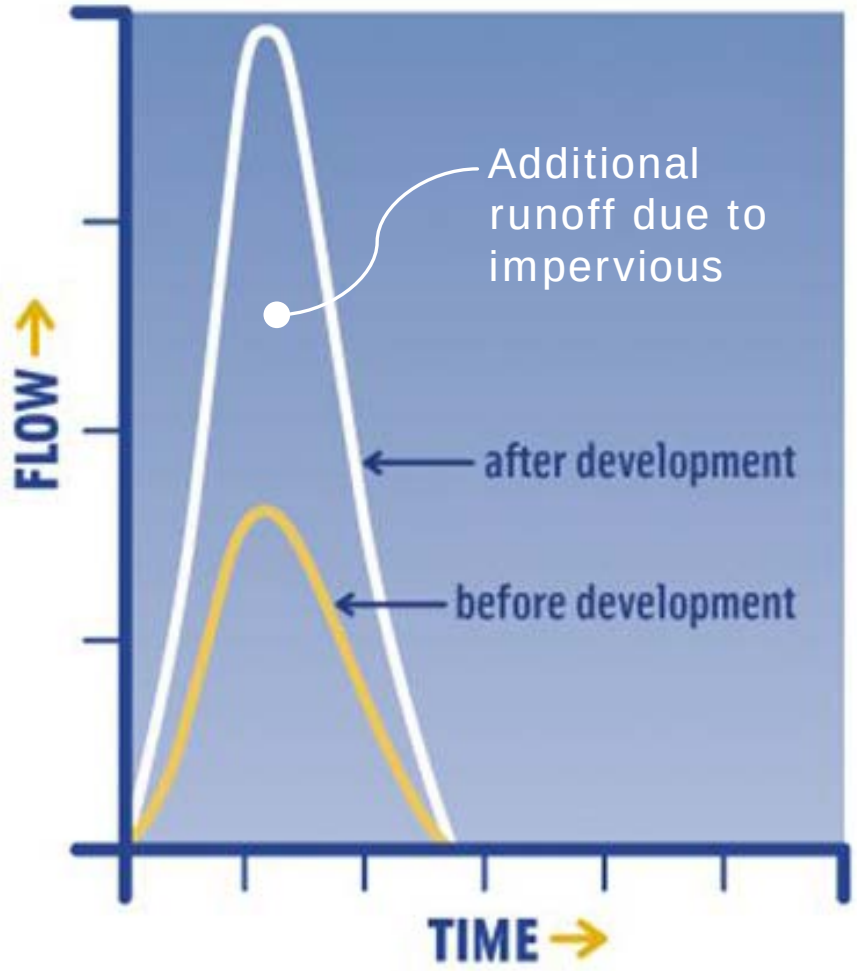
- Engineering/Development Industry since 1994
  - City Engineering Department
  - Civil Consultant/PM
  - Real Estate Developer/PM
  - Design/Build Contractor/PM
  - Technical Marketing Manager

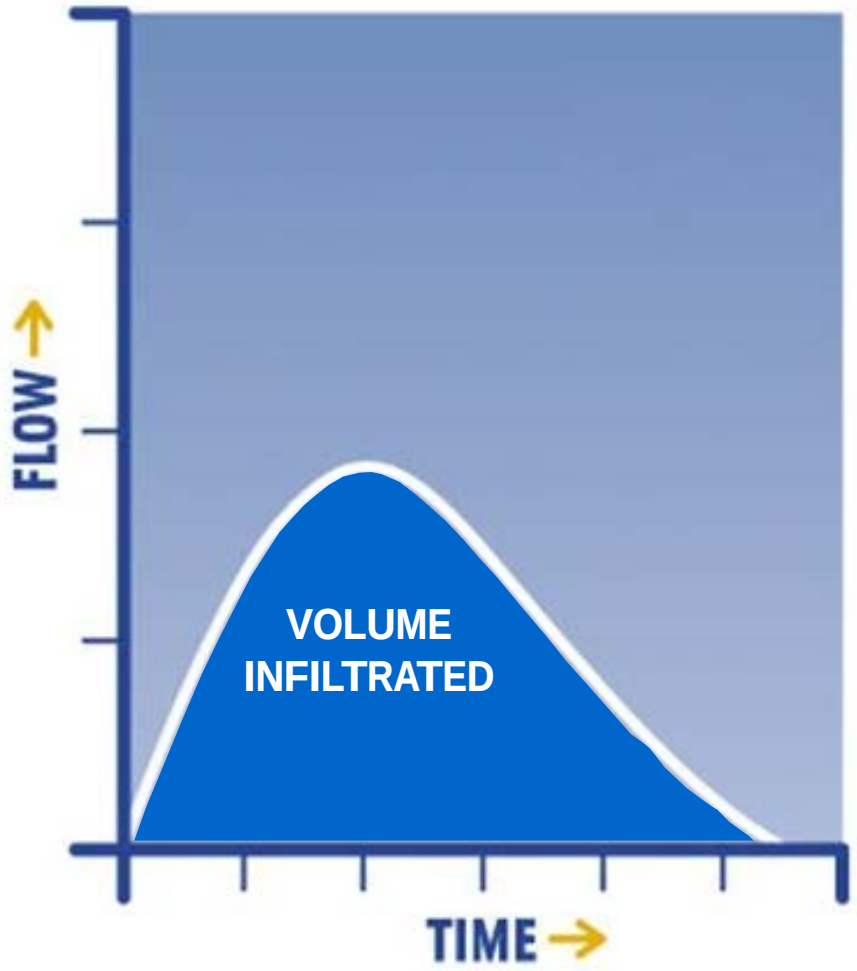
Drywell Experts

- Employee owned stormwater management company
- Started as a drilling company in 1972
- General Engineering Contractor – offices in Phoenix, AZ, Bloomington, CA, and Fairfield, CA
- Licensed in AZ, CA, NM, NV, OR, WA, TX, and MT
- Specialize in the design and installation of drywells for stormwater infiltration
- Only install and maintain drywell systems
- Revolutionized the drywell industry with the ***MaxWell®***
- More than 80,000 installations in the west

Stormwater 101

- **The Impact of Development**





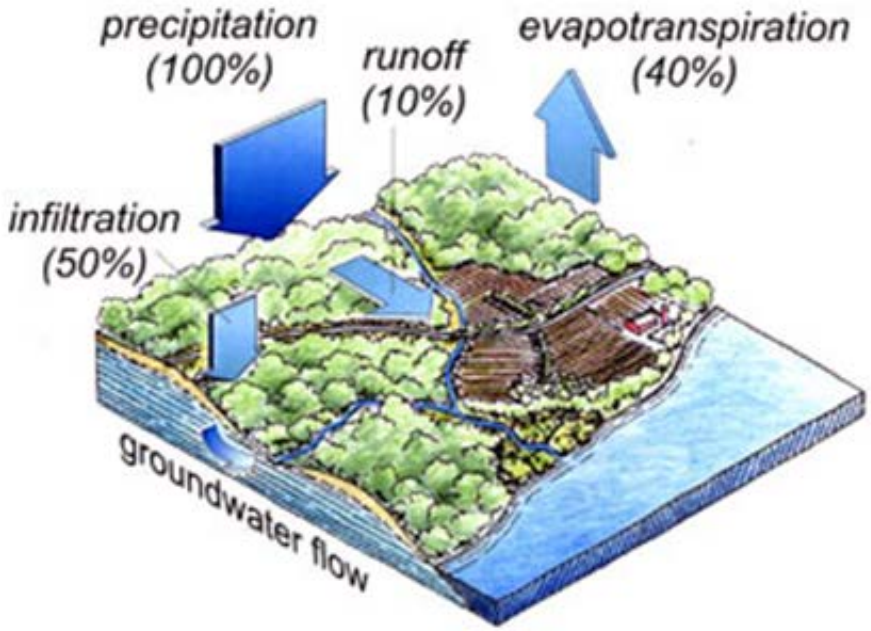
Stormwater 101

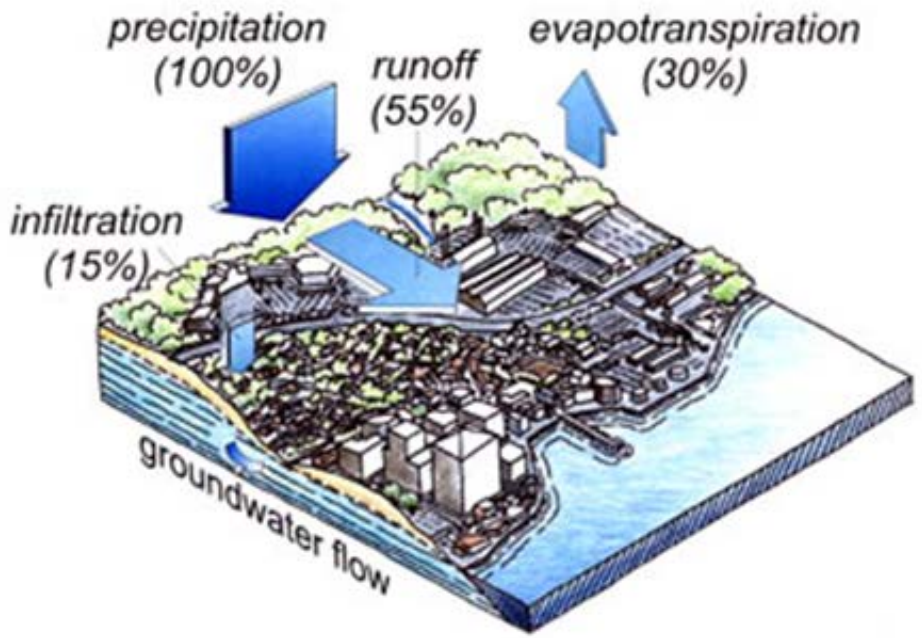
RUNOFF

45%
INCREASE

35%
DECREASE

INFILTRATION

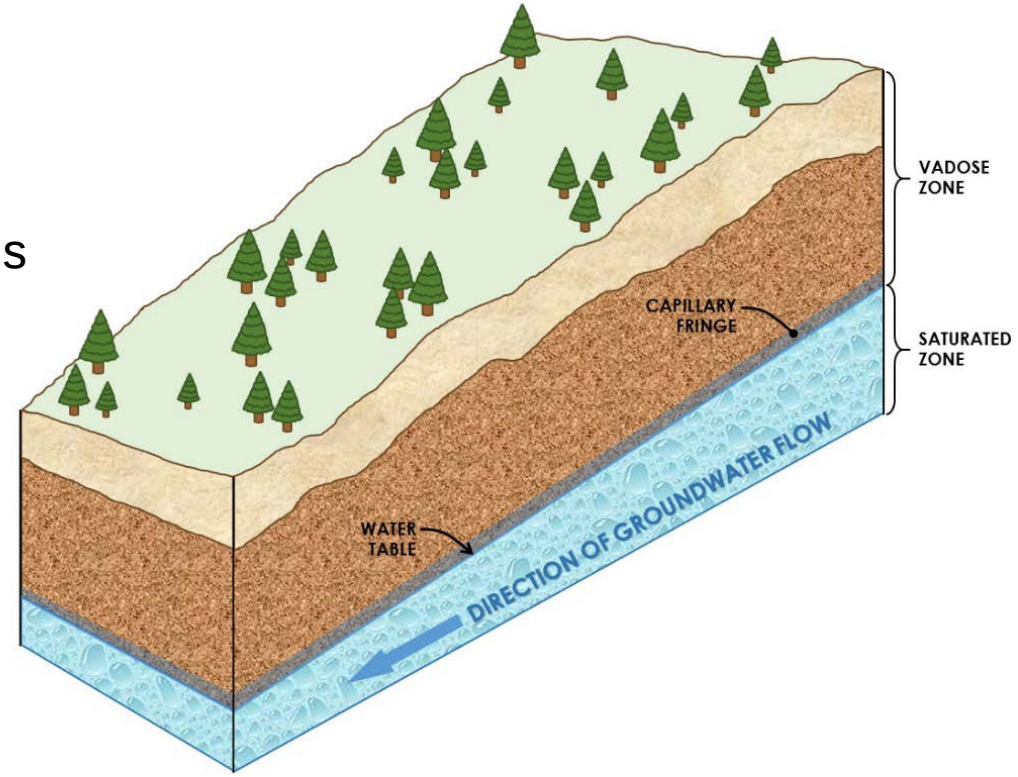




Both additional runoff and less infiltration can be big problems…

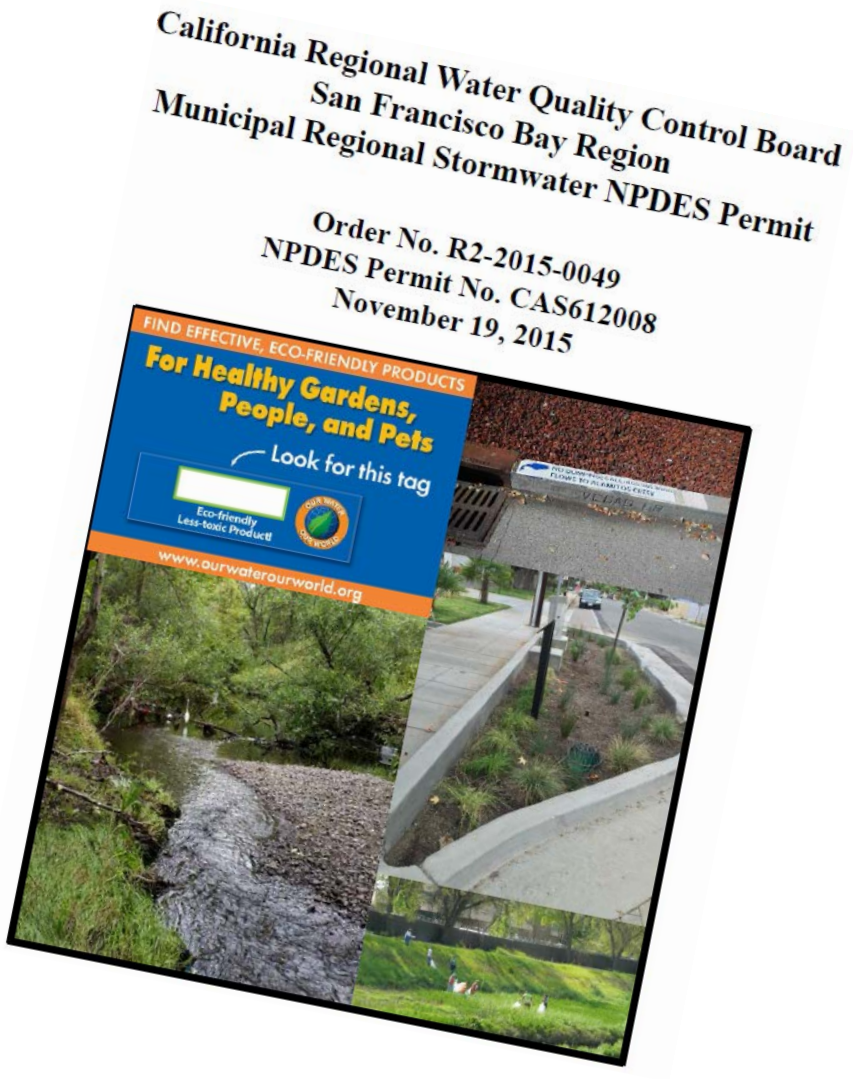
Stormwater 101

- **Managing Stormwater**
  - Old way
    - Grade to drain off site
    - Creates downstream problems
  - New way
    - Catch rain where it falls
      - Capture
      - Treat
      - Infiltrate
    - Mimic pre-development hydrology



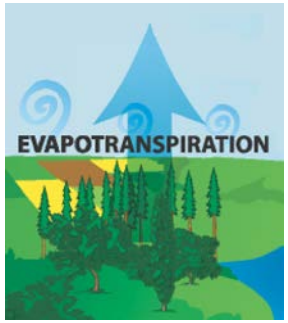
Stormwater 101

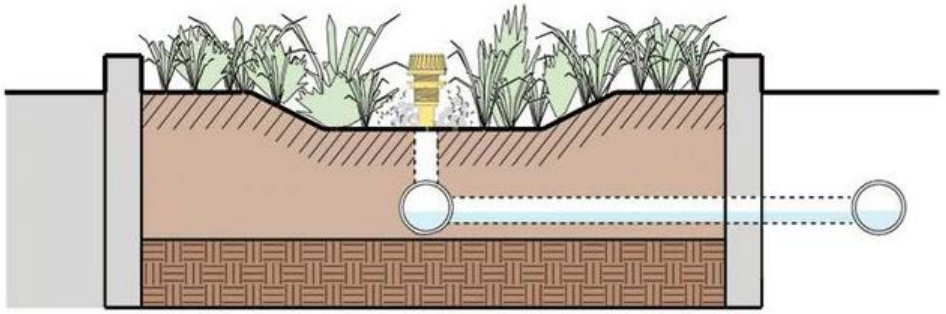
- **Provision C.3 (typical)**
  - **Project Types**
    - New development projects
    - Redevelopment projects
    - Special projects
    - Road projects
  - **Project Thresholds**
    - Size
    - Percent
  - **“Regulated Project”**



Stormwater 101

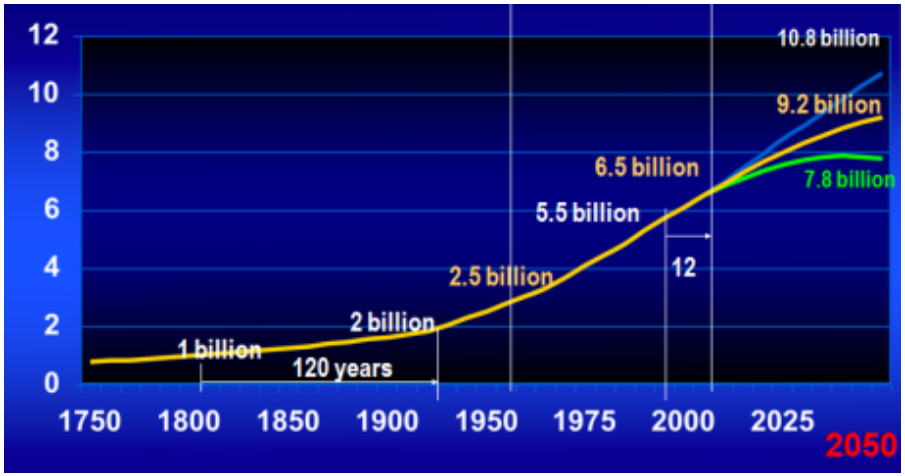
- **Most Current Regulations Require**
  - **Infiltration**
  - Harvest/use
  - Evapotranspiration
  - Biofilter/discharge





Why Infiltrate?

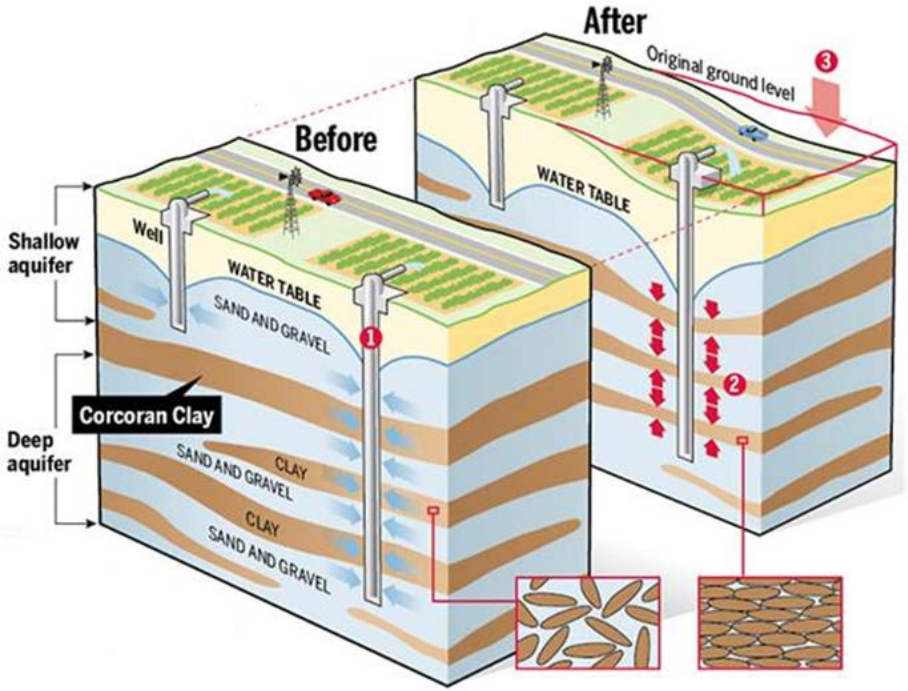
- Droughts come and go
- Take advantage of wet years
- Use aquifer as a storage tank



Why Infiltrate?

SUBSIDENCE

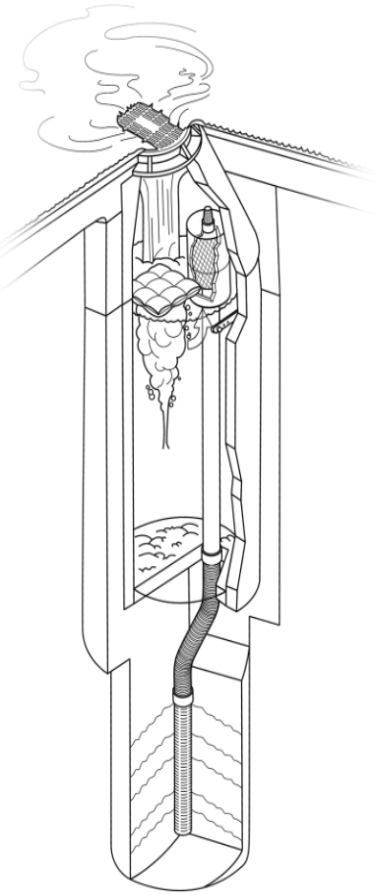
- Result of groundwater withdrawal
- Agricultural uses limit infiltration
- Infiltration can reduce further subsidence

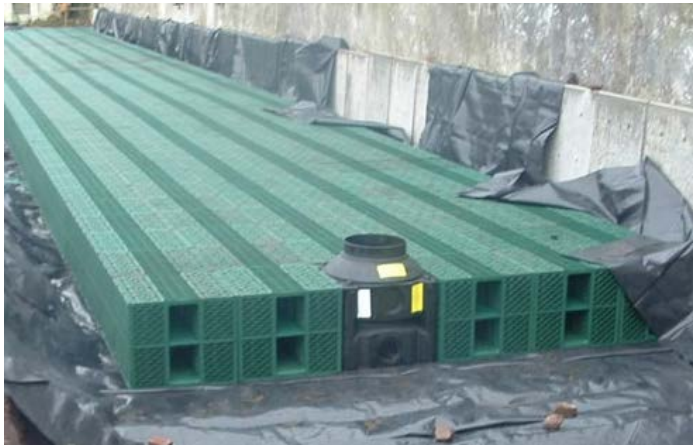


Santa Rita Bridge, Merced, CA

Getting Stormwater in the Ground

- **Types of Infiltration Systems**





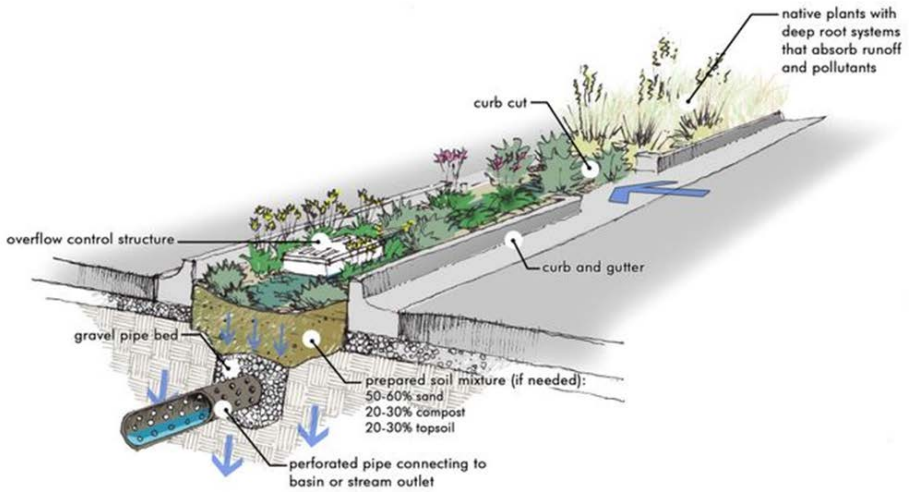
Shallow **Deep**

Shallow Infiltration Systems

- **Proprietary Infiltration Systems**
  - Ideal for well drained shallow soils
  - Acts as storage and infiltration
  - Helps with earthwork
  - Pre-treatment critical

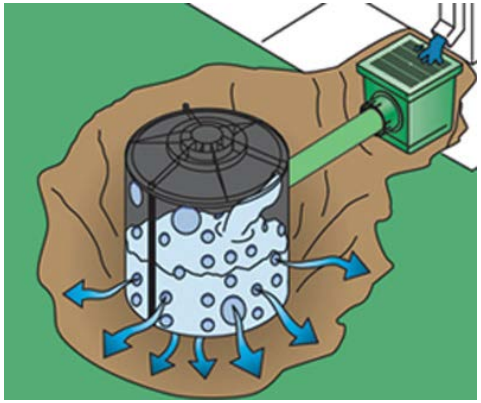
Shallow Infiltration Systems

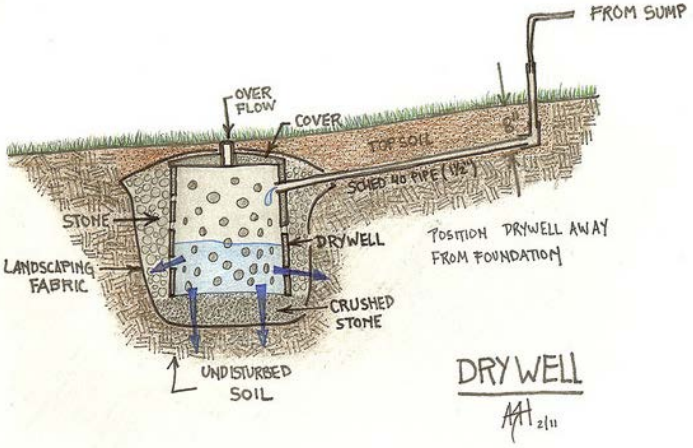
- **Natural Shallow Infiltration**
  - Bioswale
  - Rain garden
  - Infiltration trench
  - Amended soils

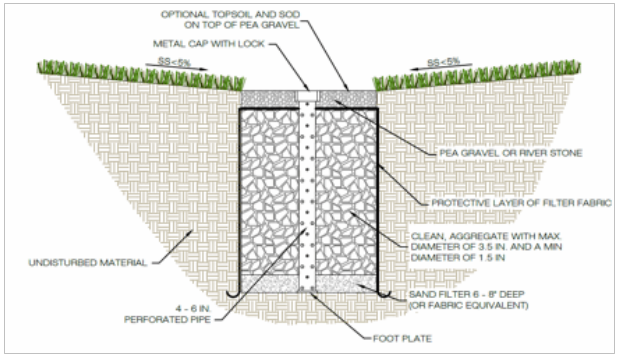


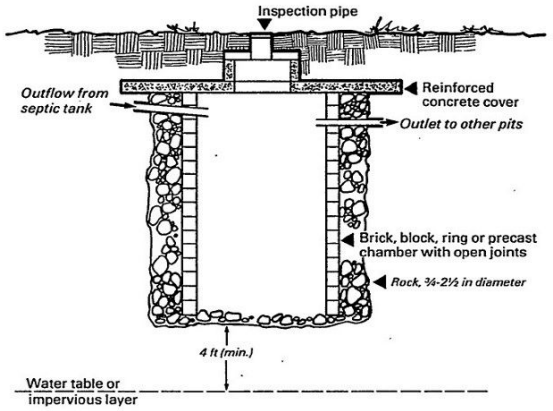
Deep Infiltration Systems

- **Drywells designs vary greatly**
  - Simple
  - No pre-treatment
  - Short life



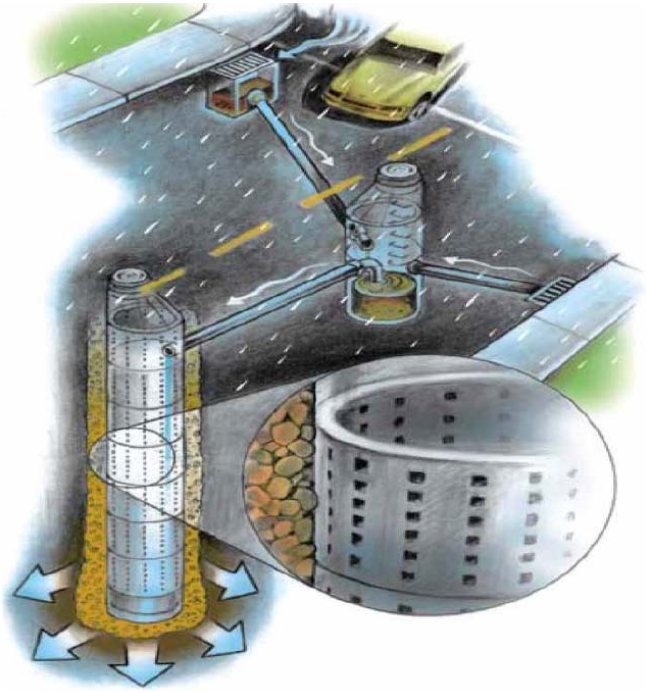


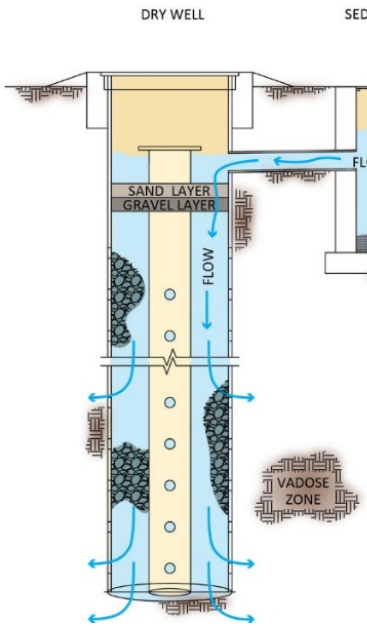


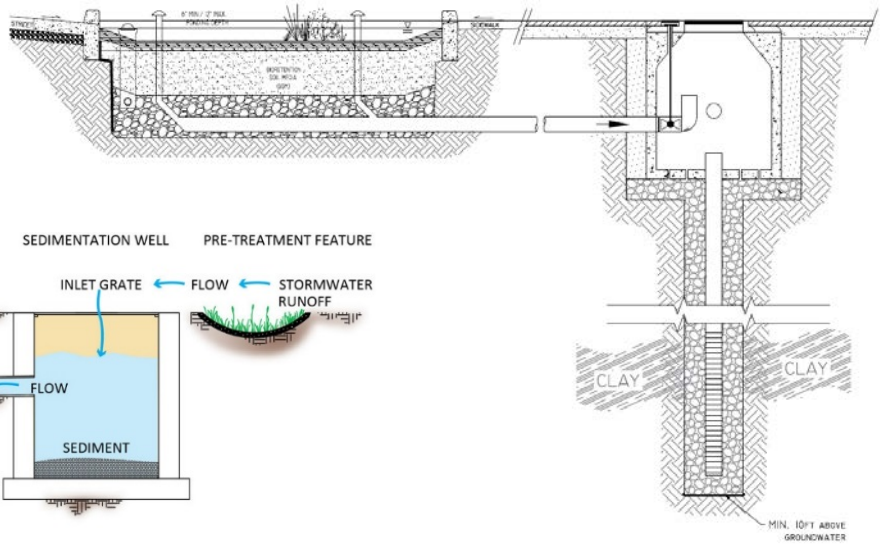


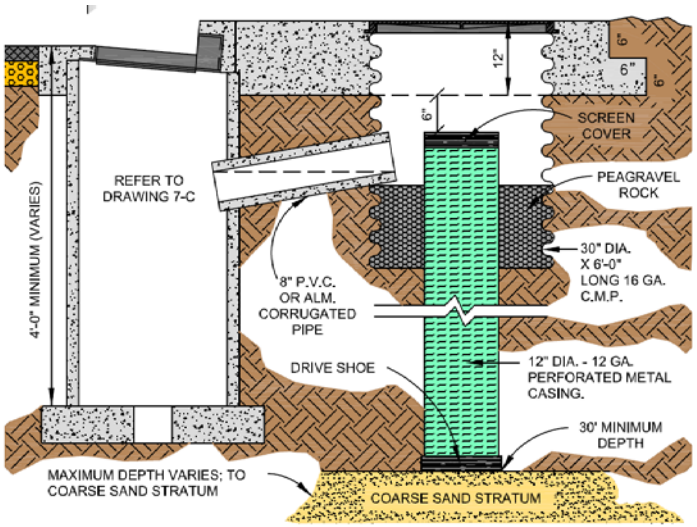
Deep Infiltration Systems

- **Drywells designs vary greatly**
  - Complex
  - With pre-treatment
  - Long life



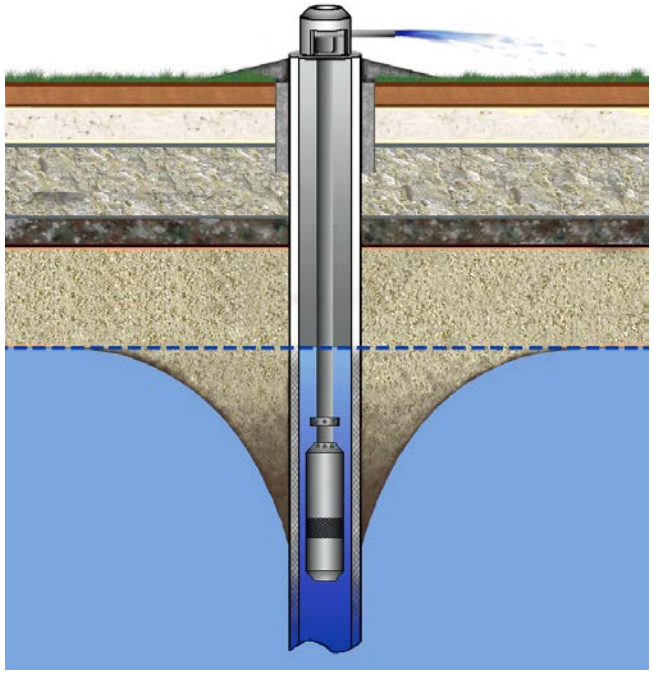


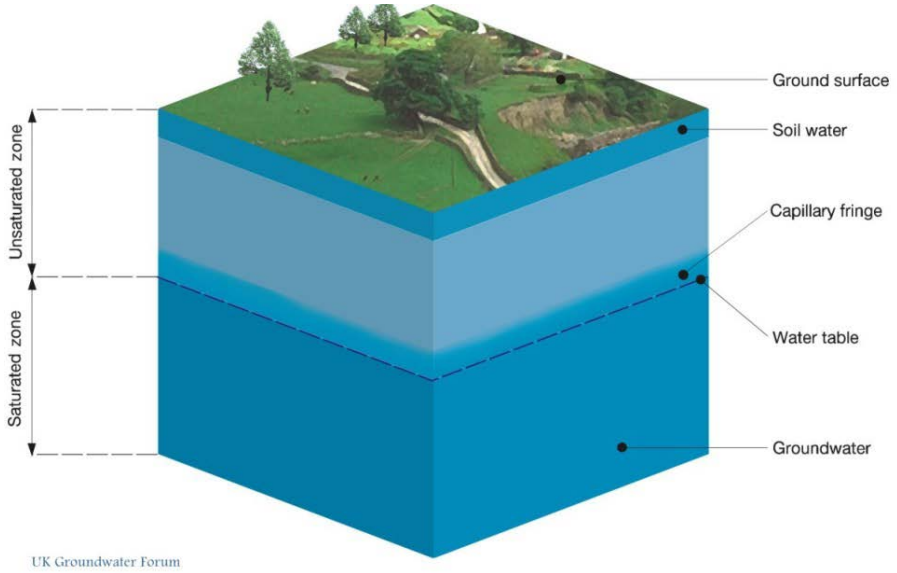




Choosing a Drywell

- **Things to identify**
  - Depth to Groundwater
  - Proximity to Water wells
  - Soil permeability (at depth)

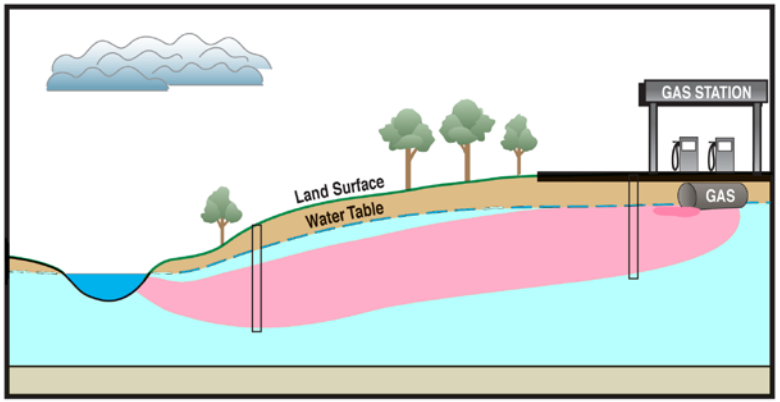


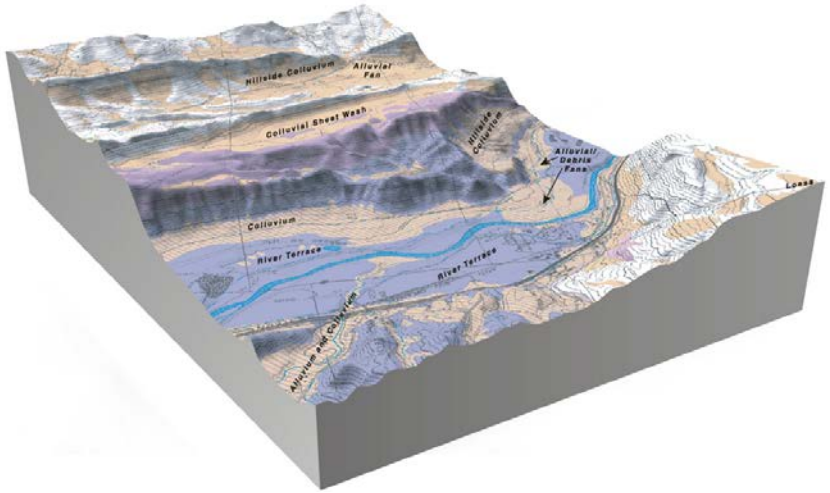


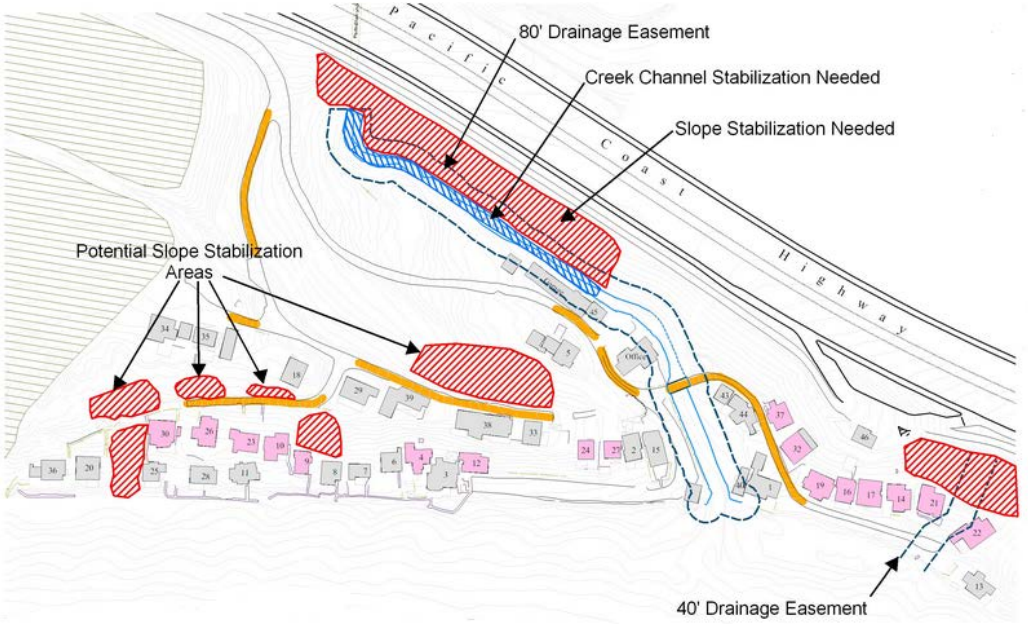
HYDROLOGIC SOIL GROUP	TYPE	PERMEABILITY
A	DEEP, WELL DRAINED SANDS AND GRAVELS	HIGH
B	MODERATELY DRAINED, MODERATELY FINE TO MODERATELY COARSE TEXTURE	MODERATE
C	IMPEDING LAYER, OR MODERATELY FINE TO FINE TEXTURE	LOW
D	CLAY SOILS, SOILS WITH HIGH WATER TABLE	VERY LOW

Choosing a Drywell

- **Things to identify**
  - Contamination
  - Site specific constraints
  - Geotechnical hazards

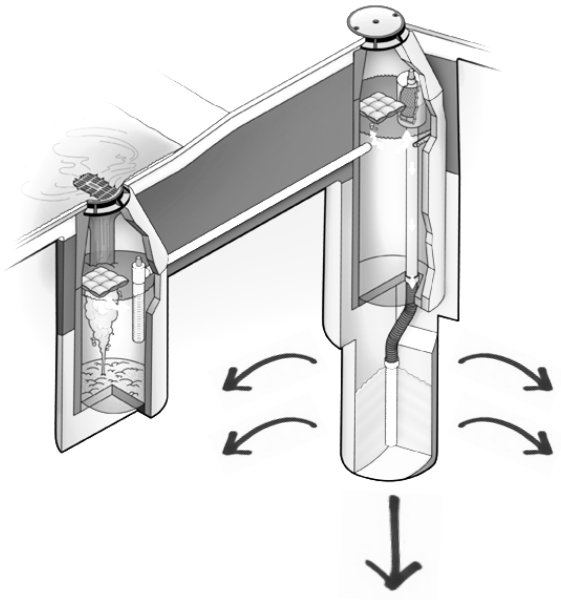






The Role of Infiltration

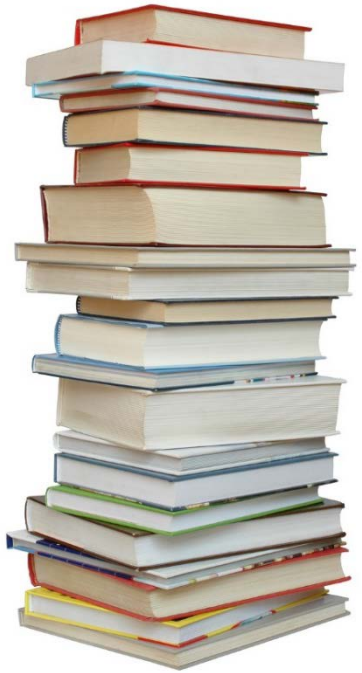
- **What role does infiltration play?**
  - Flood control measure
  - Prevents downstream erosion
  - Mitigates hydromodification
  - Maintains pre-development hydrology
  - Increases aquifer recharge
- **Added benefits of a drywell**
  - Bypasses upper confining layer
  - Maintainable for long life
  - Small footprint
  - Simple to retrofit



Note: soils do the infiltrating, not the system

Studying Drywells

- **Drywells have been studied for decades**
  - **EPA Final Determination**
  - MAG Study – Phoenix, AZ
  - Tucson Water Study – Tucson, AZ
  - USGS Report 93-4140 – Modesto, CA
  - **HydroSystems Study – Chandler, AZ**
  - Bouwer Study – Phoenix, AZ
  - **Chandler Recharge Study – Chandler**
  - **Water Augmentation Study – Los Angeles, CA**
  - **Elk Grove – City of Elk Grove, CA**
  - **Drywell Design for Enhanced Infiltration – Central Coast, CA**



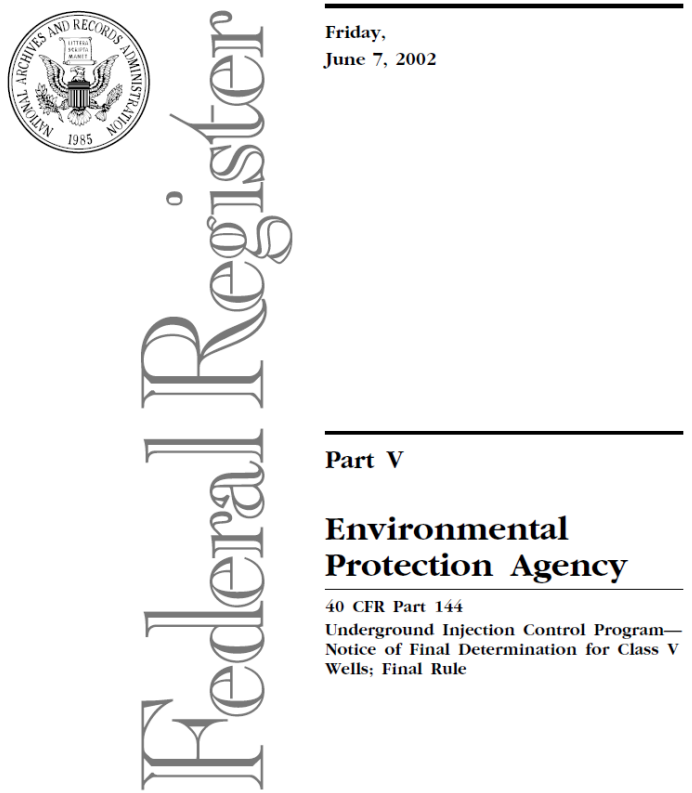
EPA Final Determination

- **Conclusions**

…"*the absence of frequent, widespread, or significant cases of actual contamination is good evidence of a* ***low potential for these wells to endanger."***

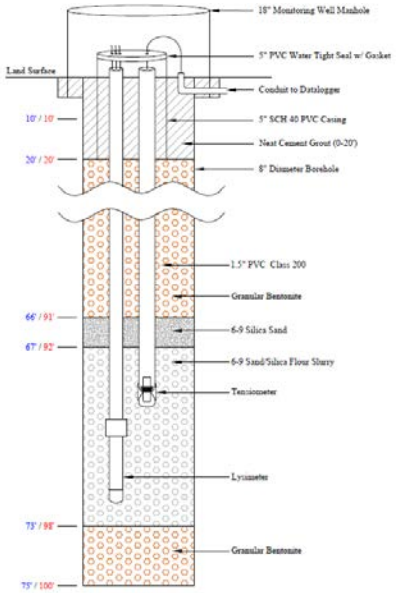
"Class V wells, as a class or sub-class, ***do not pose an endangerment to USDWs*** *since documented cases of contamination attributable to these Class V wells are rare."*

…***"did not show any evidence that Class V wells,*** *as a well class, or any Class V sub-class,* ***are contaminating USDWs."***



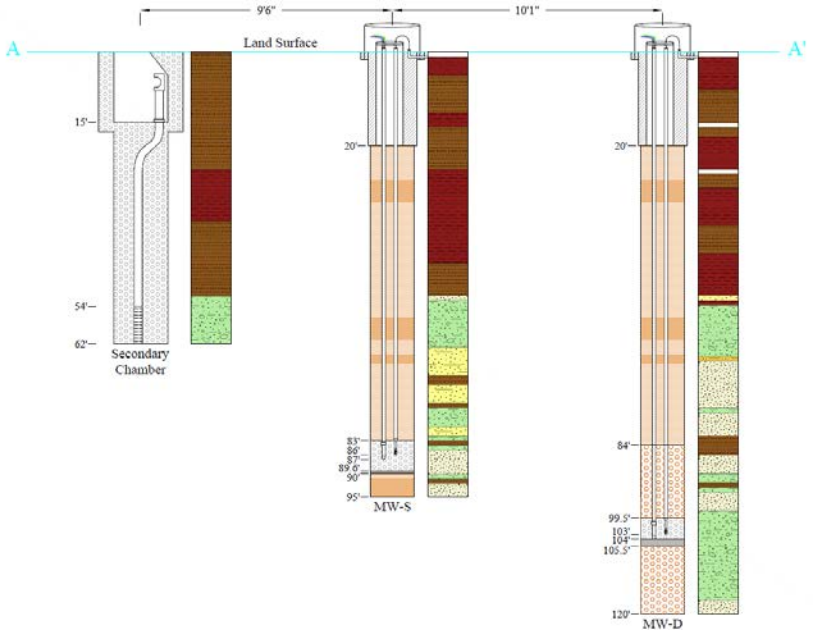
HydroSystems Study – Chandler, AZ

- **Reason for study**
  - How effective is MaxWell Plus at pre-treatment?
  - 24.3 total acres
  - 81% impervious
  - Dual chamber drywell system



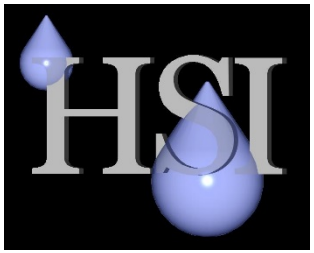
HydroSystems Study

- **Study Description**
  - 7 month study (2010 – 2011)
  - 17 storms/6 events sampling
  - 7.47” total rainfall
  - 92% average TSS removal
  - 3,800,000 gallons recharged
  - Effective mitigation of all pollutants



HydroSystems Study

- **Conclusions**
  - *"…quality of the stormwater that was processed through the MaxWell Plus exceeded expectations."*
  - *"…supports the use of the drywells for efficient treatment and recharge of stormwater runoff in commercial areas."*
  - *"…does not pose a significant threat to groundwater quality."*
  - *"…significant portion of stormwater runoff to be recharged into the subsurface instead of being routed off site."*



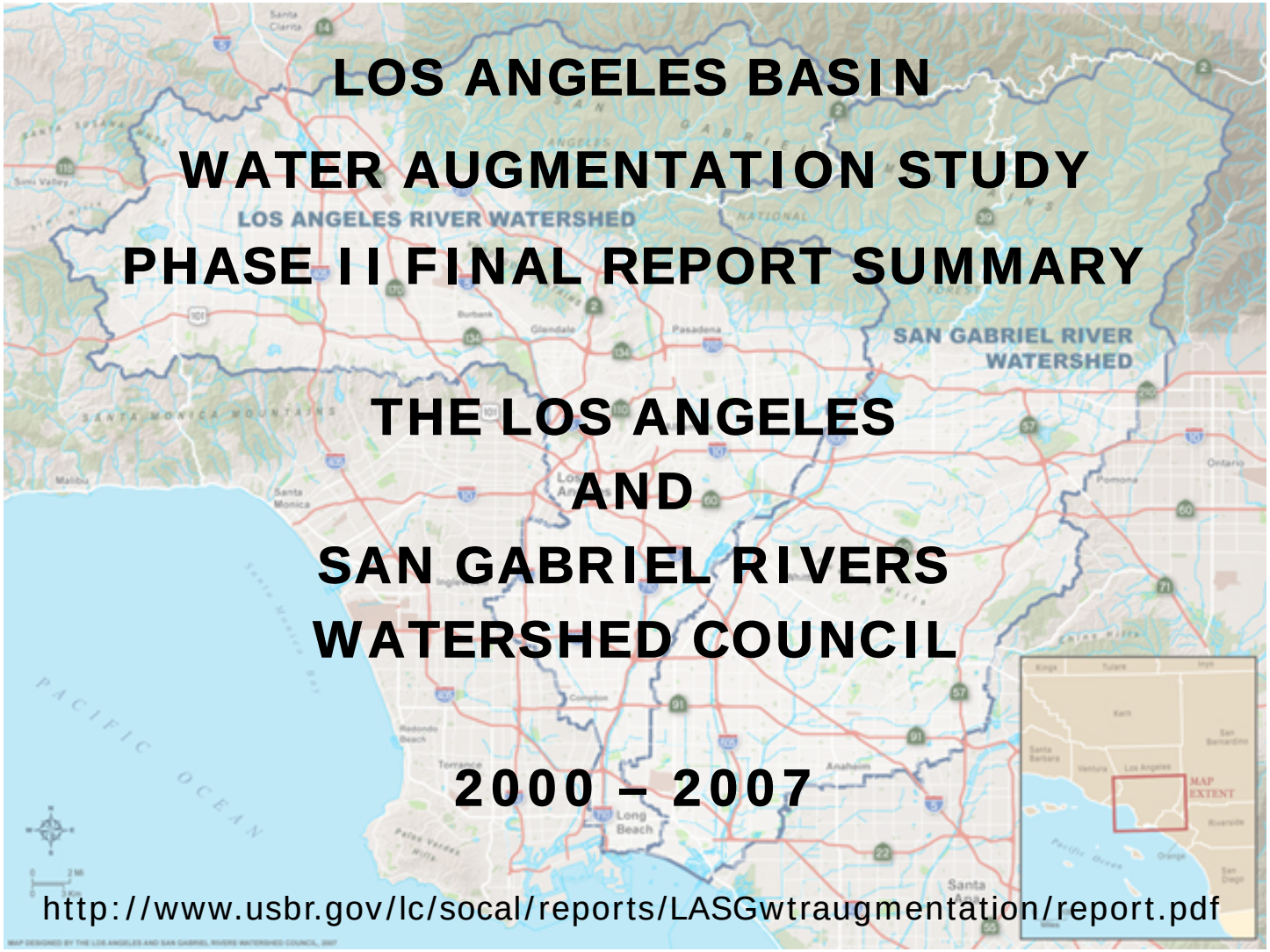
Chandler Recharge Study – 2004

- **Reason for study**
  - How does City's Stormwater Policy affect groundwater recharge?
  - Stormwater retention and drywells increase groundwater recharge
  - Average recharge on undeveloped land = 191 AFA
  - Average recharge on urbanized land = 2,610 AFA
  - Study estimates a 1,266% increase
  - *"…groundwater recharge from stormwater runoff and capture represents a potentially significant water resource for the City."*

Chandler · Arizona

GSA GeoSystems Analysis, Inc. Innovative Solutions

Water Augmentation Study



Water Augmentation Study

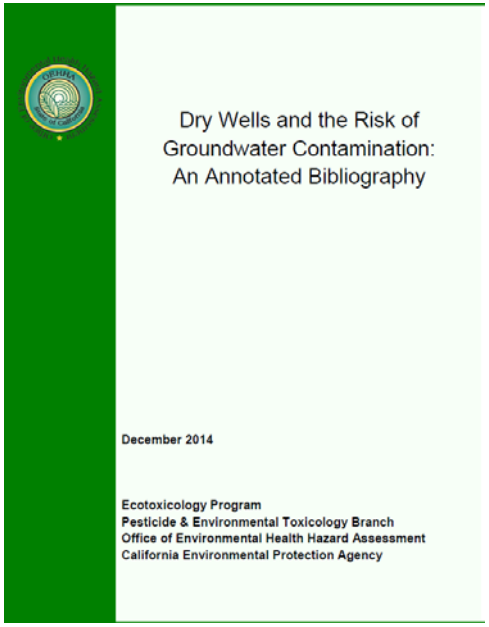
- **Reason for Study**
  - Is it safe/effective to infiltrate urban stormwater into aquifer?
  - Estimated 578,000 acre-feet/year
  - Stormwater BMPs varied
  - Land use at test sites varied
  - 7 year study period
  - Results = infiltration good

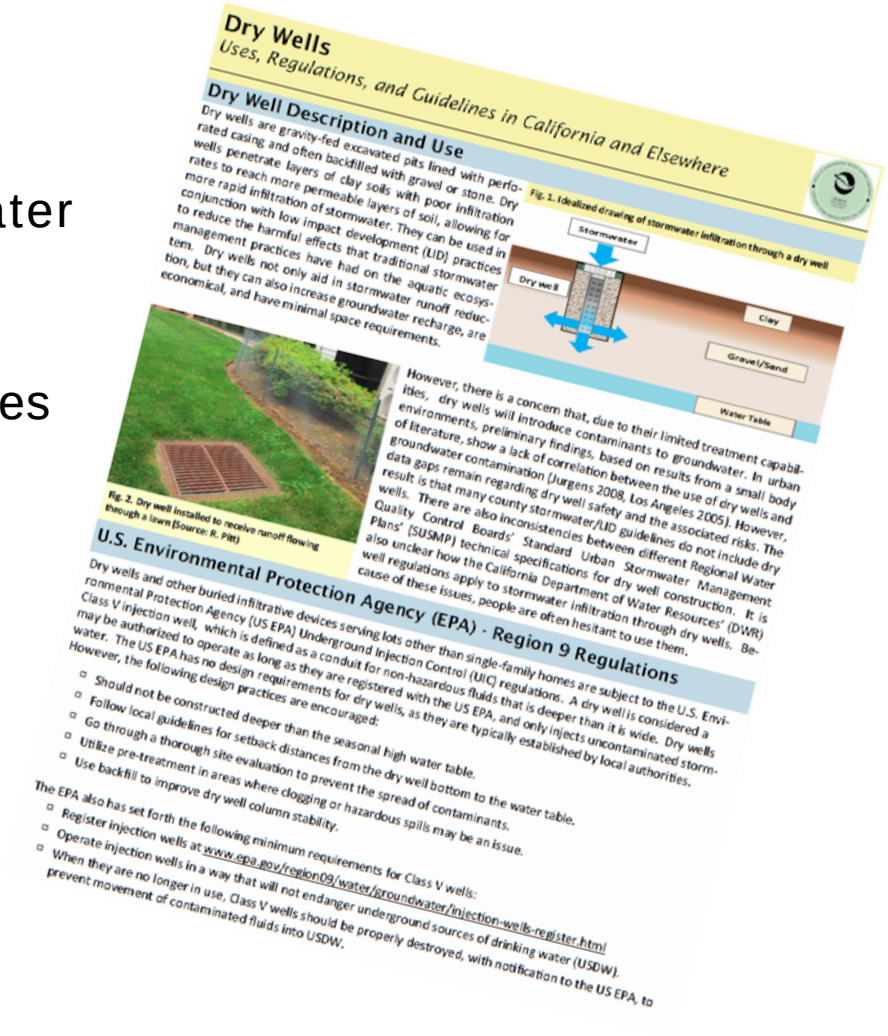
Water Augmentation Study

- **Study Conclusions**
  - *"…no apparent trends to indicate that stormwater infiltration will negatively impact groundwater."*
  - *"…suggested that groundwater quality at the six monitored sites was stable or improved for most constituents."*
  - *"…implement decentralized stormwater management practices to advance infiltration…"*
  - *"Soil appears to be very effective in removing TSS and bacteria from stormwater."*

Elk Grove Drywell Study – 2014

- **Reason for study**
  - Infiltrate stormwater
    - without impacting groundwater
    - alleviate flooding
  - Review of existing drywell studies




Dry Wells
Uses, Regulations, and Guidelines in California and Elsewhere

Dry Well Description and Use

Dry wells are gravity-fed excavated pits lined with perforated casing and often backfilled with gravel or stone. Dry wells penetrate layers of clay soils with poor infiltration rates to reach more permeable layers of soil, allowing for more rapid infiltration of stormwater. They can be used in conjunction with low impact development (LID) practices to reduce the harmful effects that traditional stormwater management practices have had on the aquatic ecosystem. Dry wells not only aid in stormwater runoff reduction, but they can also increase groundwater recharge, are economical, and have minimal space requirements.

Fig. 1. Idealized drawing of stormwater infiltration through a dry well

Fig. 2. Dry well installed to receive runoff flowing through a lawn (Source: R. Pitt)

However, there is a concern that, due to their limited treatment capabilities, dry wells will introduce contaminants to groundwater. In urban environments, preliminary findings, based on results from a small body of literature, show a lack of correlation between the use of dry wells and groundwater contamination (Jurgens 2008, Los Angeles 2005). However, data gaps remain regarding dry well safety and the associated risks. The result is that many county stormwater/LID guidelines do not include dry wells. There are also inconsistencies between different Regional Water Quality Control Boards' Standard Urban Stormwater Management Plans' (SUSMP) technical specifications for dry well construction. It is also unclear how the California Department of Water Resources' (DWR) well regulations apply to stormwater infiltration through dry wells. Because of these issues, people are often hesitant to use them.

U.S. Environmental Protection Agency (EPA) - Region 9 Regulations

Dry wells and other buried infiltrative devices serving lots other than single-family homes are subject to the U.S. Environmental Protection Agency (US EPA) Underground Injection Control (UIC) regulations. A dry well is considered a Class V injection well, which is defined as a conduit for non-hazardous fluids that is deeper than it is wide. Dry wells may be authorized to operate as long as they are registered with the US EPA, and only injects uncontaminated stormwater. The US EPA has no design requirements for dry wells, as they are typically established by local authorities. However, the following design practices are encouraged:

- Should not be constructed deeper than the seasonal high water table.
- Follow local guidelines for setback distances from the dry well bottom to the water table.
- Go through a thorough site evaluation to prevent the spread of contaminants.
- Utilize pre-treatment in areas where clogging or hazardous spills may be an issue.
- Use backfill to improve dry well column stability.

The EPA also has set forth the following minimum requirements for Class V wells:

- Register injection wells at www.epa.gov/region09/water/groundwater/injection-wells-register.html
- Operate injection wells in a way that will not endanger underground sources of drinking water (USDW).
- When they are no longer in use, Class V wells should be properly destroyed, with notification to the US EPA, to prevent movement of contaminated fluids into USDW.

Elk Grove Drywell Study

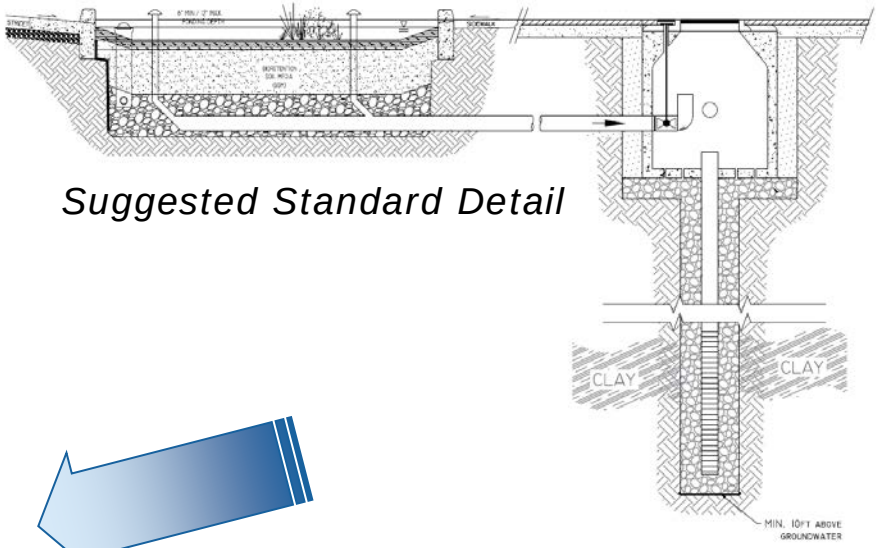
- **Locations of studies reviewed**
  - Millburn, NJ
  - Park Ridge, WI
  - Los Angeles, CA
  - Modesto, CA
  - Hawaii, HI
  - Portland, OR
  - Tacoma – Pierce County, WA
  - Pima County, AZ
  - Missoula, MT
  - Tucson, AZ
- **Basic findings**
  - Drywells don't appear to contaminate groundwater
  - Use pre-treatment
  - Consider use of drywells on a site by site basis
  - Vadose zone soils provide excellent filtration
  - Stormwater is a valuable resource

Elk Grove Drywell Study

- **Review of "Drywell Studies"**
  - *"…little evidence stormwater had a negative impact on groundwater…"*
  - *"…use pre-treatment to minimize the likelihood of groundwater contamination and clogging of the drywell…"*
  - *"Using urban runoff to recharge groundwater is a practical option for expanding local water supplies."*
  - *"…infiltrating runoff can make significant contributions to recharge…"*
  - *"…metals were attenuated in the vadose zone…"*

Central Coast LID Initiative

- **Suggested Drywell Detail for Enhanced Infiltration**
  - Geosyntec 2015
  - Evaluated drywell BMPs
  - Provided recommendations for:
    - statewide regulations
    - drywell maintenance
    - site specific infiltration testing
    - drywell design requirements
    - evaluation criteria for drywell use



Suggested Standard Detail

Central Coast LID Initiative

- **Proposed Drywell Design Guidelines**
  - Well drained soils only
  - Test for infiltration rate at proposed depth
  - Separation set for:
    - groundwater, water well, other drywell
  - Penetrate 10’ into permeable soil
  - Provide setbacks from slopes, foundations, etc
  - Avoid areas of known contamination
  - Common sense safety factors
  - Register drywells with EPA

Central Coast LID Initiative

- **Findings**
  - *"…drywells provide significantly greater stormwater runoff volume reductions and aquifer recharge…"*
  - *"…drywells enhance infiltration by penetrating clay and other less permeable soil layers that otherwise limit infiltration…"*
  - *"…combining biofiltration and drywells can optimize water resource benefits…"*
  - *"…State level drywell regulations and a standardized drywell BMP are needed to give practitioners the proper guidance for siting and design…"*

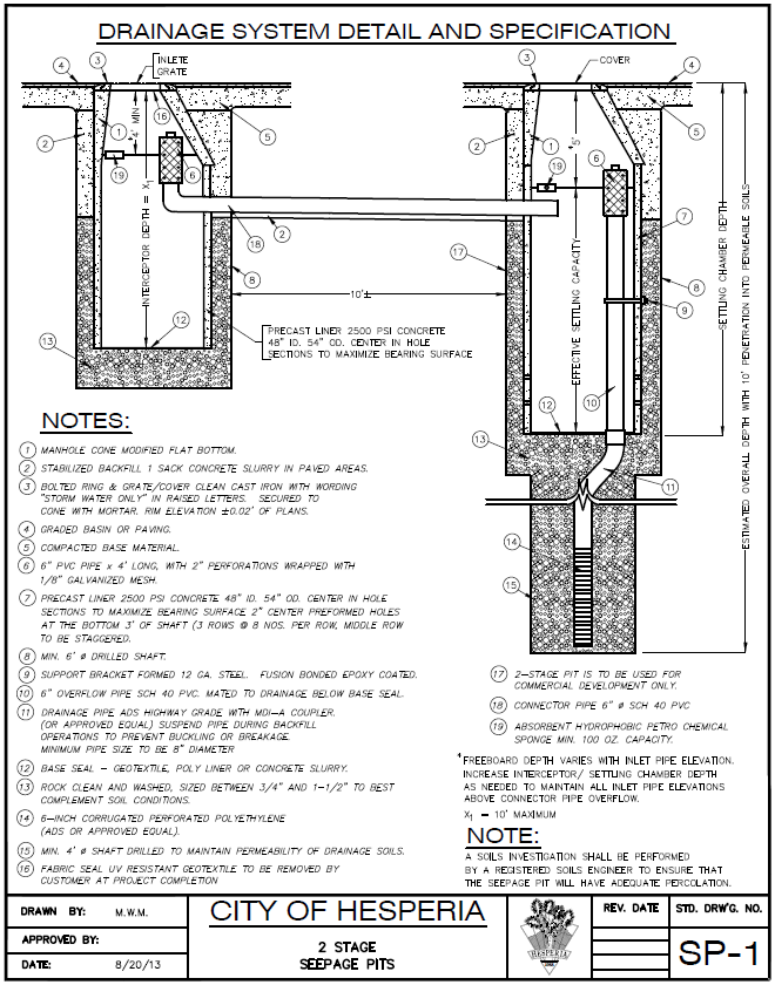
Sample of Current Regulations

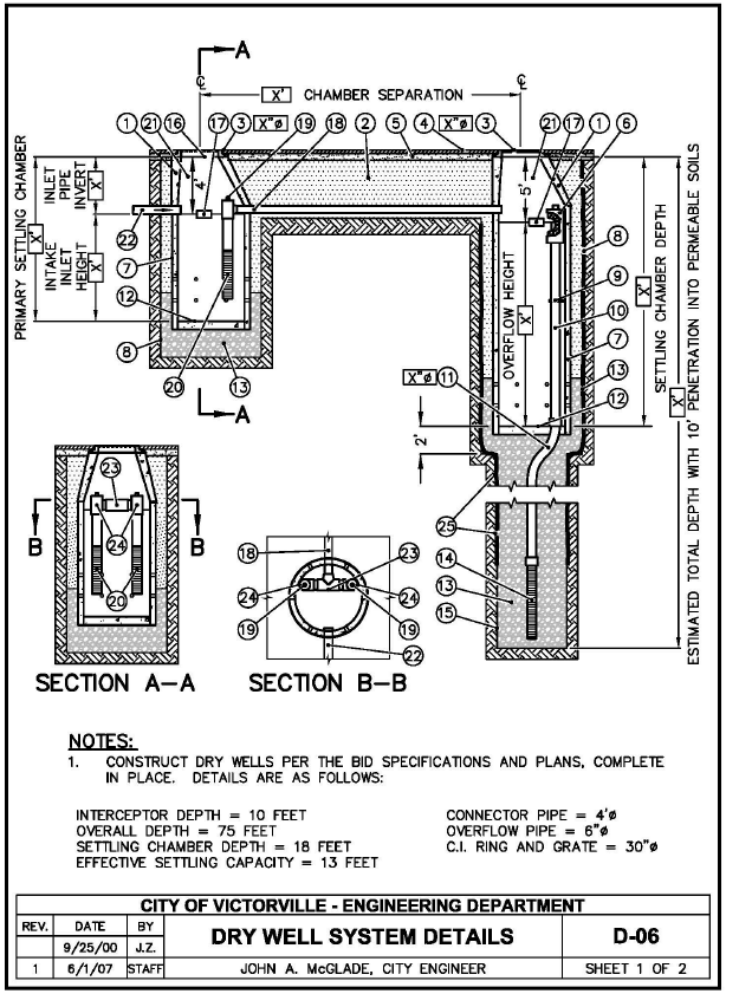
	Year	Use Low Impact Development	Promote Infiltration First	Regulation Allows Drywells
Alameda County	2007	✓	✓	
Bakersfield	2013	✓	✓	
Central Coast	2013	✓	✓	✓
Central Valley	2015	✓	✓	
Contra Costa County	2015	✓	✓	✓
Fresno	2013	✓	✓	
Placer County	2012	✓	✓	✓
San Francisco	2015	✓	✓	✓
San Mateo County	2013	✓	✓	✓
Santa Clara County	2012	✓	✓	
Stanislaus County	2011	✓	✓	✓
Yolo County	2010	✓	✓	✓

Cities With Drywell Details

- **Many Cities Across the US have adopted Drywell Details**
  - Bend, OR
  - Chandler, AZ
  - Cheney, WA
  - Coeur d'Alene, ID
  - Covington, WA
  - Crystal Lake, IL
  - Glendale, AZ
  - Goodyear, AZ
  - Hesperia, CA
  - Kennewick, WA
  - Kirkland, WA
  - Los Angeles, CA
  - Manzanita, OR
  - Mesa, AZ
  - New Haven, CT
  - Oakdale, CA
  - Lake Oswego, OR
  - Palm Desert, CA
  - Palm Springs, CA
  - Palmdale, CA
  - Portland, OR
  - Rancho Mirage, CA
  - Redmond, OR
  - San Bernardino, CA
  - Spokane, WA
  - Surprise, AZ
  - Vancouver, WA
  - Victorville, CA
  - Woodland, WA

City Drywell Examples

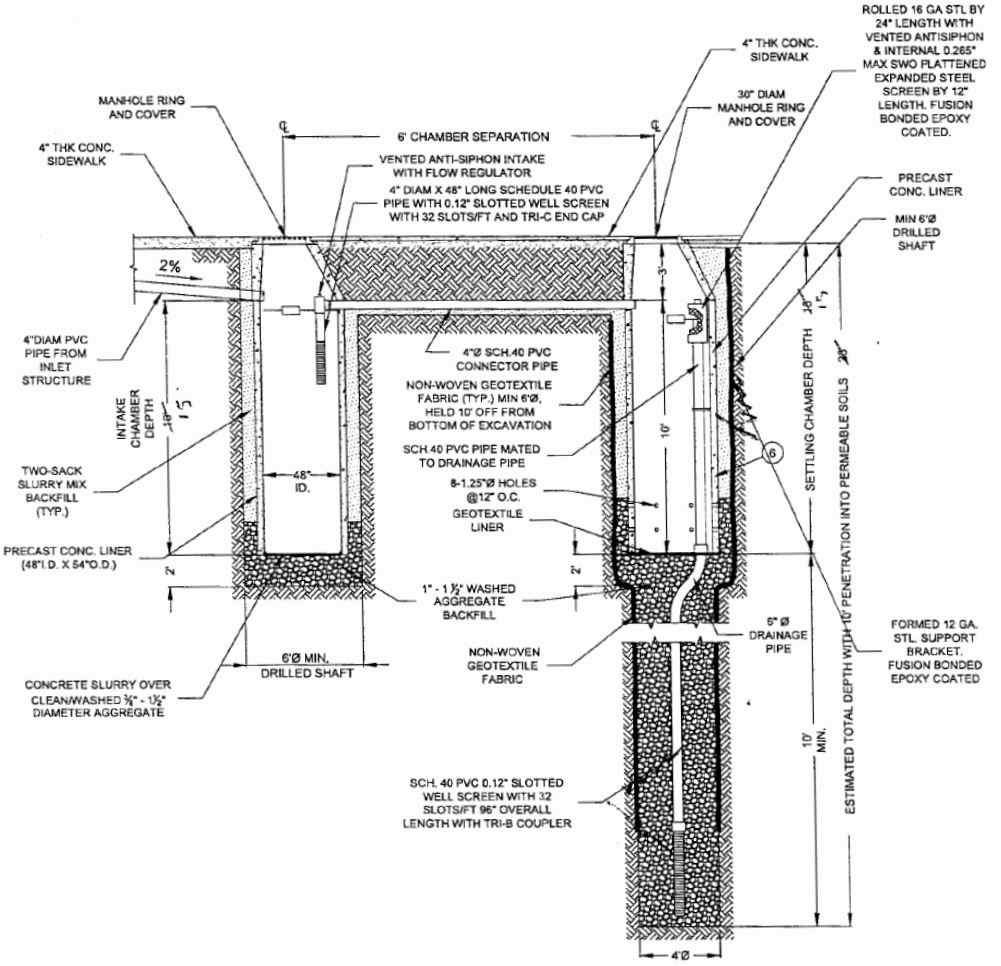


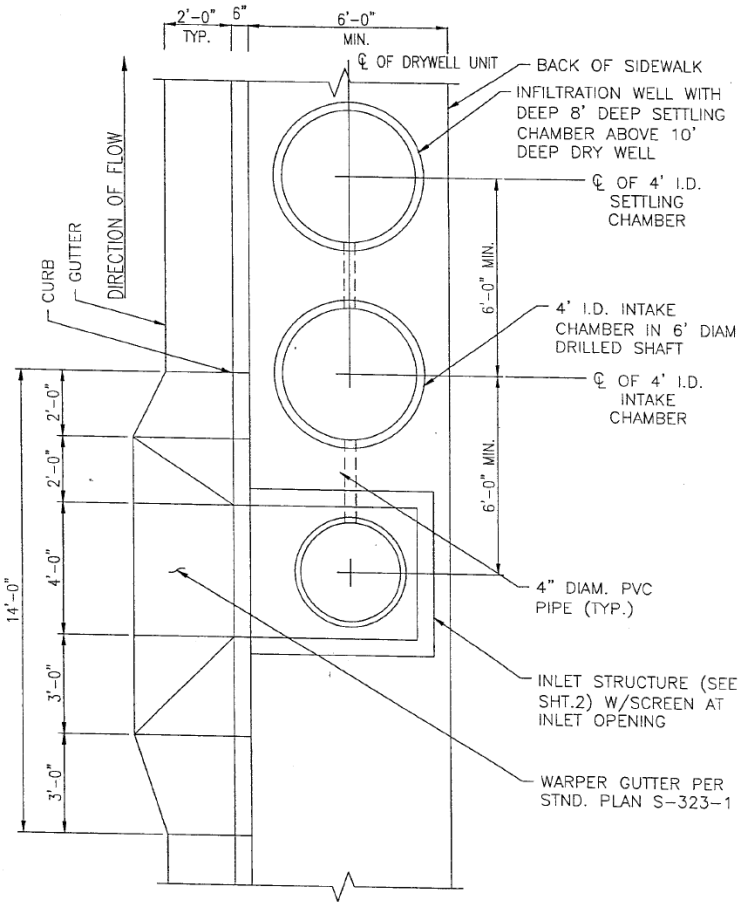


Hesperia, CA

Victorville, CA

City Drywell Examples

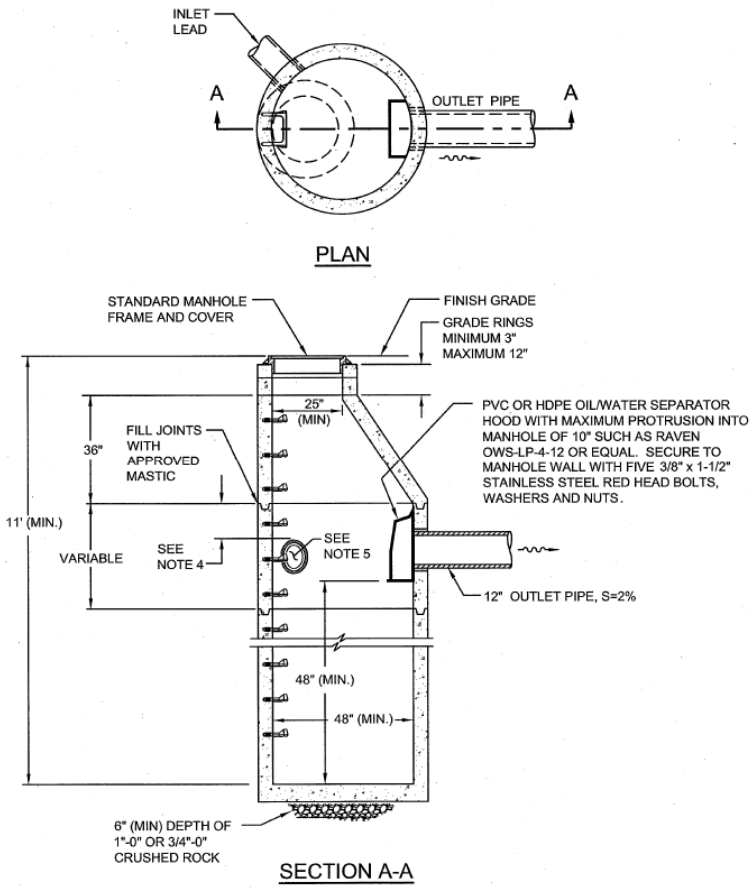




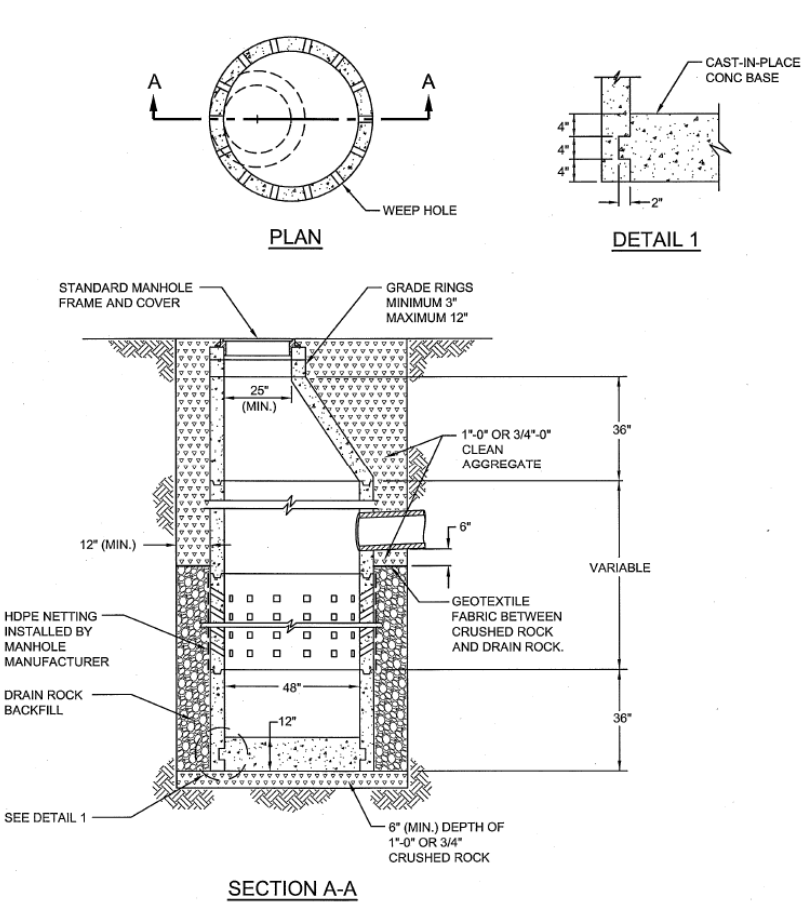
Los Angeles, CA

City Drywell Examples

Sedimentation Well

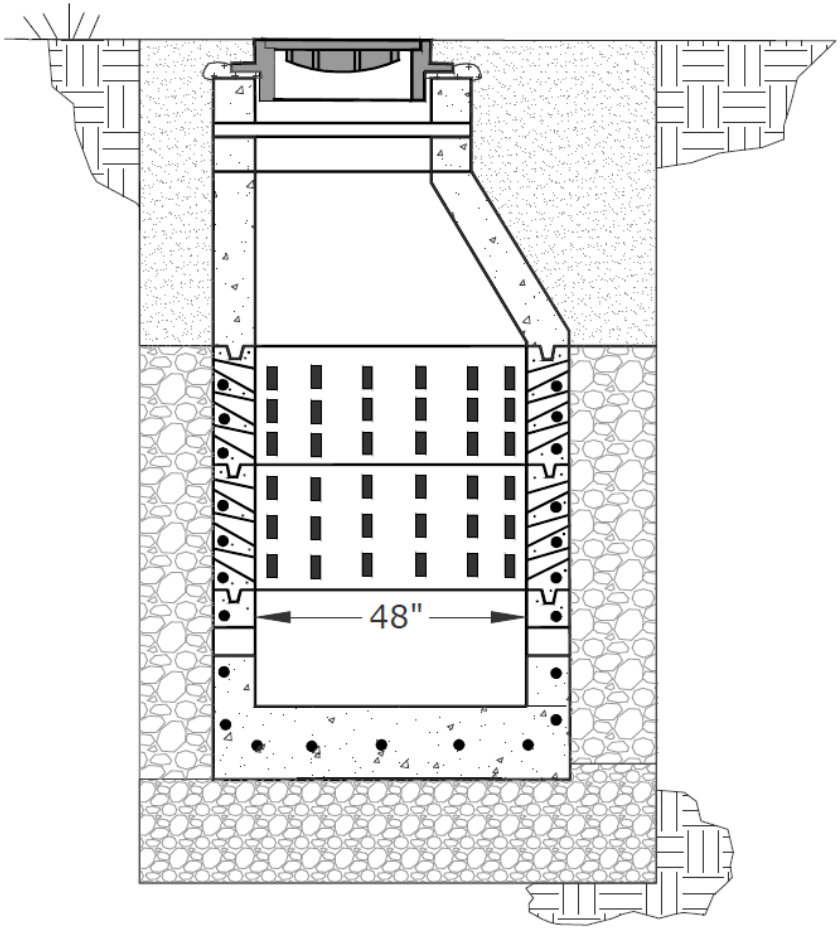


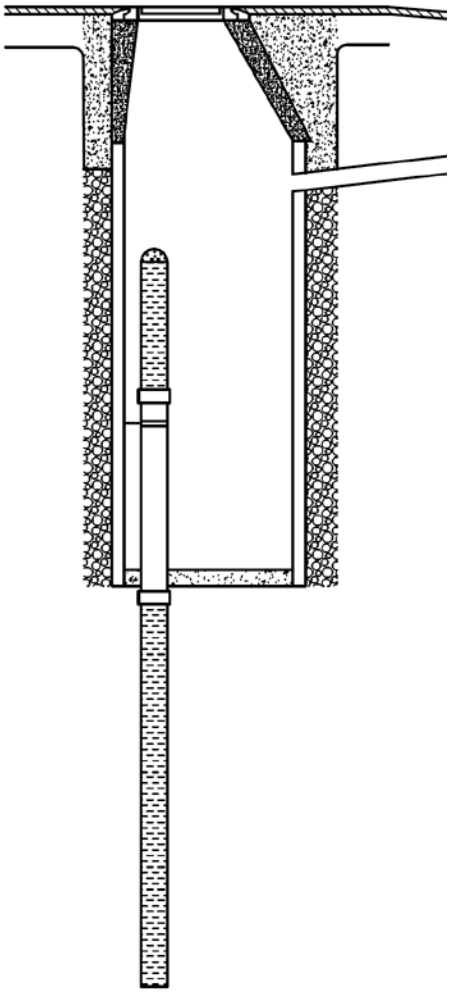
Drywell



Portland, OR

City Drywell Examples



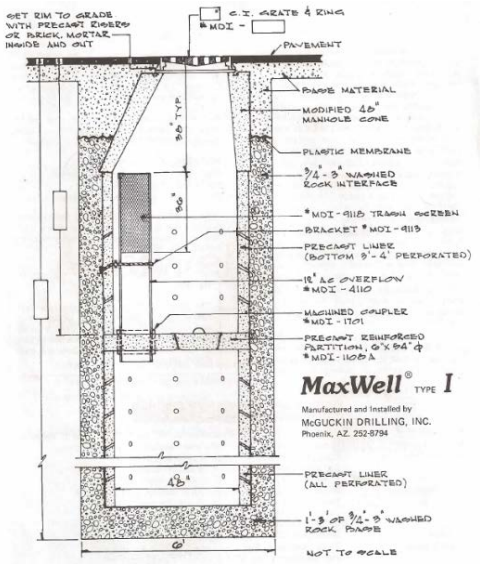


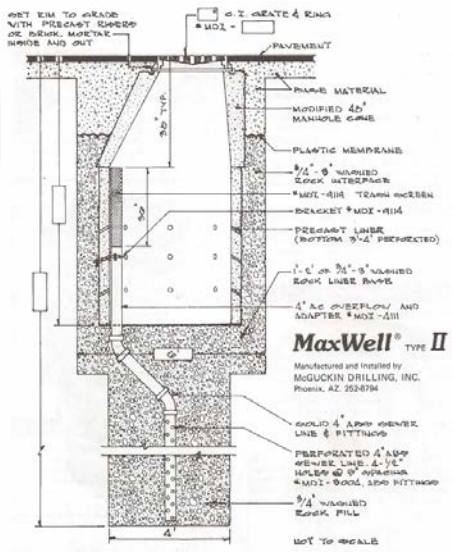
Lake Oswego, OR

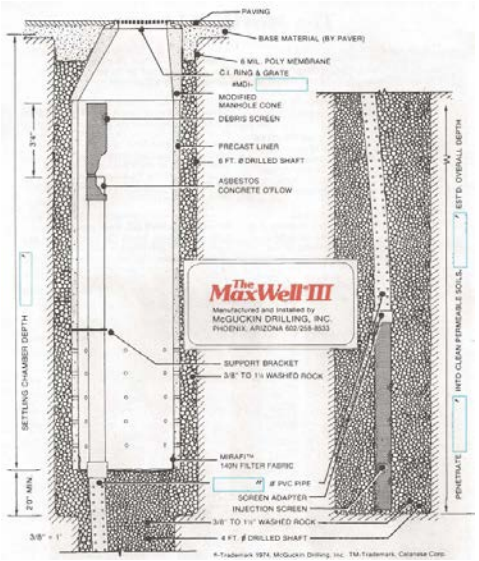
Palm Desert, CA

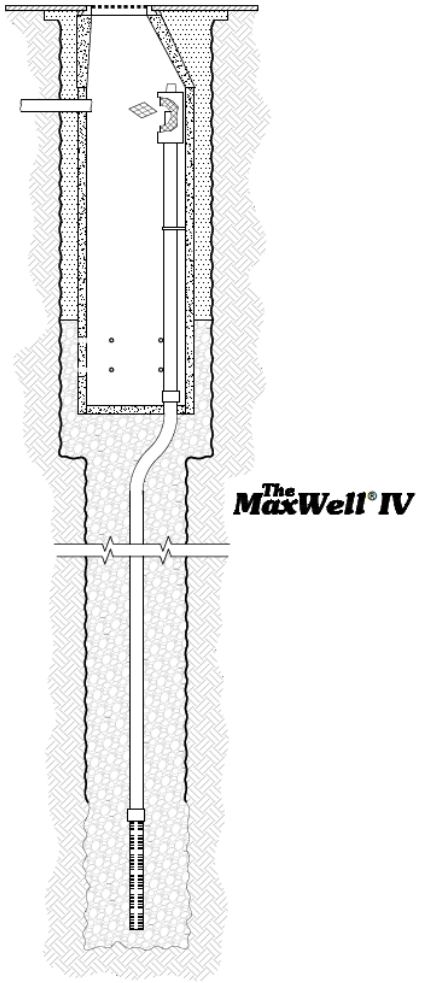
Engineered Drywell

- **Modern Engineered Drywell**
  - Pre-treatment device
  - Infiltration device
  - Site specific
  - Engineered design
  - Technique is critical



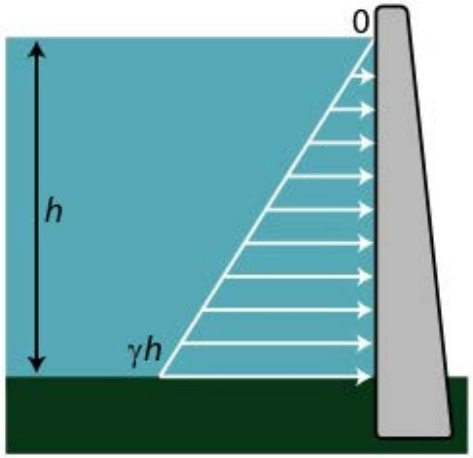


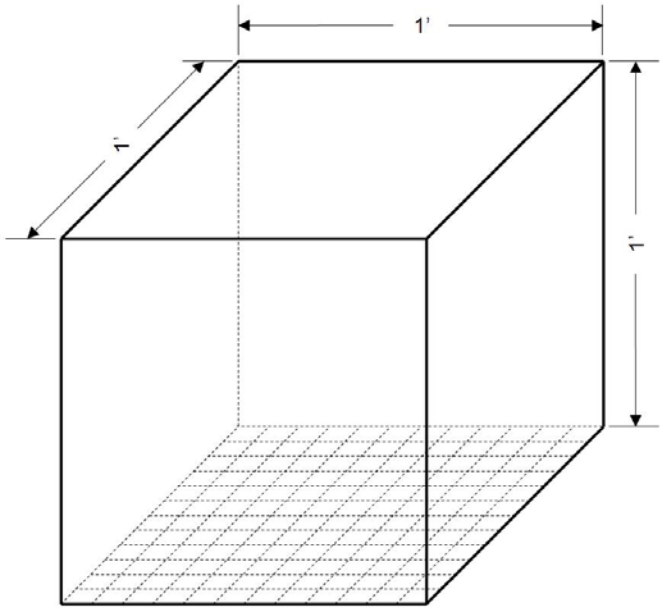




Engineered Drywell

- **Effectiveness of Deep Infiltration**
  - Permeable soils are typically >25’
  - Deeper soils are typically more permeable – alluvium and sand
  - Taller water column increases pressure and infiltration rate
    - 1’ of depth ≈ 0.43 PSI
      - 69’ deep ≈ 30 PSI
      - Pressure increases perc rate
    - Huge difference maker





Water Density = 62.4 lb/ ft^3

$$\frac{62.4\frac{lb}{ft^2}}{\frac{144in^2}{ft^2}} = 0.433psi$$

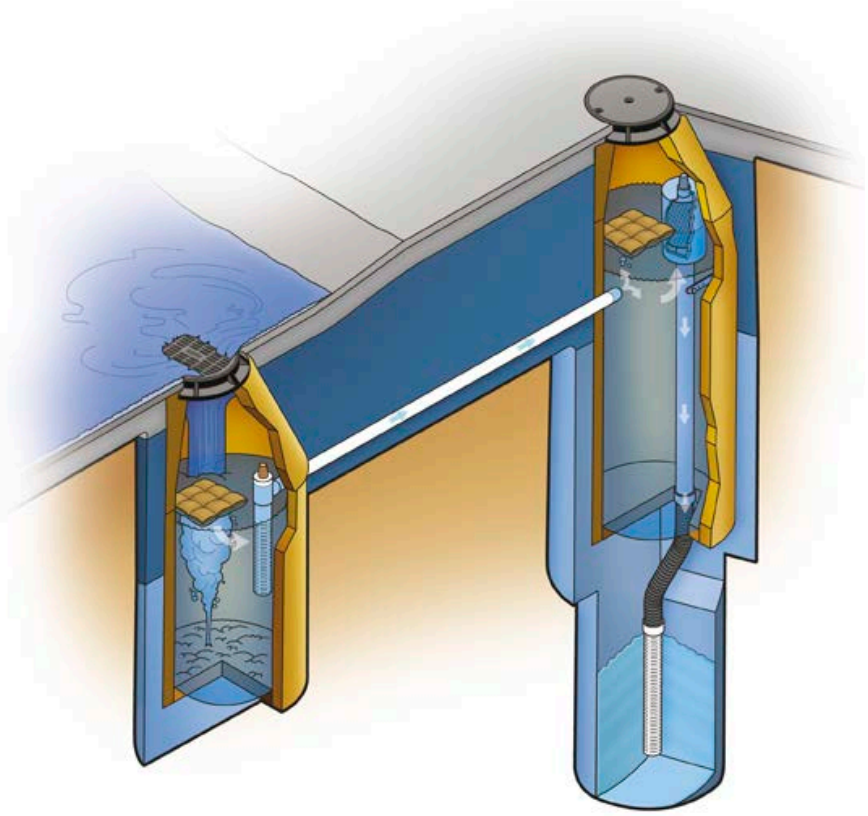
Engineered Drywell

- **Single Chamber**
  - Ideal in large landscaped areas
  - Use with bioswale type BMPs
  - Settling chamber for TSS removal
  - Screen/Shield keeps trash out
  - Floating hydrocarbons captured
  - Number of drywells is calculated

Note: soils do the infiltrating, not the system

Engineered Drywell

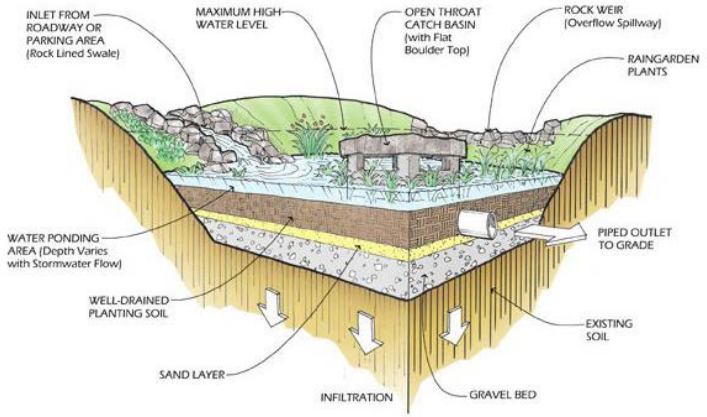
- **Dual chamber**
  - Ideal for large impervious areas
  - Greater sediment capture potential
  - With or without bioswale type BMPs
  - Extra pre-treatment
  - Stormwater treated twice
  - Number of drywells is calculated



Note: soils do the infiltrating, not the system

Selecting a Drywell - Recap

- **Ideal Site Conditions**
  - Groundwater depth > 130’
  - No proposed HazMat use/storage
  - Room for bioswale and drywell
  - Confining layer near surface
  - Generous landscape areas
  - No water wells in vicinity
  - Contamination free



Drywell Installation

DRILLING AND BUILDING AN ENGINEERED DRYWELL

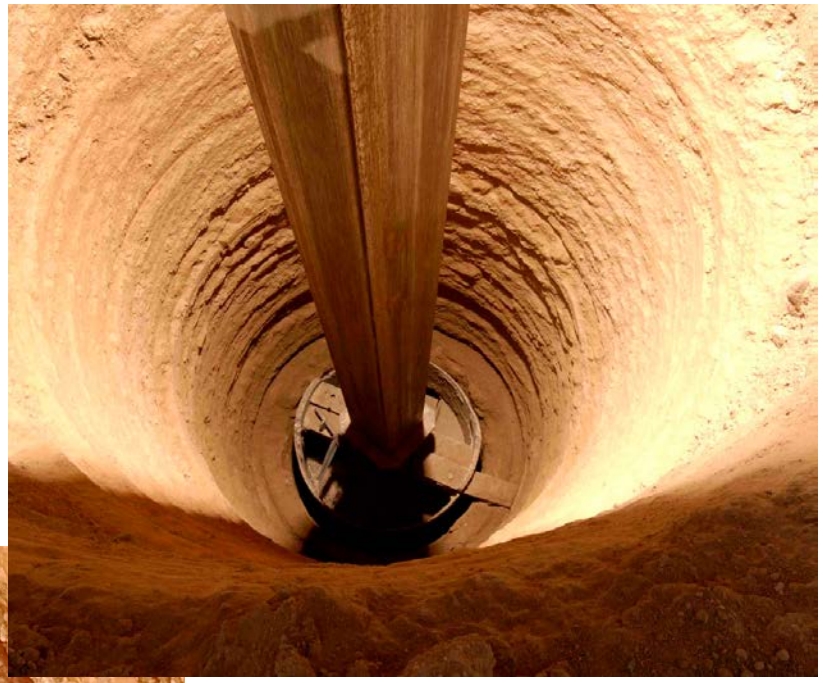
EASY as 1 2 3

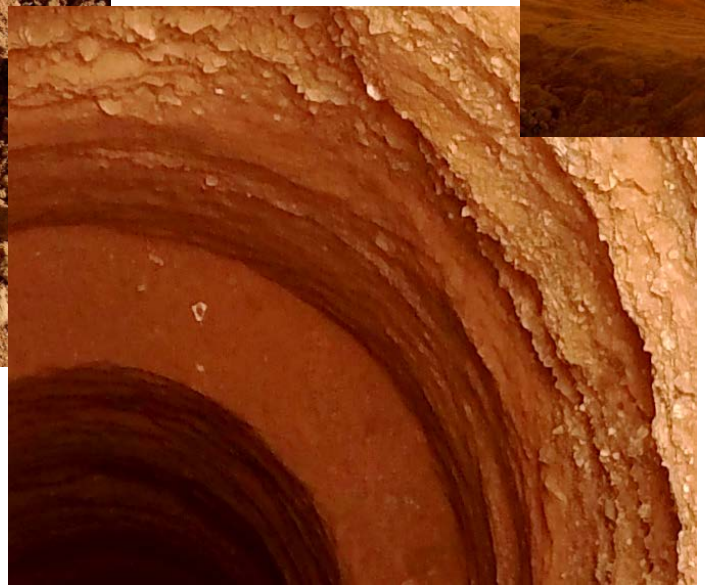
Drywell Installation

- Drilling a new drywell

Drywell Installation

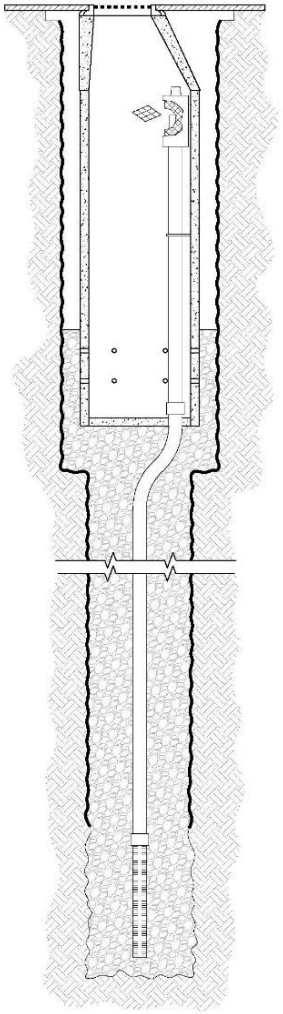
- 4’ diameter lower shaft for well construction and gravel pack
- 6’ diameter upper shaft for precast concrete liner construction





Drywell Installation

- Geotextile fabric prevents the migration of fines into gravel pack



Drywell Installation

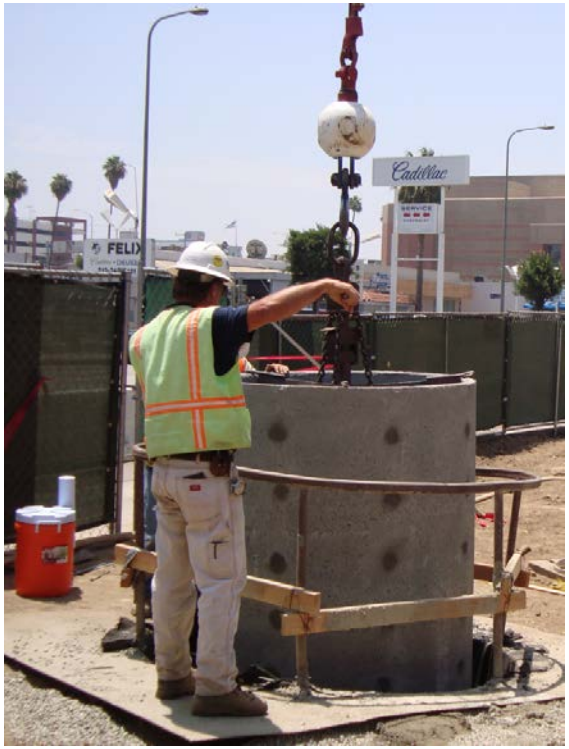
- Installing downhole components

Drywell Installation

- Installing the gravel pack

Drywell Installation

- Placing concrete liner

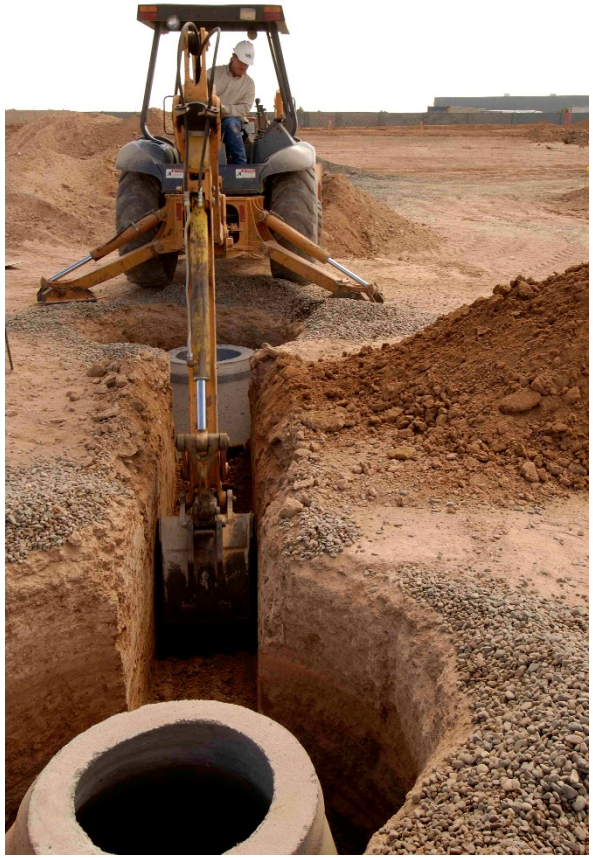


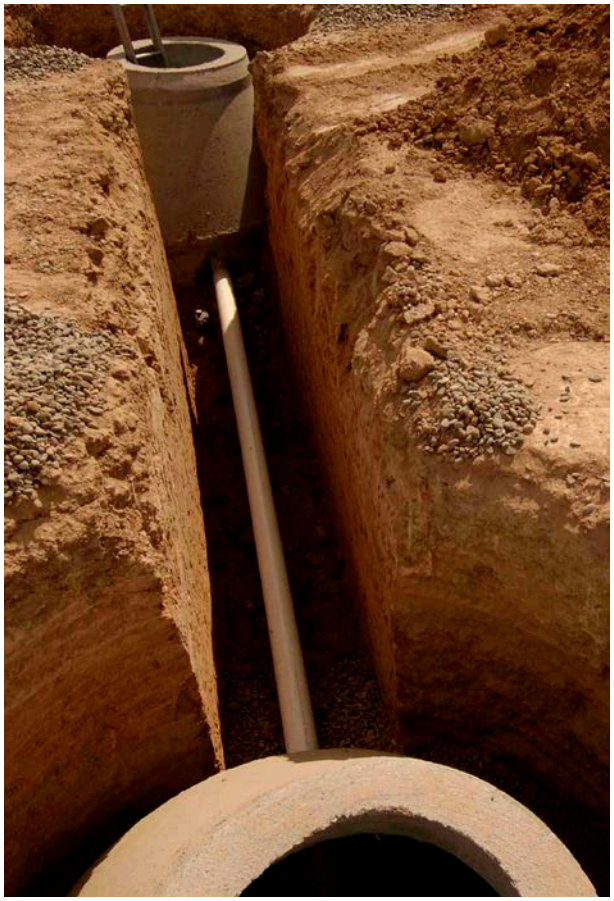
Drywell Installation

- Setting the cone to final grade

Drywell Installation

- Installing the crossover pipe





Drywell Installation

- Completing crossover pipe

Drywell Installation

- Backfill with 2 sack slurry to grade
  - Locks components in place
  - Prevents subsidence

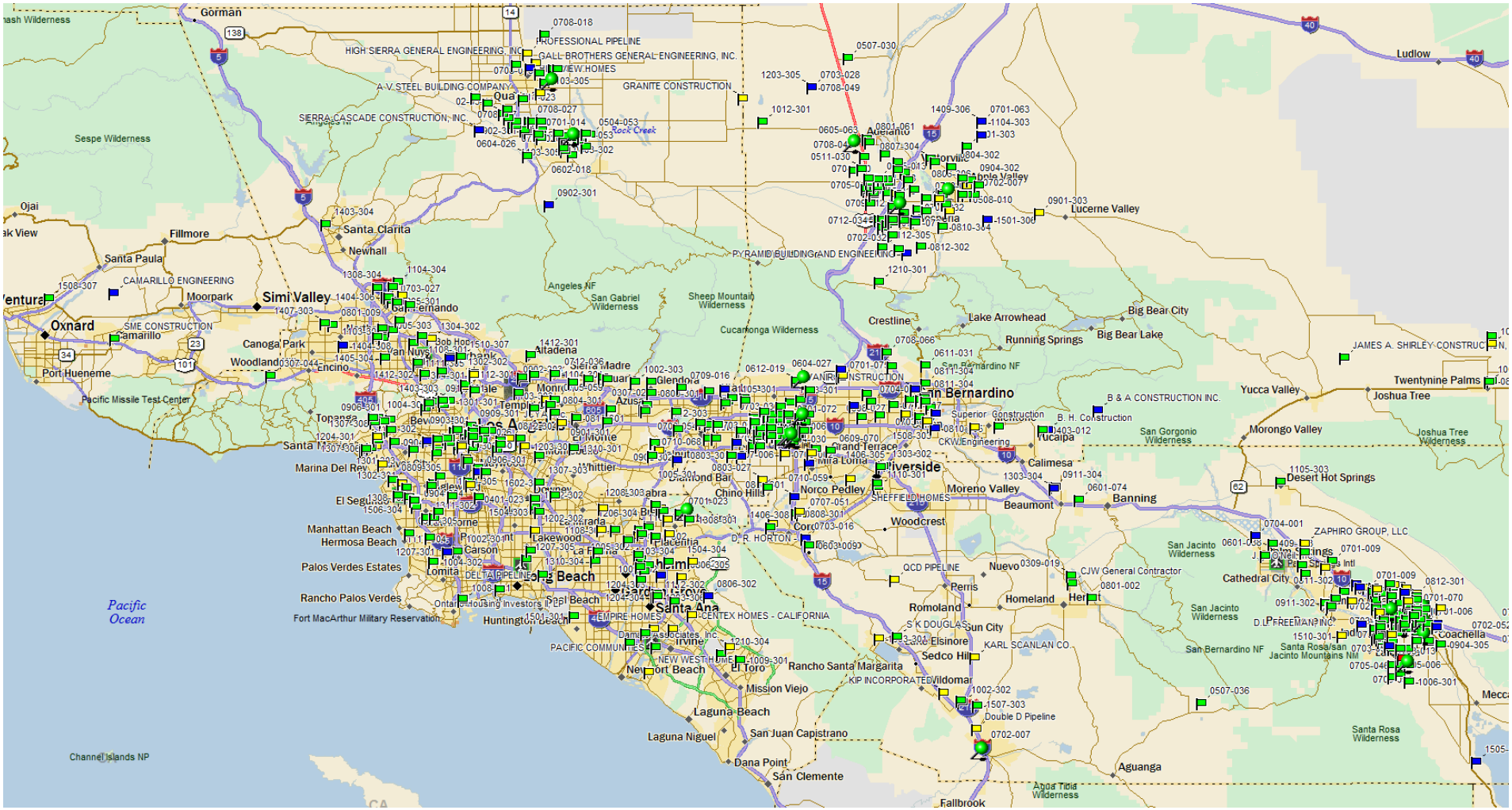
Drywell Installation

- Installing protective fabric
- Removed when all site work is complete

How does MaxWell® Plus Operate?

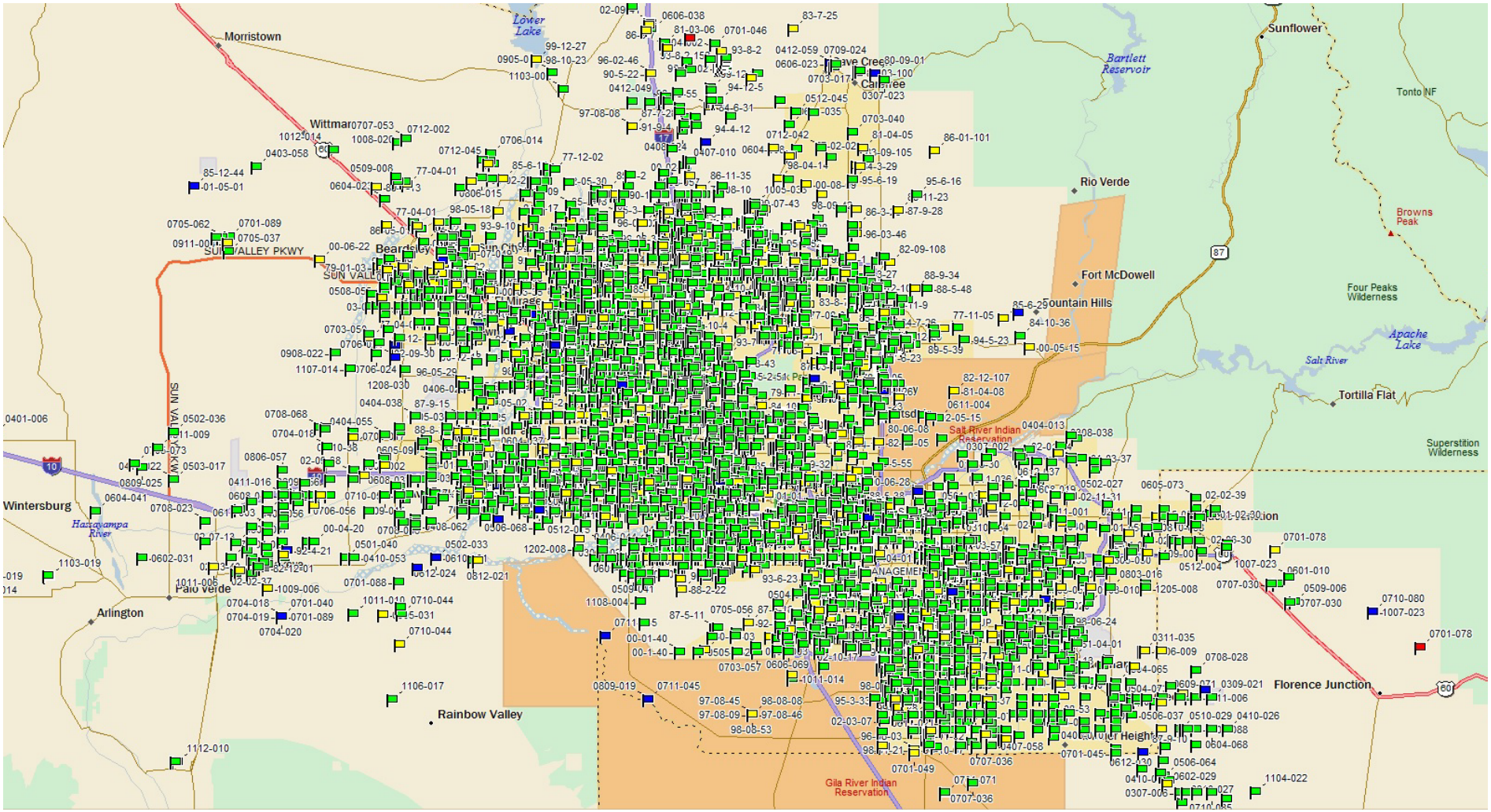
CA Drywell Database

- ± 15,000 installations



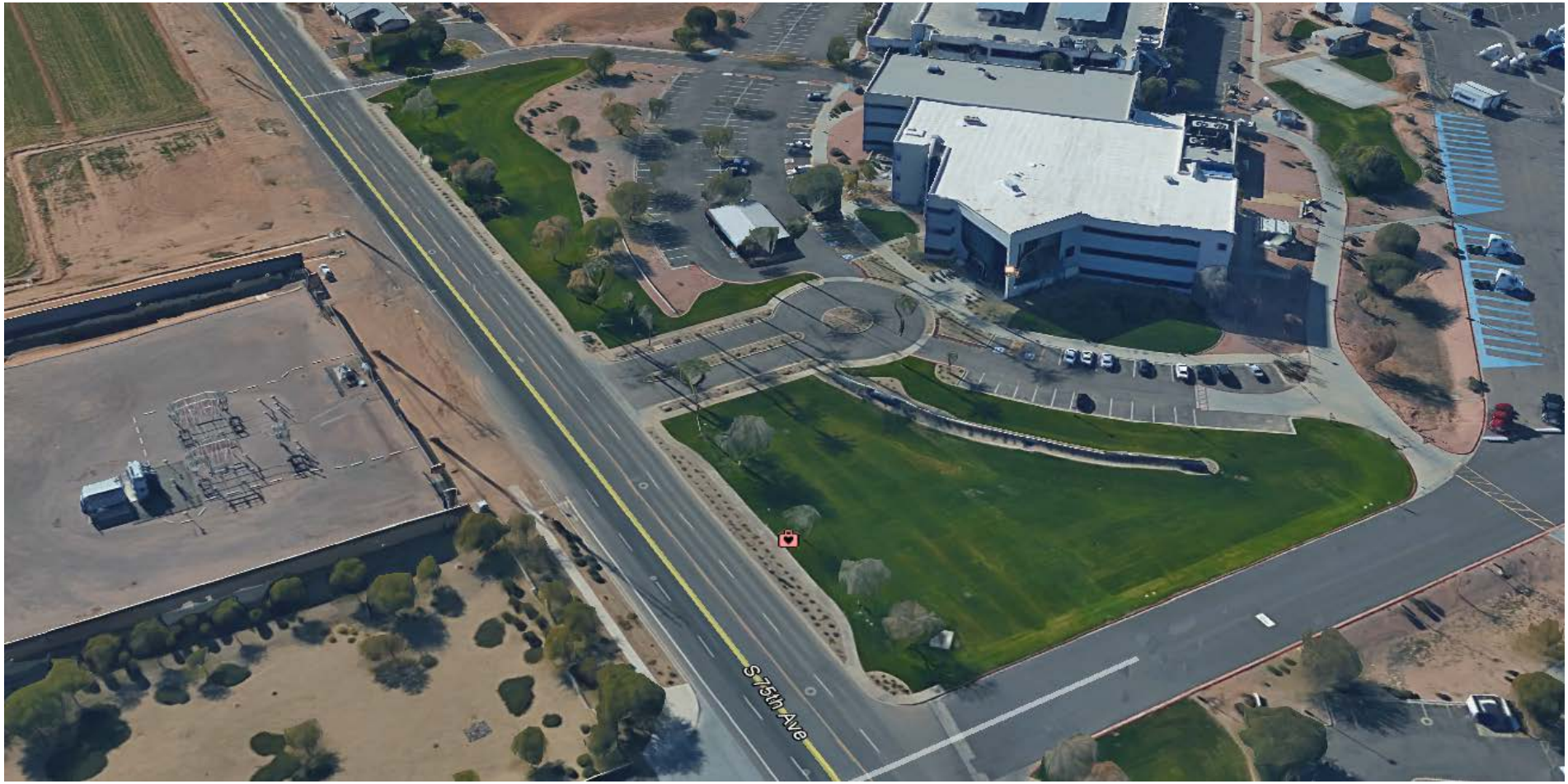
AZ Drywell Database

- ± 65,000 installations



Typical Application

- Commercial Office



Typical Application

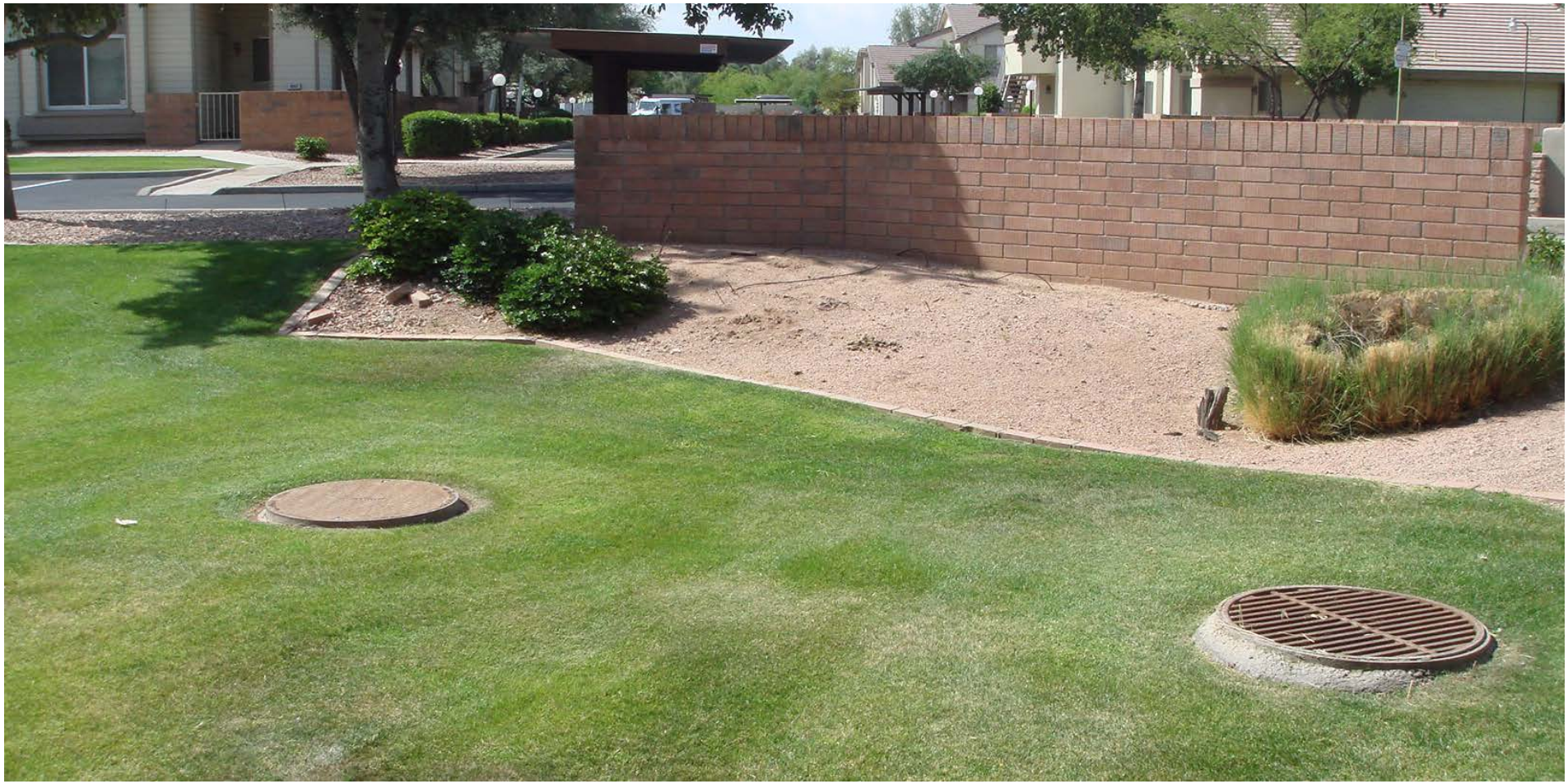
- Warehouse/Distribution Center

Typical Application

- Single Family Residential

Typical Installation

- **Dual Chamber System** in a residential area



Typical Installation

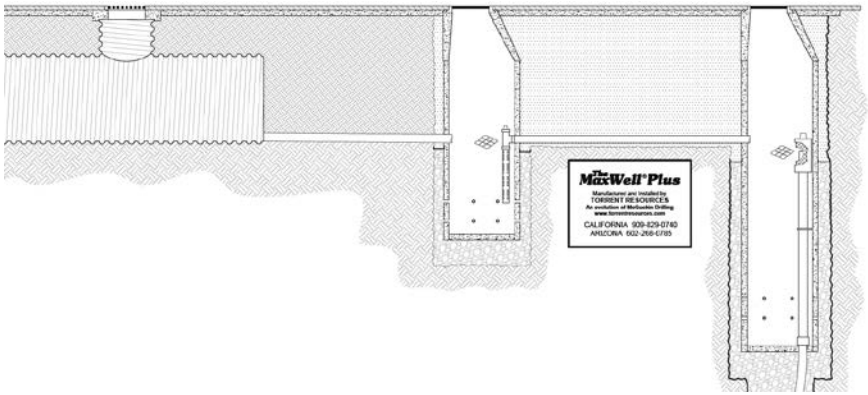
- **Single Chamber System** in a residential area

Typical Installation

- **Dual Chamber System** in commercial area

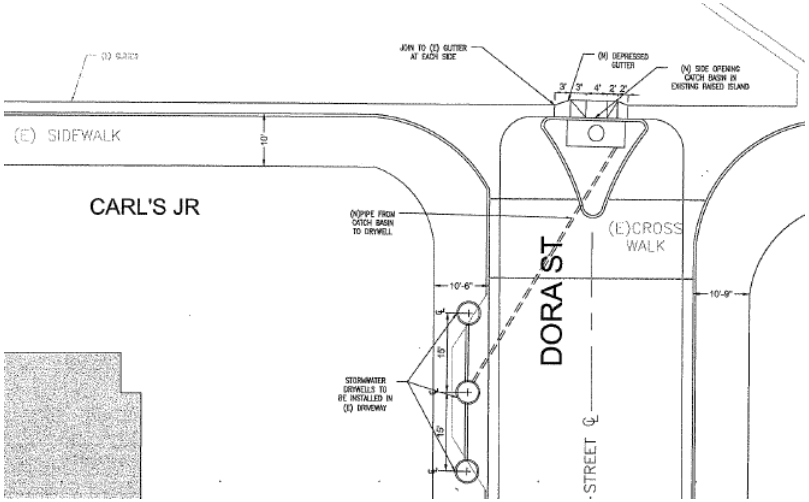
Typical Installation

- **Tying into UG Storage**
  - Large detention system feeding into primary chamber



Specialty Installation

- **Glen Oaks Boulevard Project**
  - Green Street retrofit in LA
  - Dual Chamber System systems
  - Up to 9.3 million gallons per year

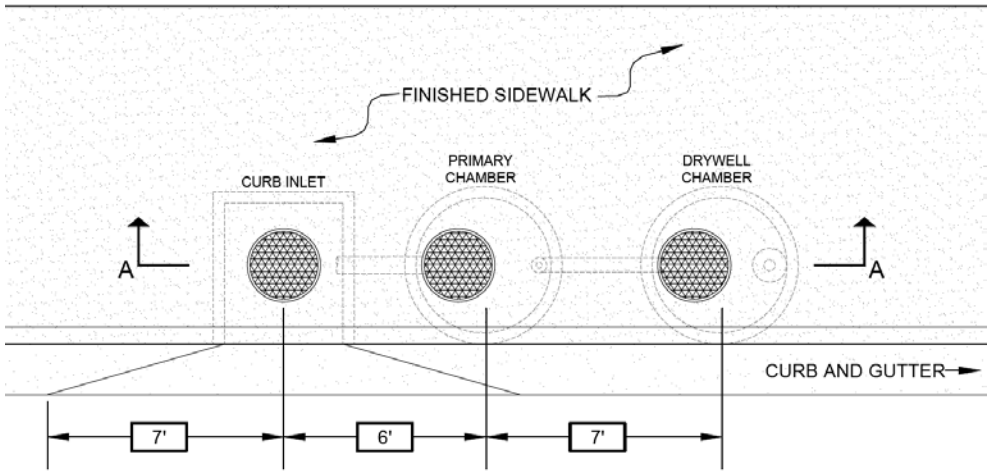


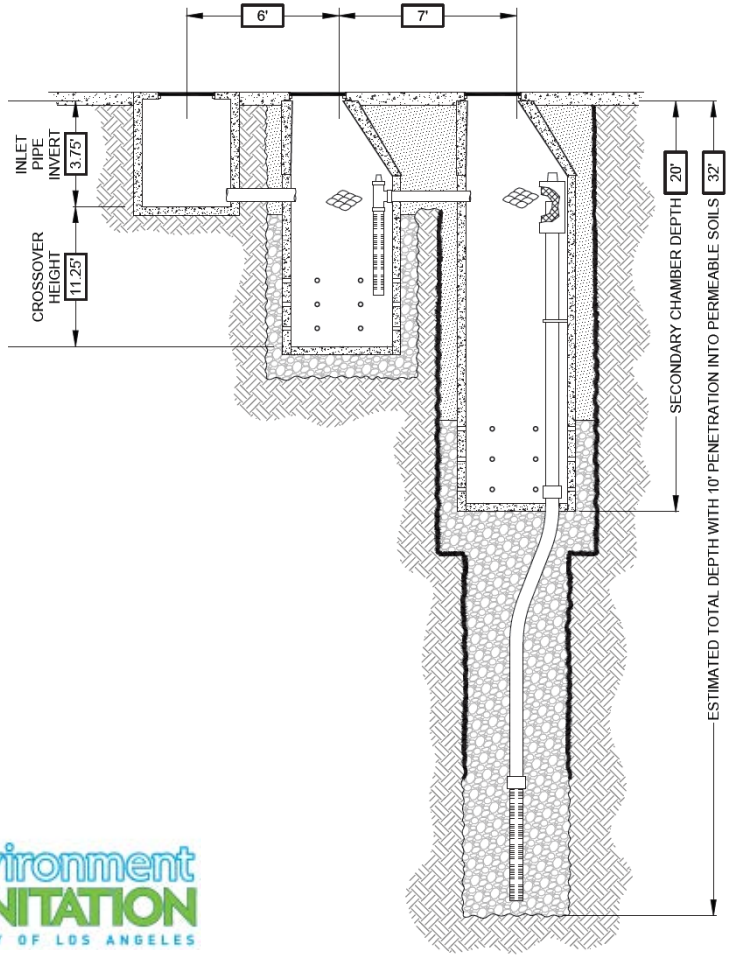
Specialty Installation

- **Glen Oaks Boulevard Project**
  - Funded through Proposition O
  - Praised as “the most cost effective of all Prop O projects.”
  - Meter to track recharge

Specialty Installation

- **Sun Valley EDA Project**
  - Green Street retrofit in Los Angeles
  - Dual chambered drywell and curb inlet



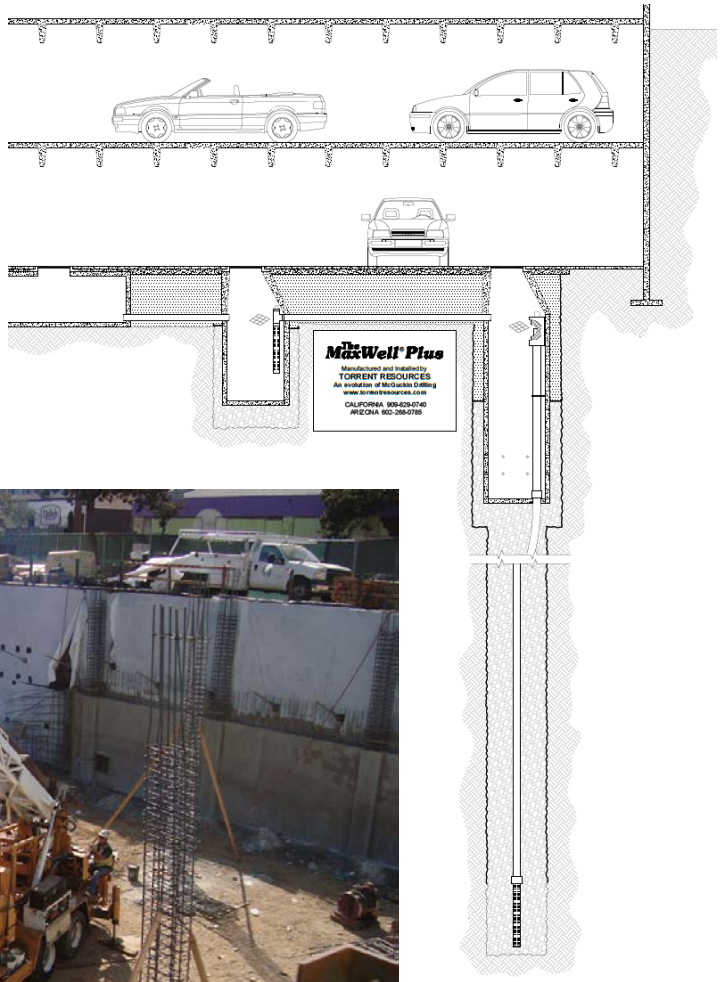


Specialty Installation

- **Sun Valley EDA Project**
- Project details
  - 146 acre watershed
  - 93 acre feet/year available
  - 46 drywells installed

Specialty Installation

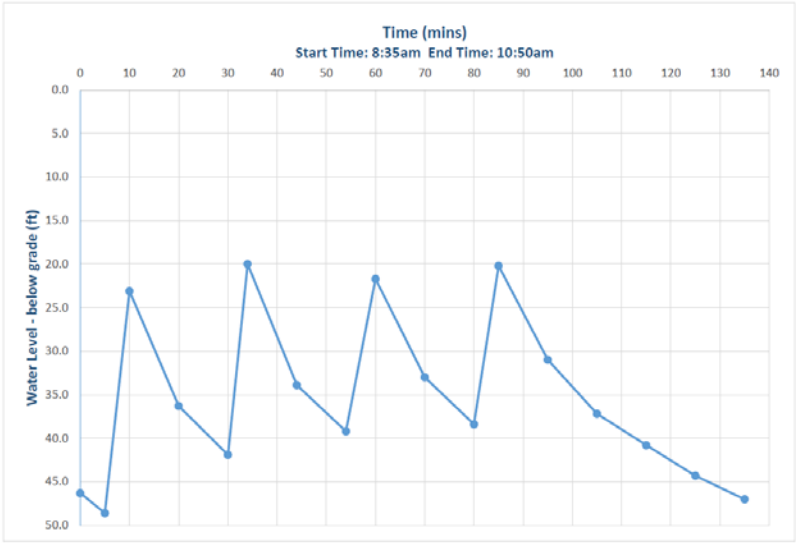
- **Urban Infill Downtown LA**
  - Installed in lowest level



Ideally Suited for a Confining Layer

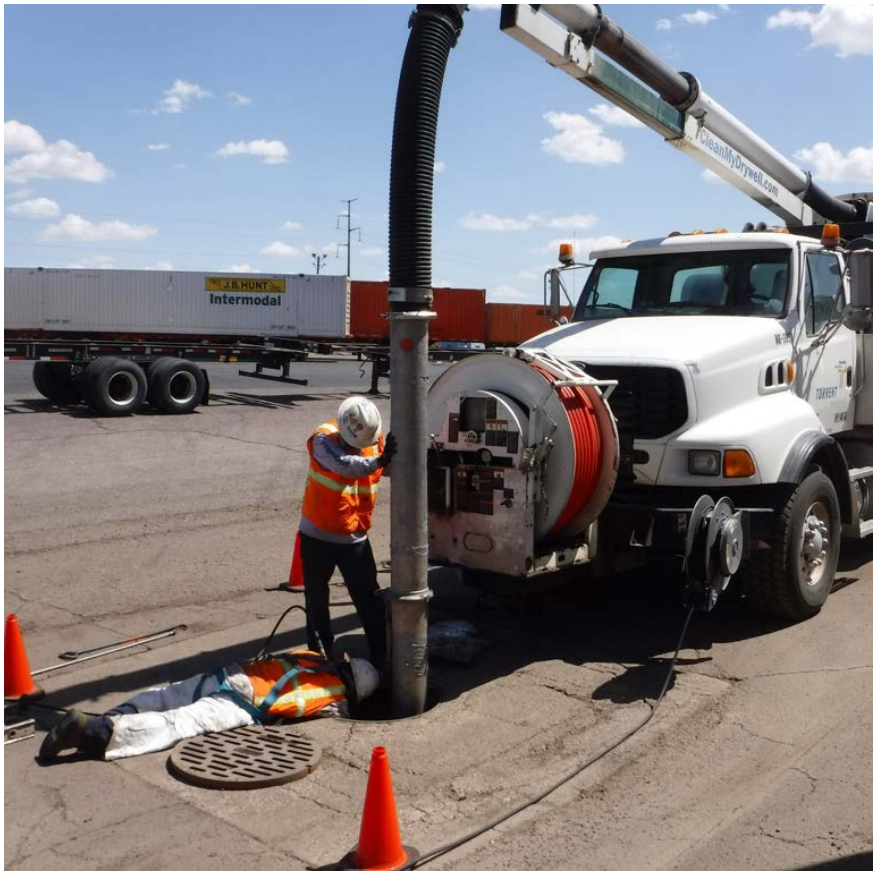
- **San Diego Project**
  - Clays at surface
  - Evaluated deeper soils
  - Better material beneath
  - Drywells performed
  - Cost savings

Time (am)	Time (mins)	Water Level - Below Grade (ft)
8:30	Add 40 gallons (pre-soak)	
8:35	0	46.3
8:39	5	48.6
8:40	Add 40 gallons	
8:45	10	23.1
8:55	20	36.3
9:05	30	41.9
9:06	Add 22.5 gallons	
9:09	34	20.0
9:19	44	33.9
9:29	54	39.2
9:30	Add 25 gallons	
9:35	60	21.7
9:45	70	33.0
9:55	80	38.4
9:56	Add 25 gallons	
10:00	85	20.2
10:10	95	31.0
10:20	105	37.2
10:30	115	40.8



Drywell Maintenance

- **System Maintenance is Simple**
  - Regular maintenance = longevity
  - Indefinite life span



MaxWell™ DRAINAGE SYSTEMS

TORRENT RESOURCES INCORPORATED
AZ Lic. ROC070465 A, ROC047067 B-4; ADWR 363
CA Lic. 528080 A, C-42, HAZ - *NV Lic.* 0035350 A - *NM Lic.* 90504 GF04

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Phoenix Arizona 85040-1391
phone 602-268-0785
fax 602-268-0820
www.TorrentResources.com
An evolution of McGuckin Drilling

California
661-947-9836
Nevada
702-366-1234

TORRENT RESOURCES

IMPORTANT MAINTENANCE DATA AND WARRANTY INFORMATION

This property is equipped with the finest on-site drainage system ever designed. With regular inspection and maintenance, it will last for many years. The reverse of this sheet has an illustration that shows just how the standard ***MaxWell™*** works to trap silt and trash, and dispose of surplus surface water.

MAINTENANCE

Once each year, and after every major storm, you can check the debris level in your ***MaxWell*** settling chamber by dropping a weighted tape measure through the surface grate. On MaxWell Plus™ systems, the primary settling chamber can be checked the same way.

When the measurement to the bottom of the chamber is less than specified under "cleanout depth," or if the floating absorbent pillow is submerged, the ***MaxWell*** should be serviced.

MaxWell drainage systems are designed to efficiently dispose of retained stormwater. Drainage time is normally dependent upon site design, user convenience or rainfall intensity. If drainage appears slow, or if water is standing for more than 36 hours, the system should be inspected.

For your convenience, Torrent Resources offers a complete Maintenance Program including Service Maintenance Agreements. Please call us for information on this valuable service.

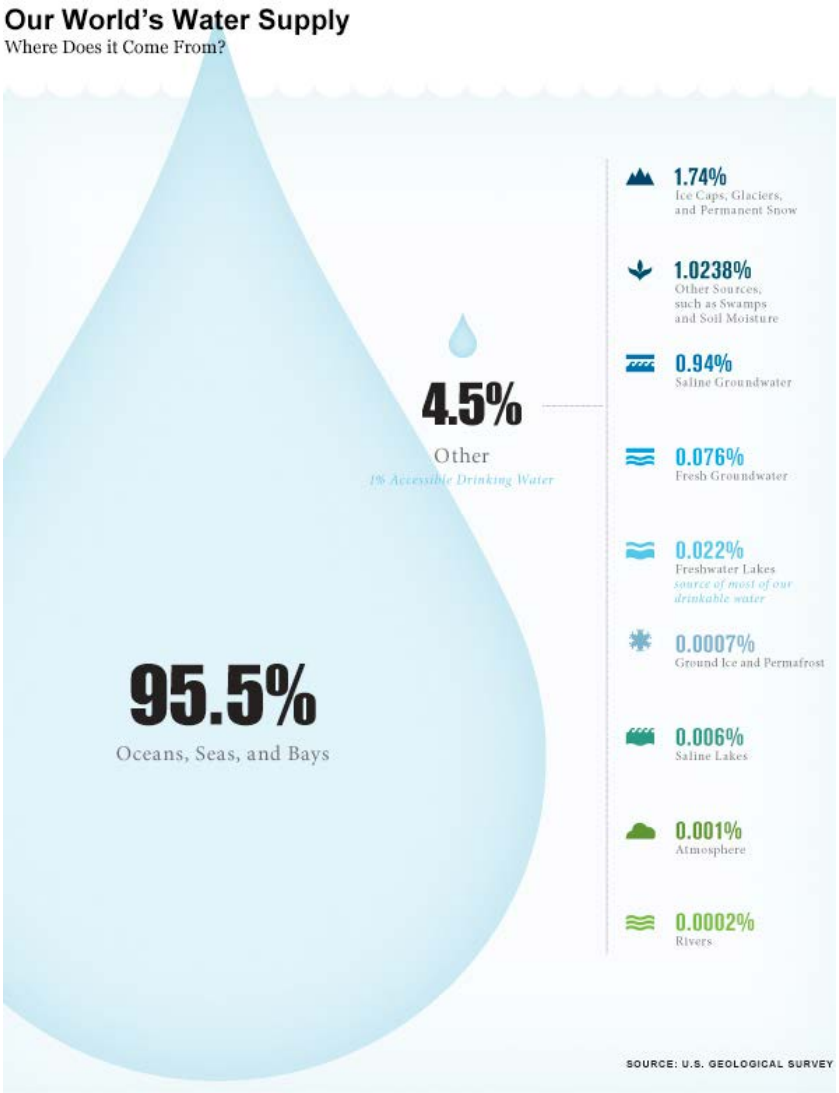
Engineered Drywells are Proven

- **Benefits of engineered drywells**
  - Minimal risk of aquifer contamination
  - Get past confining layer
  - Recharge groundwater
  - Long service life
  - Small footprint
  - Low cost
  - Fast to construct
  - Simple to maintain
  - Handles flow or volume based designs

Water is Precious

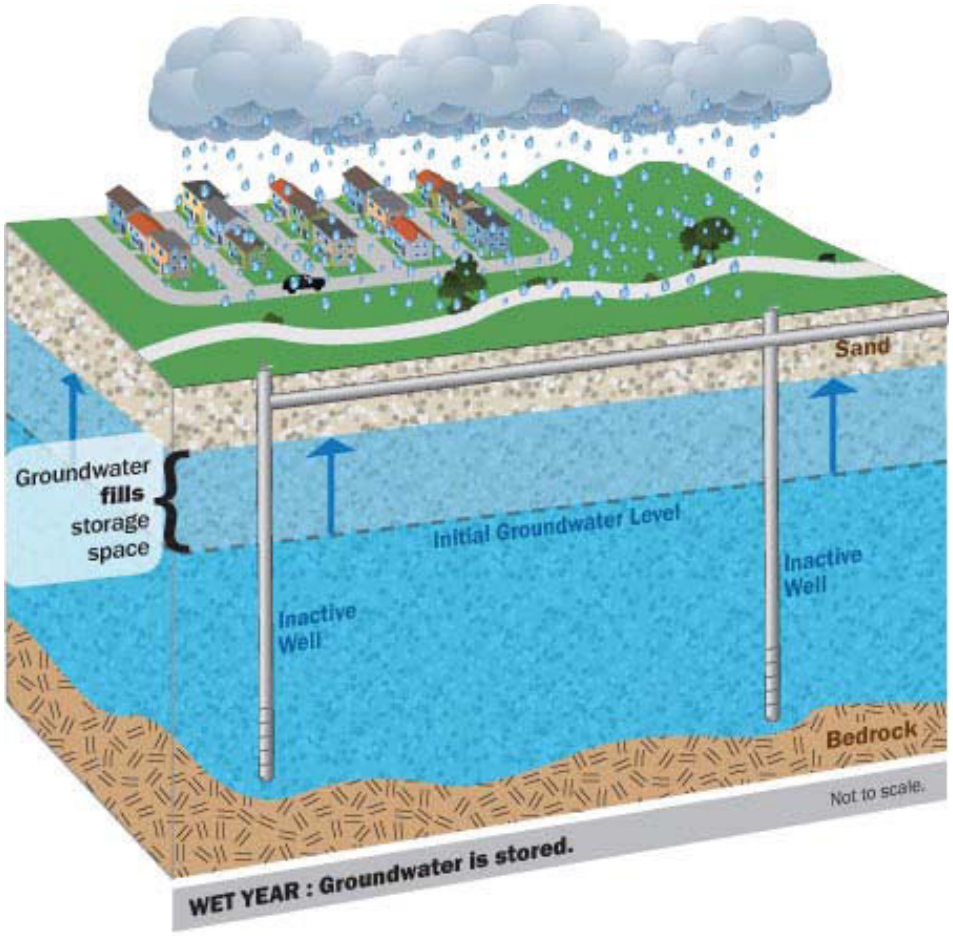
- **Manage what we have…**
  - Salt water 95.5%
  - Fresh water 4.5%
    - Available fresh water ≈ 0.1%

Water Form	Percent
Salt Water	95.5%
Ice Caps	1.74%
Swamps	1.0238%
Saline Groundwater	0.094%
Fresh Groundwater	0.076%
Lakes	0.022%
Saline Lakes	0.006%
Atmosphere	0.001%
Permafrost	0.0007%
Rivers	0.0002%



Secure Water Supply

- **Reservoirs**
- **Desalination Plants**
- **Aquifer Storage**
  - Aquifer capacity is enormous
  - Won't evaporate
  - Improves ecosystem
  - Minimal permitting
  - Low environmental impact
  - Lowest cost



Info from Stanford Woods Institute – Water in the West

Conclusions

- Stormwater is a valuable resource
- Infiltration (recharge) is beneficial
- Investigate proposed site carefully
- Incorporate pre-treatment
- Drywell guidance needed
- Look to others for guidance

Question and Answer

ANY QUESTIONS?

THANK YOU

WE ARE HAPPY TO PROVIDE COPIES OF ANYTHING DISCUSSED TODAY