Building and Testing Rain Gardens

To Meet NPDES Retention and Hydromodification Management Requirements

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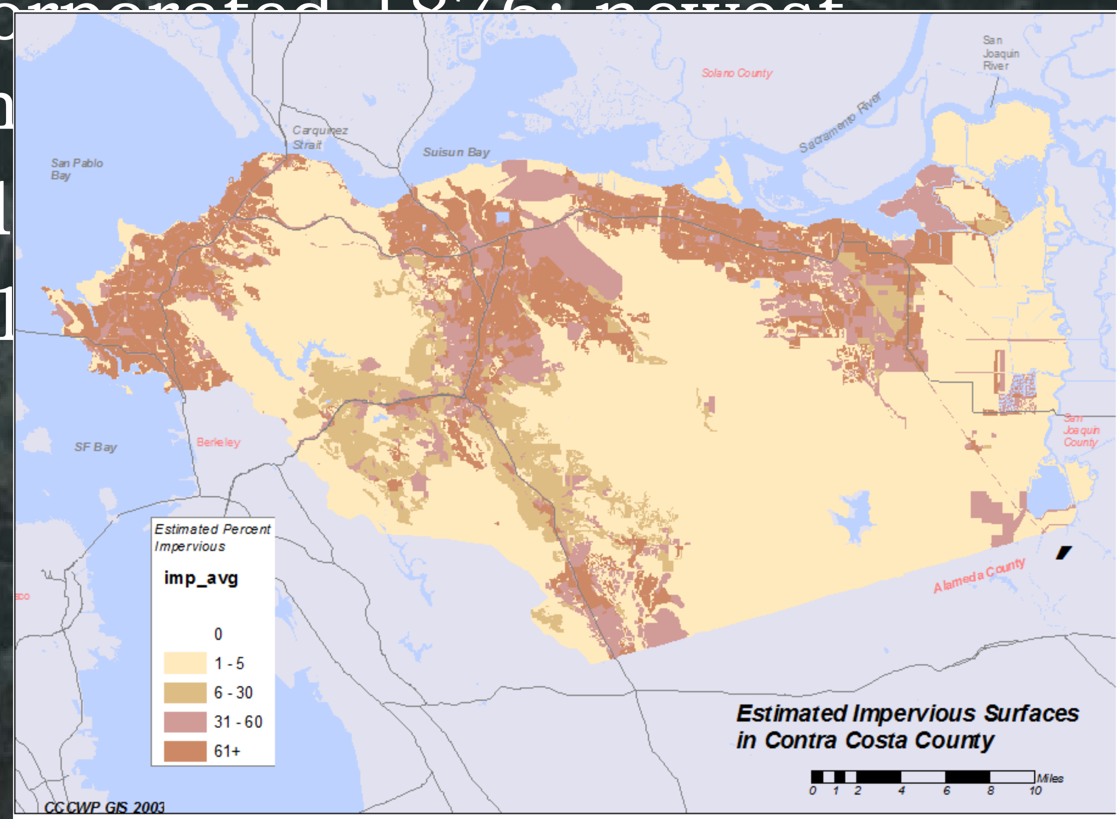
CASQA Conference, September 27, 2011

CONTRA COSTA
CLEAN WATER
PROGRAM

- 21 Copermittees
- One million residents
- Oldest city inco
  incorporated in
- Annual rainfall
- Mostly clay soil



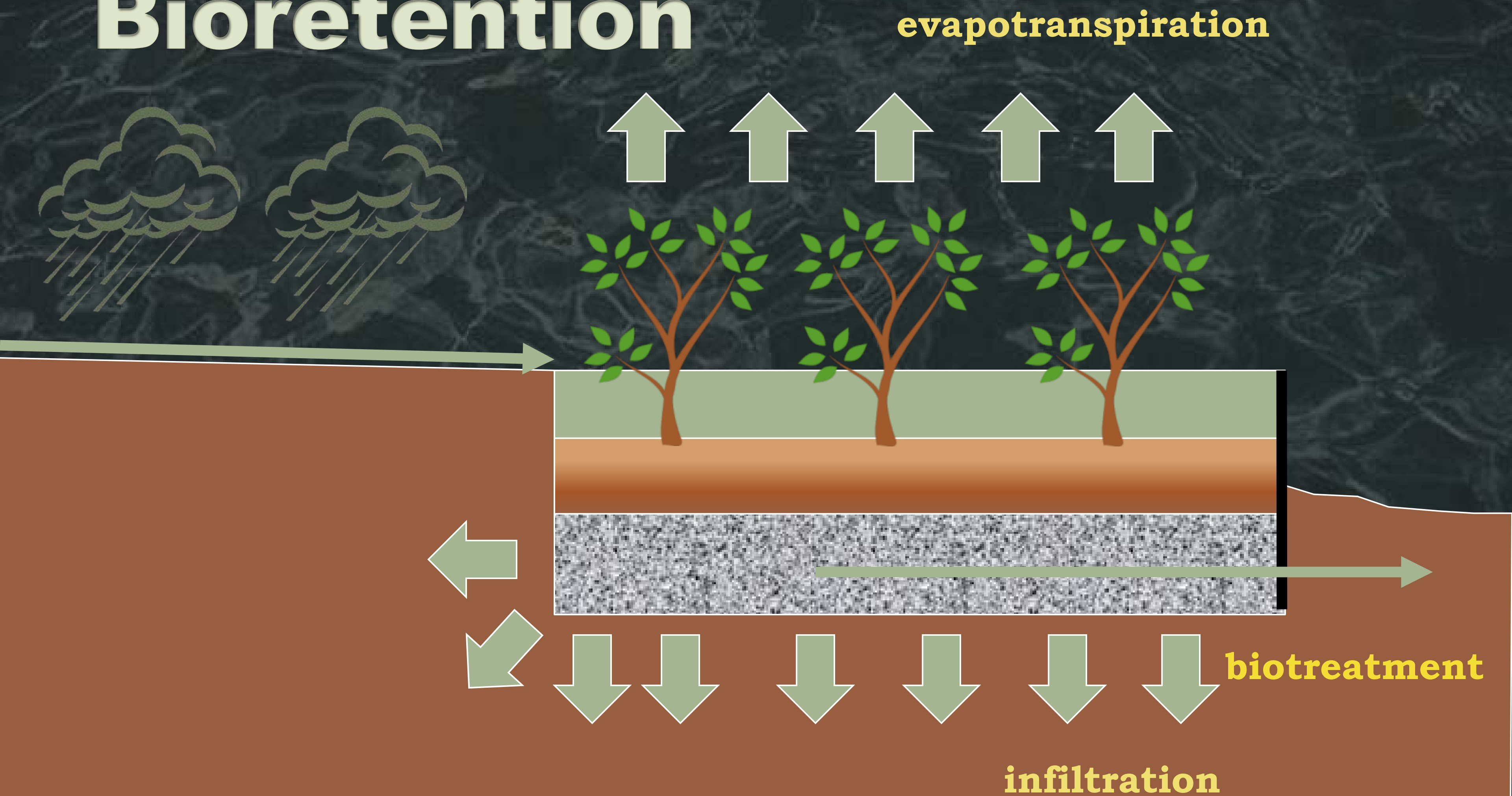
LID in Contra Costa

- *Stormwater C.3 Guidebook* published 2005
  - LID approach to treatment
  - Well received and widely implemented
  - Continuously improved under direction of municipal staff
  - Fifth Edition published 10/20/2010
- Hydrograph Modification Management Plan (HMP) approved 2006
  - Uses LID to control flow peaks and durations
  - Based on computer-modeled performance of bioretention and other LID facilities
- HMP requires monitoring 5 locations to validate model

Topics

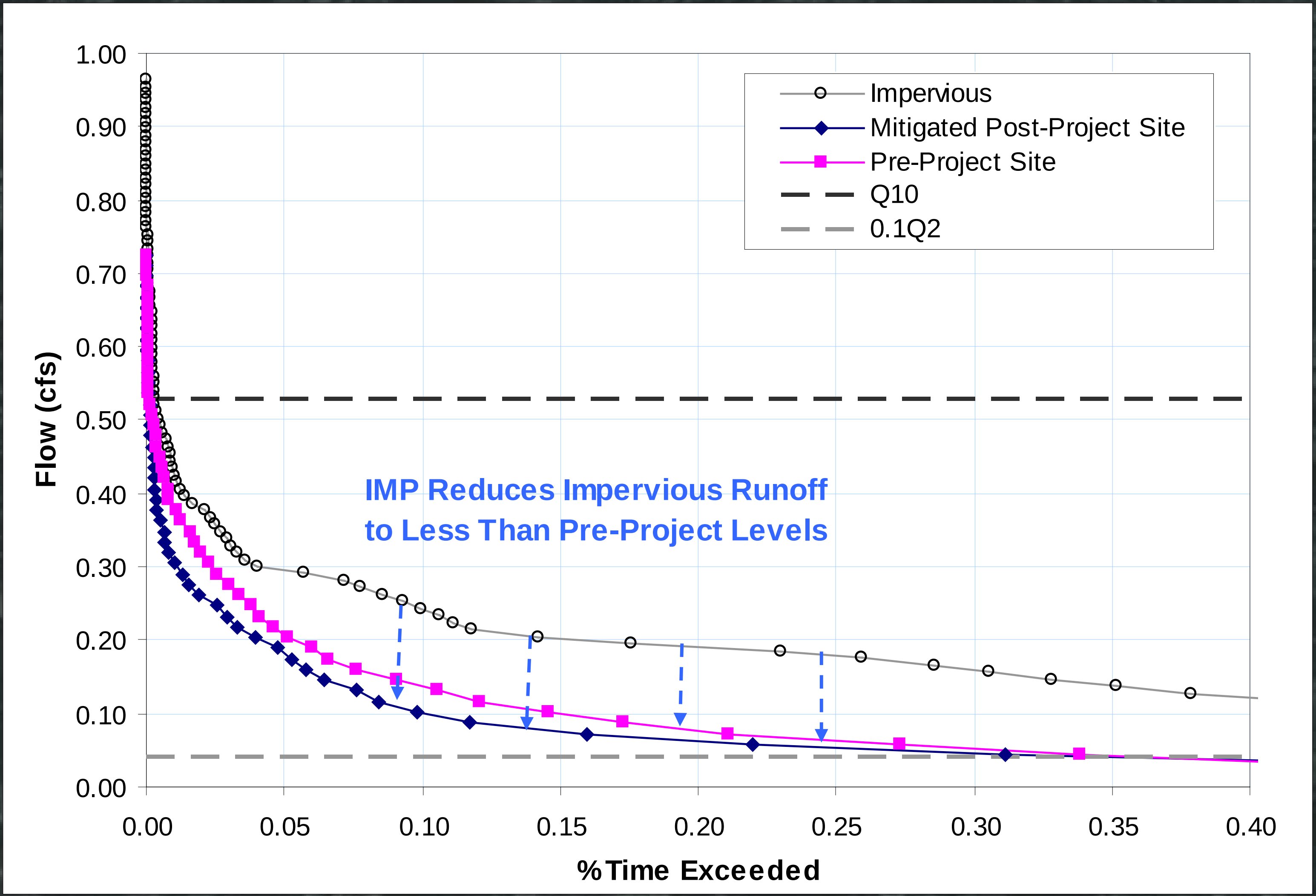
- Bioretention:
  - What we don't know
  - Why we need to know it
- Model of Bioretention Performance
  - Rate and duration of underdrain discharge
- Design of Our Experiment to Validate Model
- Design and Construction of Bioretention Facilities and Monitoring Instrumentation
  - Office Building
  - Residential Townhouse Development

Bioretention

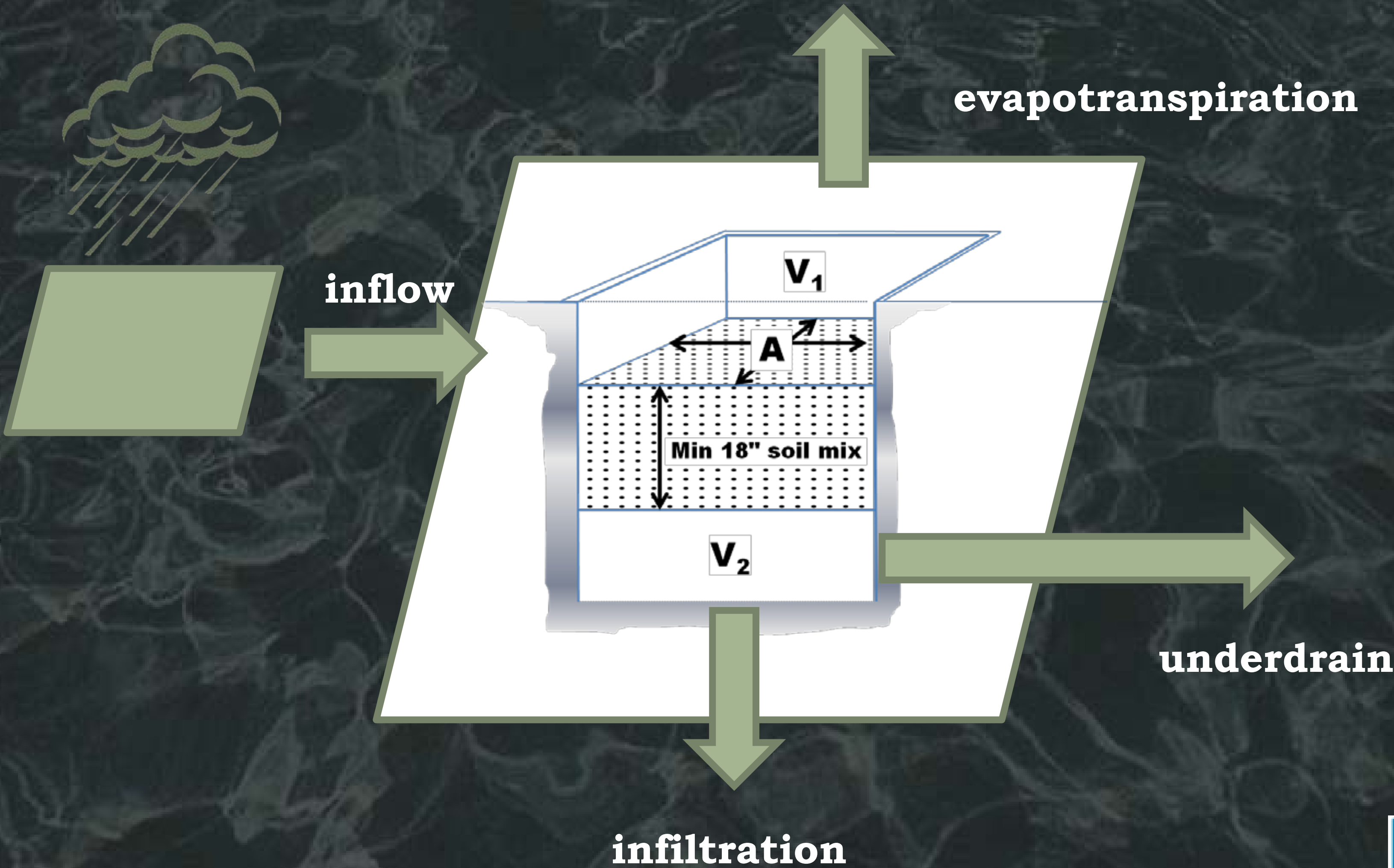


What proportion of runoff goes where?

Hydromod: What's it mean?



Modeling Bioretention



About the Model

- A watershed model (HSPF) was adapted to characterize bioretention performance.
  - Stage-storage discharge relationships for each layer represented within FTABLEs in HSPF.
  - At each time step, moisture content of the bioretention soil media, matric head within soil pores, and hydraulic conductivity of the soil media are recalculated.
- Watershed models are typically calibrated using stream gage data. This model is uncalibrated.

Limitations of the model

- Pan evaporation was used to calculate evapotranspiration.
- Single, textbook values were used for hydraulic conductivity of underlying soils.
- Lateral movement of moisture from the bioretention media and gravel layer into the surrounding soil was not accounted for.
- The effects of head above the underlying soil surface were not accounted for.

Model output: hourly flow

Hour #	Flow (cfs)
1	0.0
2	0.0
3	0.1
4	0.1
5	0.0
6	0.2
7	1.5
8	0.6
Etc.	

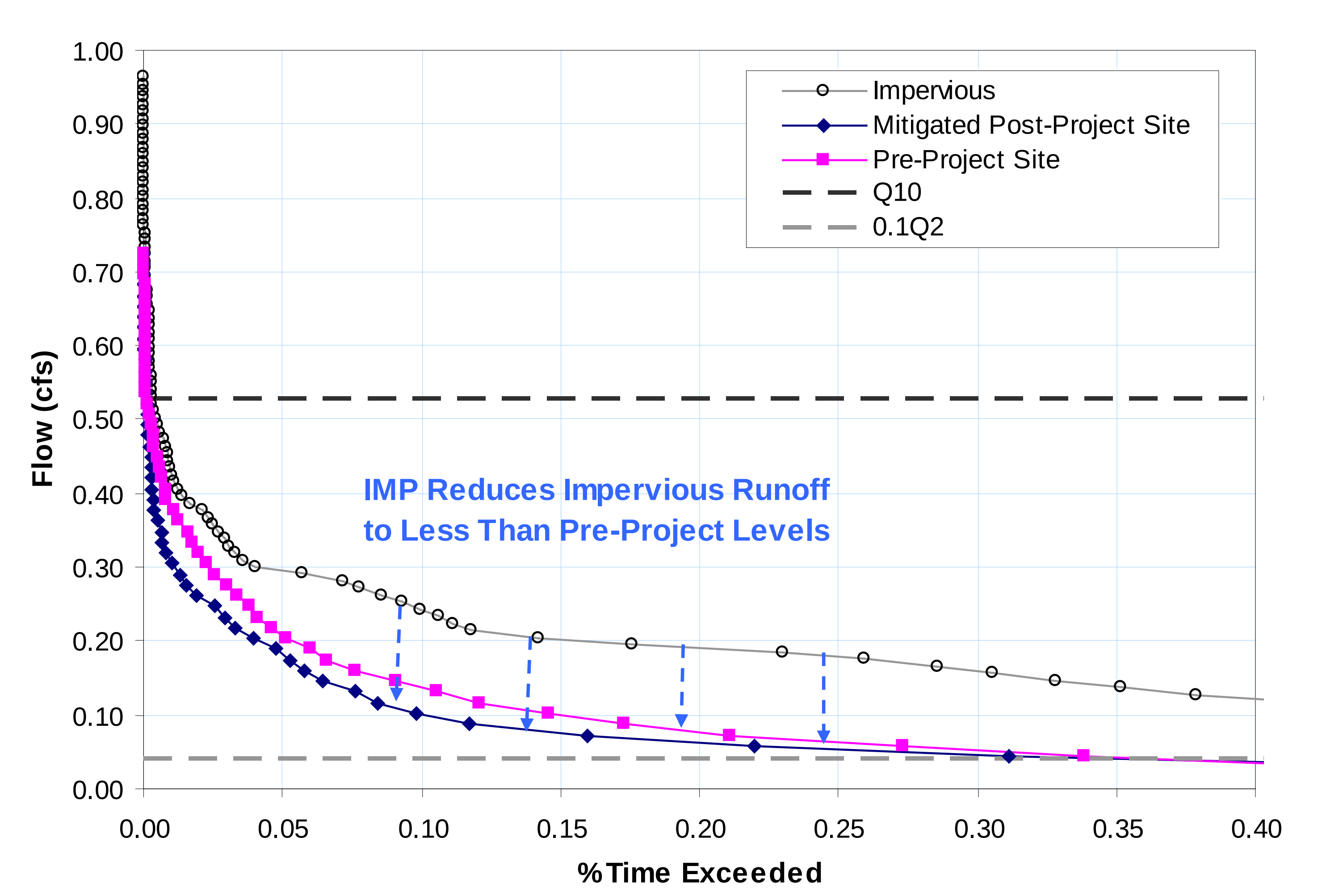
250,000 hours: Sort by flow

Hour #	Flow (cfs)	Hours exceeded
115241	10.3	0
4598	10.3	1
3672	10.2	2
115242	10.0	3
243581	10.0	4
66058	9.9	5
75291	9.8	6
186540	9.7	7
Etc.		

This flow was exceeded during 2 hours/250,000 hours (0.0008%)

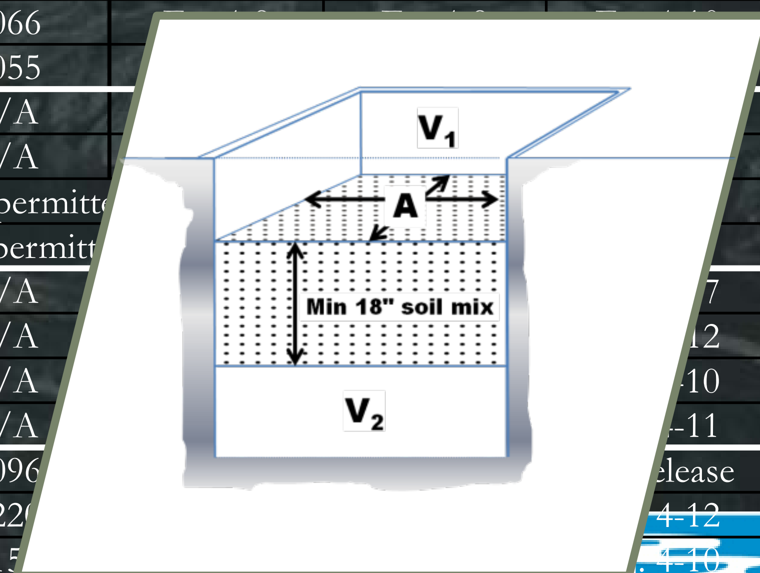
This flow was exceeded during 7 hours/250,000 hours (0.0028%)

Plot Results: Compliance

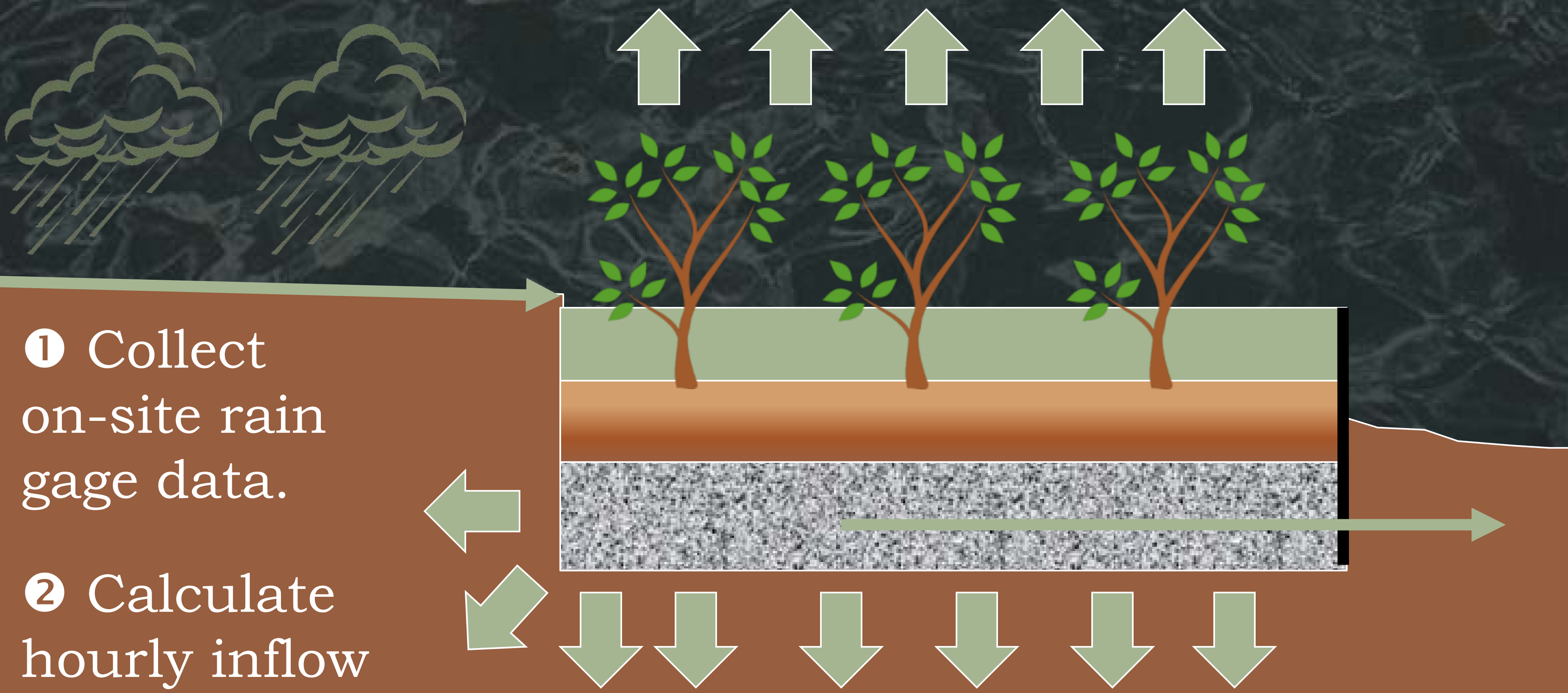


Sizing Factors

Facility Design	Soil Group	Area A (ft^2/ft^2)	Volume V_1 (ft^3/ft^2)	Volume V_2 (ft^3/ft^2)	Rainfall Adjustment for Surface Area	Rainfall Adjustment for Storage Volume	Maximum Release Rate
Bioretention Facility	A	0.07	0.058	No min.	Eq. 4-6	Eq. 4-6	No orifice
	B	0.11	0.092	No min.	Eq. 4-7	Eq. 4-7	No orifice
	C	0.06	0.050	0.066	Eq. 4-8	Eq. 4-8	Eq. 4-10
	D	0.05	0.042	0.055	Eq. 4-9*	Eq. 4-9	Eq. 4-11
Flow-through Planter	A	Not permitted in "A" soils					
	B	Not permitted in "B" soils					
	C	0.06	0.050	0.066	[illegible]	[illegible]	[illegible]
	D	0.05	0.042	0.055	[illegible]	[illegible]	[illegible]
Dry Well	A	0.05	0.130	N/A	[illegible]	[illegible]	[illegible]
	B	0.06	0.204	N/A	[illegible]	[illegible]	[illegible]
	C	Not permitte[illegible]					
	D	Not permitt[illegible]					
Cistern + Bioretention	A	0.020	0.193	N/A	[illegible]	[illegible]	[illegible]7
	B	0.009	0.210	N/A	[illegible]	[illegible]	[illegible]12
	C	0.013	0.105	N/A	[illegible]	[illegible]	[illegible]-10
	D	0.017	0.063	N/A	[illegible]	[illegible]	[illegible]-11
Bioretention + Vault	A	0.04	N/A	0.096	[illegible]	[illegible]	[illegible]elease
	B	0.04	N/A	0.22[illegible]	[illegible]	[illegible]	[illegible]4-12
	C	0.04	N/A	0.15[illegible]	[illegible]	[illegible]	[illegible]4-10
	D	0.04	N/A	0.064	N/A	Eq. 4-9	Eq. 4-11



Now, for a real installation:



❶ Collect on-site rain gage data.

❷ Calculate hourly inflow for the real tributary area

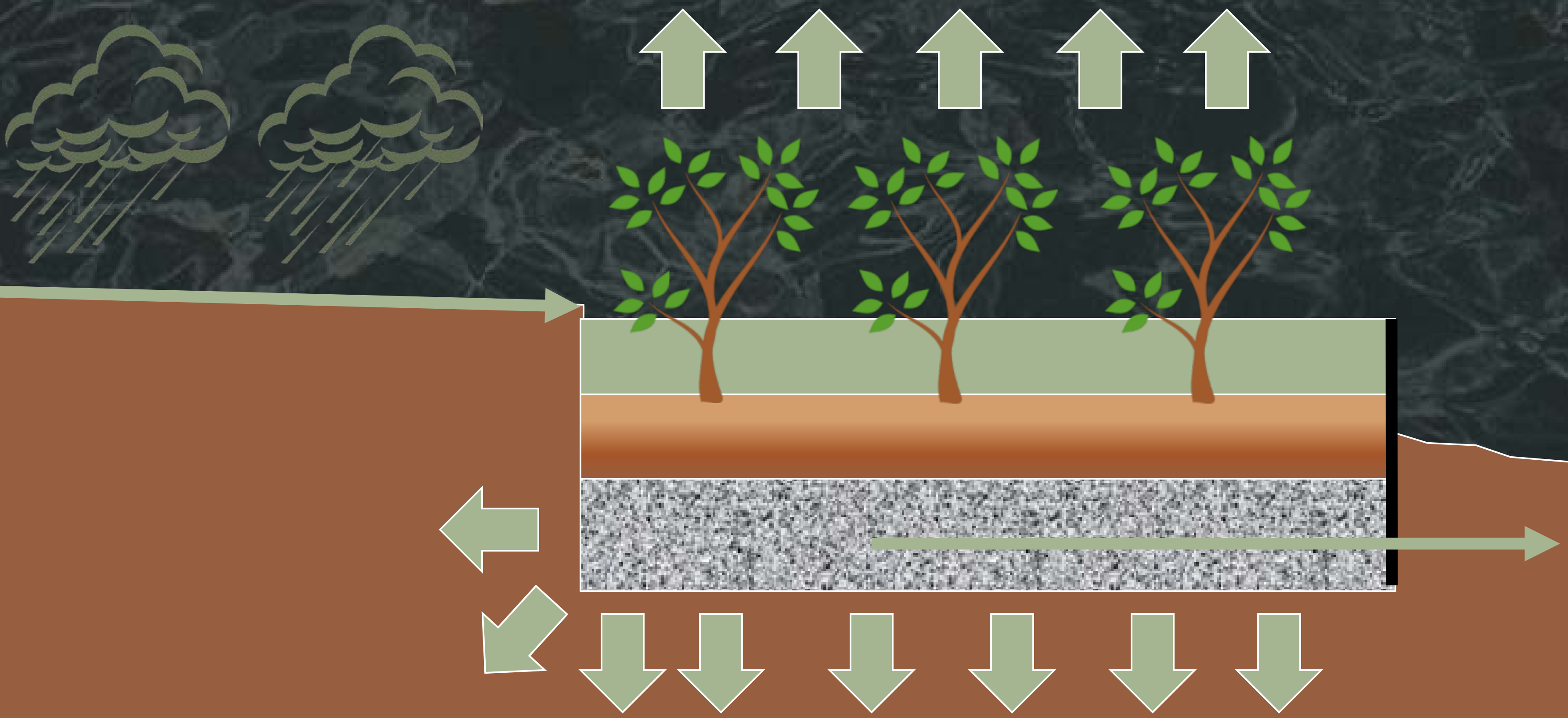
❸ Use the model to predict hourly ET, infiltration, and underdrain flow

❹ Measure actual underdrain flow.

Model Validation/Tweaking

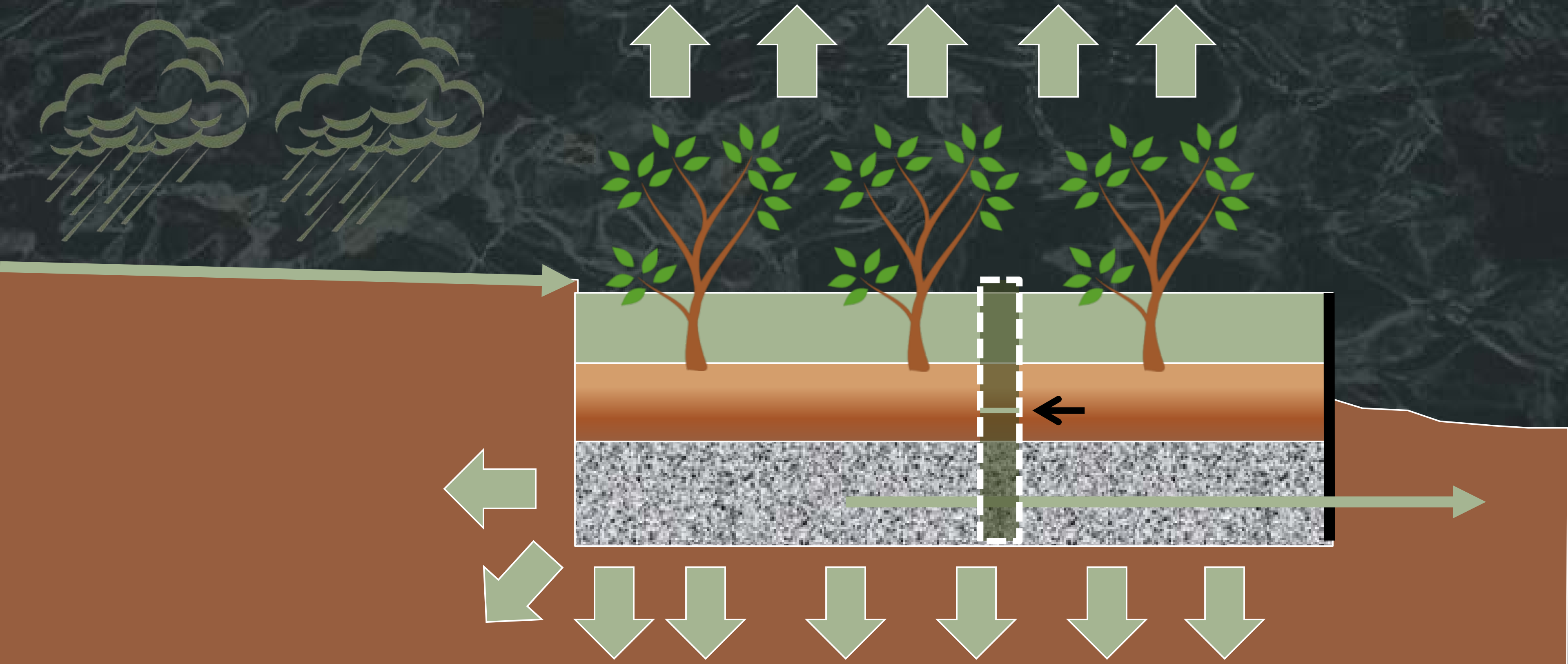
5. Compare predicted to actual outflow rates (hour by hour).
6. Tweak the model inputs so that model output more accurately represents actual underdrain discharge (hour-by-hour and storm-by-storm).
7. Then, use those new model inputs to recalculate sizing factors for bioretention minimum area (A), surface storage volume (V_1) and subsurface storage volume (V_2).

Bonus



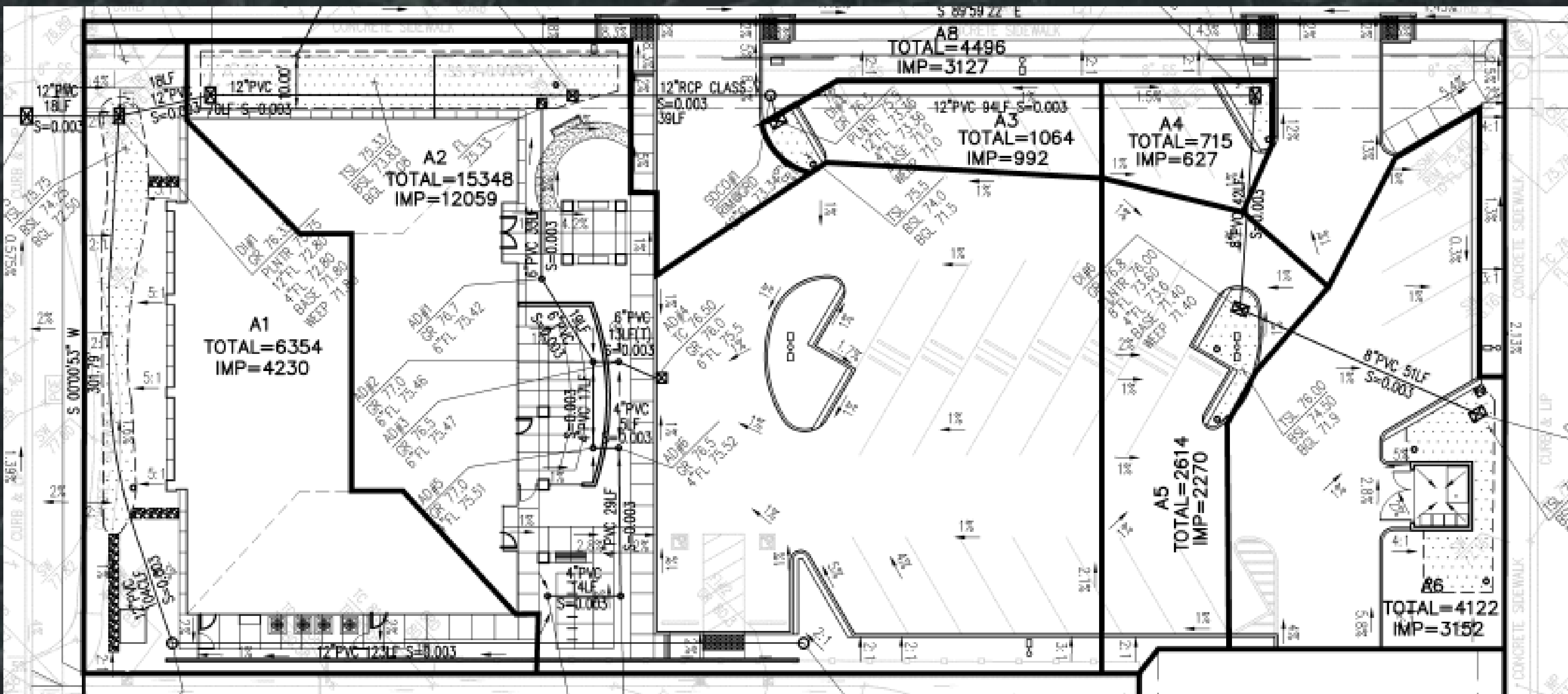
We can then input 30+ years of rainfall data and use our validated/tweaked model to predict the percent infiltrated + evapotranspirated (annual average).

Insight



**Within some of the facilities,
we will also track saturation level.**

Fire Protection Building

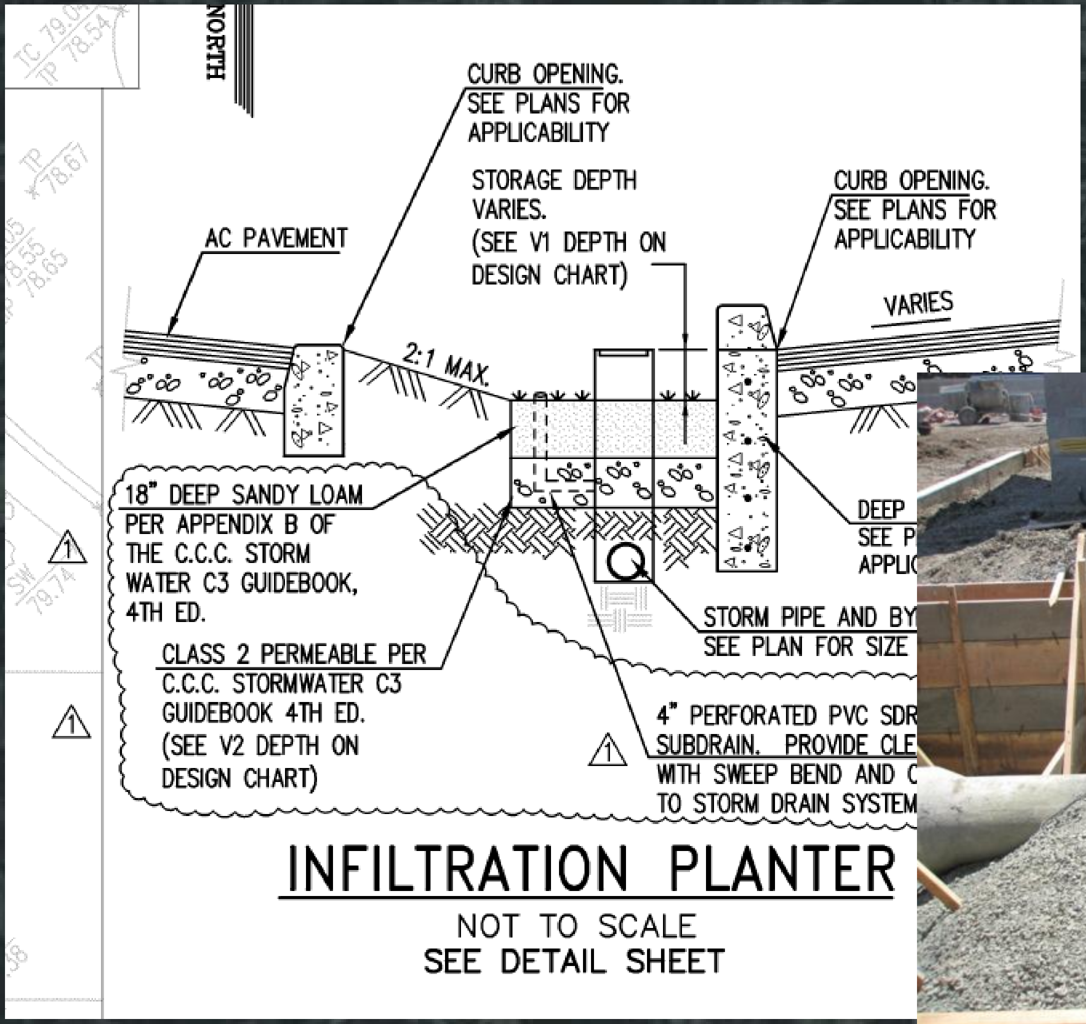


Sizing per *Guidebook*

STORM TREATMENT DESIGN (PER CONTRA COSTA COUNTY)

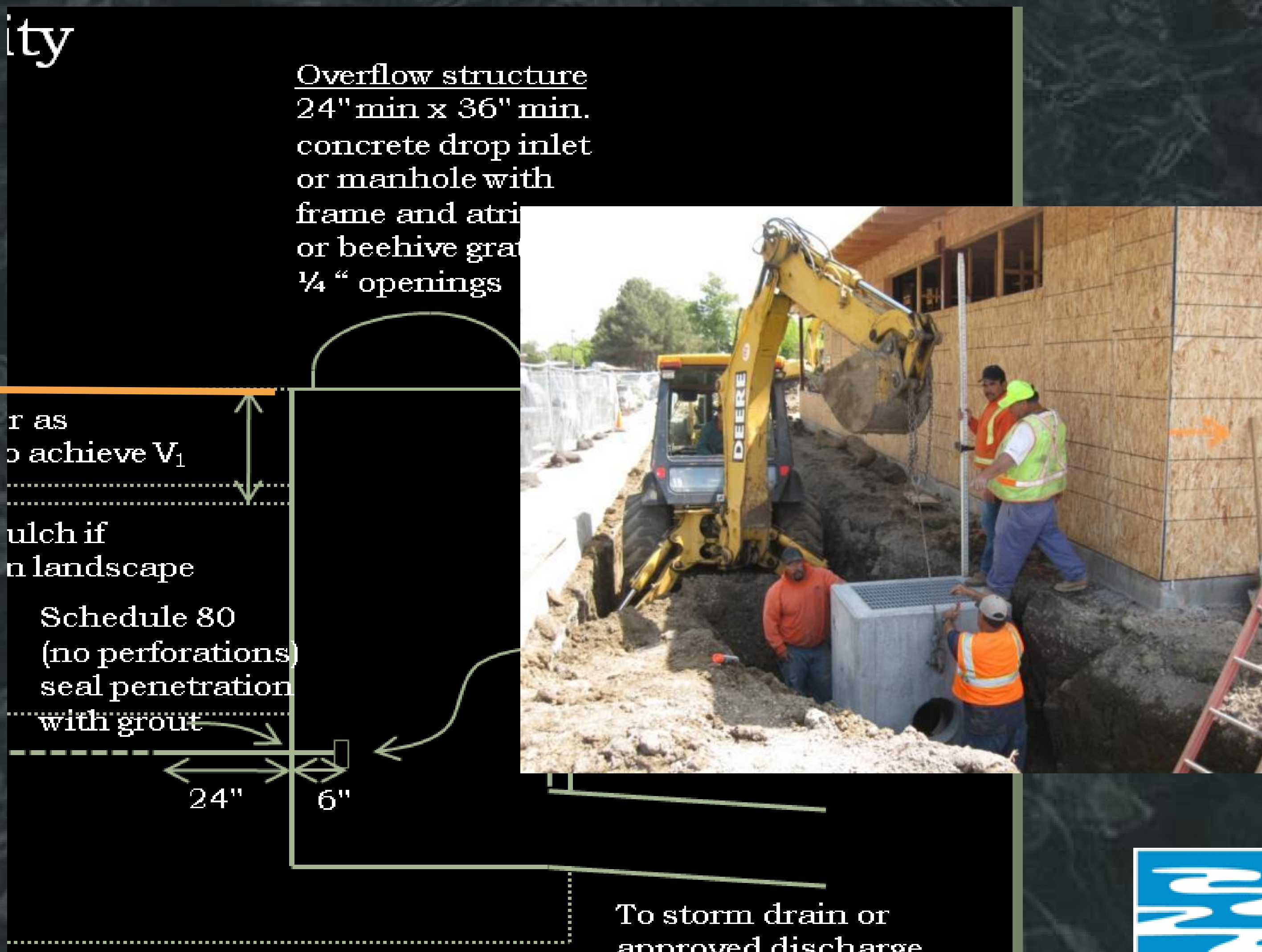
IMP NAME	TYPE	SOIL GROUP	RAIN ADJ. FACTOR	A SIZING FACTOR	V1 SIZING FACTOR	V2 SIZING FACTOR	D.M. AREA (S.F.)	RUNOFF FACTOR	MIN. SIZE (S.F.)	PLANNED SIZE (S.F.)	V1 REQUIRED (C.F.)	V1 PROVIDED (C.F.)	V2 REQUIRED (C.F.)	V2 PROVIDED (C.F.) (POROSITY=0.4)	MAX. FLOW (ORIFICE SIZE)
A1	IN-GROUND (INFILTRATION) PLANTER	D	1.27	0.05	0.042	0.055	1582	0.7	339	542	285	316 (V1-DEPTH = 7")	373	379 (V2-DEPTH=21")	0.01 CFS (0.51" DIAM.)
							4230	1							
A2	IN-GROUND (INFILTRATION) PLANTER	D	1.27	0.05	0.042	0.055	2415	0.7	873	874	734	874 (V1-DEPTH = 12")	960	961 (V2-DEPTH=33")	0.02 CFS (0.81" DIAM.)
							12059	1							
A3	IN-GROUND (INFILTRATION) PLANTER	D	1.27	0.05	0.042	0.055	0	0.7	63	72	53	72 (V1-DEPTH = 12")	70	72 (V2-DEPTH=30")	0.00 CFS (0.21" DIAM.)
							992	1							
A4	IN-GROUND (INFILTRATION) PLANTER	D	1.27	0.05	0.042	0.055	0	0.7	40	88	34	44 (V1-DEPTH = 6")	44	44 (V2-DEPTH=15")	0.00 CFS (0.17" DIAM.)
							627	1							
A5	IN-GROUND (INFILTRATION) PLANTER	D	1.27	0.05	0.042	0.055	180	0.7	152	164	127	130 (V1-DEPTH = 9.5")	167	170 (V2-DEPTH=31")	0.00 CFS (0.32" DIAM.)
							2270	1							
A6	IN-GROUND (INFILTRATION) PLANTER	D	1.27	0.05	0.042	0.055	562	0.7	225	408	189	204 (V1-DEPTH = 6")	247	258 (V2-DEPTH=19")	0.00 CFS (0.41" DIAM.)
							3152	1							
A7	SELF-TREATING (ALL PERVIOUS)	D	1.27	0.05	0.042	0.055	12767	0.7	---	---	---	---	---	---	---
							0	1							
A8	UN-TREATABLE	D	1.27	0.05	0.042	0.055	1369	0.7	---	---	---	---	---	---	---
							3127	1							
TOTAL PROJECT SITE AREA: 47480 S.F. (1.09 ACRE)							18875			2148					
							26457								

Design and Construction

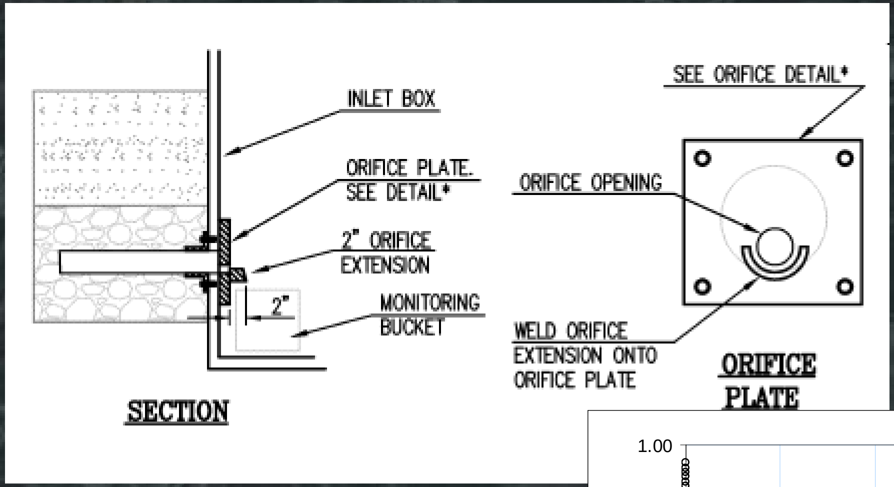


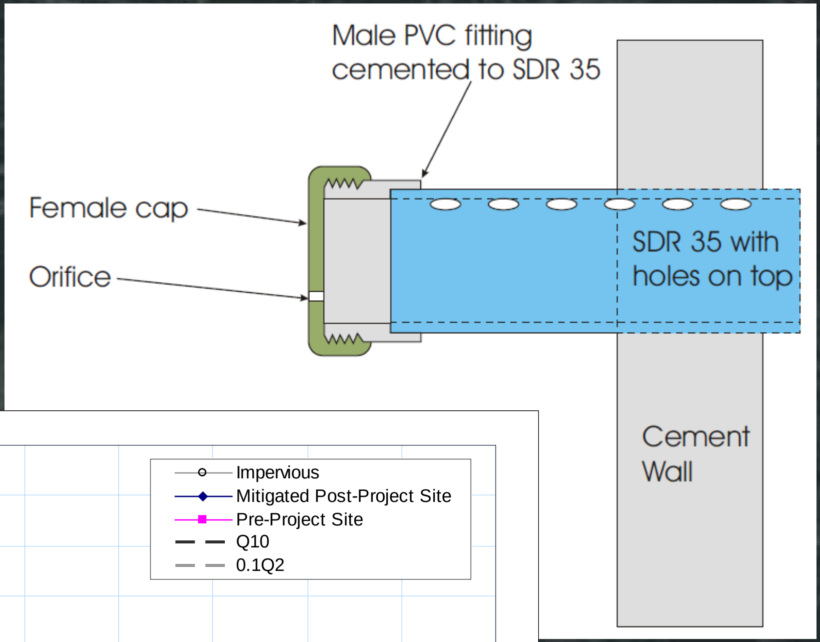
Outlet Design

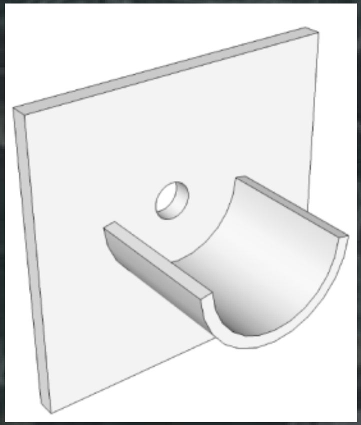
Overflow
elevation

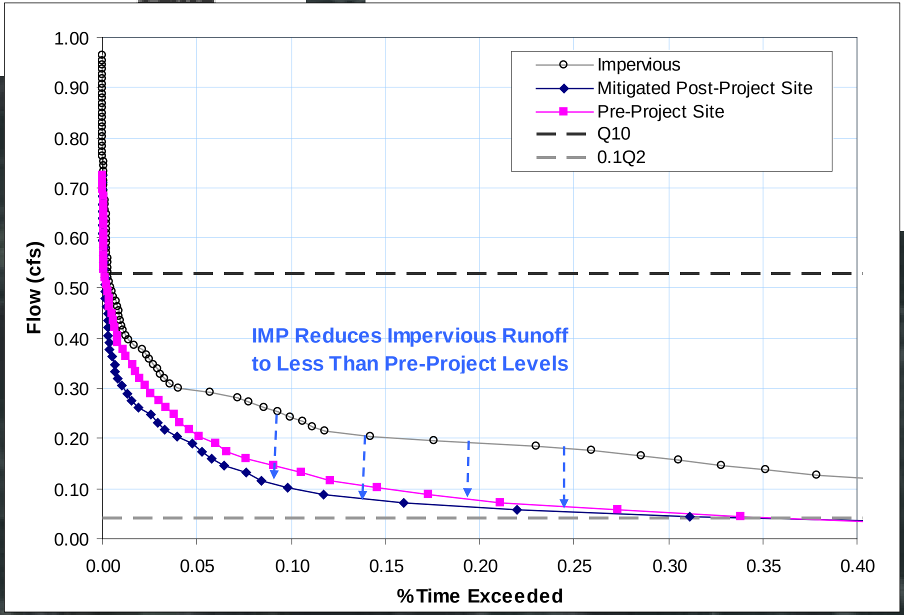


Orifice Design



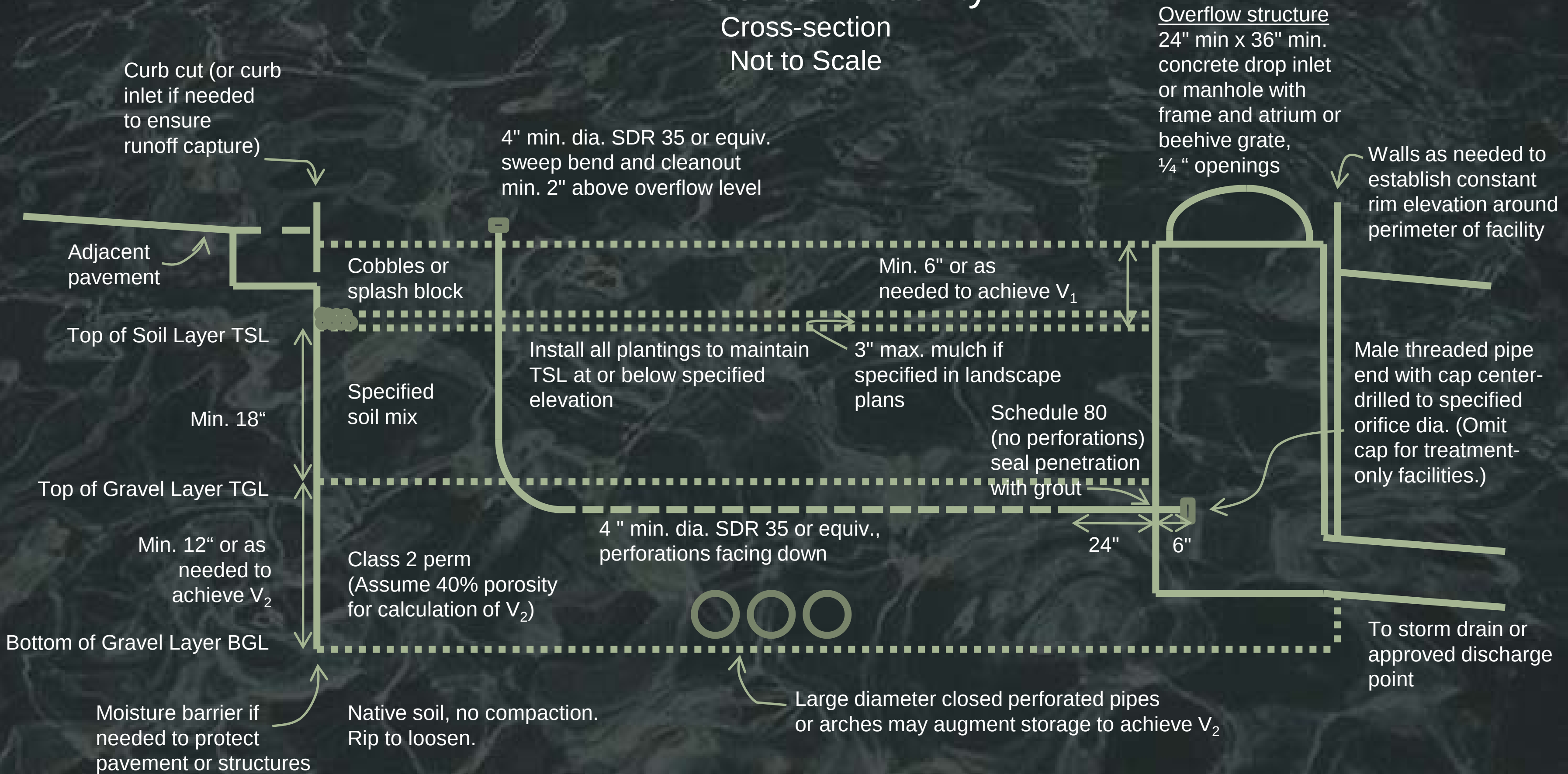






Bioretention Facility

Cross-section
Not to Scale



Notes:

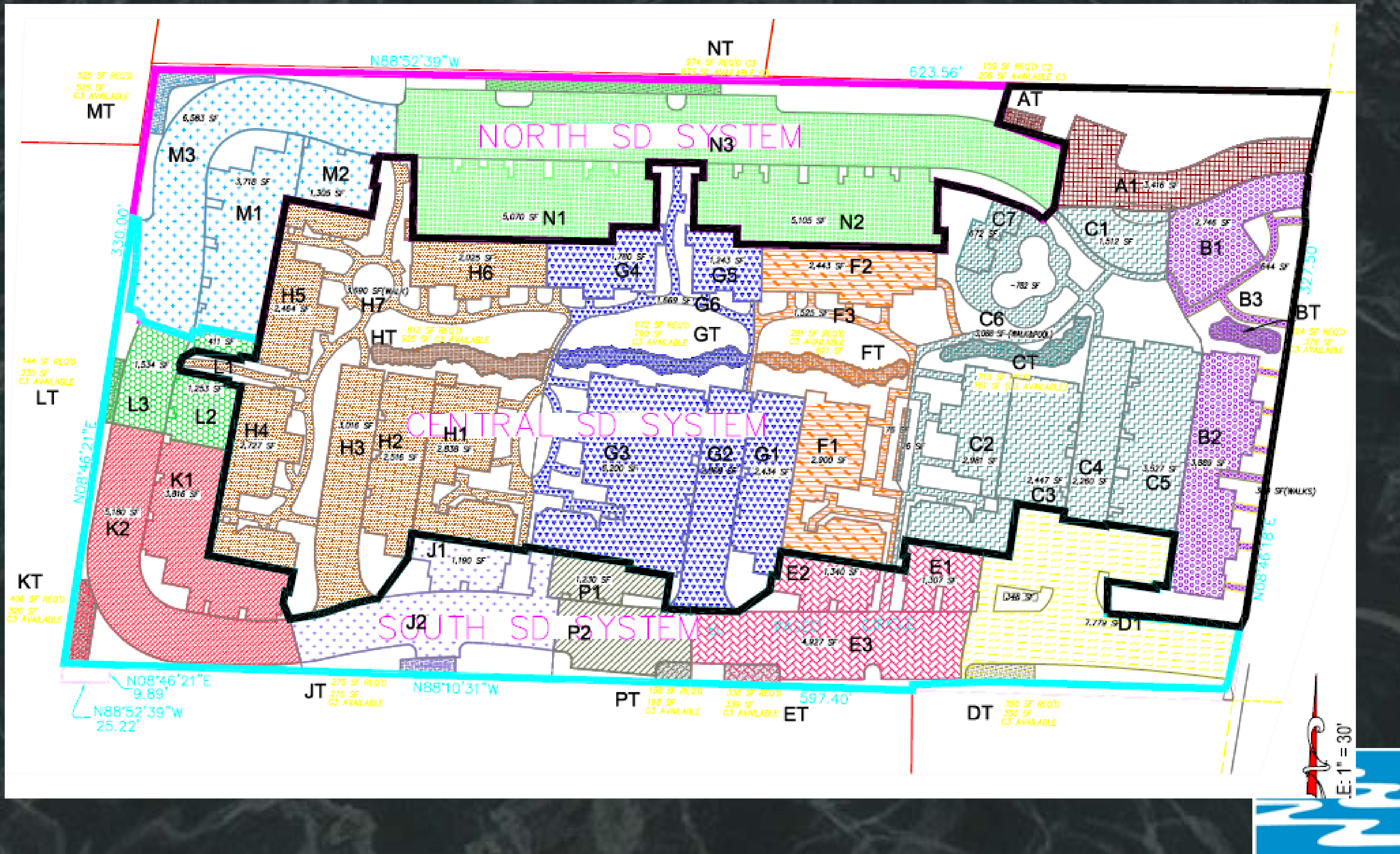
- No liner, no filter fabric, no landscape cloth.
- Maintain BGL. TGL, TSL throughout facility area at elevations to be specified in plan.
- Class 2 perm layer may extend below and underneath drop inlet.
- Preferred elevation of perforated pipe underdrain is near top of gravel layer.
- See Appendix B for soil mix specification, planting and irrigation guidance.
- See Chapter 4 for factors and equations used to calculate V_1, V_2 and orifice diameter.

Instrumentation

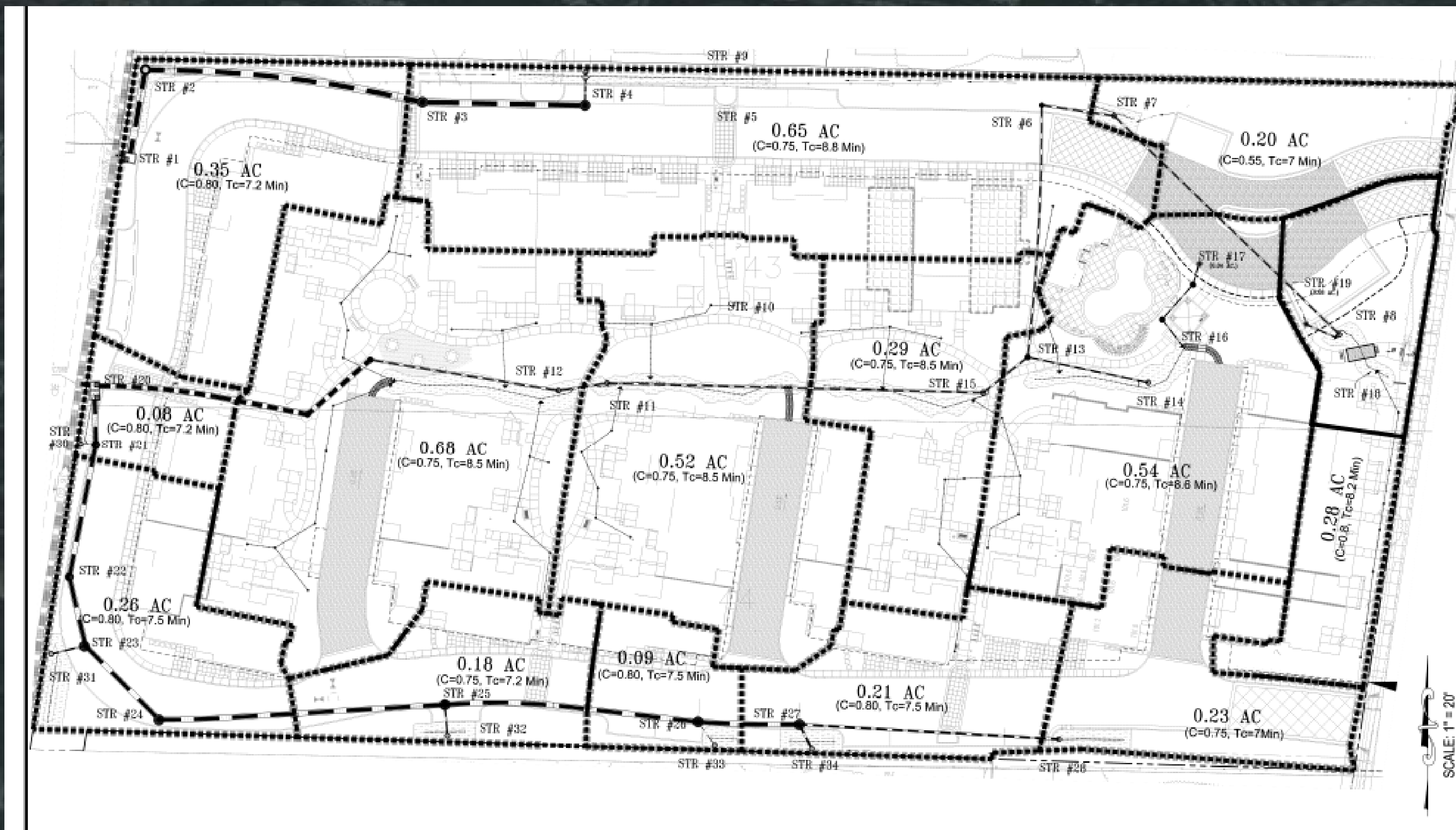
Hydro Services TV!LT Tipping Bucket

- Required 12" clear from orifice to bottom of catch basin
- Installed weir and pump system to prevent storm drain backups from flooding instrumentation

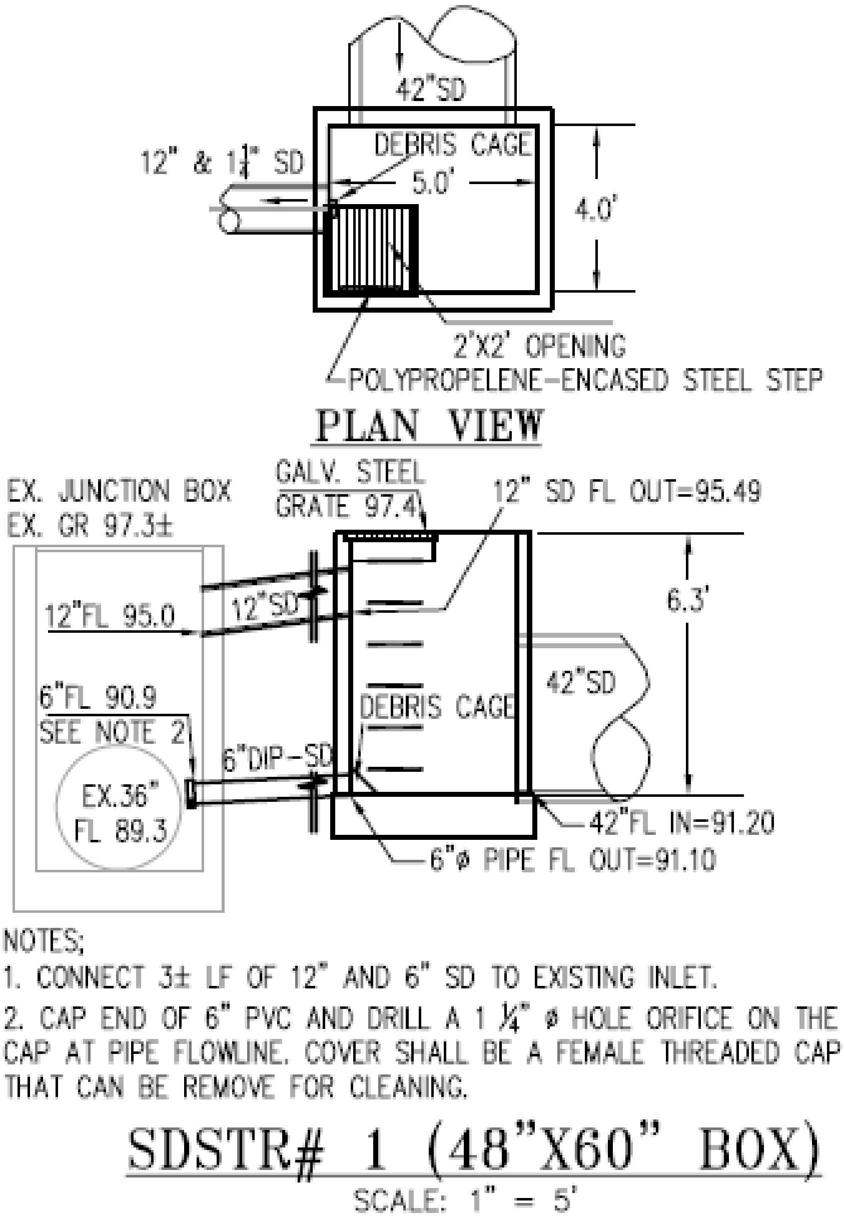
Walden Park Commons



Walden Park Commons

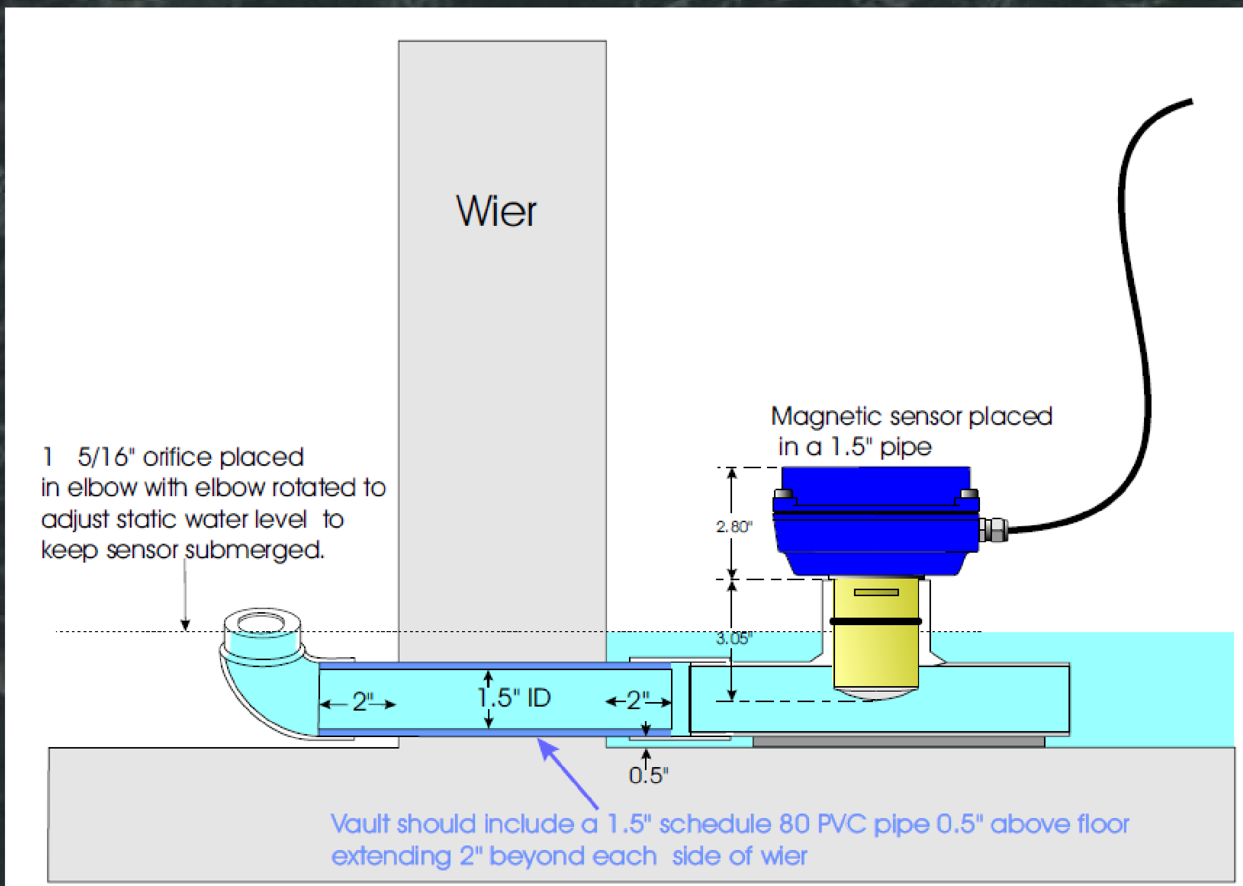


Outlet Des



42"SD
12" & 1¼" SD
DEBRIS CAGE
5.0'
4.0'
2'X2' OPENING
POLYPROPELENE-ENCASED STEEL STEP
PLAN VIEW
EX. JUNCTION BOX
EX. GR 97.3±
GALV. STEEL
GRATE 97.4
12" SD FL OUT=95.49
12"FL 95.0
12"SD
6.3'
42"SD
6"FL 90.9
SEE NOTE 2
DEBRIS CAGE
6"DIP-SD
EX.36"
FL 89.3
42"FL IN=91.20
6"ø PIPE FL OUT=91.10
NOTES;
1. CONNECT 3± LF OF 12" AND 6" SD TO EXISTING INLET.
2. CAP END OF 6" PVC AND DRILL A 1 ¼" ø HOLE ORIFICE ON THE CAP AT PIPE FLOWLINE. COVER SHALL BE A FEMALE THREADED CAP THAT CAN BE REMOVE FOR CLEANING.
SDSTR# 1 (48"X60" BOX)
SCALE: 1" = 5'

Magmeter Installation



Ready to begin monitoring

Status and Schedule

- Development projects completed summer 2011.
- Instrumentation installed September 2011.
- Data collection during 2011-2012 and 2012-2013 rainy seasons.
- Analysis of initial data during 2012.
- Report due to SF Bay Water Board April 1, 2014

Credits and Info

- Jolan Longway, City of Pittsburg
- Carlton Thompson, City of Walnut Creek
- Scott McQuarrie and Mark Boucher, Contra Costa Flood Control District
- www.cccleanwater.org or search for "Contra Costa Stormwater"