Documenting Compliance LID Design and Construction

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County of San Luis Obispo
November 8, 2018

Motivators

Regulations give you:

- A mandate
- Client support
- Acceptance of costs
- Structure
- Schedule
- Accountability

Supply your own:

- Enthusiasm
- Interest
- Energy

To achieve:

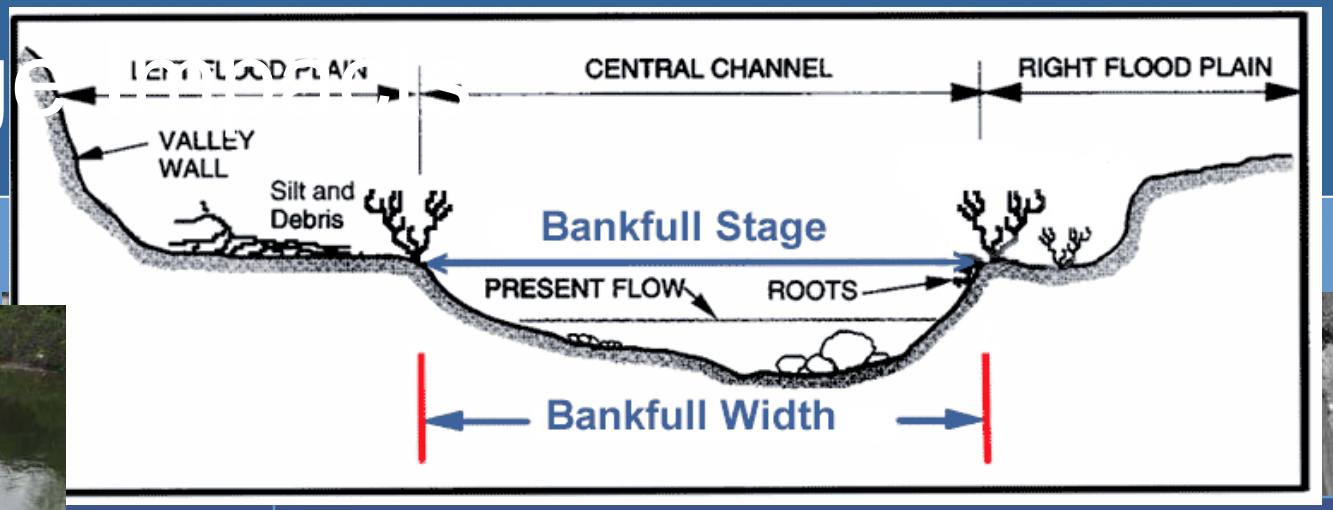
- Synergies
- Opportunities
- Elegance

Why Use Low Impact Development?

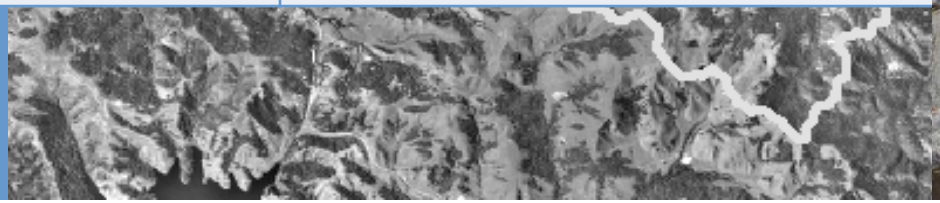
Conventional Urban Drainage

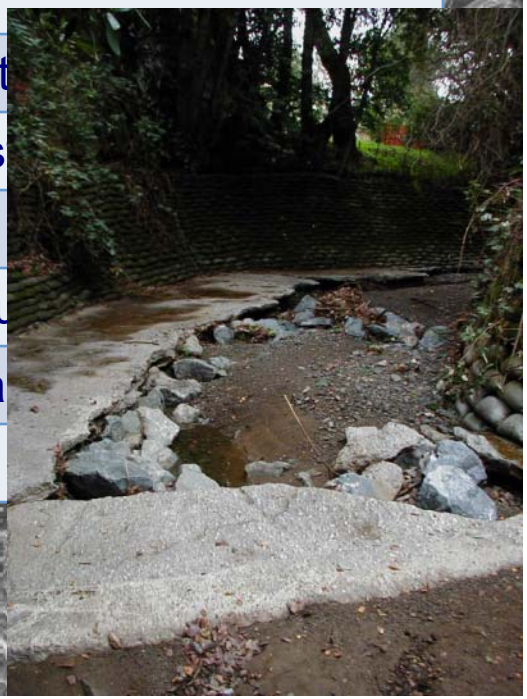
- Impervious surfaces: roofs and pavement
- Catch basins and piped drainage
- “Collect and convey” design objective

Drainage



	Watershed and Stream Scale
	Flooding and scouring of stream beds
entration	Flash flows
torms	Discharge when runoff did not
rations	Stream erosion at moderate s
mes	Higher pollutant loading
Greater runoff energy	Conveys trash and gross pollu
Decreased infiltration	Lower and less frequent strea
Dry weather discharges	High pollutant concentrations



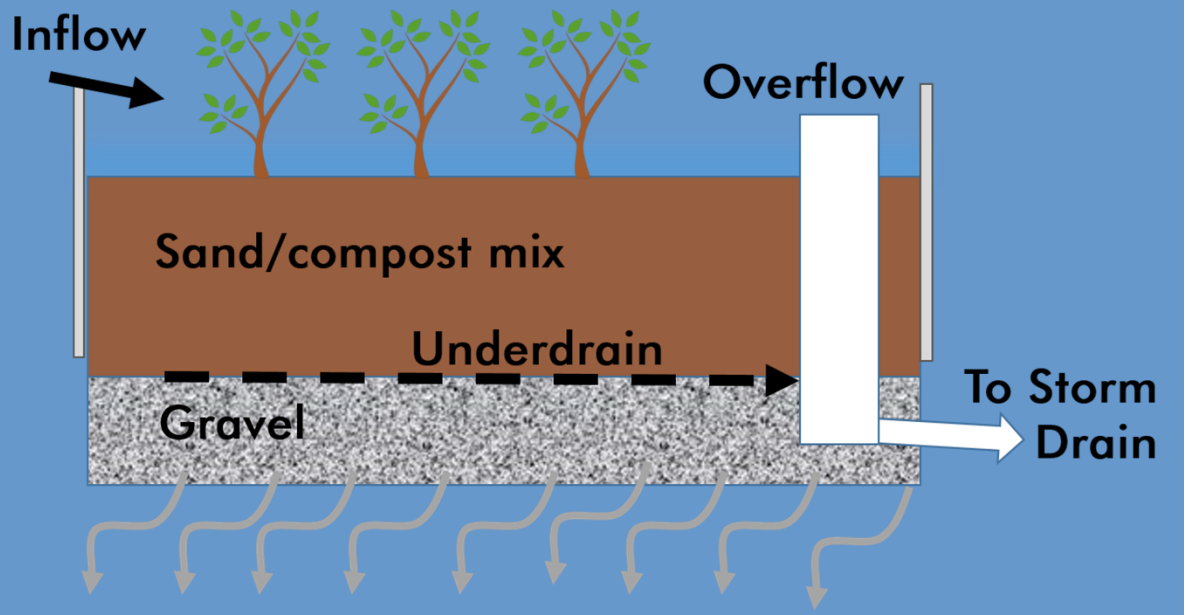


LID Design Objectives

Watershed and Stream Scale	Site scale
Reduce peak flows	Detain runoff on site
Increase time of concentration	Slow runoff from leaving site
No runoff from small storms	Infiltrate, evapotranspirate and reuse
Reduce duration of moderate flows	Let runoff seep away very slowly
Reduce runoff volume	Infiltrate and reuse where possible
Reduce runoff energy	Detain and slow flows
Increase groundwater storage and stream base flows	Facilitate infiltration
Reduce pollutants in runoff	Detain and filter runoff
Protect against spills and dumping	Disconnect drainage and filter runoff

LID Drainage Design

- Minimize roofs and paving
- Substitute pervious paving where possible
- Disperse runoff to landscaping
- Direct runoff to bioretention facilities



Bioretention Advantages

- Filtration and pollutant sequestration
- Biological processing and renewal
- No mosquito problems
- Mimic natural hydrology
- Attractive landscape amenity
- Potential use as park or playground
- Low maintenance
- Easy to inspect

Pollutant Fate and Transport

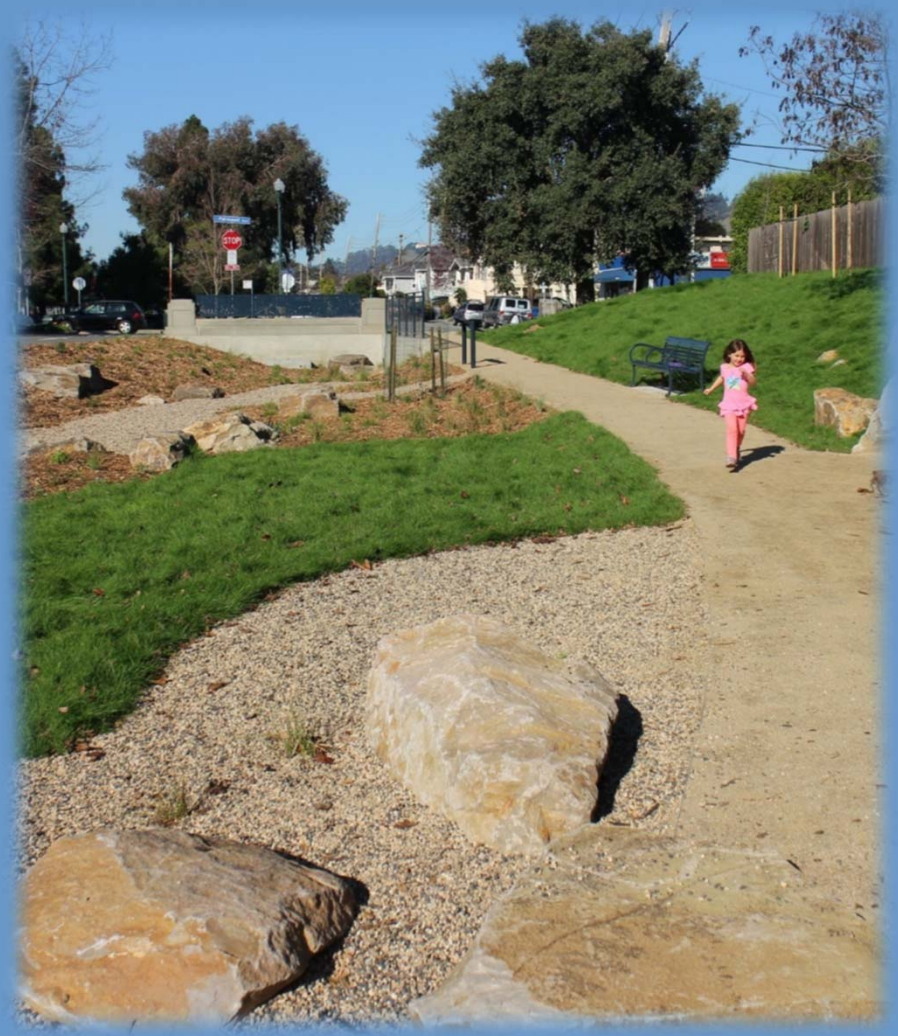
Bioretention & Urban Landscape

Resilience

Resilience


RAIN GARDEN (BIORETENTION BASIN)
The deep basin next to the park is a rain garden (bioretention basin). A rain garden acts like a giant sponge, absorbing and filtering runoff during storms. When it rains, runoff washes soot, oil, and other pollutants from our streets and yards into gutters and storm drains. The storm drains flow directly to Marsh Creek and the Delta!
In rain gardens like this one, runoff floods the surface during storms, and then seeps through a planting mix of sand and compost. Plant roots help absorb runoff and break down some pollutants. Other pollutants are safely bound up in the sand and compost mix. Filtered runoff infiltrates the ground below the rain garden, replenishing groundwater. During intense storms, excess filtered runoff seeps into a perforated pipe connected to the storm drain system.
Rain gardens also protect creeks by slowing runoff and reducing erosive flows. They prevent trash, spilled liquids, and wash waters (like from car washing) from reaching creeks during dry weather as well as during rainstorms. Rain gardens last thirty years or more with only routine maintenance of plants and landscaping—and occasional removal of trash and sediment near inlets.
Surface Runoff
Surface Runoff
Runoff From Gutters and Storm Drains
Sand and Compost Mix
Overflow Pit
Perforated Pipe
Drainage Gravel
Excess Filtered Runoff Flows Through Storm Drain System
Infiltration to Groundwater

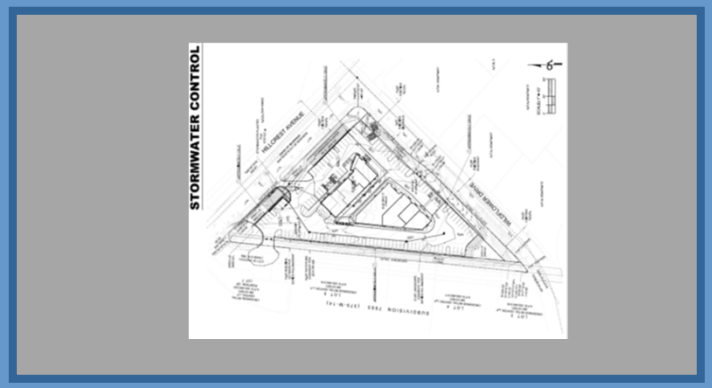
Resilience



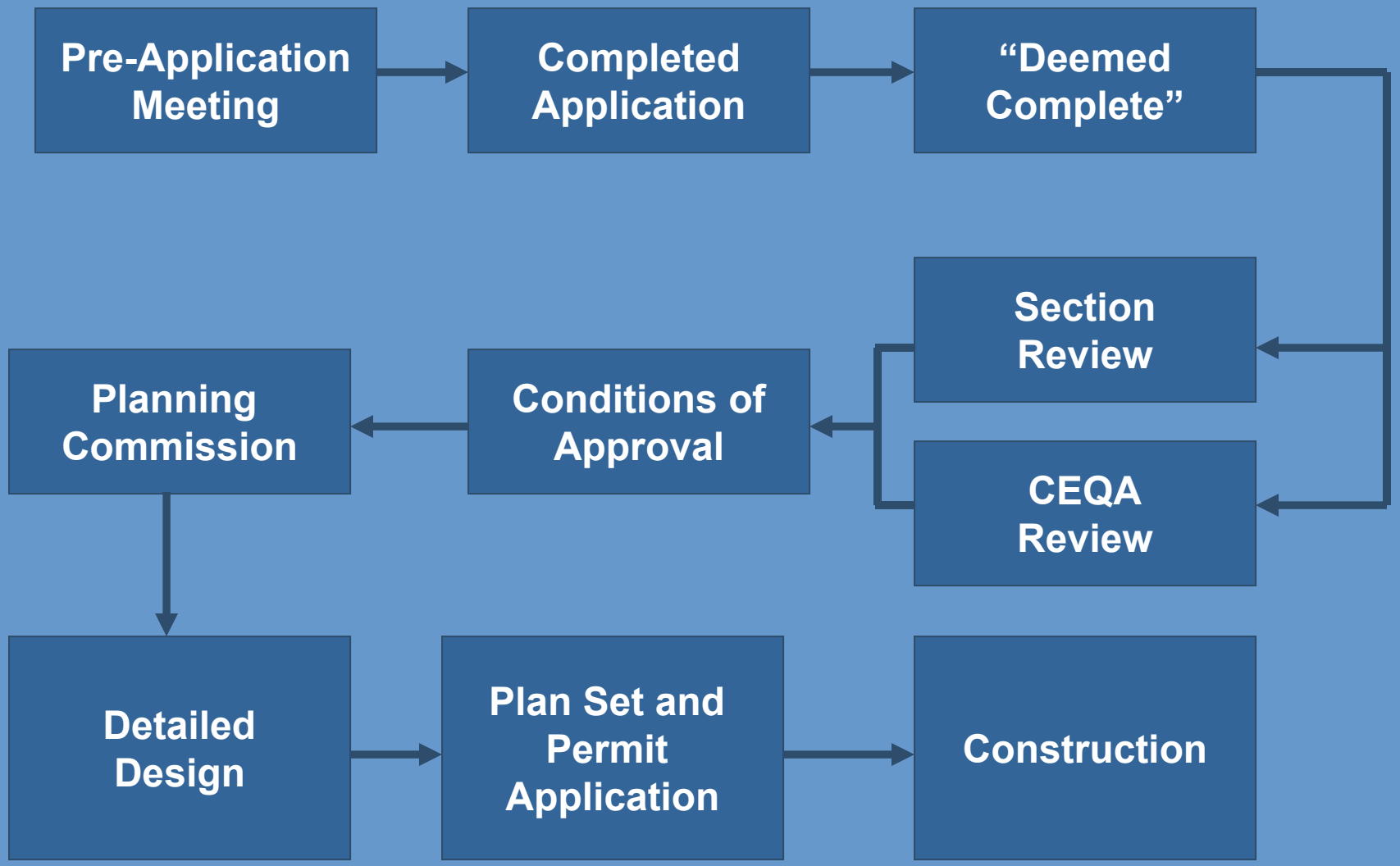
Resilience

Designing the Site for LID

Where the Rubber Meets the River



Development Process



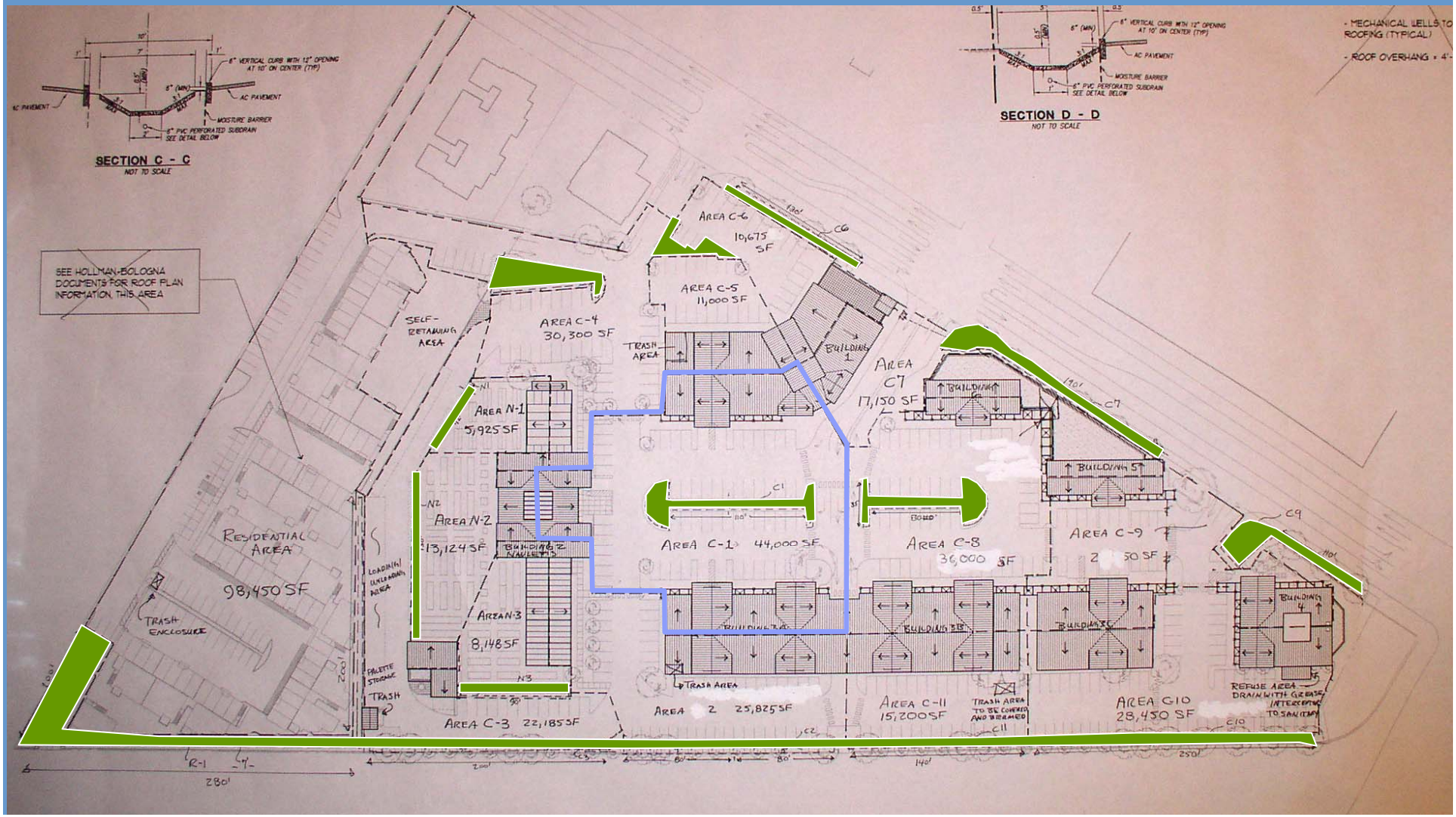
Conditions

- Applications for development approvals must incorporate Low Impact Development drainage design, and must be in accordance with the requirements and criteria in the *Guidebook.*
- For purposes of preliminary planning, these requirements and criteria include the following:
  - Disperse runoff from impervious roofs and pavement to adjacent pervious areas where feasible.
  - Include bioretention facilities to detain, retain, and treat runoff from remaining roofs and pavement.
  - Put bioretention facilities in high-visibility, well-trafficked, common accessible areas and integrate them with site landscaping.

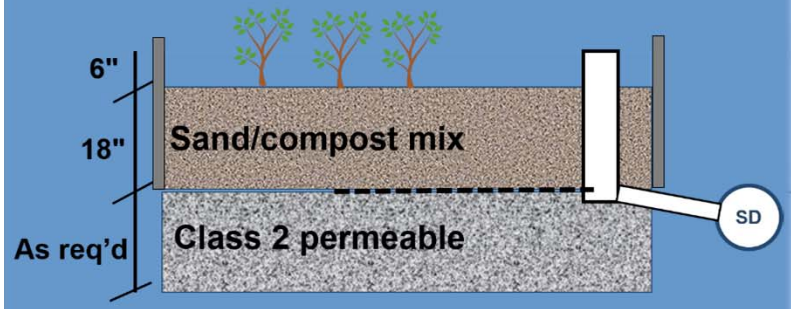
Placing bioretention on the site

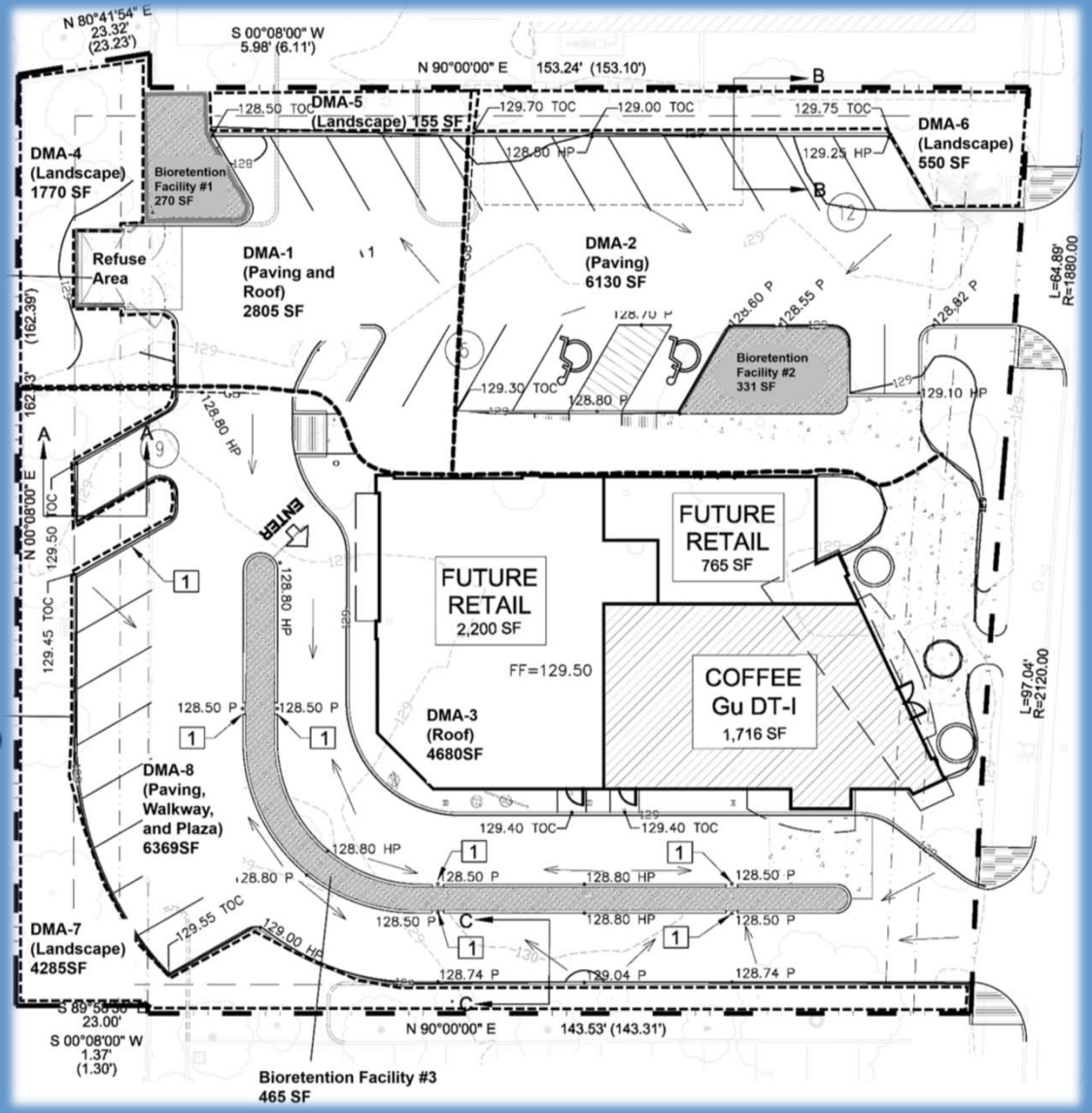
- High-visibility, well-trafficked places
- Common, accessible areas
- Dispersed throughout the site
- Drain only impervious roofs and pavement
- Use surface drainage; keep runs short
- Make facilities flat and level
- Make top of soil elevation high as possible
- Follow the design criteria

Best Planning for Parking Lots

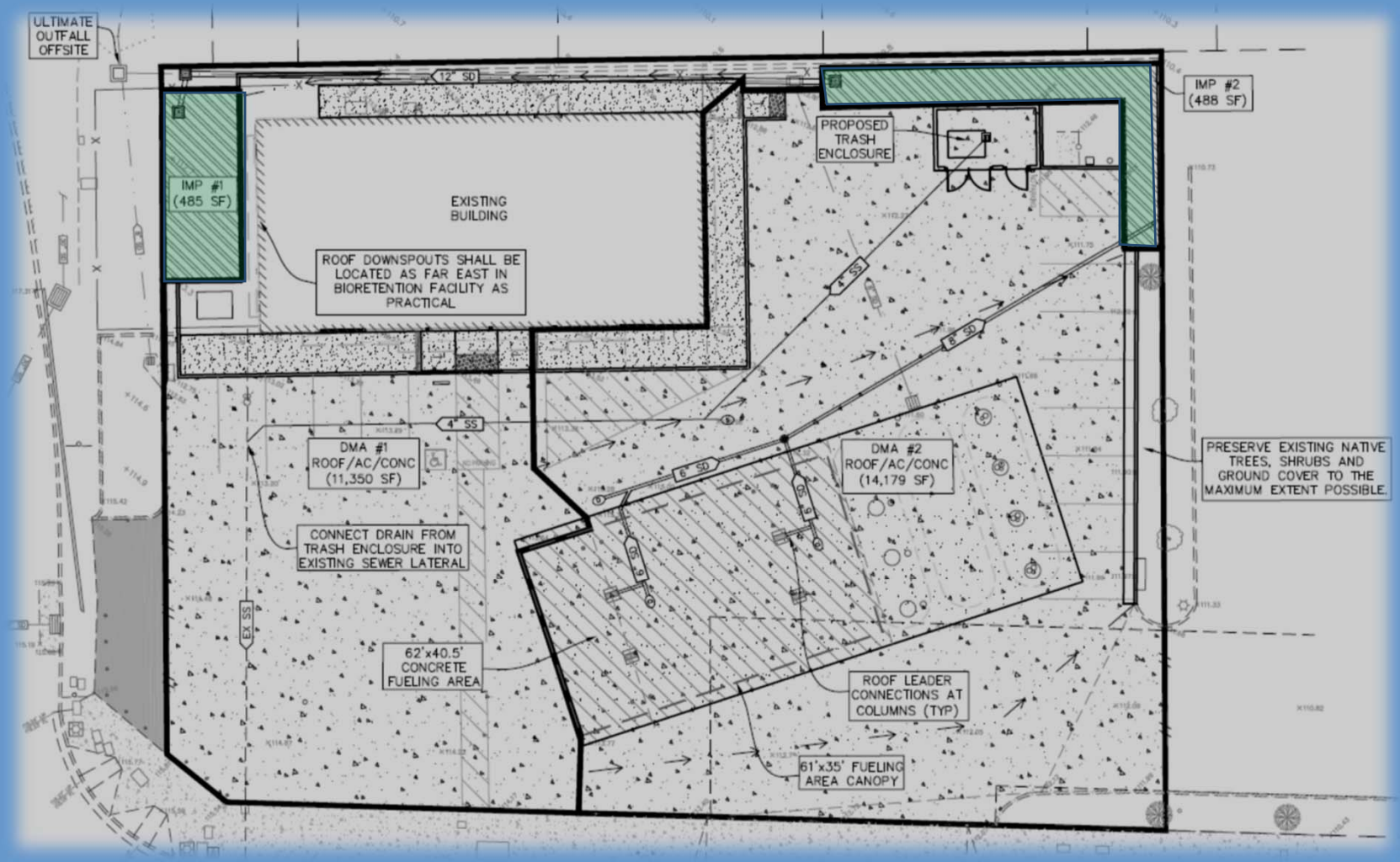


Commercial Project

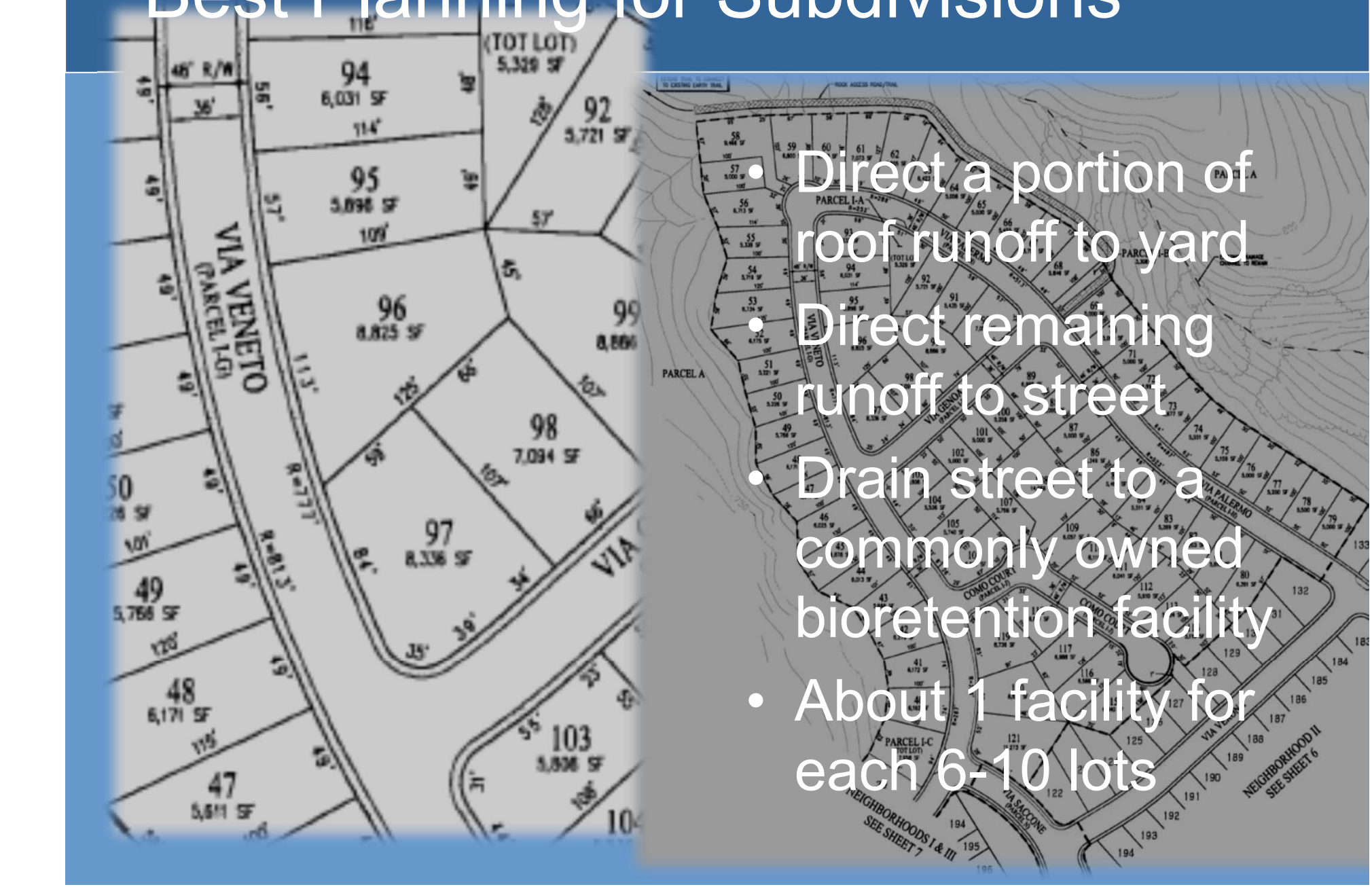




Gas Station


ULTIMATE OUTFALL OFFSITE
12" SD
IMP #1 (485 SF)
EXISTING BUILDING
ROOF DOWNSPOUTS SHALL BE LOCATED AS FAR EAST IN BIORETENTION FACILITY AS PRACTICAL
PROPOSED TRASH ENCLOSURE
IMP #2 (488 SF)
4" SS
8" SD
4" SS
DMA #1 ROOF/AC/CONC (11,350 SF)
DMA #2 ROOF/AC/CONC (14,179 SF)
6" SD
6" SD
6" SD
PRESERVE EXISTING NATIVE TREES, SHRUBS AND GROUND COVER TO THE MAXIMUM EXTENT POSSIBLE.
CONNECT DRAIN FROM TRASH ENCLOSURE INTO EXISTING SEWER LATERAL
EX SS
62'x40.5' CONCRETE FUELING AREA
ROOF LEADER CONNECTIONS AT COLUMNS (TYP)
61'x35' FUELING AREA CANOPY

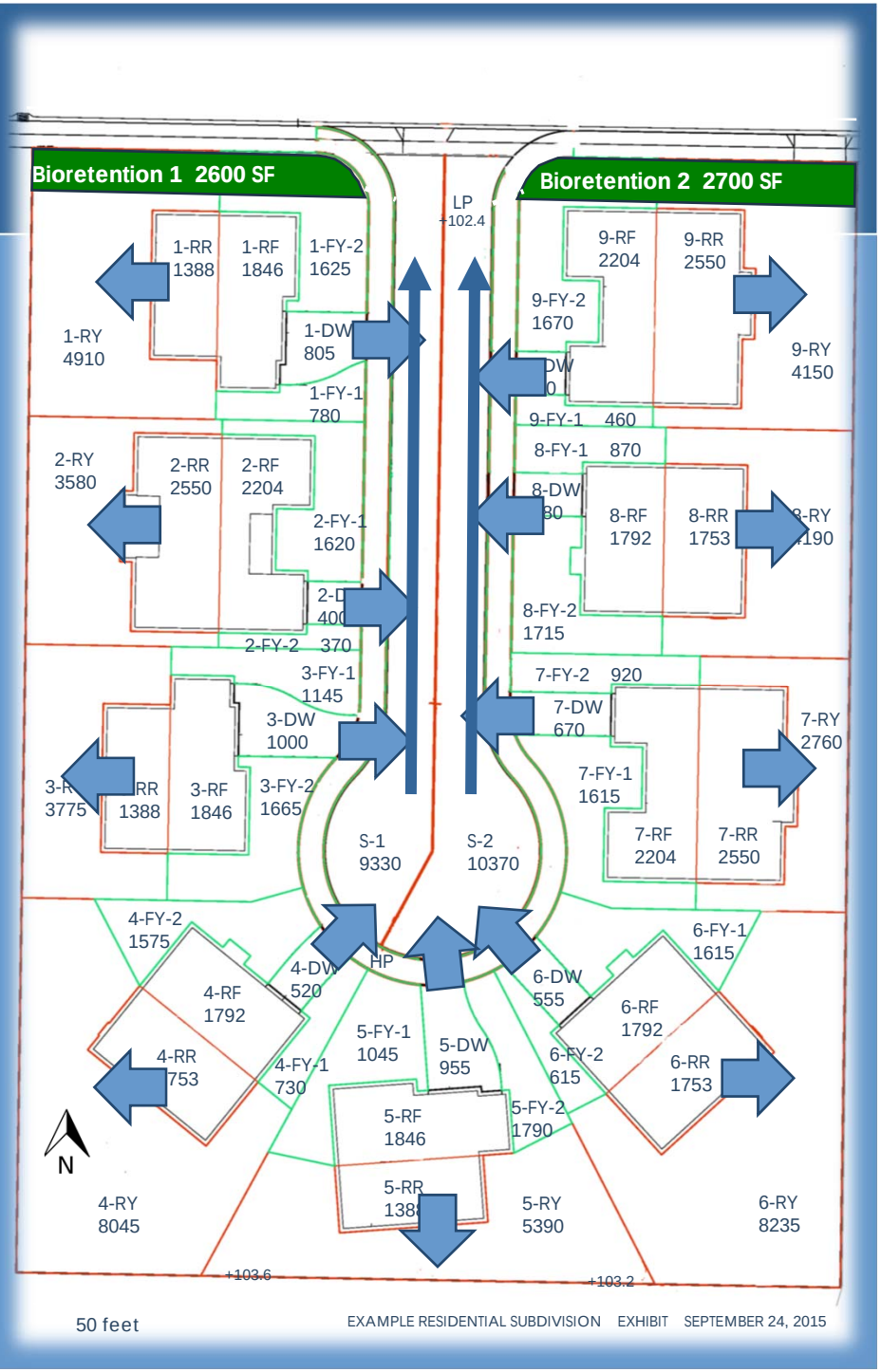
Best Planning for Subdivisions



- Direct a portion of roof runoff to yard
- Direct remaining runoff to street
- Drain street to a commonly owned bioretention facility
- About 1 facility for each 6-10 lots

Subdivisions

- Drain a portion of each roof to yard
- Drain driveways to street
- Drain street to bioretention facilities on commonly owned parcels



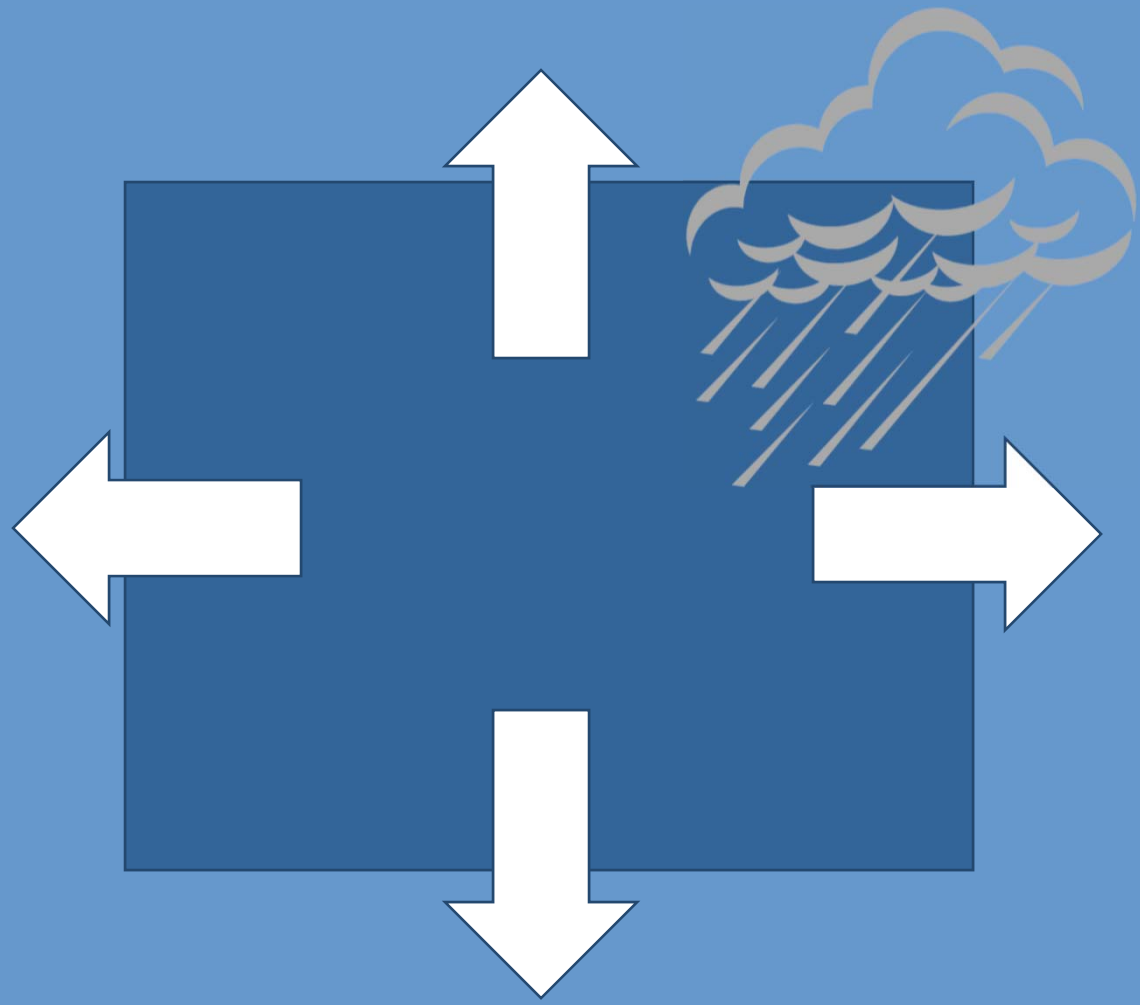
Avoid design conflicts

- Elevations consistent with grading and architectural plans
- Facilities do not interfere with parking or pedestrian circulation
- Protection of adjacent paving and structures has been considered
- Utilities are located elsewhere

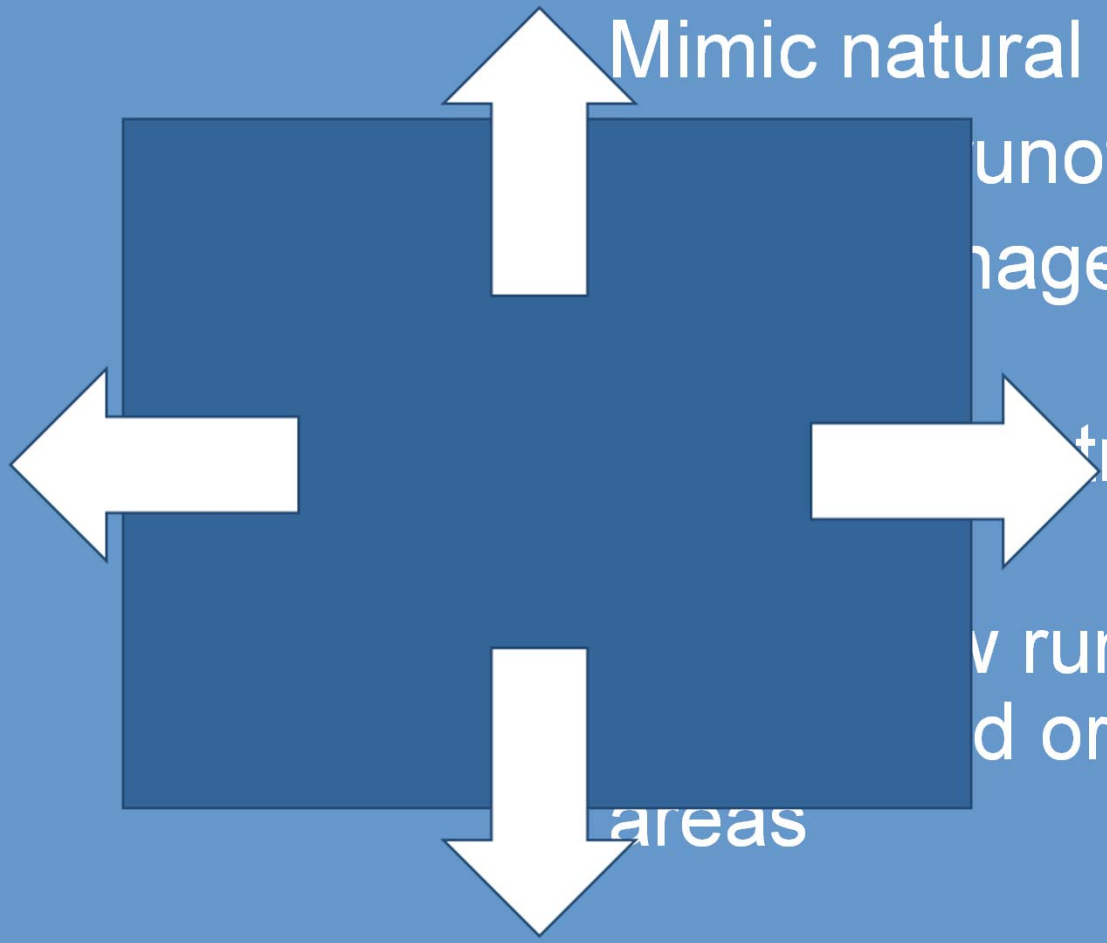
Documenting that Your LID Design Achieves Compliance

Documenting LID Site Design

LID Site Design Principles



LID Site Design Principles



Mimic natural hydrology

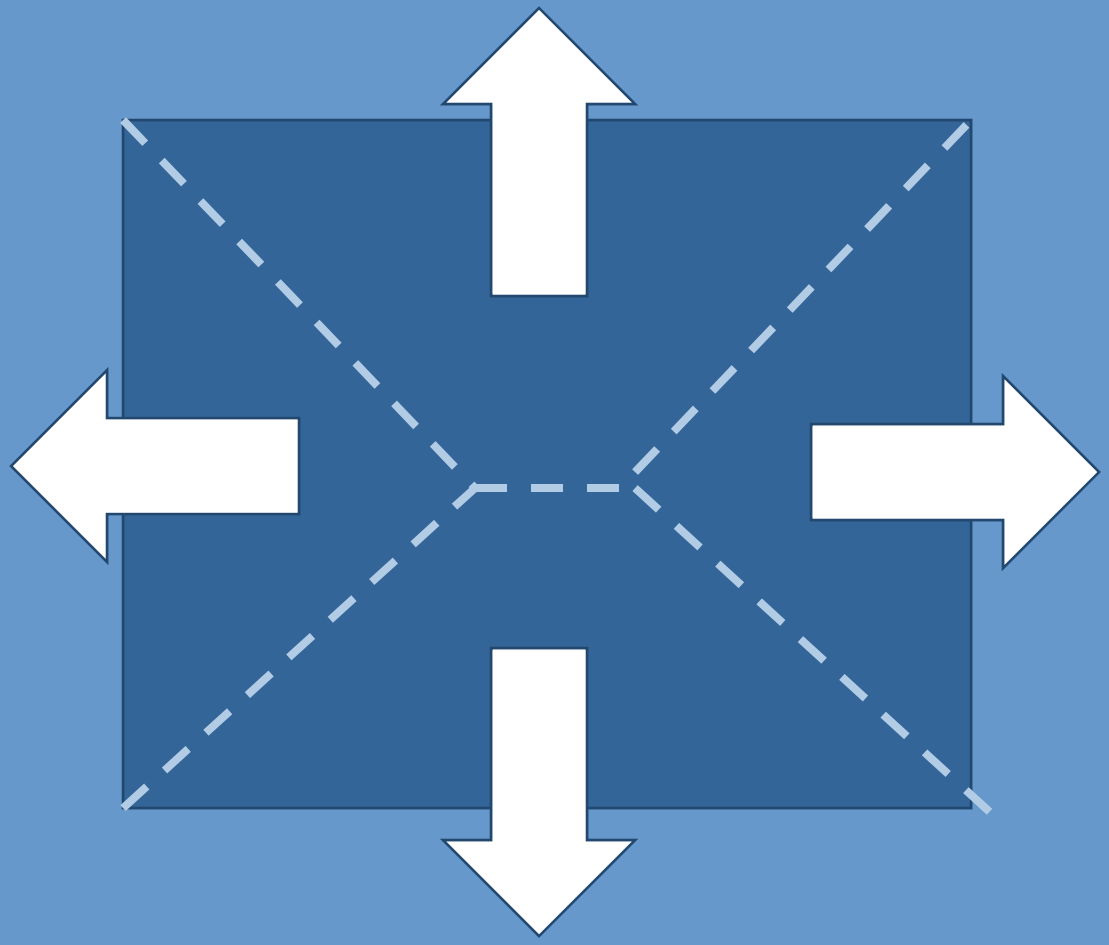
unoff

nage areas

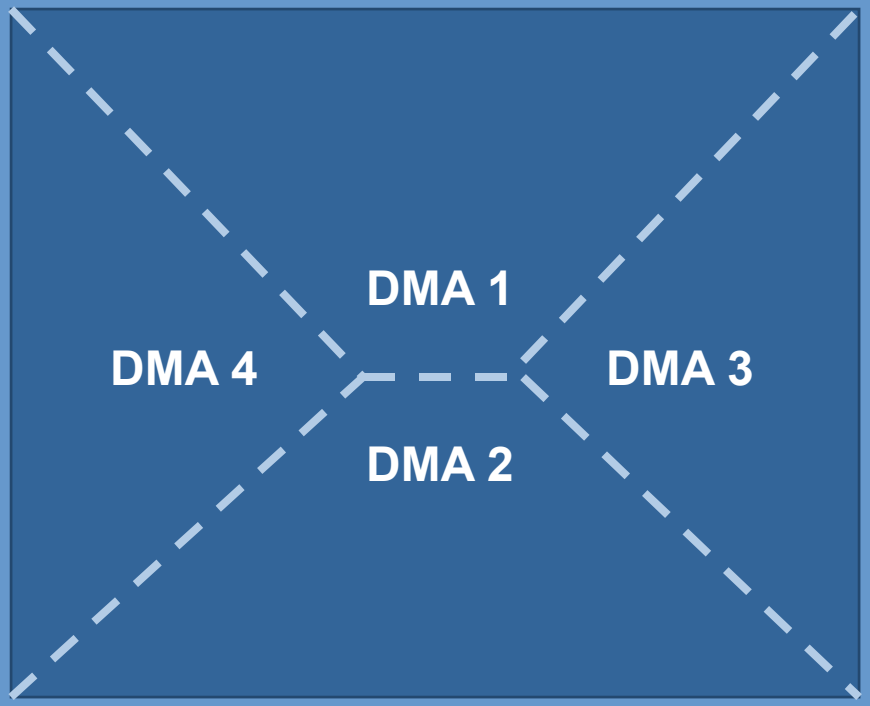
trate

v run-on from
d or natural
areas

Drainage Management Areas

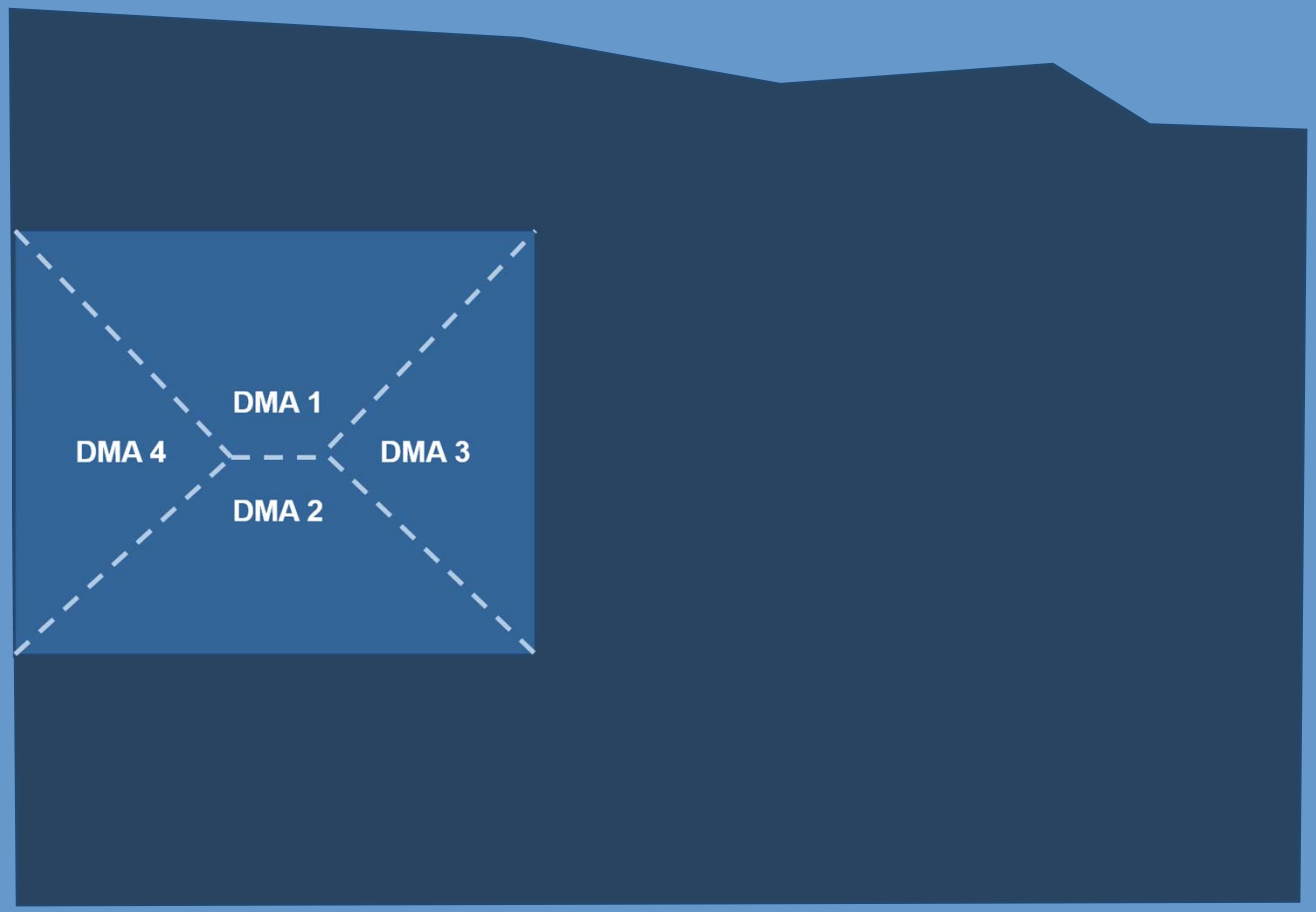


Drainage Management Areas

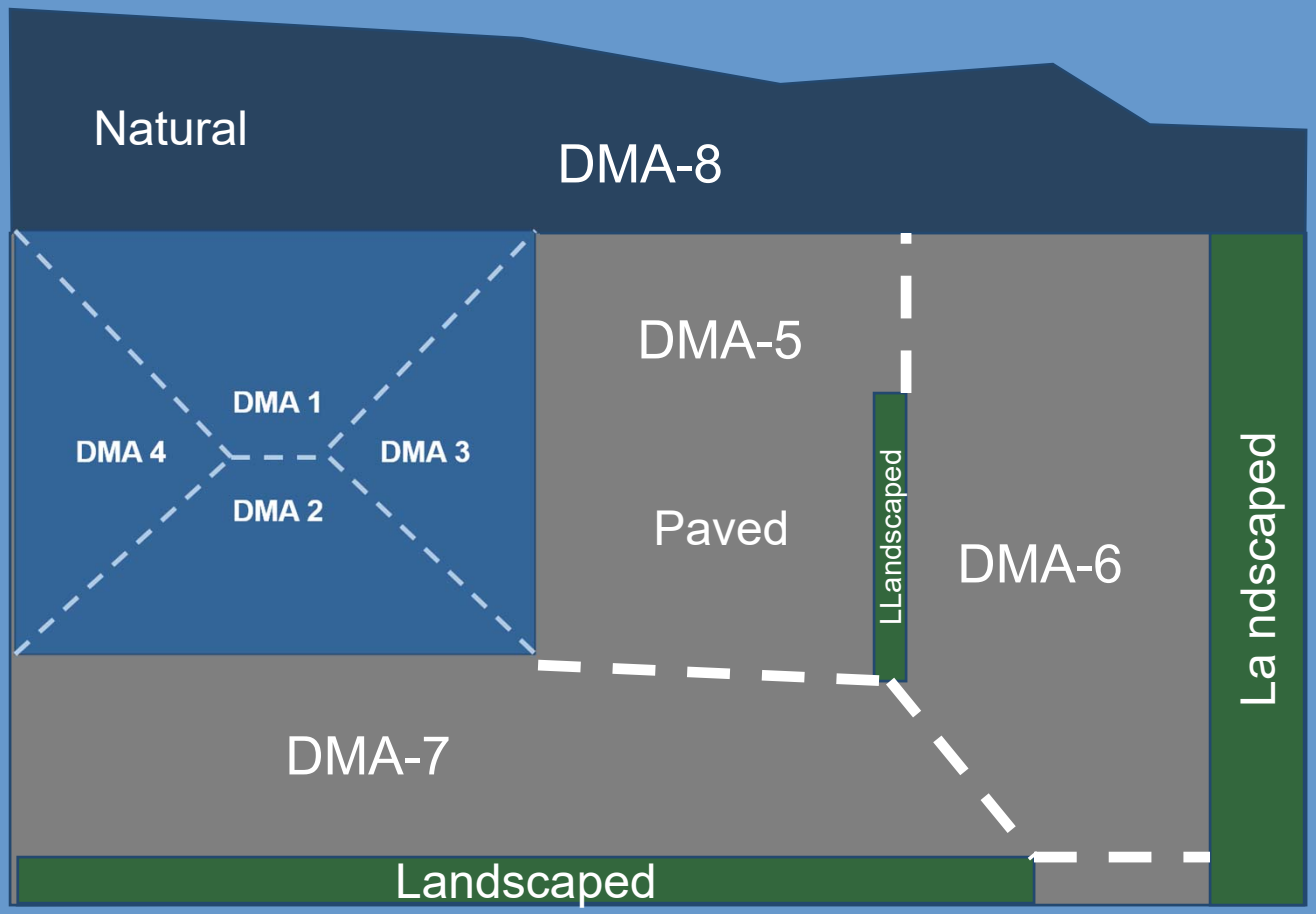


Drainage Management Areas

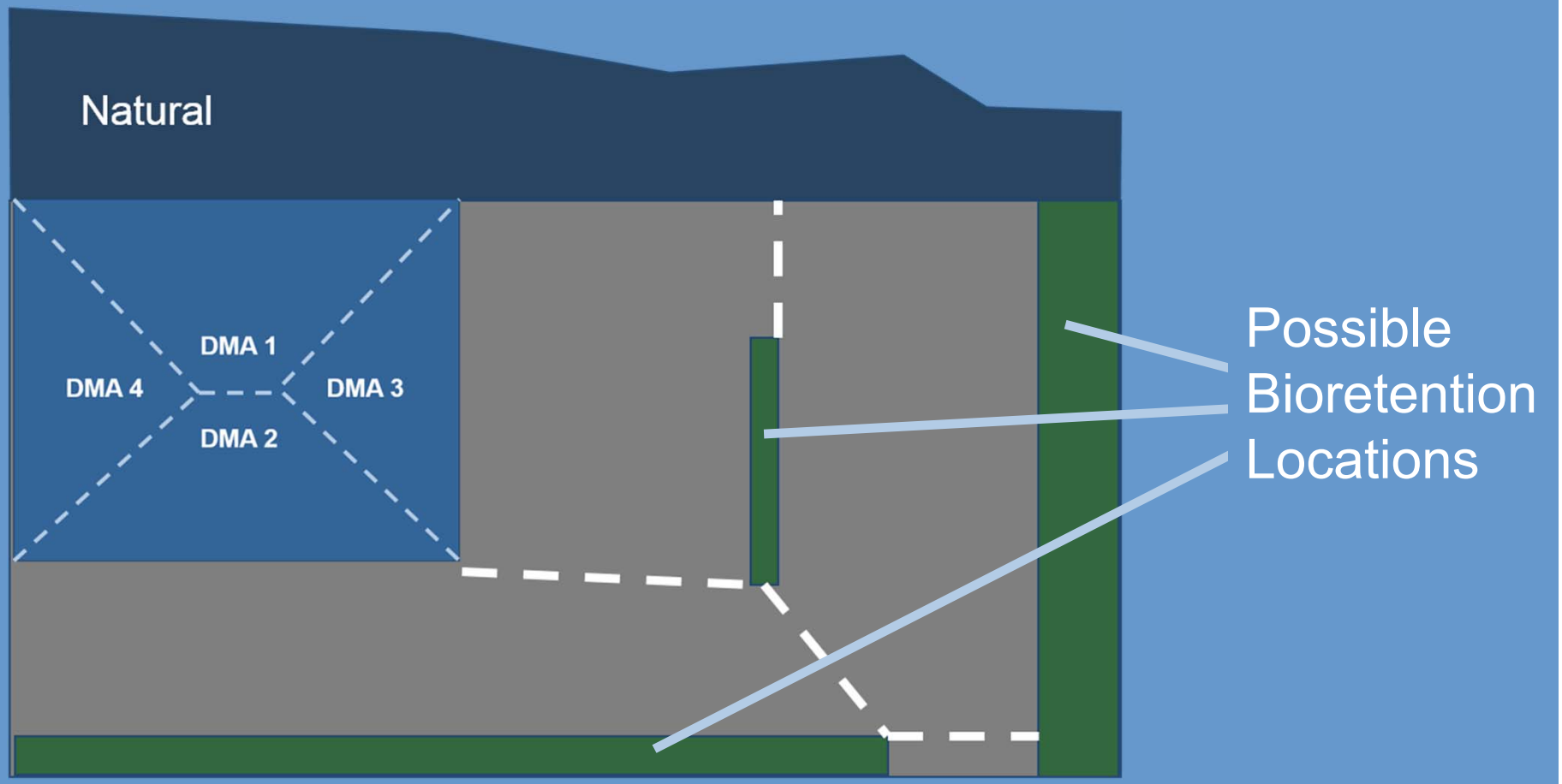
4-2



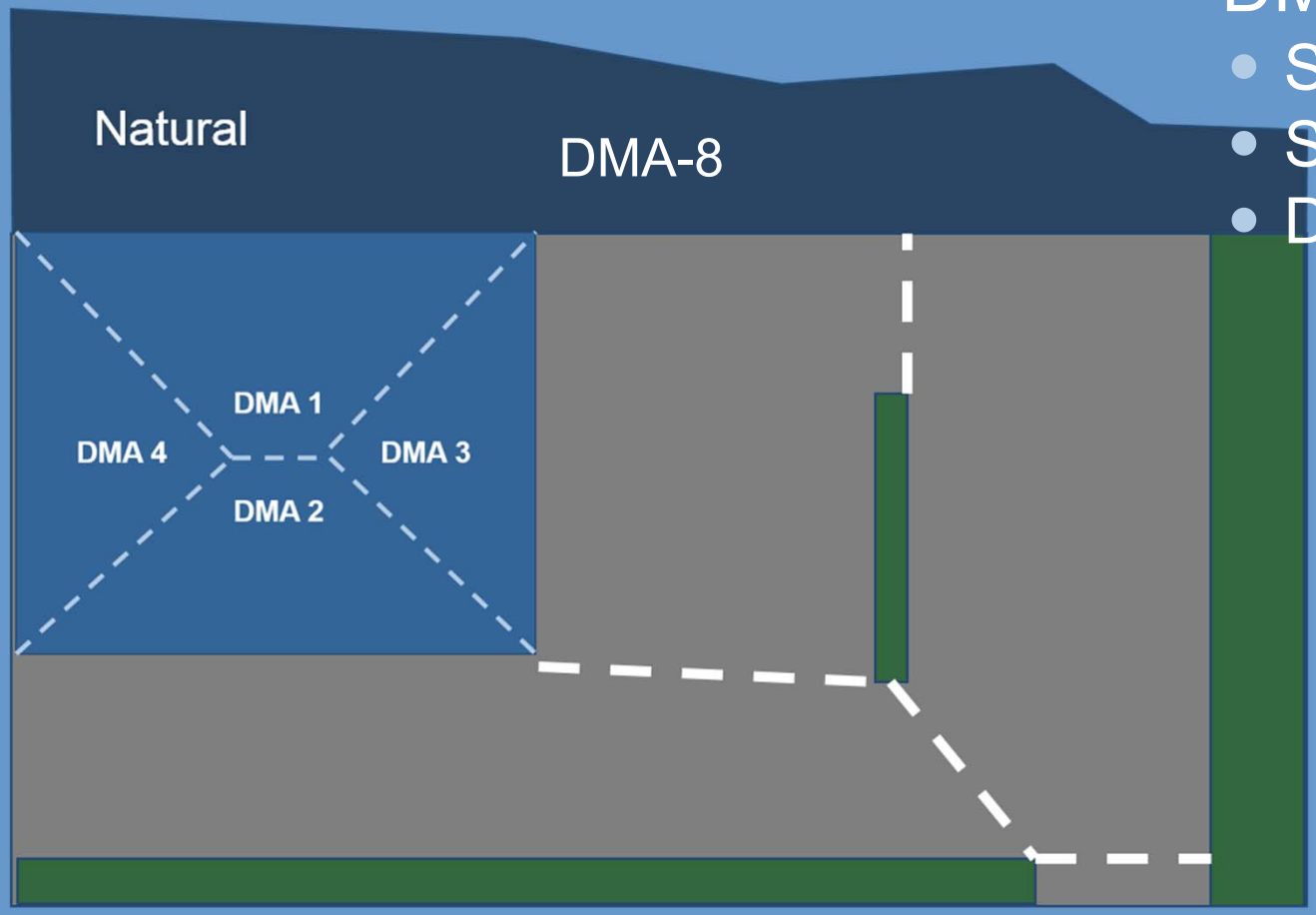
Drainage Management Areas



Drainage Management Areas

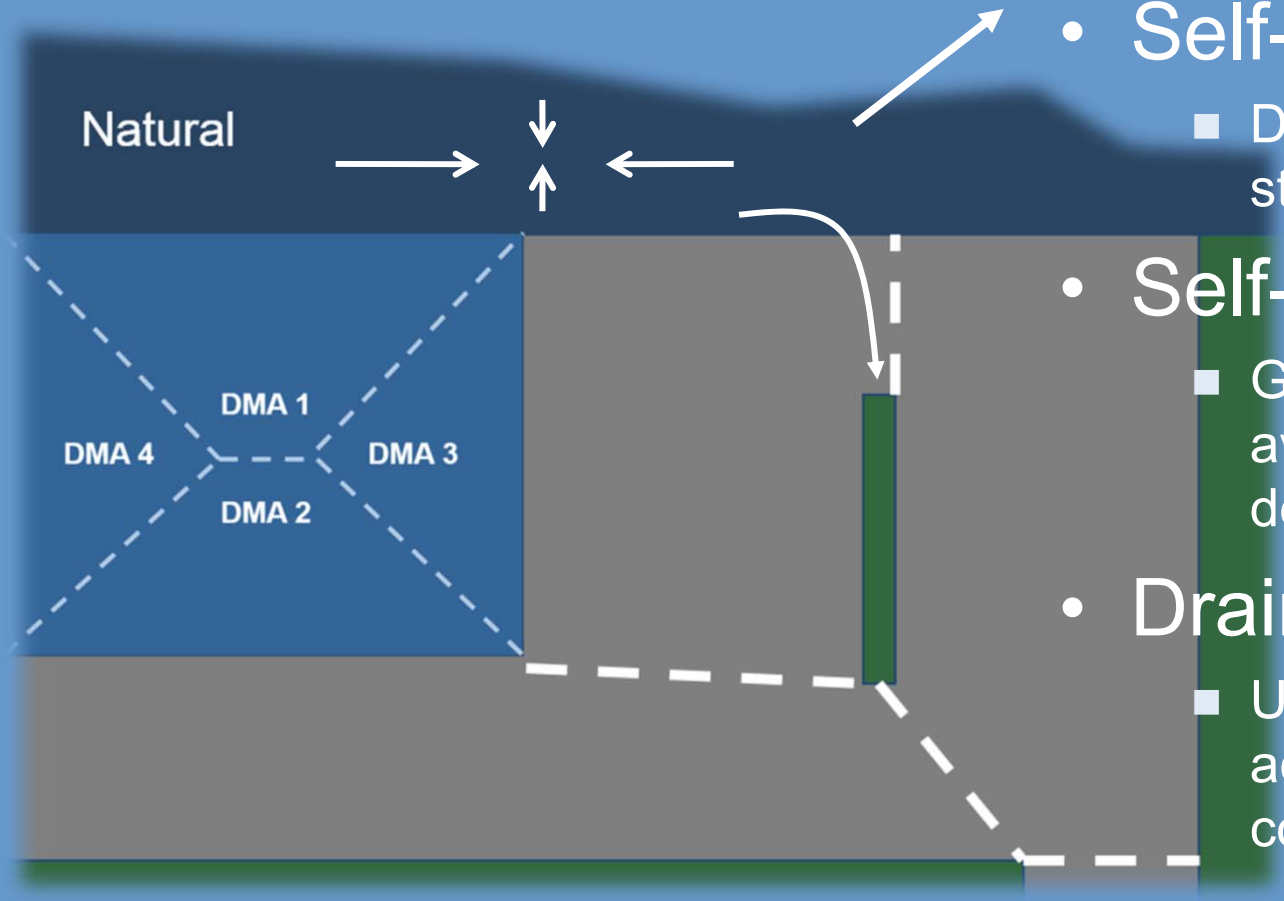


Options – Pervious DMAs



- DMA-8
  - Self-treating?
  - Self-retaining?
  - Drain to Facility?

DMA 8

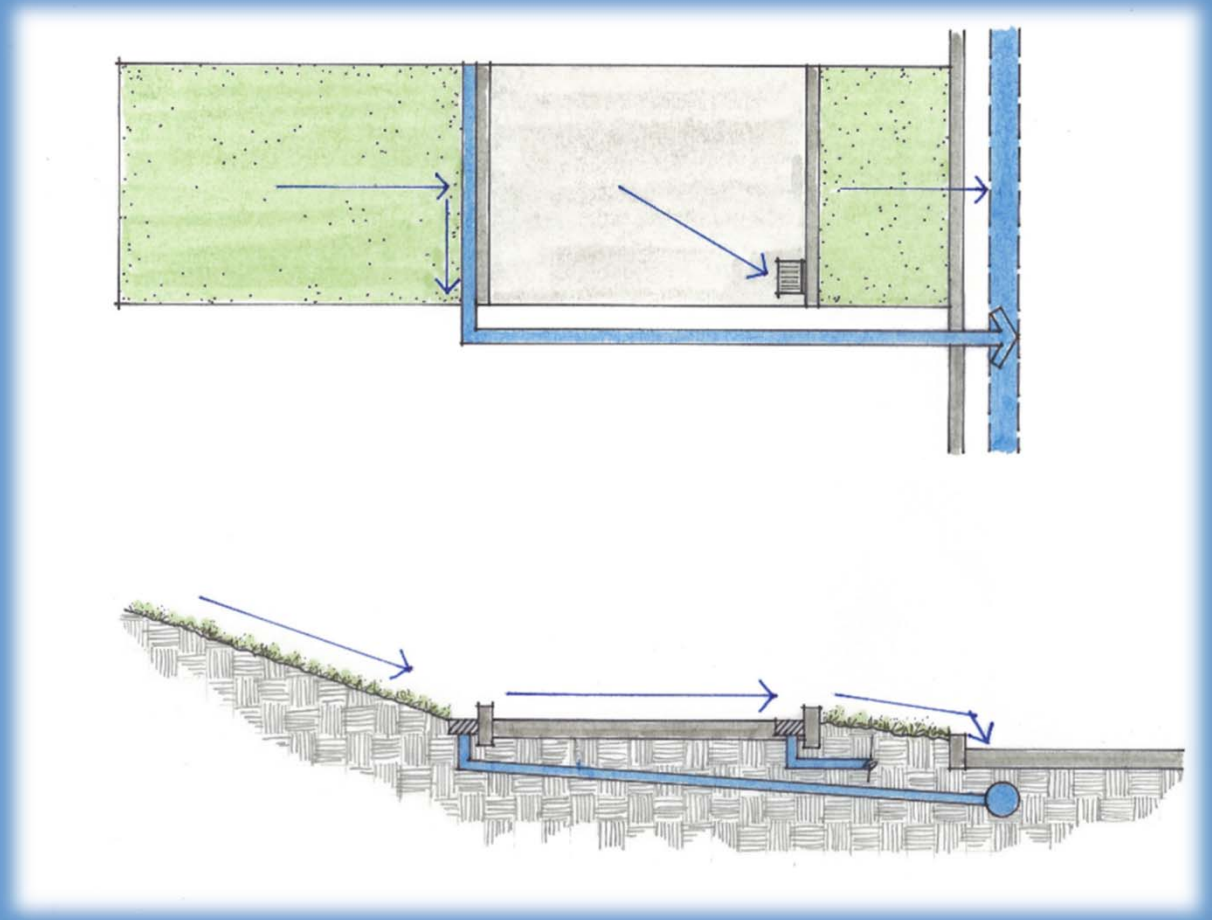


- Self-Treating
  - Drain directly to storm drain system
- Self-Retaining
  - Grade concave to average one-inch depth
- Drain to Facility
  - Use runoff factor to account for contribution

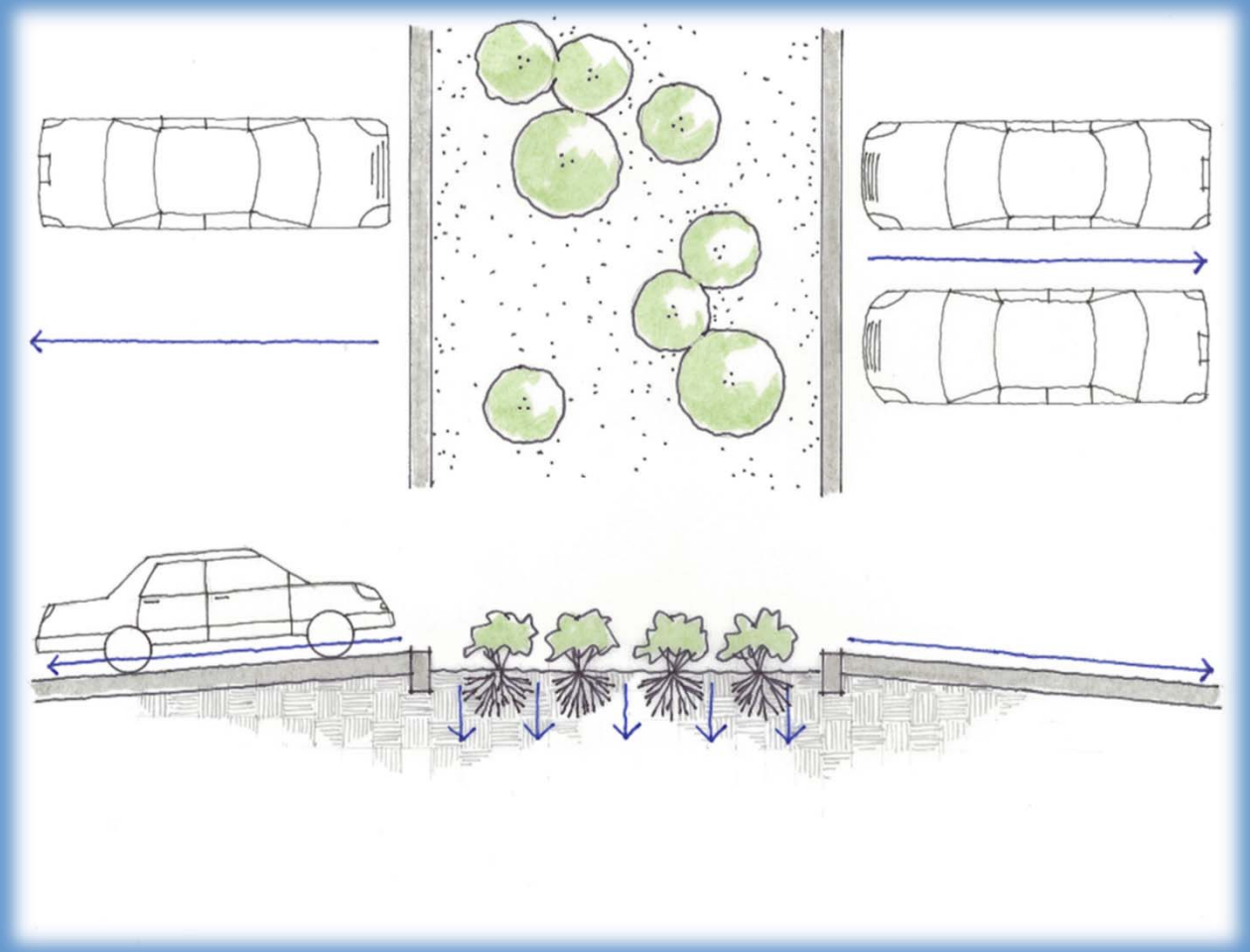
Self-Treating and Self-Retaining

- Essential to LID design
- Track and quantify runoff reduction
- Steps:
  - Delineate Drainage Management Areas
  - Classify DMAs
    1. Self-treating areas
    2. Self-retaining areas
    3. Areas draining to self-retaining areas
    4. Areas that drain to IMPs

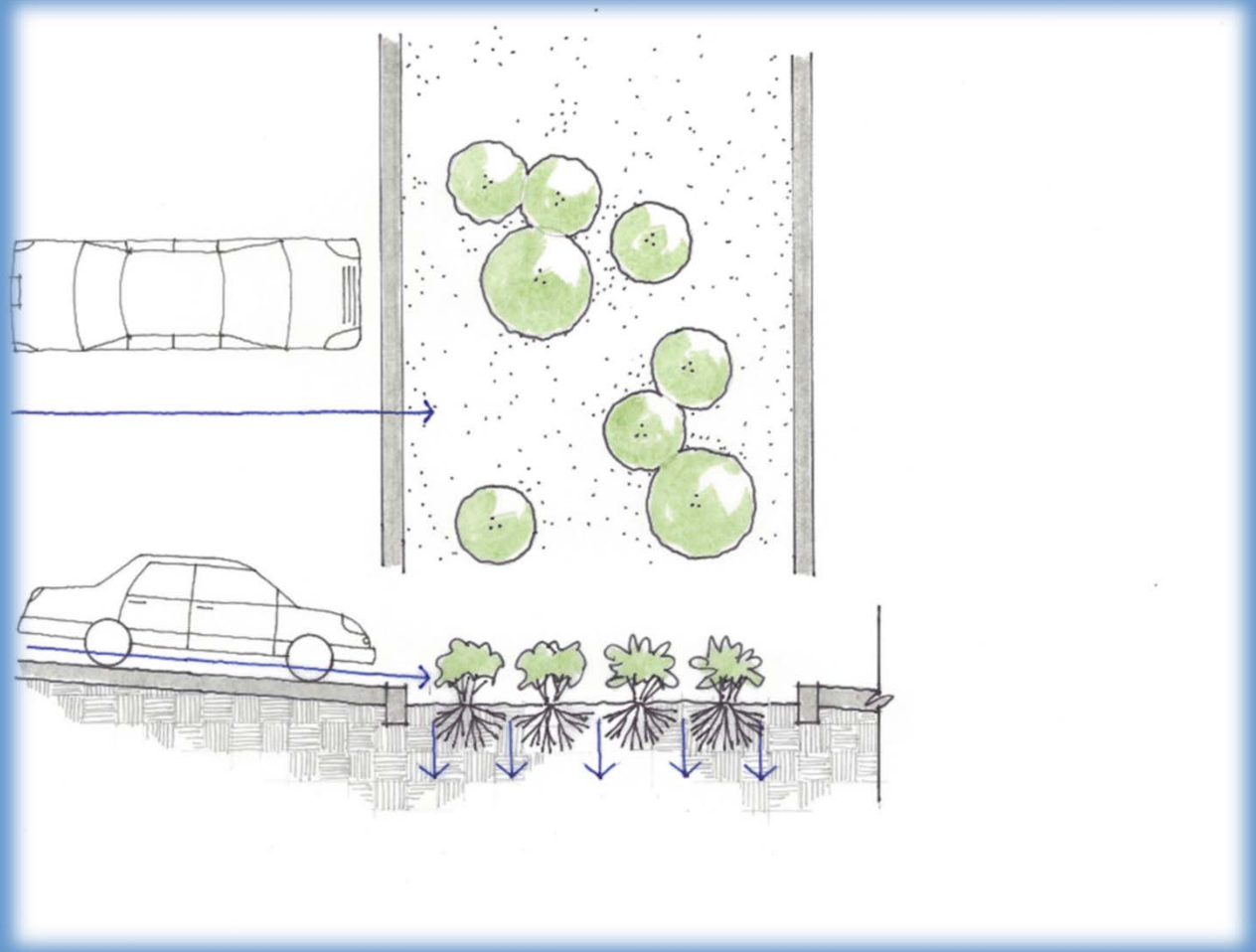
Self-treating Areas



Self-retaining Areas

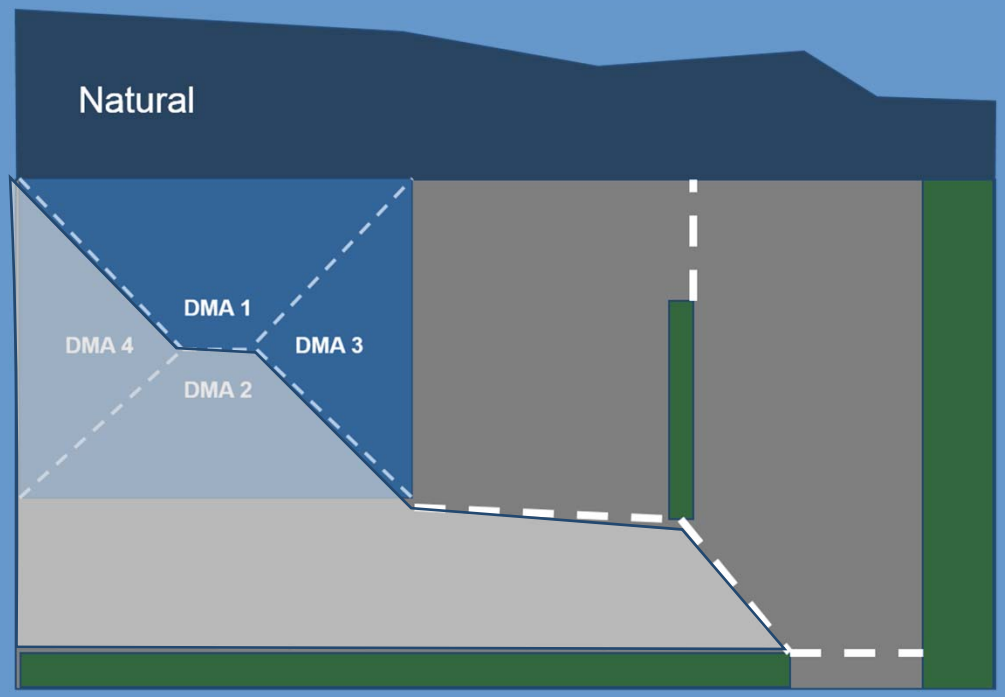


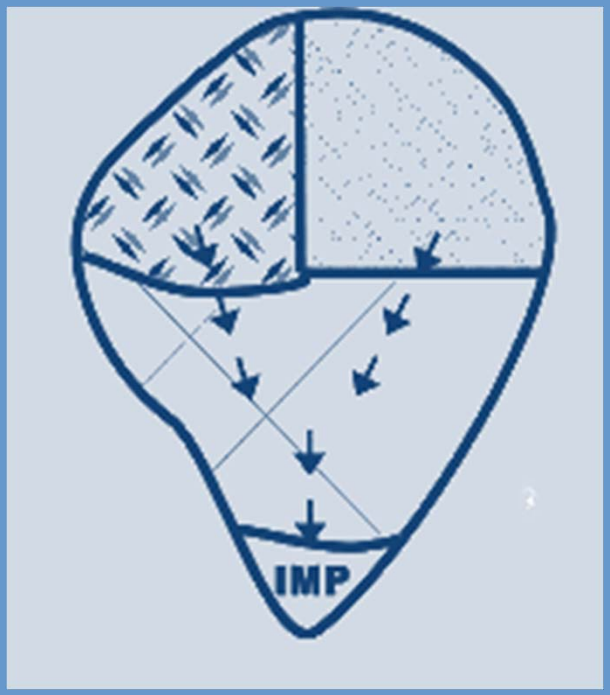
Areas draining to self-retaining



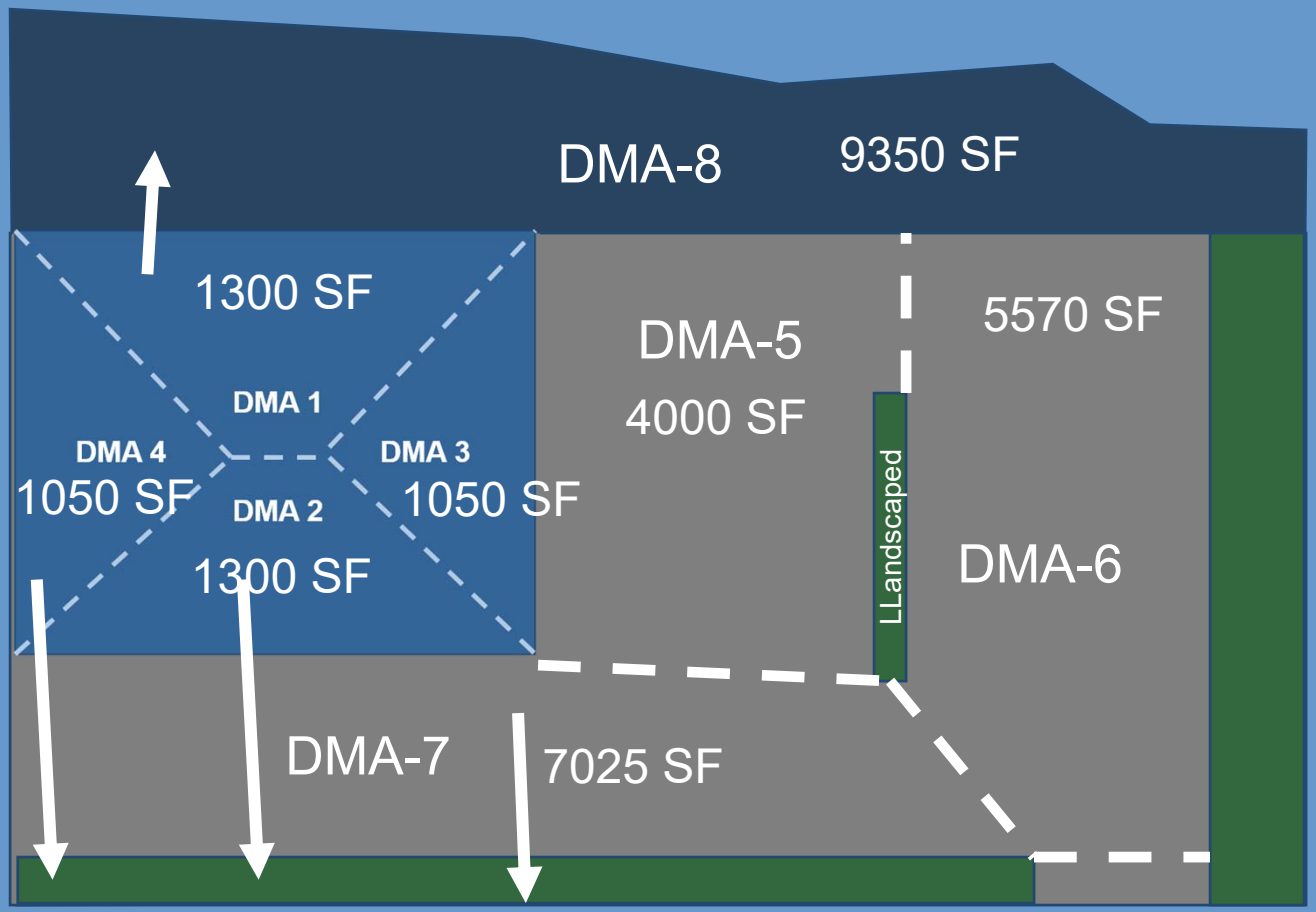
Options – Combining DMAs

Option to combine DMAs if they have identical runoff factors (for example, roofs and paving) and drainage is routed to the same location.



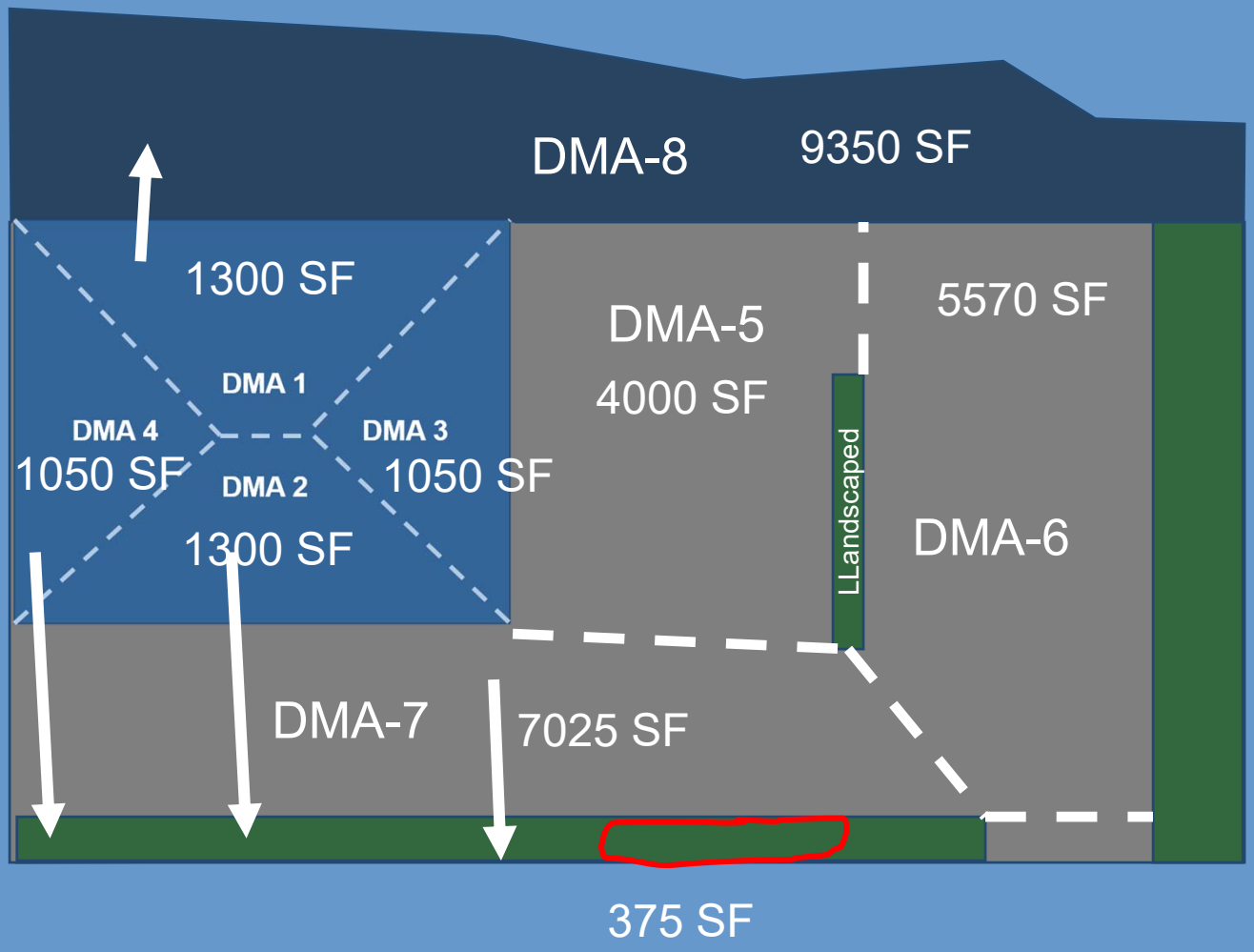


Tabulate DMAs



DMA	SF
1	1300
2	1050
3	1300
4	1050
5	4000
6	5570
7	7025
8	9350
Total	**30645**

Select and Lay Out Facilities



DMA	SF
1	1300
2	1050
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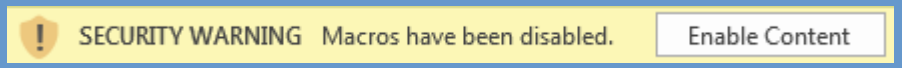
5	4000
6	5570
7	7025
8	9350
Total	**30645**

Using the Updated Central Coast SCM Sizing Calculator

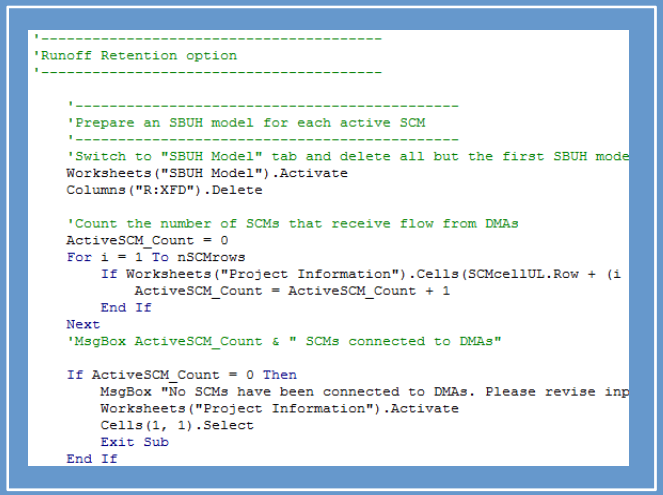
Tool for PCR Compliance

1. Calculator implements *routing method* allowed in the PCRs
2. Calculates bioretention dimensions for Tier 2 and Tier 3 projects
   - Uses SBUH model to compute minimum SCM dimensions
3. Functions as interactive design aid to improve drainage and bioretention configuration

Features and Notes



- MS Excel workbook with VBA code to guide data entry and hydraulic calculations
  - ***Allow "Macros" when opening***
- Worksheets are protected
  - ***prevent changes in format***, row and column locations, etc.
  - protect embedded equations



```
'----------------------------------------
'Runoff Retention option
'----------------------------------------

    '-----------------------------------------------
    'Prepare an SBUH model for each active SCM
    '-----------------------------------------------
    'Switch to "SBUH Model" tab and delete all but the first SBUH mode
    Worksheets("SBUH Model").Activate
    Columns("R:XFD").Delete

    'Count the number of SCMs that receive flow from DMAs
    ActiveSCM_Count = 0
    For i = 1 To nSCMrows
        If Worksheets("Project Information").Cells(SCMcellUL.Row + (i
            ActiveSCM_Count = ActiveSCM_Count + 1
        End If
    Next
    'MsgBox ActiveSCM_Count & " SCMs connected to DMAs"

    If ActiveSCM_Count = 0 Then
        MsgBox "No SCMs have been connected to DMAs. Please revise inp
        Worksheets("Project Information").Activate
        Cells(1, 1).Select
        Exit Sub
    End If
```

yellow = data entry

Name
DMA #1
DMA #2

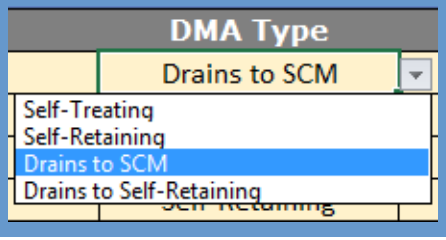
blue = generated results

Min. Required Storage Vol. (ft3)
455
109

grayed-out = not used

Surface Type

- Combo box/drop down lists are used wherever possible to guide data entry values:



Features and Notes (Cont.)

- Calculator contains four worksheets:
  1. Project Information:
     - Project site, DMA, SCM characterization and results summary
  2. SBUH Model:
     - Location where model calculations are performed
  3. *SCS, SBUH Equations:*
     - *Reference equations used by Calculator*
  4. *Lookups, Constants:*
     - *Values used in drop down lists and equations*

Core of the user interface:

Background calculations:

Project Information Worksheet

Central Coast Region
Stormwater Control Measure
Sizing Calculator

Version: 11/18/2014

1. Project Information

Project name:	Working test
Project location:	Working test
Tier 2/Tier 3/Tier 4:	Tier 3 - Retention
Design rainfall depth (in):	2.4
Total project area (ft2):	14000
Total new impervious area (ft2):	10000
Total replaced impervious in a USA (ft2):	0
Total replaced impervious not in a USA (ft2):	0
Total pervious/landscape area (ft2):	0

Enter project site location and characteristics using drainage planning documents

2. DMA Characterization

Add DMA Row | Remove DMA Row

Name	DMA Type	Area (ft2)	Surface Type	New, Replaced?	Connection
DMA #6a	Drains to SCM	10000	Roof	New	SCM #1
DMA #7	Self-Treating	4000			
DMA #8	Drains to SCM	10000	Roof	Replaced	SCM #2

DMA Summary Area

Total project impervious area (ft2):	20000
New impervious area (ft2):	10000
Replaced impervious within a USA (ft2):	0
Replaced impervious not in a USA (ft2):	10000
Total pervious/landscape area (ft2):	0

Define Drainage Management Areas. Add/remove and modify characteristics

3. SCM Characterization

Add SCM Row | Remove SCM Row

						Flow Control	Reservoir
Name	SCM Type	Safety Factor	SCM Soil Type	Infilt. Rate (in/hr)	Area (ft2)	Orifice?	Depth (in)
SCM #1	Bioretention	1	HSG C/D	0.25	700	Yes	8
SCM #2	Direct Infiltration	2	HSG C/D	0.25	700		

Define SCM characteristics

Project Information Overview (Cont.)

After DMAs and SCMs are defined, click to launch sizing calculations

4. Run SBUH Model

Launch Model

5. SCM Minimum Sizing Requirements

SCM Name	Min. Required Storage Vol. (ft3)	Depth Below Underdrain (ft)	Drain Time (hours)
SCM #1	455	2.27	2.8
SCM #3	109	0.45	0.0

Calculator runs SBUH model and provides min. volume, depth and drainage time for each SCM

6. Self-Retaining Area Sizing Checks

Self-Retaining DMA Name	Self-Retaining DMA Area (ft2)	Tributary DMA Name	Tributary DMA Area (ft2)	Area Ratio
DMA - SRA #1	4300	DMA #2	2500	0.58

Calculator tracks connections and tributary area ratio for each Self-Retaining Area

DMA Characteristics Table

Add or remove DMAs here: not by manually inserting/deleting rows

2. DMA Characterization | Add DMA Row | Remove DMA Row

Name	DMA Type	Area (ft2)	Surface Type	New, Replaced?	Connection
DMA #1	Self-Treating	5000			
DMA #3	Drains to SCM	4000	Grouted unit pavers	New	SCM #1
DMA - SRA #1	Self-Retaining	4300			
Building Roof DMA	Drains to Self-Retaining	2000	Roof		DMA - SRA #1

Provide descriptive name

Select:
1) Self-Treating
2) Self-Retaining
3) Drains to SCM
4) Drains to Self-Retaining

Enter DMA Area

Select:
1) Roof
2) Concrete/asphalt
3) Grouted unit pavers
4) Pervious concrete
5) Porous asphalt
6) Unit pavers in sand
7) Open/porous pavers
8) Crushed aggregate
9) Turfblock
10) Landscape

For impervious areas, select:
1) New
2) Replaced
3) Replaced in an Urban Sustainability Area

Select DMA connection for "Drains to SCM" and "Drains to Self-Retaining" DMA types:

SCM Characteristics Table

Flow Control	Reservoir
Orifice?	Depth (in)
No	
Yes	6

NEW

Add or remove SCMs here: not by manually inserting/deleting rows

3. SCM Characterization — Add SCM Row | Remove SCM Row

Name	SCM Type	Safety Factor	SCM Soil Type	Infilt. Rate (in/hr)	Area (ft2)
SCM #1	Direct Infiltration	2	HSG A/B	0.75	800
SCM #3	Bioretention	1	HSG A/B	0.75	500
SCM #8	Bioretention	1	HSG A/B	0.75	450
SCM #8B	Bioretention	1	HSG A/B	0.75	600

Provide descriptive name

Select:
1) Direct Infiltration
2) Bioretention

Safely factor is computed

Select:
1) HSG A/B
2) HSG C/D
3) Site-specific

Reads selection on the left:
A/B = 0.75 in/hr
C/D = 0.25 in/hr
Site-specific = user-provided

Enter SCM plan area

Notes:

- You will need to enter SCMs here before you can "connect" DMAs to them
- You can iteratively modify SCM characteristics to test design concepts and fine tune your design

Launching Model and Viewing Results

4. Run SBUH Model

Launch Model

5. SCM Minimum Sizing Requirements

SCM Name	Min. Required Storage Vol. (ft3)	Depth Below Underdrain (ft)	Drain Time (hours)
SCM #1	831	2.60	4.3
SCM #3	136	0.68	0.0

Model results/minimum sizing is reported here.

Note: Drain Time = 0 means the bioretention is dry before the 24 storm has ended (exfiltration > inflow)

6. Self-Retaining Area Sizing Checks

Self-Retaining DMA Name	Self-Retaining DMA Area (ft2)	Tributary DMA Name	Tributary DMA Area (ft2)	Tributary / SRA Area Ratio
DMA - SRA #1	4300	Building Roof DMA	2000	0.47

Self-Retaining Area tributary connections are reported here. If the Tributary Area Ratio > 2 the cells turns red.

SBUH Model Worksheet

Yellow-shaded cells are copied from “Project Information” sheet

Blue-shaded cells contains results that are copied to the “Project Information” sheet

SCM #1

SBUH Parameters:											SCM Parameters:			
Design rainfall depth (in) =	2.00										Plan area (ft2) =		800	
Model time step (min) =	10										Sizing factor =		0.114	
DMA Summary	Area (ft2)	CN	S	Weighting							Design infiltration rate (in/hr) =		0.75	
New impervious area:	7000	98	0.20	1							Safety factor =		2	
Replaced impervious in USA:	0	98	0.20	0							SCM Exfiltration rate (cfs) =		0.0139	
Replaced impervious not USA:	0	98	0.20	0.5							Drainage time (hours) =		4	
Landscape area:	0	68	4.71	1							Minimum storage volume (ft3) =		831	
Solid unit pavers set in sand:	0	89	1.24	1							Gravel volume (ft3) =		2076	
Non-runoff generating area:	4300	N/A	N/A	N/A							Gravel depth (ft) =		2.6	
Travel path length (ft) =	150.3												*% inflow that*	
Time of concentration (min) =	5.0	*(rain/runoff)*		*(rain/runoff)*		*(rain/runoff)*					*runoff %*	*direct rain vol*	*is exfiltrated*	*(max/total vol.)*
		89%		*10%*		*51%*					*89%*	*133.3*	*100%*	*36%*

SBUH Runoff Calculations | **Bioretention Hydraulics**

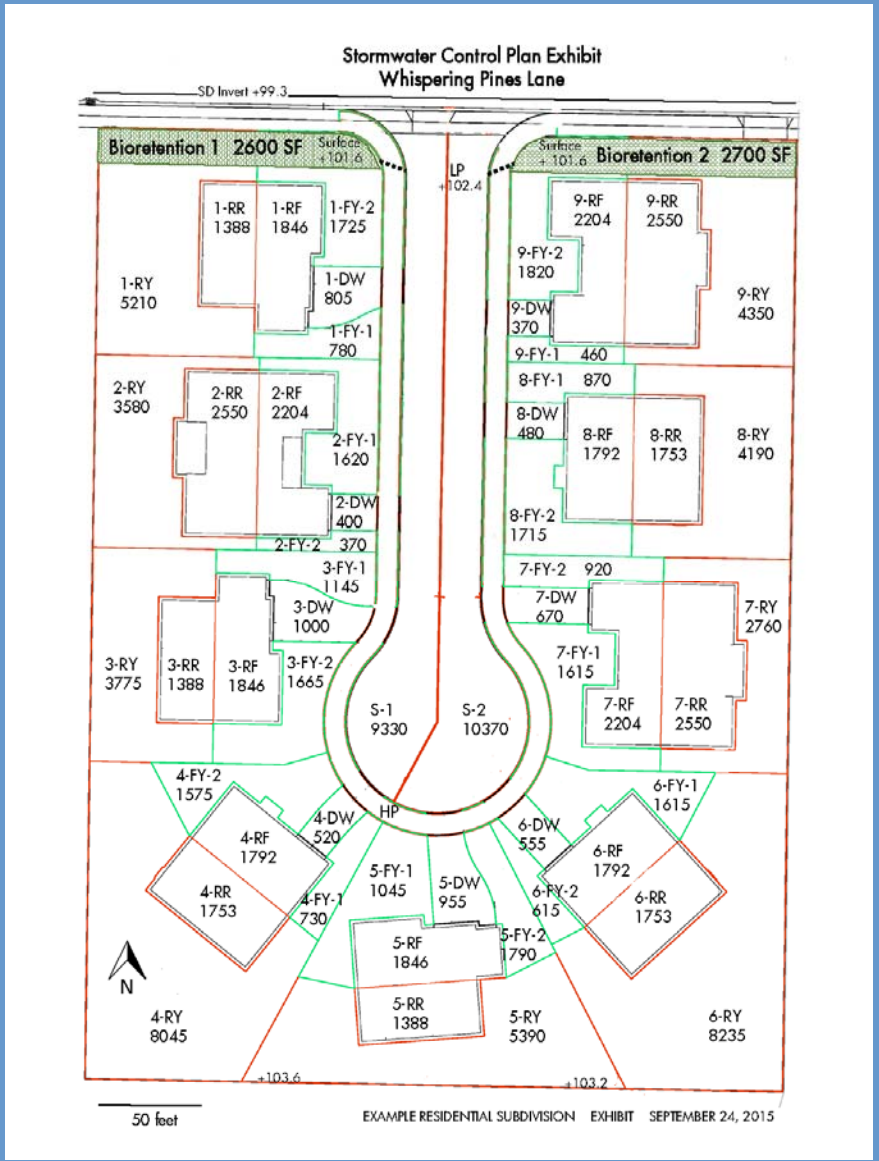
				Impervious		Landscape		Solid unit pavers set in sand							
Time (minutes)	Distribution (Type I)	Rainfall Depth (in)	Cumulative Rainfall (in)	Cumulative Runoff Depth (in)	Instantaneous Runoff (in)	Cumulative Runoff Depth (in)	Instantaneous Runoff (in)	Cumulative Runoff Depth (in)	Instantaneous Runoff (in)	Instantaneous Runoff Rate (cfs)	Routed Flow Rate (cfs)	Stormwater Inflow (ft3)	Direct Rain (ft3)	Exfiltration Outflow (ft3)	Bioretention Water Volume (ft3)
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0027	0.0054	0.0054	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3600	-0.3600	0.0000
20	0.0026	0.0052	0.0106	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3467	-0.3467	0.0000
30	0.0027	0.0054	0.0160	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3600	-0.3600	0.0000

SBUH runoff and routing calculations. Equations are visible to the user

Bioretention hydraulic calculations

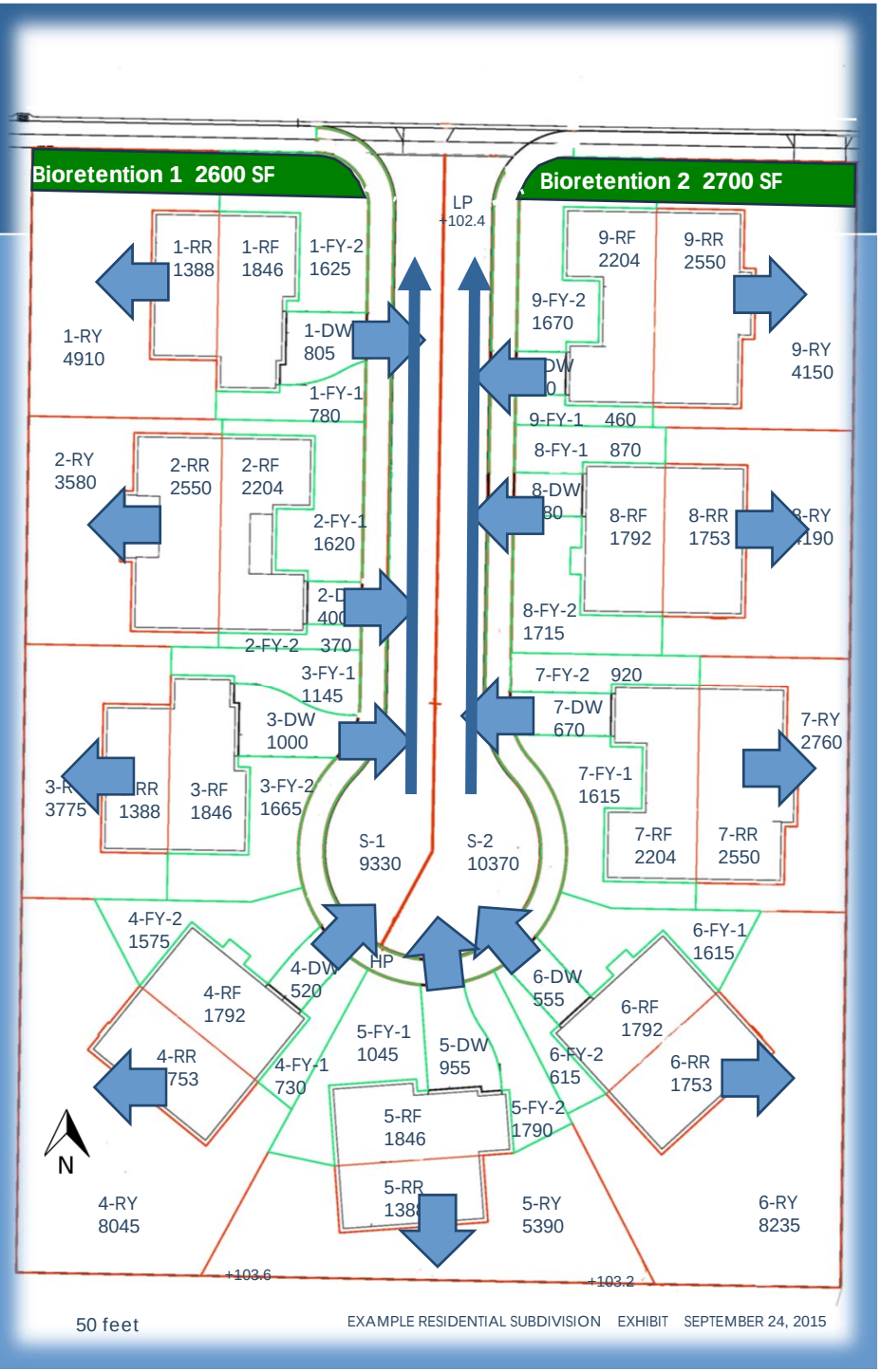
Whispering Pines Lane Example

- Using Calculator as design aid
- Testing design iterations



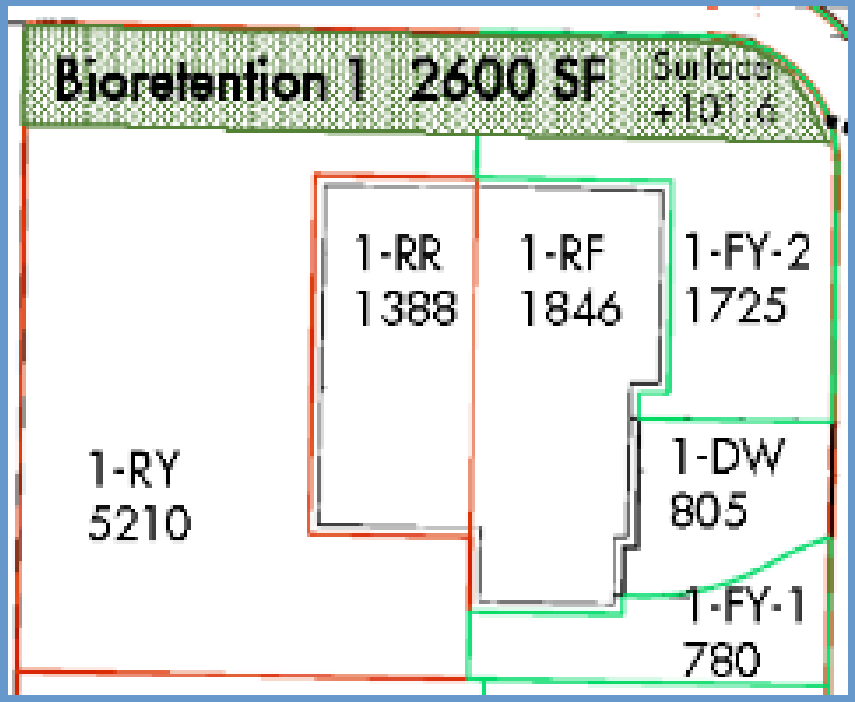
Subdivisions

- Drain a portion of each roof to yard
- Drain driveways to street
- Drain street to bioretention facilities on commonly owned parcels



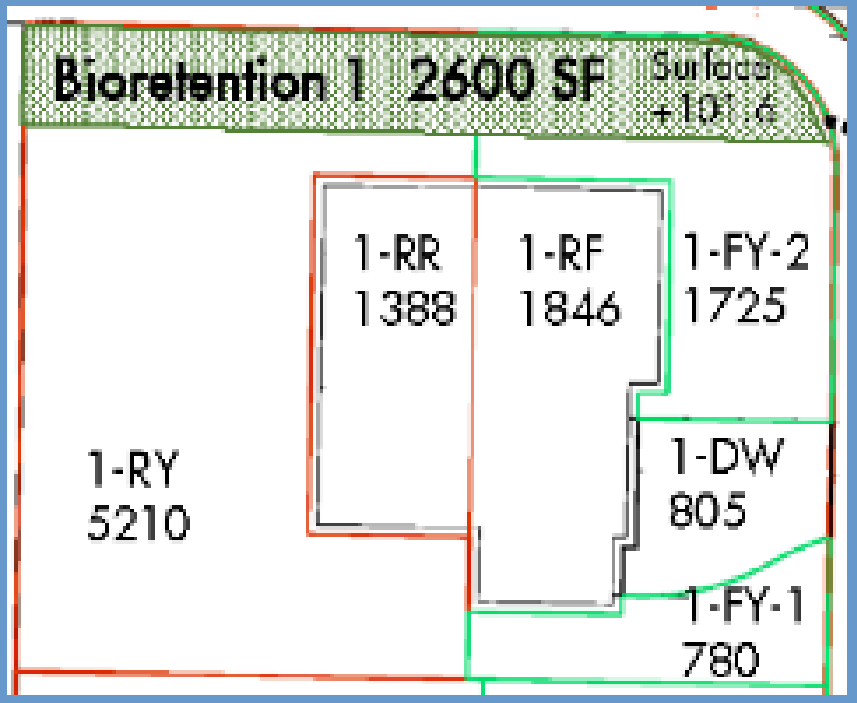
Detailed DMA Setup

- Describing DMAs
  - Go to the level of detail that can affect SCM design
    - Different surface types
    - Different control approach



Detailed DMA Setup

- Each DMA gets a line in the *DMA Characterization* table



2. DMA Characterization

Add DMA Row | Remove DMA Row

Name	DMA Type	Area (ft2)	Surface Type	New, Replaced?	Connection
1-RF	Drains to SCM	1846	Roof	New	Bioretention-1
1-RR	Drains to Self-Retaining	1388	Roof		1-RY
1-DW	Drains to SCM	805	Concrete or asphalt	New	Bioretention-1
1-FY-1	Self-Retaining	780			
1-FY-2	Self-Retaining	1625			
1-RY	Self-Retaining	4910			

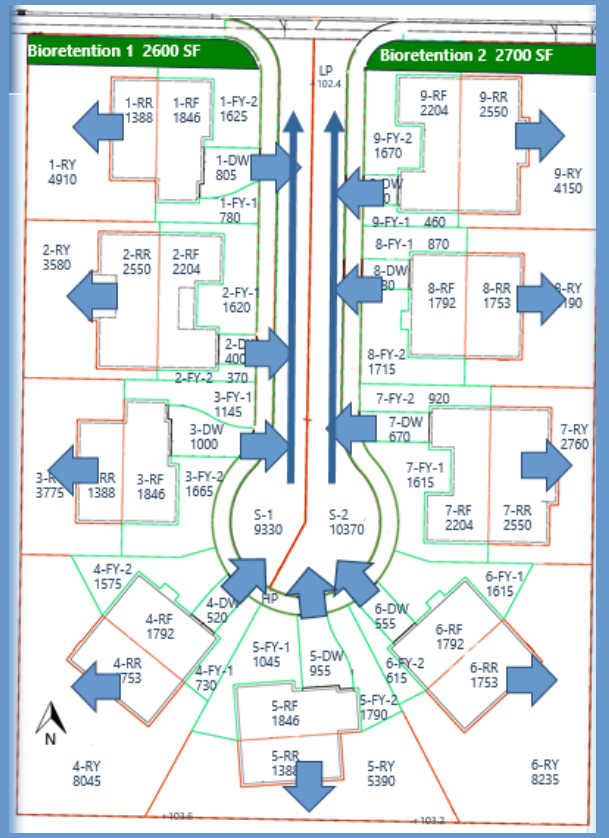
All DMAs Defined

2. DMA Characterization — Add DMA Row | Remove DMA Row

Name	DMA Type	Area (ft2)	Surface Type	New, Replaced?	Connection
1-RF	Drains to SCM	1846	Roof	New	Bioretention-1
1-RR	Drains to Self-Retaining	1388	Roof		1-RY
1-DW	Drains to SCM	805	Concrete or asphalt	New	Bioretention-1
1-FY-1	Self-Retaining	780			
1-FY-2	Self-Retaining	1625			
1-RY	Self-Retaining	4910			
2-RF	Drains to SCM	2204	Roof	New	Bioretention-1
2-RR	Drains to Self-Retaining	2550	Roof		2-RY
2-DW	Drains to SCM	400	Concrete or asphalt	New	Bioretention-1
2-FY-1	Self-Retaining	1620			
2-FY-2	Self-Retaining	370			
2-RY	Self-Retaining	3580			

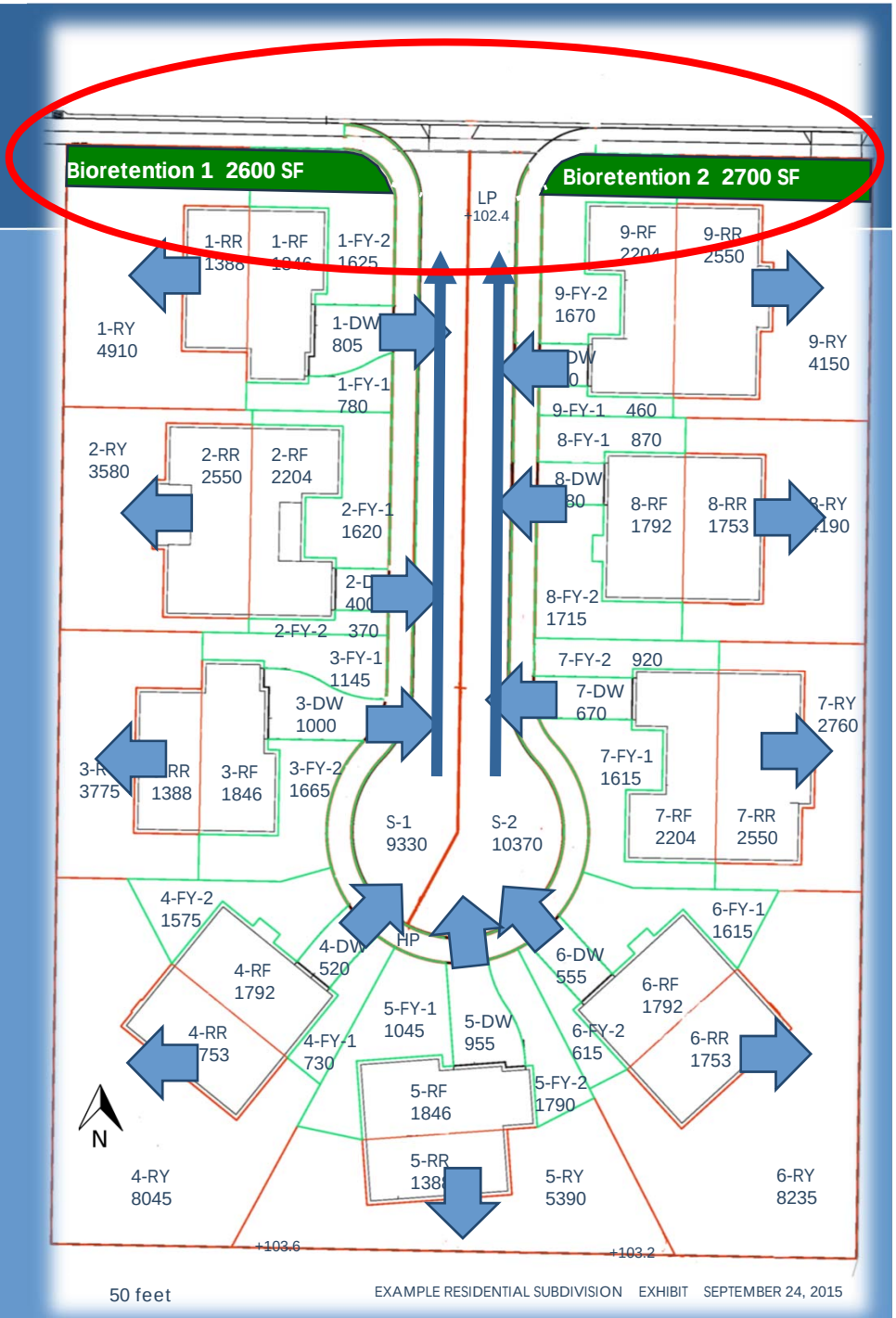
▪ ▪ ▪

7-RF	Drains to SCM	2204	Roof	New	Bioretention-2
7-RR	Drains to Self-Retaining	2550	Roof		7-RY
7-DW	Drains to SCM	670	Concrete or asphalt	New	Bioretention-2
7-FY-1	Self-Retaining	1615			
7-FY-2	Self-Retaining	920			
7-RY	Self-Retaining	2760			
8-RF	Drains to SCM	1792	Roof	New	Bioretention-2
8-RR	Drains to Self-Retaining	1753	Roof		8-RY
8-DW	Drains to SCM	480	Concrete or asphalt	New	Bioretention-2
8-FY-1	Self-Retaining	870			
8-FY-2	Self-Retaining	1715			
8-RY	Self-Retaining	4190			
9-RF	Drains to SCM	2204	Roof	New	Bioretention-2
9-RR	Drains to Self-Retaining	2550	Roof		9-RY
9-DW	Drains to SCM	370	Concrete or asphalt	New	Bioretention-2
9-FY-1	Self-Retaining	460			
9-FY-2	Self-Retaining	1670			
9-RY	Self-Retaining	4150			
S-1	Drains to SCM	9330	Concrete or asphalt	New	Bioretention-1
S-2	Drains to SCM	10370	Concrete or asphalt	New	Bioretention-2



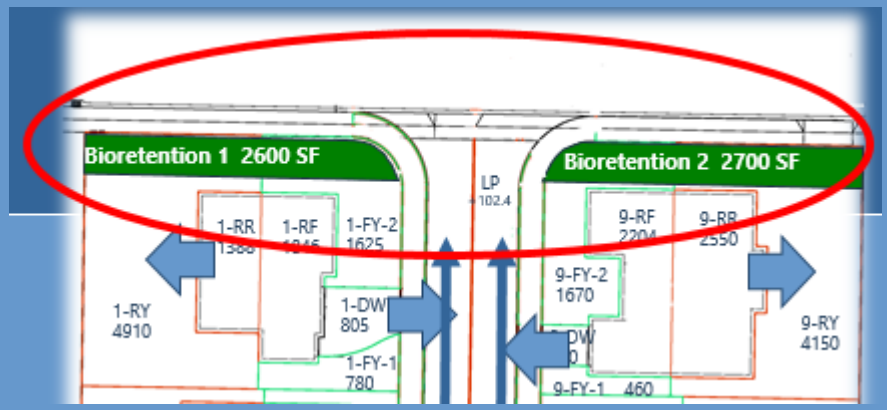
SCM Setup

- Project reserves two bioretention areas
  - 2600 and 2700 ft2
- Site grading must promote drainage into these areas



Detailed SCM Setup

- Define SCM configuration
  - SCM name, type
  - Soil, SCM area
  - Flow control orifice?



3. SCM Characterization			Add SCM Row	Remove SCM Row		Flow Control	Reservoir
Name	SCM Type	Safety Factor	SCM Soil Type	Infilt. Rate (in/hr)	Area (ft2)	Orifice?	Depth (in)
Bioretention-1	Bioretention	1	HSG C/D	0.25	2600	No	
Bioretention-2	Bioretention	1	HSG C/D	0.25	2700	No	

Run Calculator SBUH Model

- Check self-retaining area ratios (<2:1)
- Calculate min. SCM storage volume

6. Self-Retaining Area Sizing Checks

Self-Retaining DMA Name	Self-Retaining DMA Area (ft2)	Tributary DMA Name	Tributary DMA Area (ft2)	Tributary / SRA Area Ratio
1-FY-1	780		0	0.00
1-FY-2	1625		0	0.00
1-RY	4910	1-RR	1388	0.28
2-FY-1	1620		0	0.00
2-FY-2	370		0	0.00
2-RY	3580	2-RR	2550	0.71
3-FY-1	1145		0	0.00
3-FY-2	1665		0	0.00
3-RY	3775	3-RR	1388	0.37
4-FY-1	730		0	0.00
4-FY-2	1575		0	0.00
4-RY	8045	4-RR	1753	0.22
5-FY-1	1045		0	0.00
5-FY-2	1790		0	0.00
5-RY	5390	5-RR	1388	0.26
6-FY-1	1615		0	0.00
6-FY-2	615		0	0.00
6-RY	8235	6-RR	1753	0.21
7-FY-1	1615		0	0.00
7-FY-2	920		0	0.00
7-RY	2760	7-RR	2550	0.92
8-FY-1	870		0	0.00
8-FY-2	1715		0	0.00
8-RY	4190	8-RR	1753	0.42
9-FY-1	460		0	0.00
9-FY-2	1670		0	0.00
9-RY	4150	9-RR	2550	0.61

4. Run SBUH Model

Launch Model

5. SCM Minimum Sizing Requirements

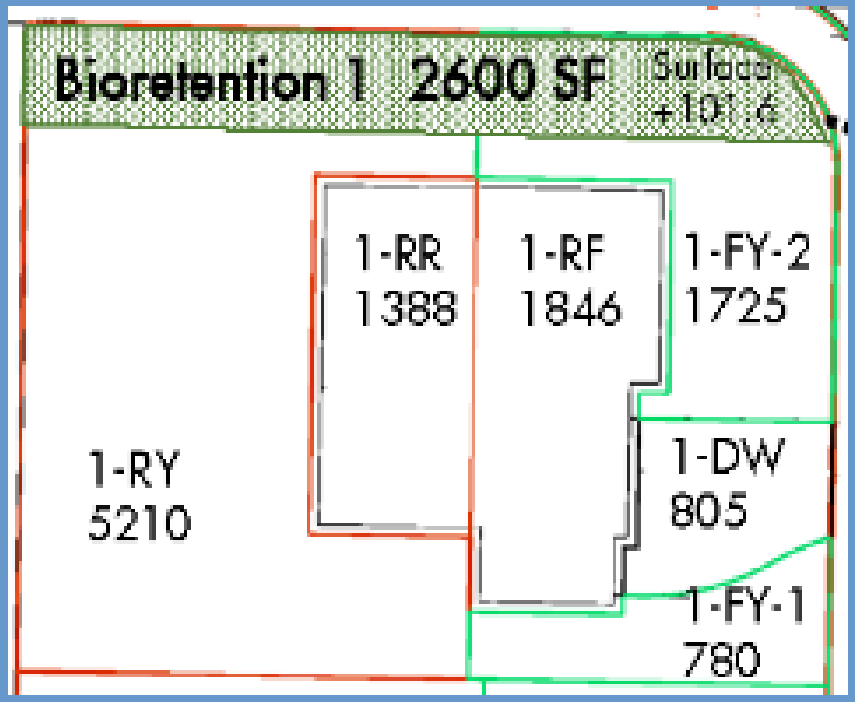
SCM Name	Min. Required Storage Vol. (ft3)	Depth Below Underdrain (ft)	Drain Time (hours)
Bioretention-1	1194	1.15	2.9
Bioretention-2	1439	1.33	4.6

Calculator as Design Aid

- After initial SCM sizing, iterate on stormwater design options:
  - Reduce impervious areas
  - Modify surface types to reduce runoff and/or integrate runoff management into landscape (drain to self-retaining areas)
  - Configure bioretention with flow control orifice and deeper surface reservoir

Surface Type Options

- Look for options to reduce runoff
- Drainage ideas?
  1. Route 1-RF to backyard self-retaining area
  2. Driveway as unit pavers in sand
  3. Driveway drains to 1-FY-2



Effect of Surface Type

Option	Effect
Route 1-RF to backyard self-retaining area	1846 ft2 removed from bioretention drainage area
Driveway as unit pavers in sand	Runoff factor reduced from 1.0 to 0.2
Driveway drains to 1-FY-2	805 ft2 removed from bioretention drainage area

- Consider other drainage design concerns
  - soggy yards, driveway elevation, etc.

Adding a Flow Control Orifice

- Holds water in SCM longer and allows for more infiltration → smaller volume
- Gravel volumes reduced typically 20+% percent
- Engineers balance design complexity with potential space/cost savings

Flow Orifice Example

- 10,000 ft2 impervious tributary area
- SCMs with and without flow control orifice

3. SCM Characterization — Add SCM Row | Remove SCM Row

Name	SCM Type	Safety Factor	SCM Soil Type	Infilt. Rate (in/hr)	Area (ft2)	Flow Control Orifice?	Reservoir Depth (in)
SCM-1	Bioretention	1	HSG C/D	0.25	800	No	
SCM-2	Bioretention	1	HSG C/D	0.25	800	Yes	6

4. Run SBUH Model

Launch Model

5. SCM Minimum Sizing Requirements

SCM Name	Min. Required Storage Vol. (ft3)	Depth Below Underdrain (ft)	Drain Time (hours)
SCM-1	1487	4.65	74.3
SCM-2	987	3.08	49.3

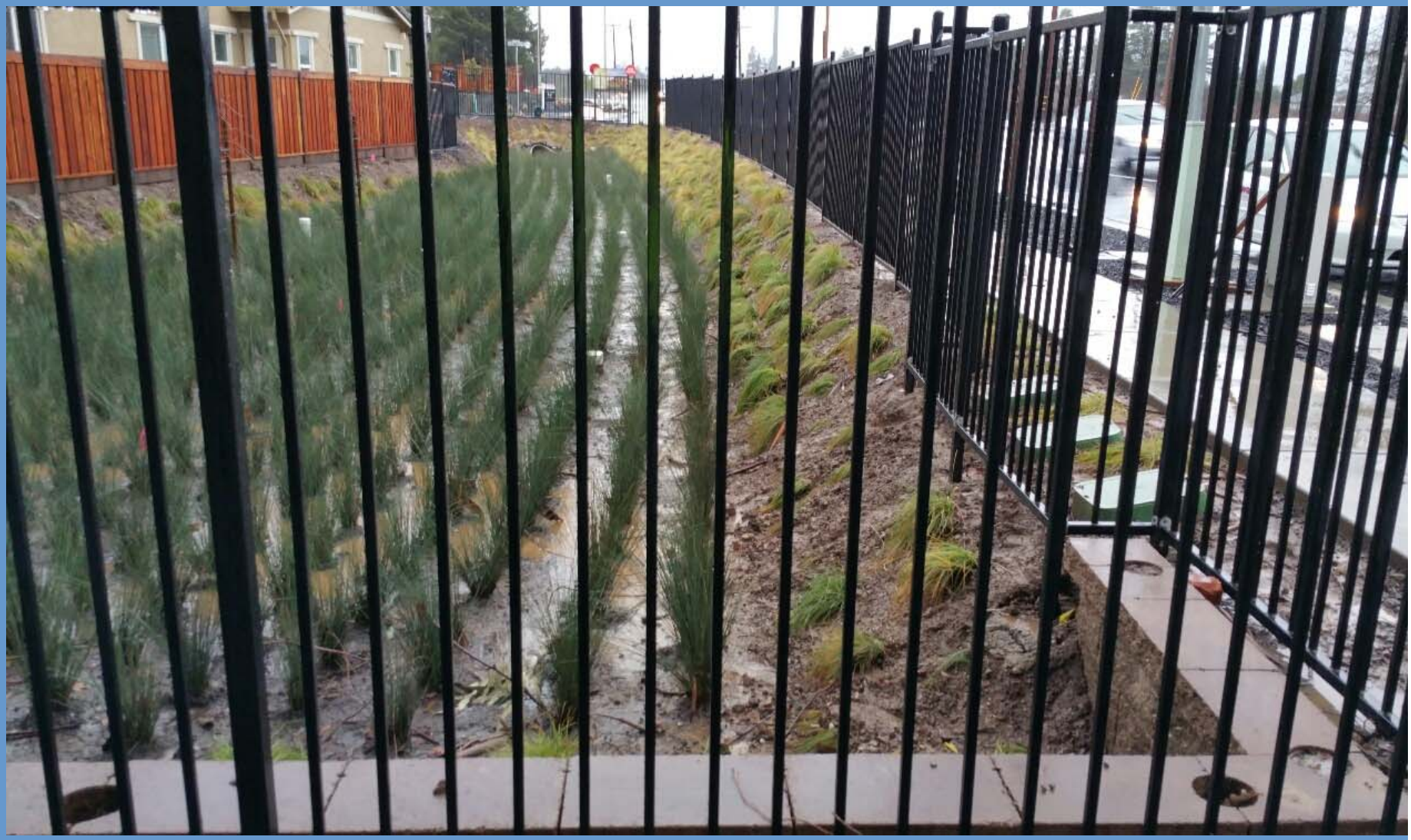
SCM volume reduction

Bioretention Design and Construction

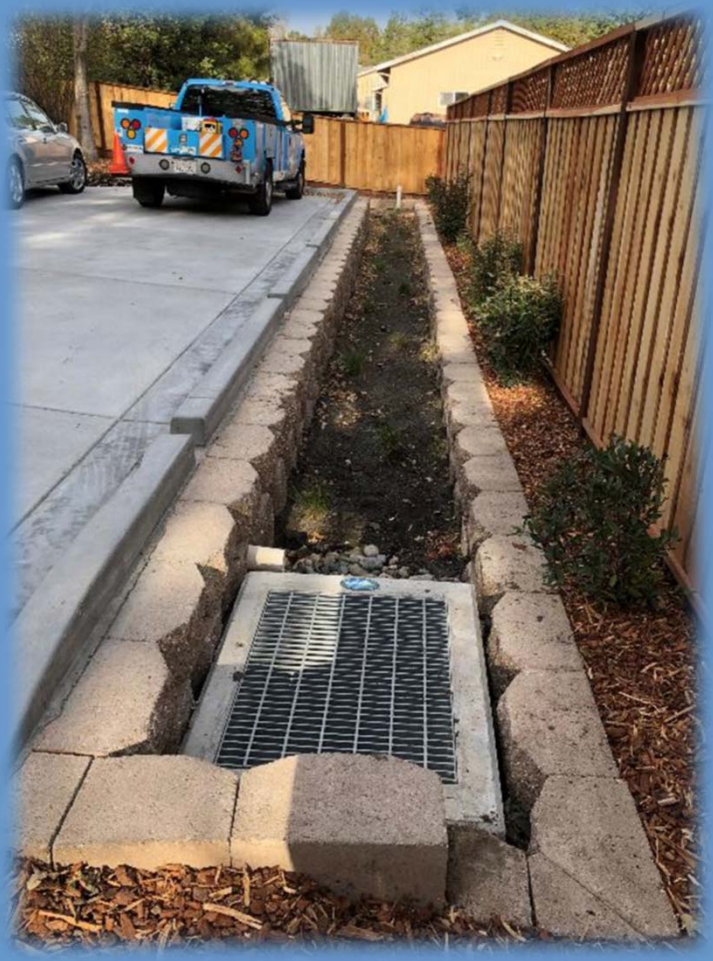
Dan Cloak

Don’t create pits

Don’t create pits



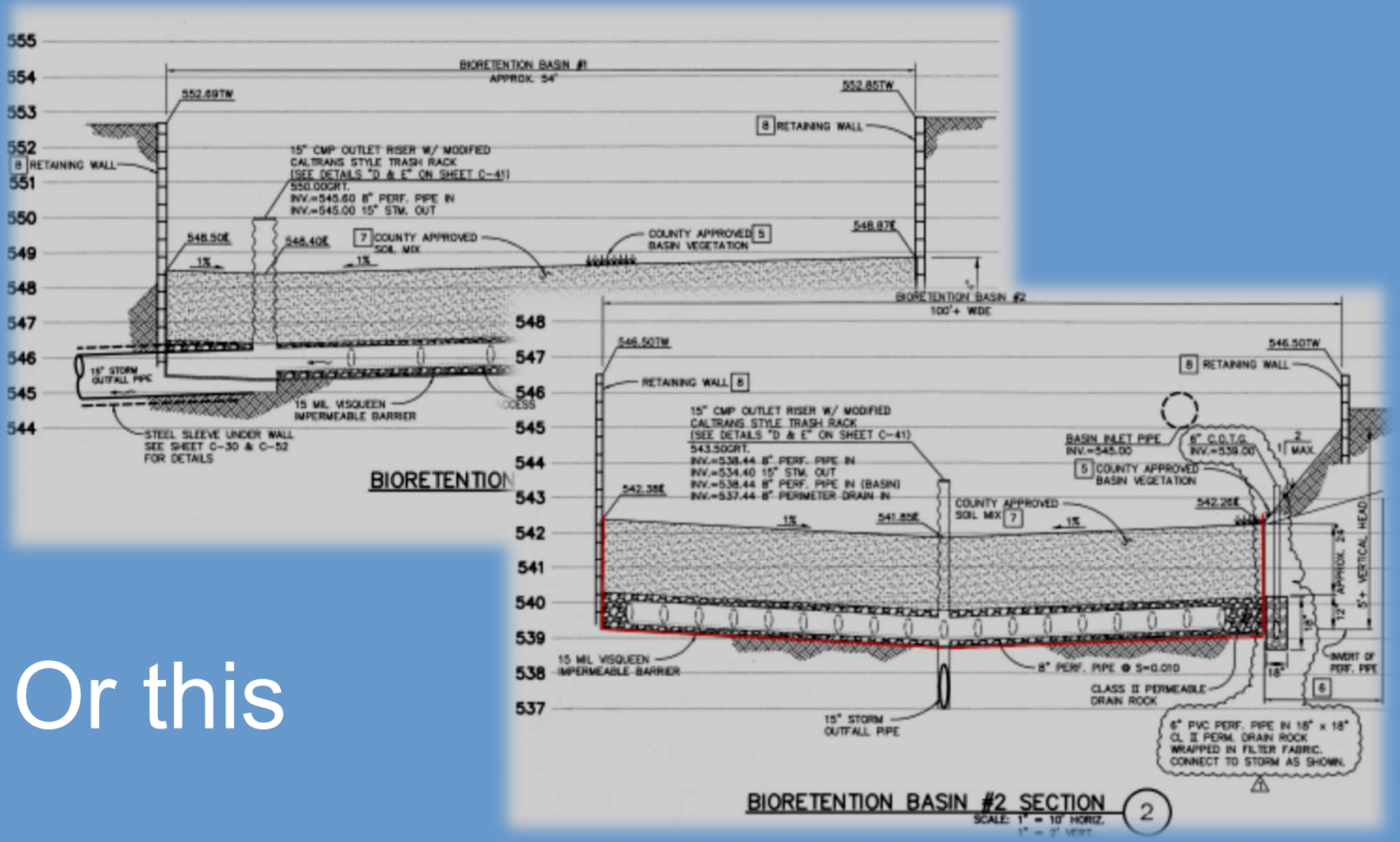
Problems with pits



Make This Happen

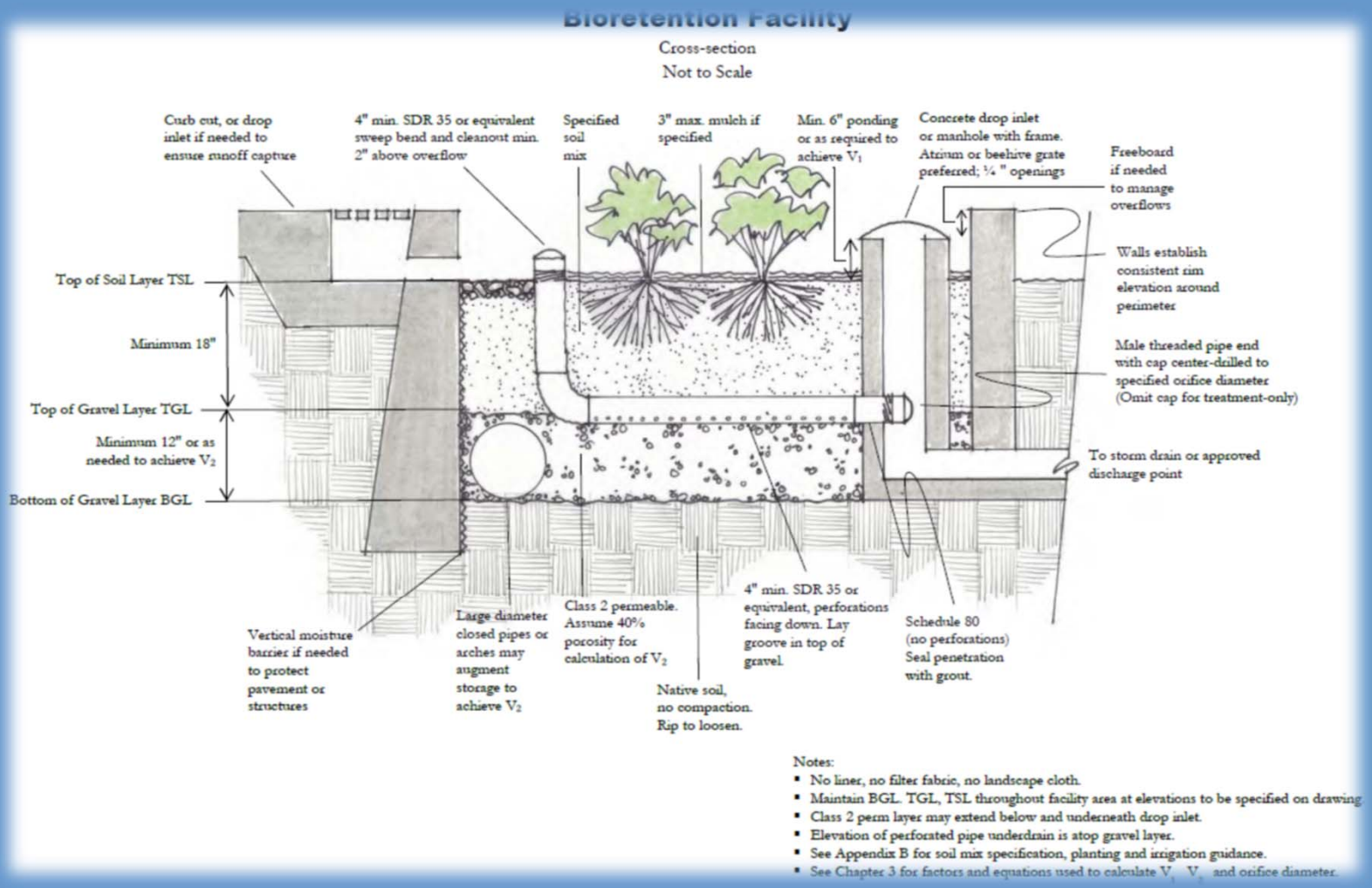
- Bioretention facilities are level so they "fill up like a bathtub."

Not this

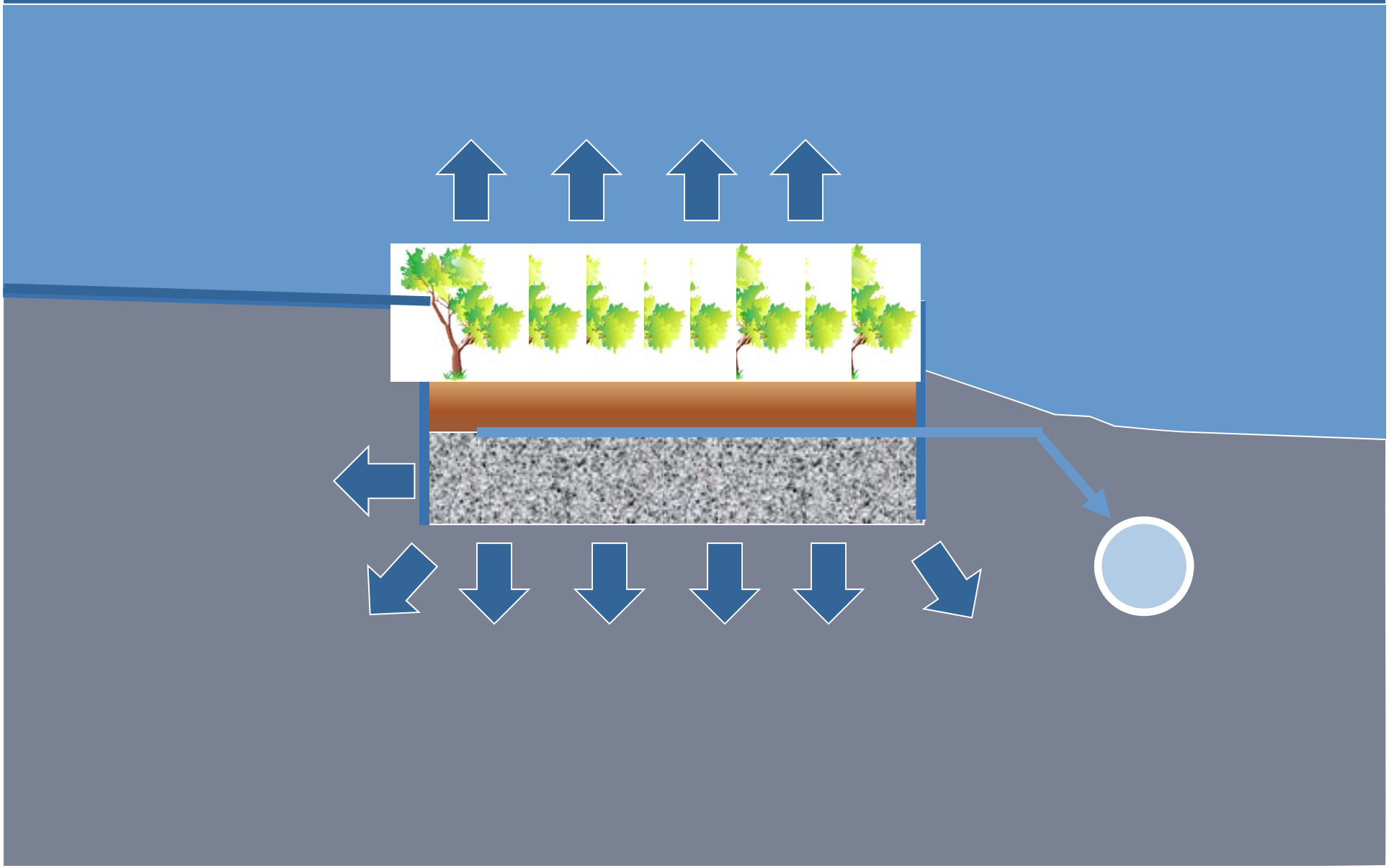


Or this

Bioretention Design Criteria



Flat, Flat, Flat



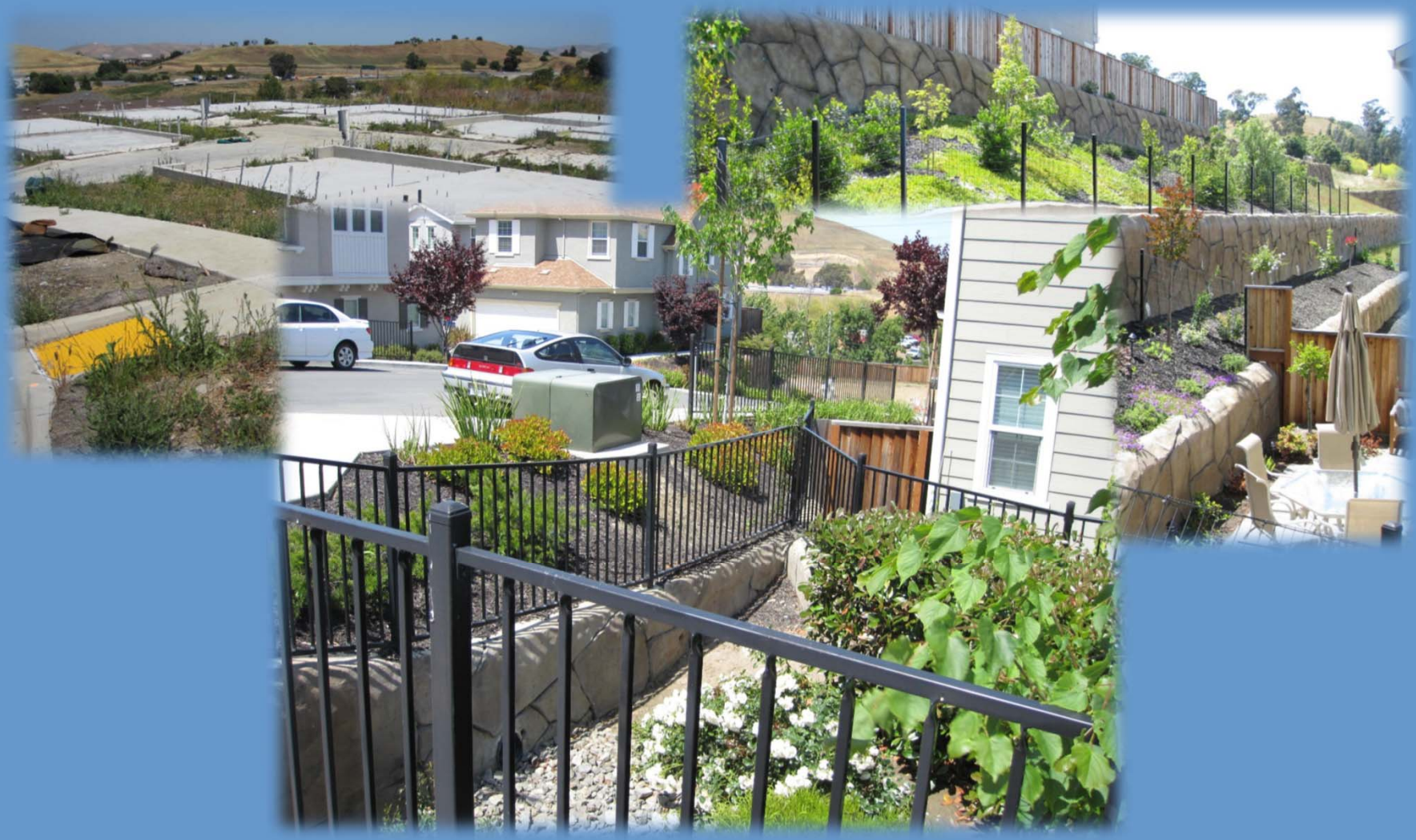
Flat, Flat, Flat

Flat, Flat, Flat

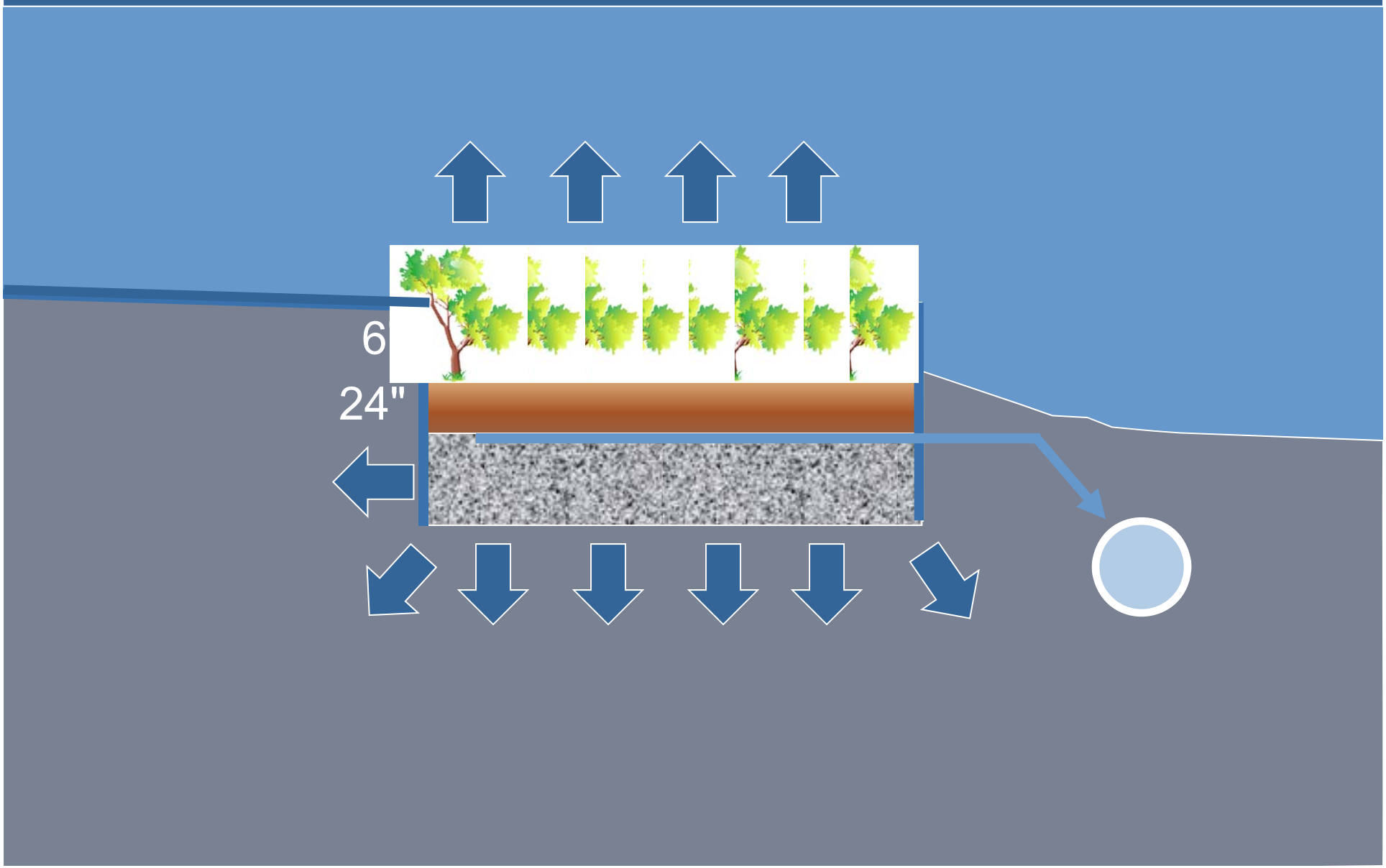
Foundations and Pavement

Foundations and Pavement

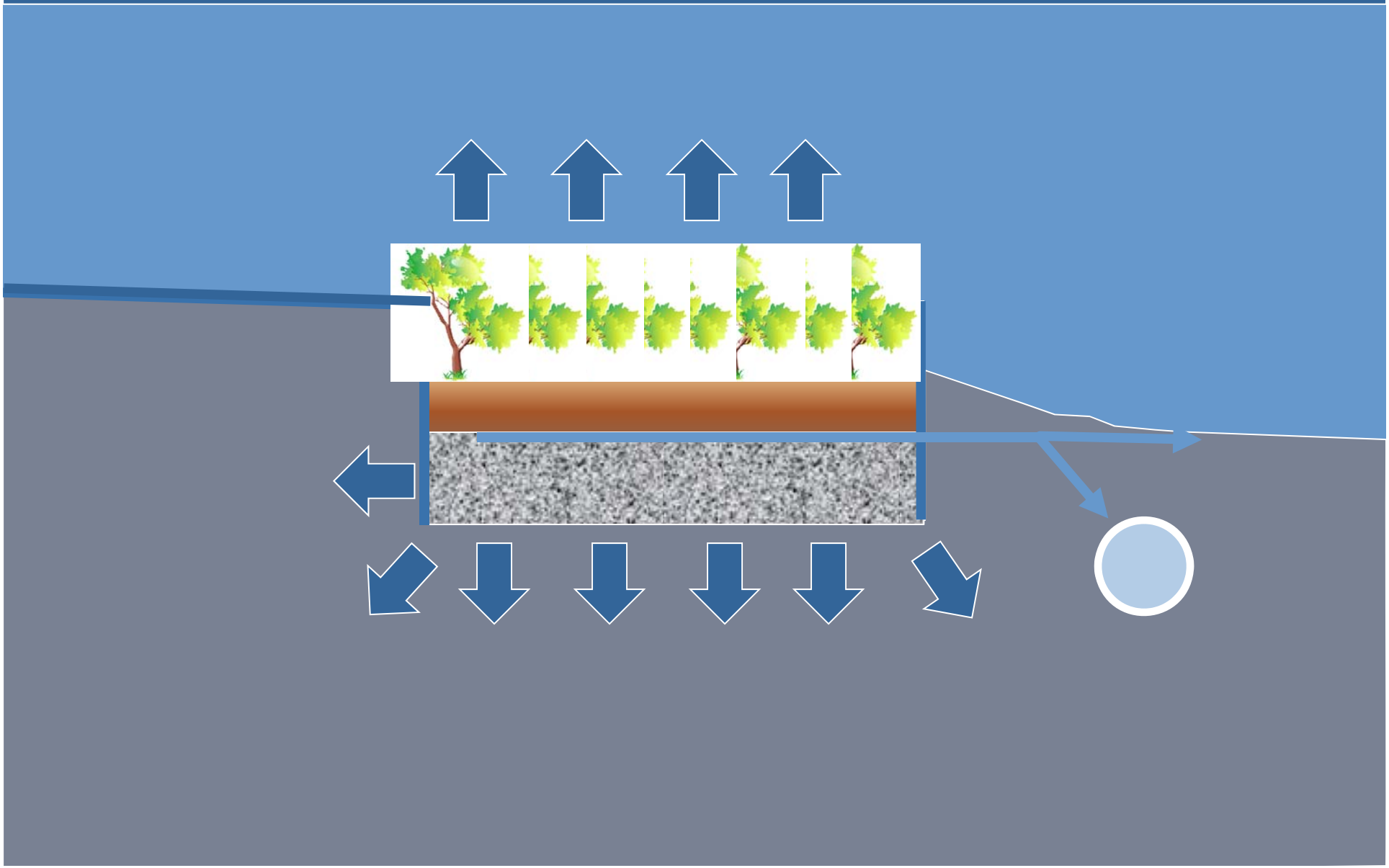
Geotechnically Difficult Sites



High Groundwater

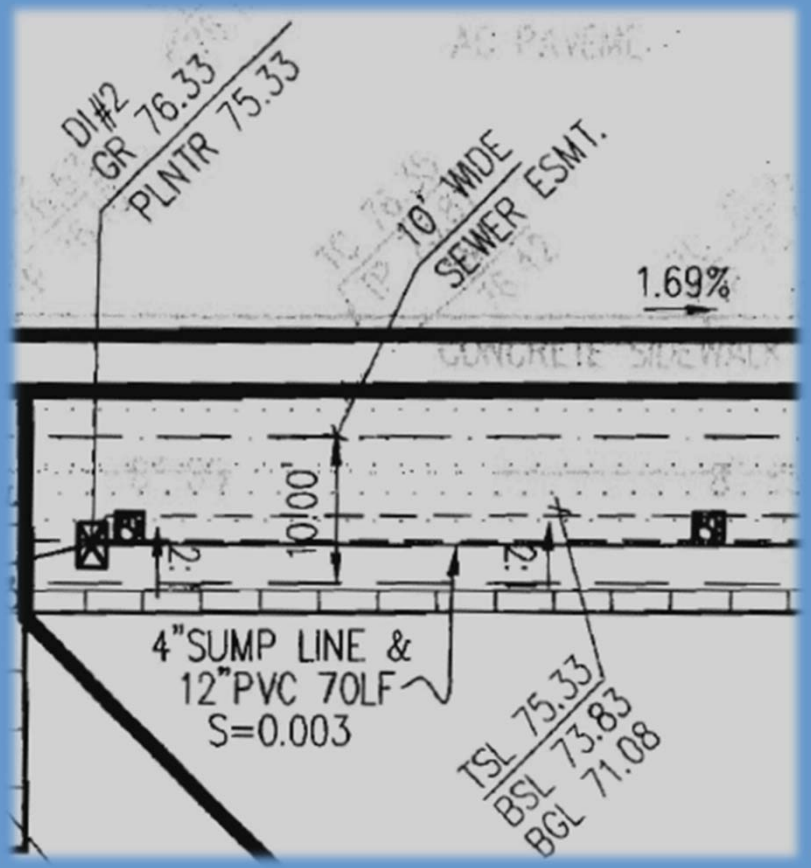


No Storm Drain



Call out elevations

- Outlet structure
  - Top of overflow grate
  - Underdrain connection
- Inlet
  - Flow line at inlet
  - Top of curb
  - Top of adjacent paving
- Soil layers
  - Top of soil layer
  - Bottom of gravel layer
  - Bottom of soil layer



Overflow Structure

Overflow elevation

Gravel and Underdrain

- Class 2 permeable
  - Caltrans spec 68-2.02(F)(3)
- No filter fabric
- Underdrain
  - Discharge elevation at top of gravel layer
  - PVC SDR 35 or equivalent; holes facing down
  - Solid pipe for 2' closest to outlet structure
  - Cleanout

Planting Medium

- 60-70% **Washed** Sand
  - ASTM C33 for fine aggregate
- 30-40% Compost
  - Certified through US Composting Council Seal of Testing Assurance Program
- Install in 8"-12" lifts
- Do not compact
- Do not overfill
- Leave room for mulch

Planting

- Select plants for fast-draining soils
- Select for facility location
- Avoid problem conditions
  - Overly dense plantings
  - Aggressive roots
  - Invasive weeds
  - Need for a lot of irrigation or for fertilization

Irrigation

- Separate Zone for Bioretention
- Drip Irrigation
- Smart Controllers

Construction

- Layout
- Excavation
- Overflow or Surface Connection
- Underground connection (underdrain)
- Drain rock/subdrain
- Soil Mix
- Irrigation
- Planting
- Final

Construction Inspection

- Yes, inspections are needed
- Special inspections (or inspectors) may be appropriate
- Edit construction checklist and deliver to general contractor at pre-construction meeting
- Make sure landscape contractor gets the message(s)
  - Elevations
  - Additions of material
  - Fertilizers

2-Year Warranty Recommended

- Extension of standard 1-year warranty for landscaping
- Allows identification and correction of problems during rainy season

Key O&M Requirements

- Composted mulch
- No fertilizer
  - See instructions for using compost tea
- Weed manually
  - Listed “natural” herbicides for invasions
- No synthetic pesticides
  - Beneficial nematodes or listed natural pesticides

Typical maintenance plan

- Inspect weekly for trash and remove
- Weed monthly
- Check drainage and inspect facilities before the rainy season
- Inspect after each significant rainfall
- Annual vegetation cut-back and maintenance