Green Stormwater Infrastructure:

local case study in cost effectiveness and sustainability

1. Guiding principles

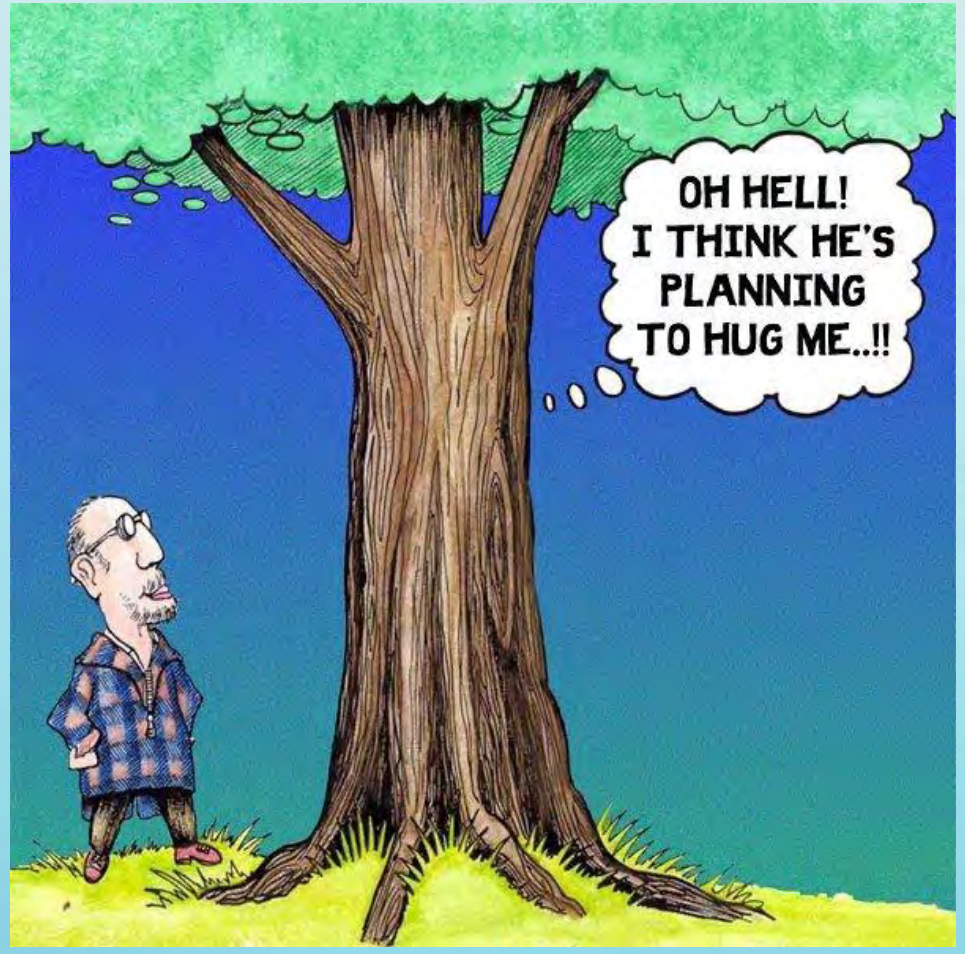
2. Some theoretical language

3. Implementation: the fun stuff, finally!

Sustainability is achieved by cost effectiveness

- Multifunctional landscape
- Ease of installation
- Local sourcing of material
- Minimal heavy equipment use
- Ease of maintenance
- Let nature do the job….natural nutrient cycle

We all love trees….



But let’s keep our rational cap on.

Trees are the biggest plant therefore have the biggest potential in Green storm water infrastructure

Why don’t we see more trees in GSI?

Not talking about engineered grey storm infrastructure

http://forestsforwatersheds.org

Benefits are:

- Economical
- Environmental
- community

Some facts:

Multi- function tool: Rainfall interception

Trees intercept rainfall in their canopy, reducing the amount of rain that reaches the ground. A portion of this captured rainwater evaporates from tree surfaces:

Surface area of a 20” oak

- Average leaf amount: 700.000
- Average leaf surface: 2 sq inch
- Total average leaf surface: 1.400.000 sq inch
- Or 9722 sqft, above a 1256 sqft ground area
- Bark area has been shown to intercept approximately 1.5% of rainfall. Leaf area amount up to 10% !

Increased ground Infiltration

The mean soil infiltration rate fells from 12.4 in/hr to 4.4 in/hr when a study site was converted from forest to suburban turf (Kays, 1980).

Increases soil water storage
Lengthens the amount of time before rainfall becomes runoff.

Forested land produces very little runoff, which can reduce downstream flood flows that erode stream channels, damage property and destroy habitat.

Urban forest.

Water quality benefits

- Trees prevent erosion of sediment by stabilizing the soil, and by substantially **dispersing raindrop energy**
- Trees take up storm water pollutants such as **nitrogen** from soil and groundwater: the **water pollutant feeds plants** !!!
- Forested areas can filter sediment and associated pollutants from runoff
- Plants break down pollutants commonly found in urban soils, groundwater, and runoff, such as metals, pesticides and solvents.
- Woody plants are able to **dissipate the energy** of storm flow, minimizing its erosion capacity.
    - Common statements associated with water benefits of urban forests

Designing with trees: soil

Soil is the base of the green storm water system; the container holding water and nutrients.

Sylvia McNeil, BCMA
“Developing productive soils in the residential setting, 2016”:

- “Healthy soil is created by the power of **plants** and the **relationship** of the soil organisms that rely on **organic matter** for their habitat and food”
- Roots, macro and micro organisms **work together** to regulate **water** and air availability.

Our Goal: Facilitate the soil ecosystem

Work with the natural nutrient cycle

Be aware of the local weather patterns

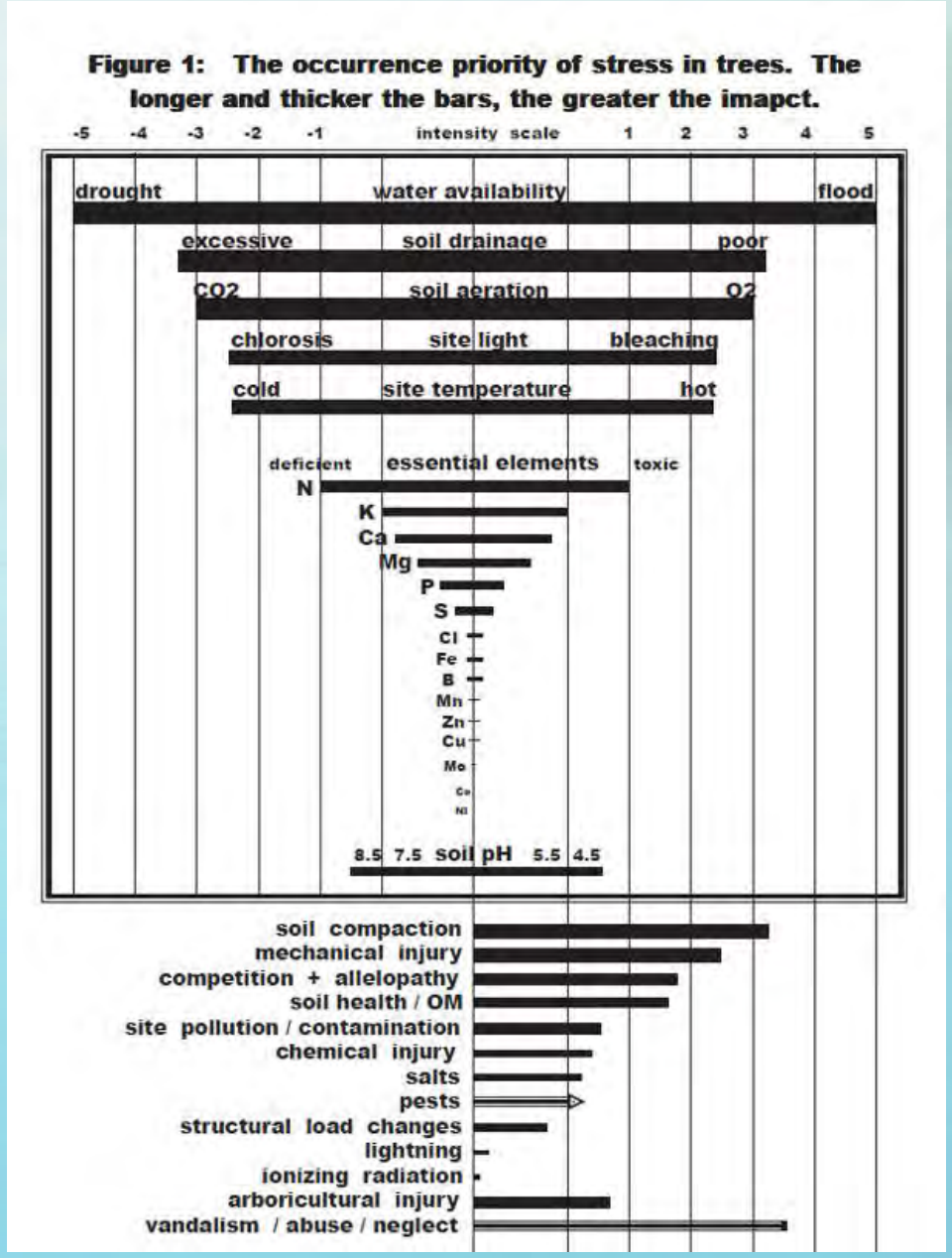
Use plant diversity

Think soil quality

Water availability, soil drainage, and soil aeration are all impacted by soil compaction.

Soil bulk density testing is an easy process to determine compaction levels.

Fig 1 by Dr. Kim Coder, 2007.



Soil Density, Root growth, and Texture

Soil texture	Ideal bulk densities (g/cm3)	Bulk densities that may affect root growth (g/cm3)	Bulk densities that restrict root growth (g/ cm3)
Sands, loamy sands	<1.60	1.69	>1.80
Sandy loams, loams	<1.40	1.63	>1.80
Sandy clay loams, loams, clay loams	<1.40	1.60	>1.75
Silts, silt loams	<1.30	1.60	>1.75
Silt loams, silty clay loams	<1.10	1.55	>1.65
Sandy clays, silty clays, some clay loams (35-45% clay)	<1.10	1.49	>1.58
Clays (>45% clay)	<1.10	1.39	>1.47

The contracting process

Grow plants in this soil?
“Red Death” Dirt

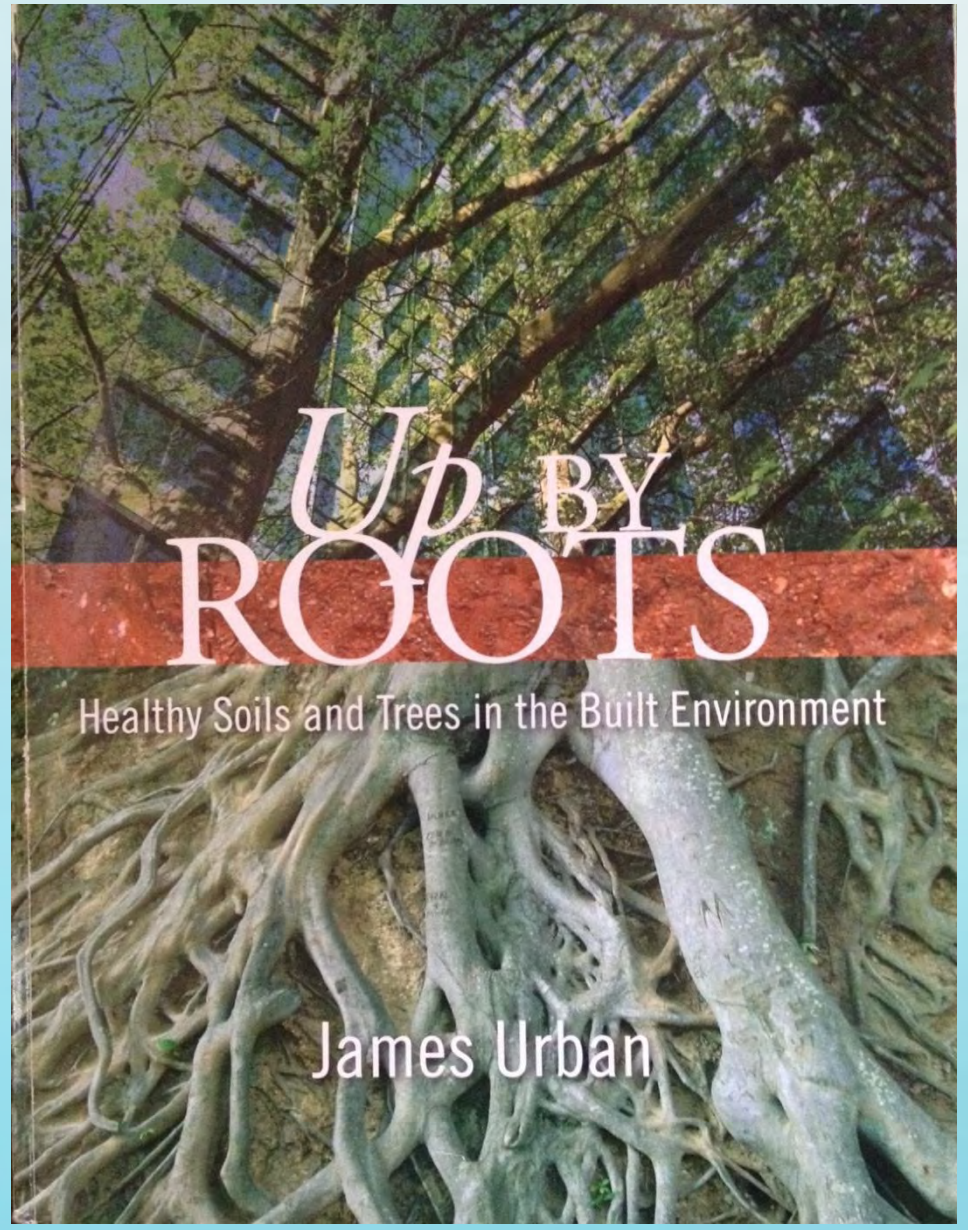
No nutrients or life, and not allowed as top soil per city of Austin technical manual

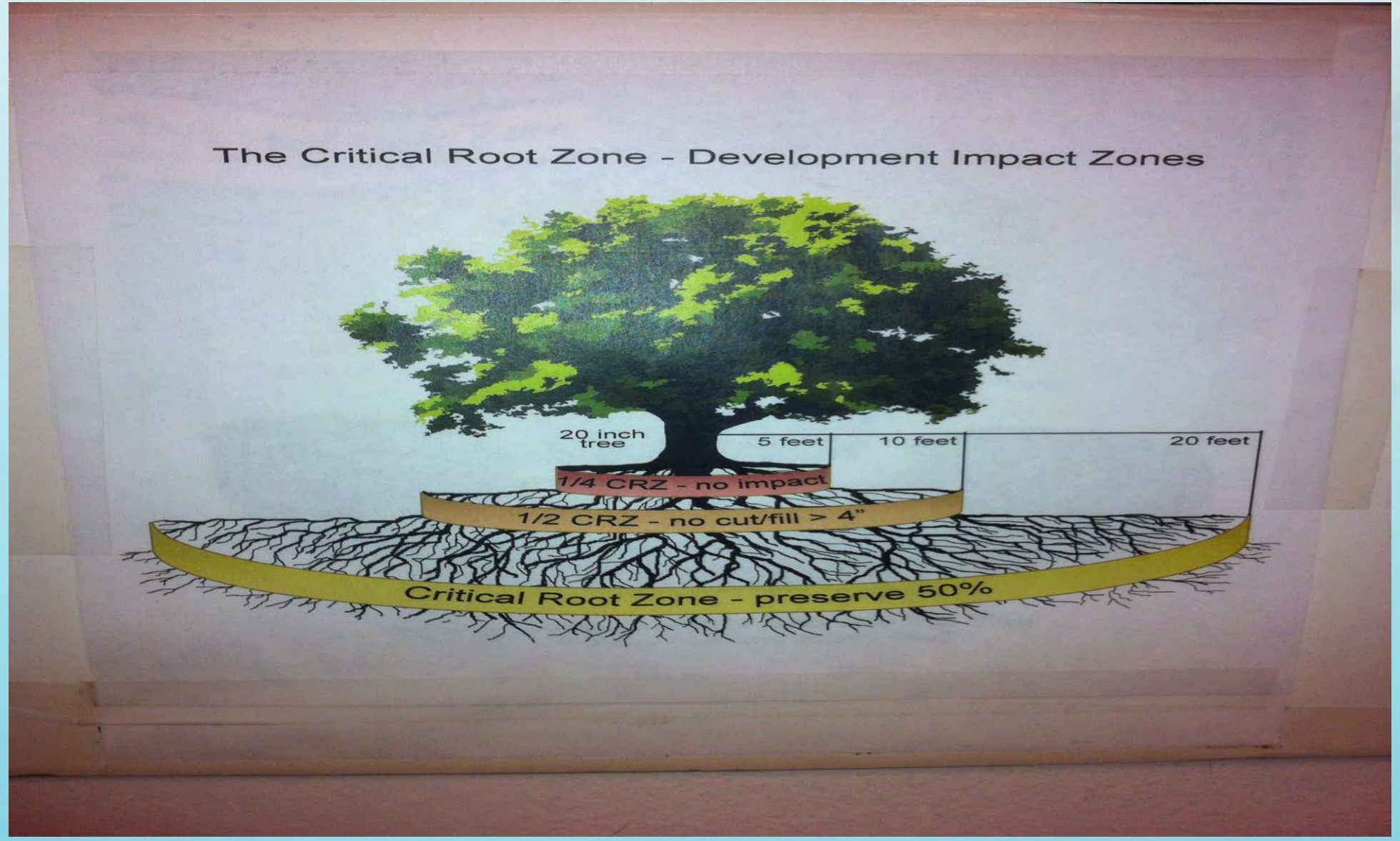
Compaction:

the process of killing soil and loosing water.

Soil

- How much?
- Where?


Up BY ROOTS
Healthy Soils and Trees in the Built Environment
James Urban


The Critical Root Zone - Development Impact Zones
20 inch tree
5 feet
10 feet
20 feet
1/4 CRZ - no impact
1/2 CRZ - no cut/fill > 4"
Critical Root Zone - preserve 50%

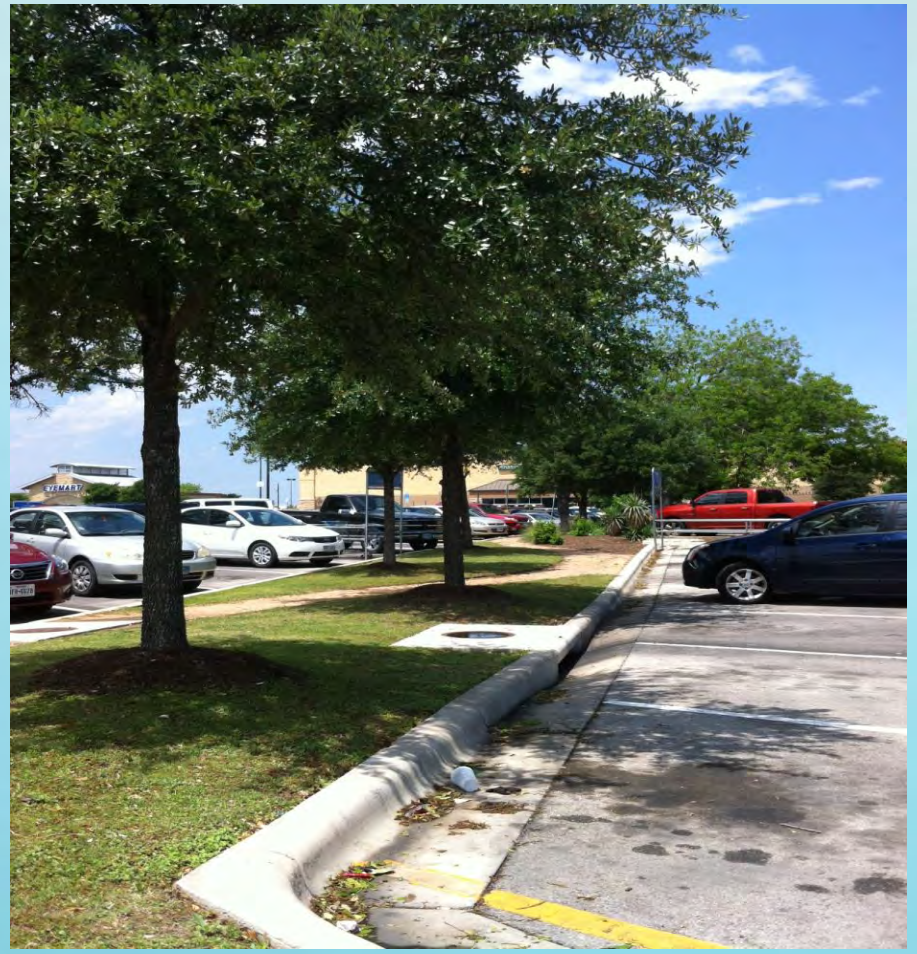
Soil and water requirements by tree size

Caliper	CRZ (sqft)	Soil volume (2ft depth cu ft)	Water (gal)
2	13	26	31.2
10	314	628	753.6
20	1256	2512	3014
30	2826	5652	6782.40

Note: water requirement is calculated based on a 1.2 gal per cu ft of soil for soil saturation. Soil volume recommendation is an industry standard.

Note 2: The USA spends more money studying soil on Mars than on earth. Soil: the Last Frontier…

Thinking outside the pipe



Stormwater Facility


WAL-MART
VISION CENTER

Sample designs: parking lots

Think soil volumes and water management.

Local conditions guide design principles

- Responsive design
- Adaptive management
- Maintenance

Local conditions:

- High volume of rainfall separated by periods of drought.

- Rainfall averages 24” annually in central Texas
- Central Texas is heavily wooded on both black-land prairie and hill country karst limestone clay: plants can work without irrigation after establishment
- Plants are able to survive thanks to the water holding capacity of our karst hills, clay soils and plants characteristics.
- Nitrogen production slows at temperatures above 80 degrees F and stop at 90 to 95 degrees F: establish plants during the right time of the year. Early fall is ideal for large plants.


10/17/2011
River Bend Ln
Dudley Ranch Rd
Halloween 2013 flood, Martindale Tx
Google earth
1995
Imagery Date: 10/17/2011 29°51'08.61" N 97°52'11.30" W elev 524 ft eye alt 2978 ft

If improperly designed, elements will reshape the landscaping. Trees have a much higher capacity for water regulation: they are just bigger…

From water shedding to water collecting earthworks. “The Earth is not flat” concept.

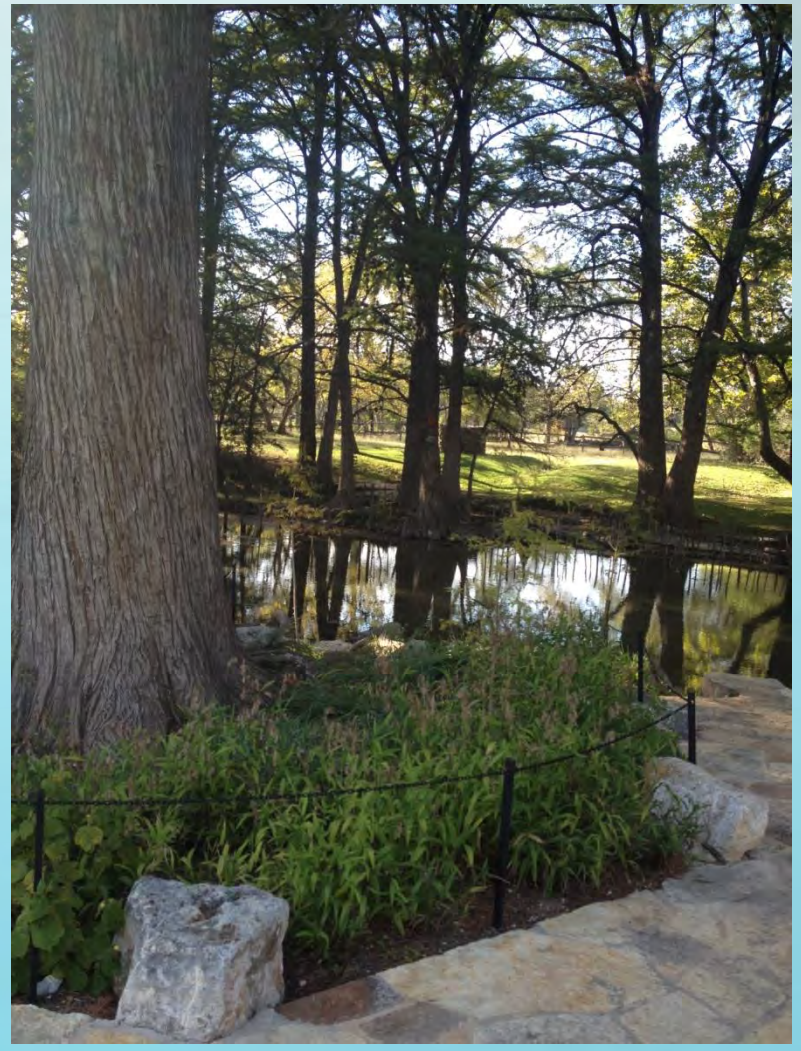
- Check dams
- Berms
- Swales
- Infiltration trenches
- Basins
- Runoff coefficient
- Erosion control
- Grade

Species selection:

Aquatic
vs riparian
vs upland

Native plants are adapted to local climate and soil, but we need to distinguish between native aquatic or riparian plants and upland plants:.

Blue Hole, Wimberley



Species selection: think ecosystem

- Upper layer: Live and red oak-Juniper-Cedar Elm-Legume complex
- Mid layer: shrubs and small trees. Mexican and red buckeye, plum trees, Mountain laurels, Sumacs, Texas persimmon, palmettos and various acacias/mimosas
- Ground layer: grasses, and perennials.
- Vines: Virginia creeper, trumpet vines,…
- Plants that bloom and seed are different times for wildlife benefits

Implementation

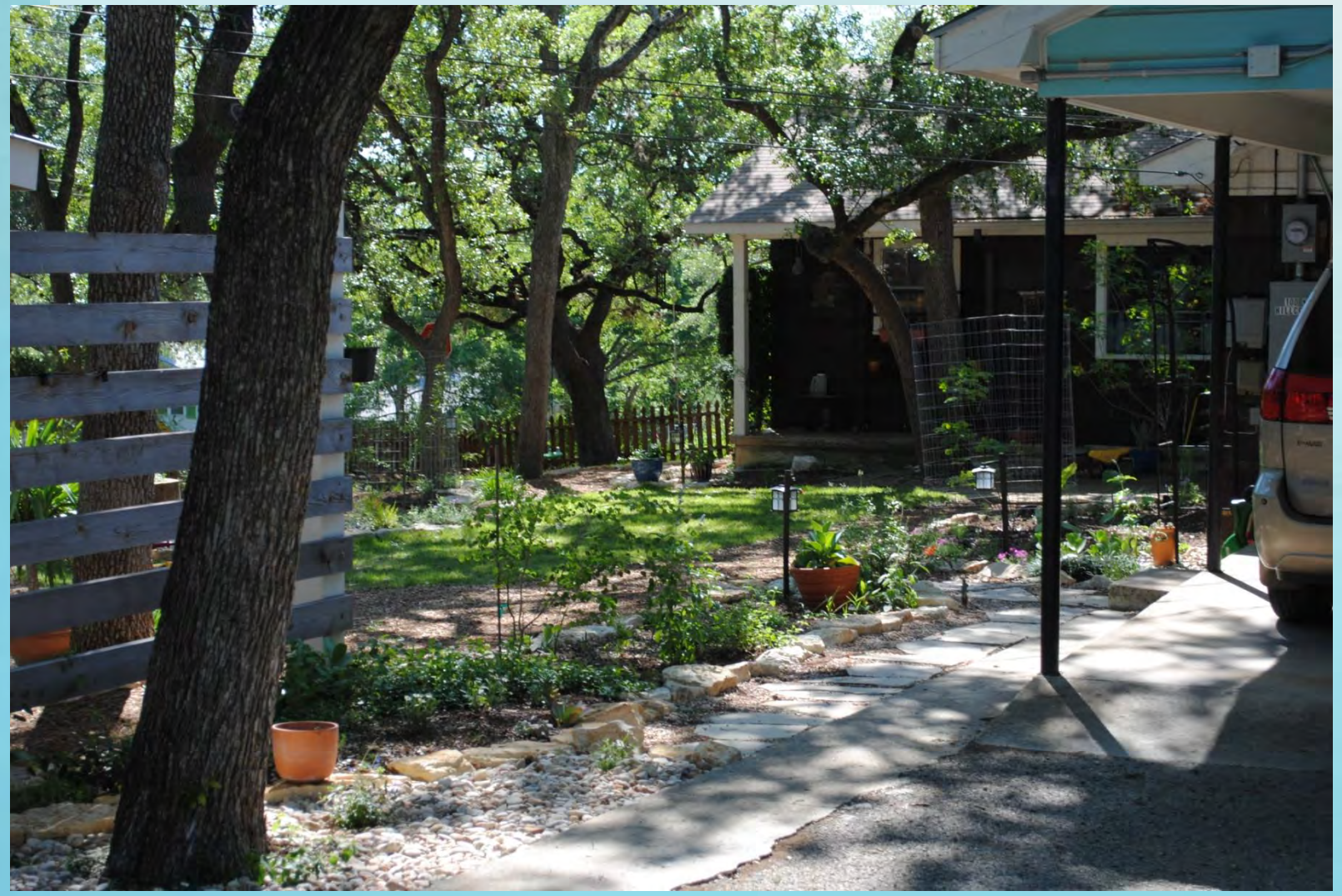
- Retrofit of a 1950 st augustine urban lot. 1/3 ac.
- Early spring 2012
- Classic balcones fault/hill country setting
- Traditional irrigation system using 30.000 gal monthly.

Soil Life: Organic matter is essential

Implementation

“Earthworks”: Earth is not flat…

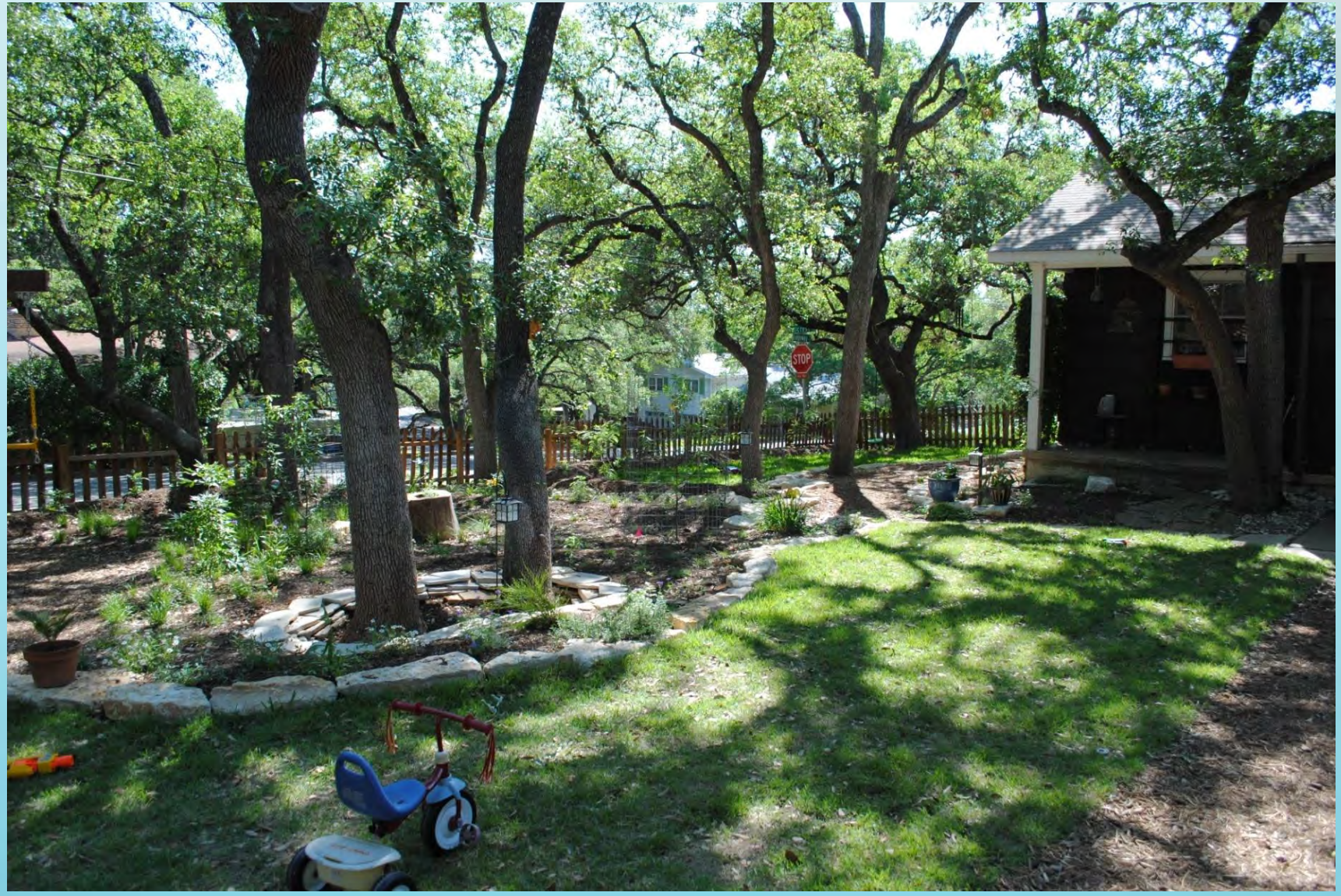
Check dams and infiltration trench



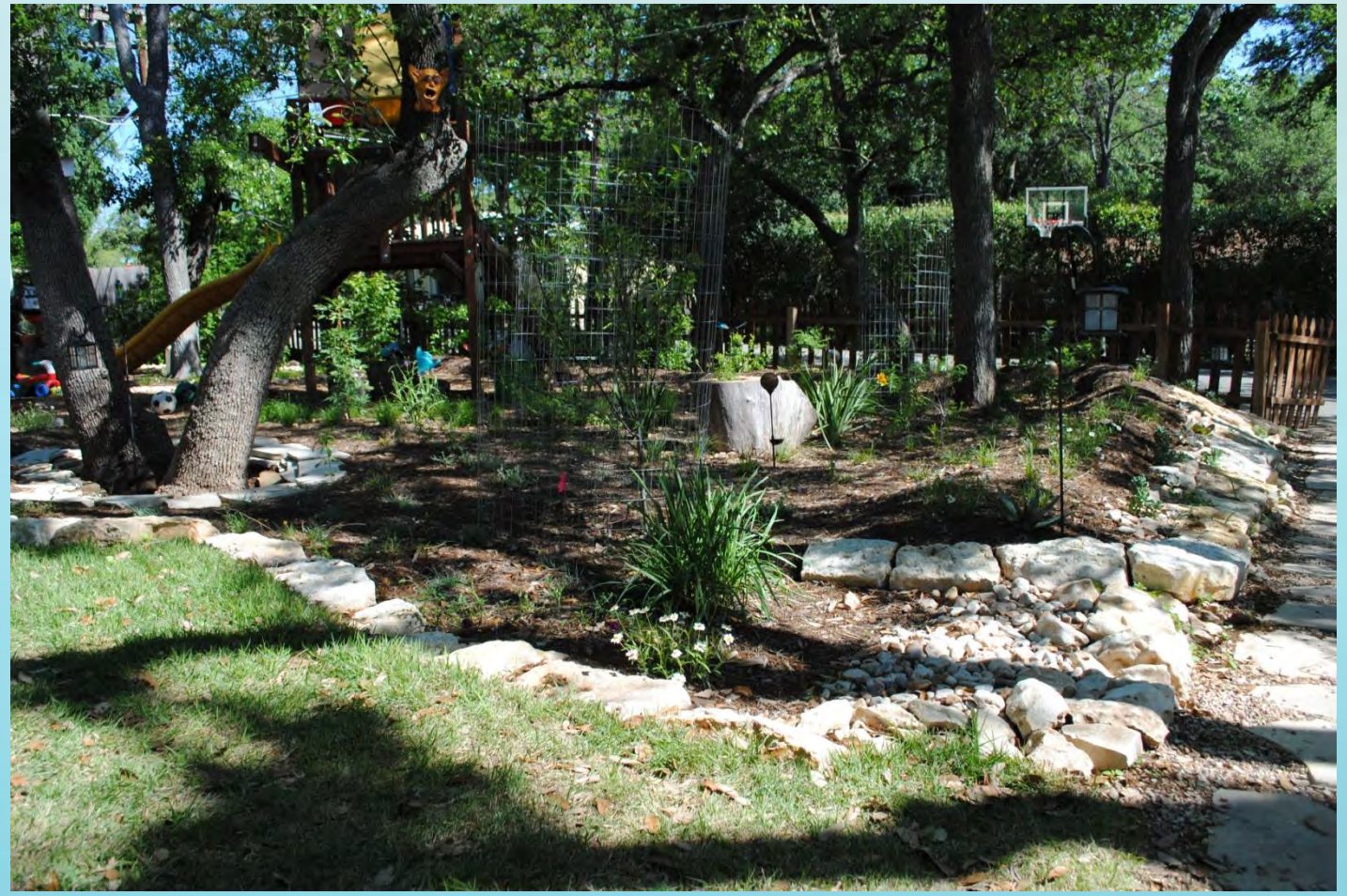
Divide and conquer:

- Start on top
- prevent large flow build up.
- Encourage sheet flow when possible
- Water flows underground also…

An experiment in water frequency



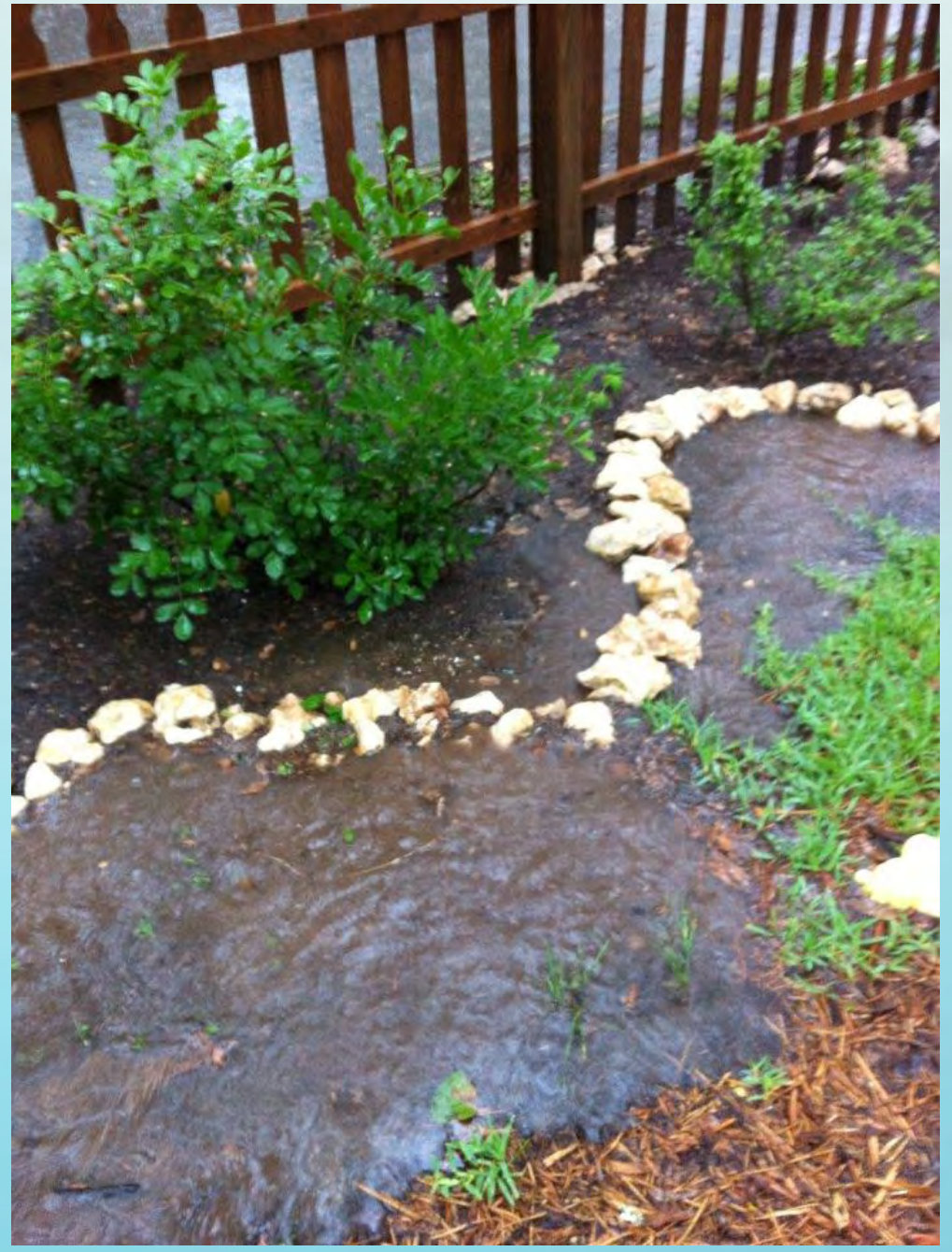
Overflow of first basin



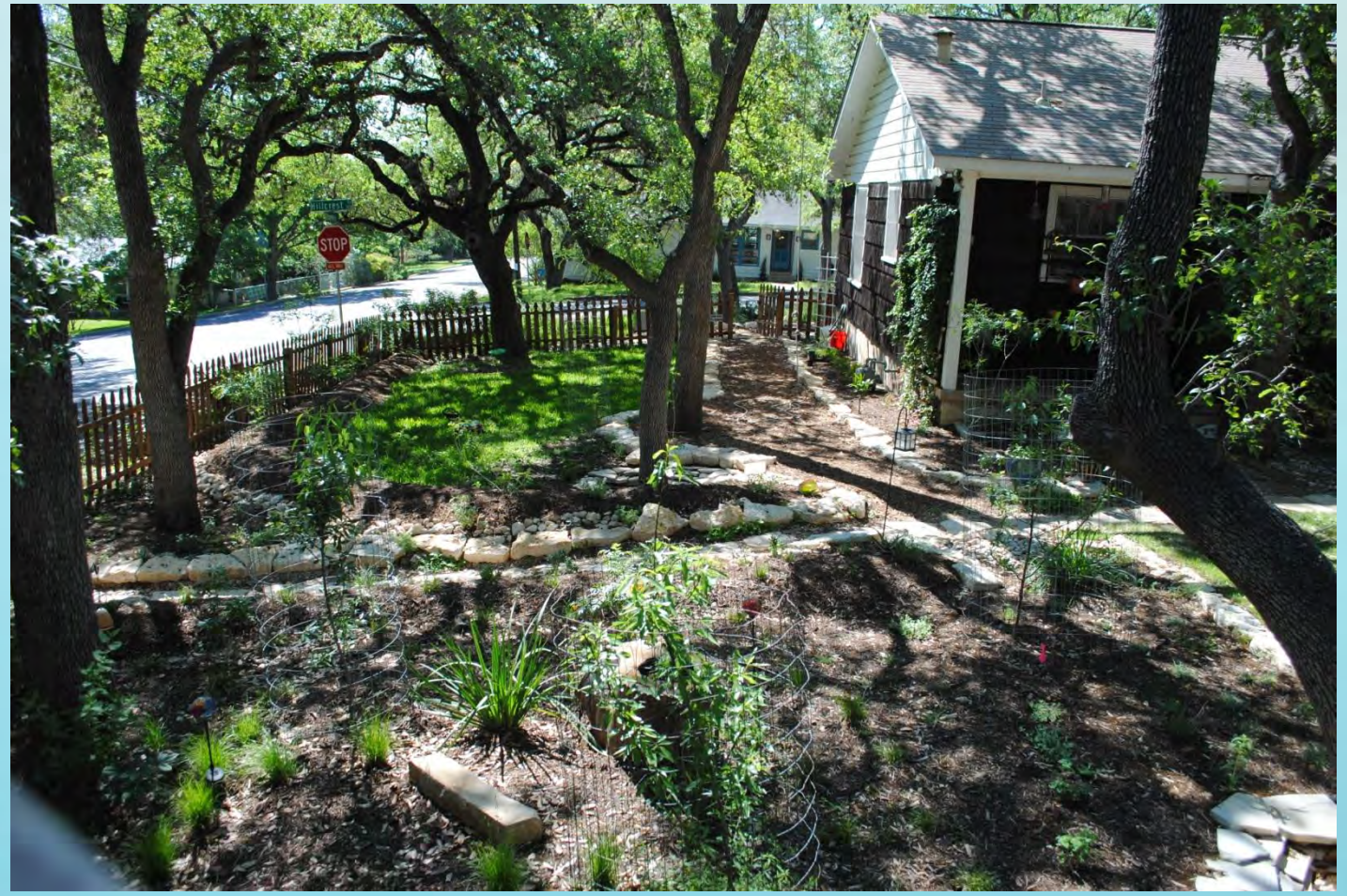
Edging as mini checkdams:

no cement

locally sourced rock from planting holes



Flow from 1st basin to second basin


STOP

Top Infiltration trench drain into second basin. Grade!

100% of 2” rainfall controlled on site.

Front yard gate into lower basin

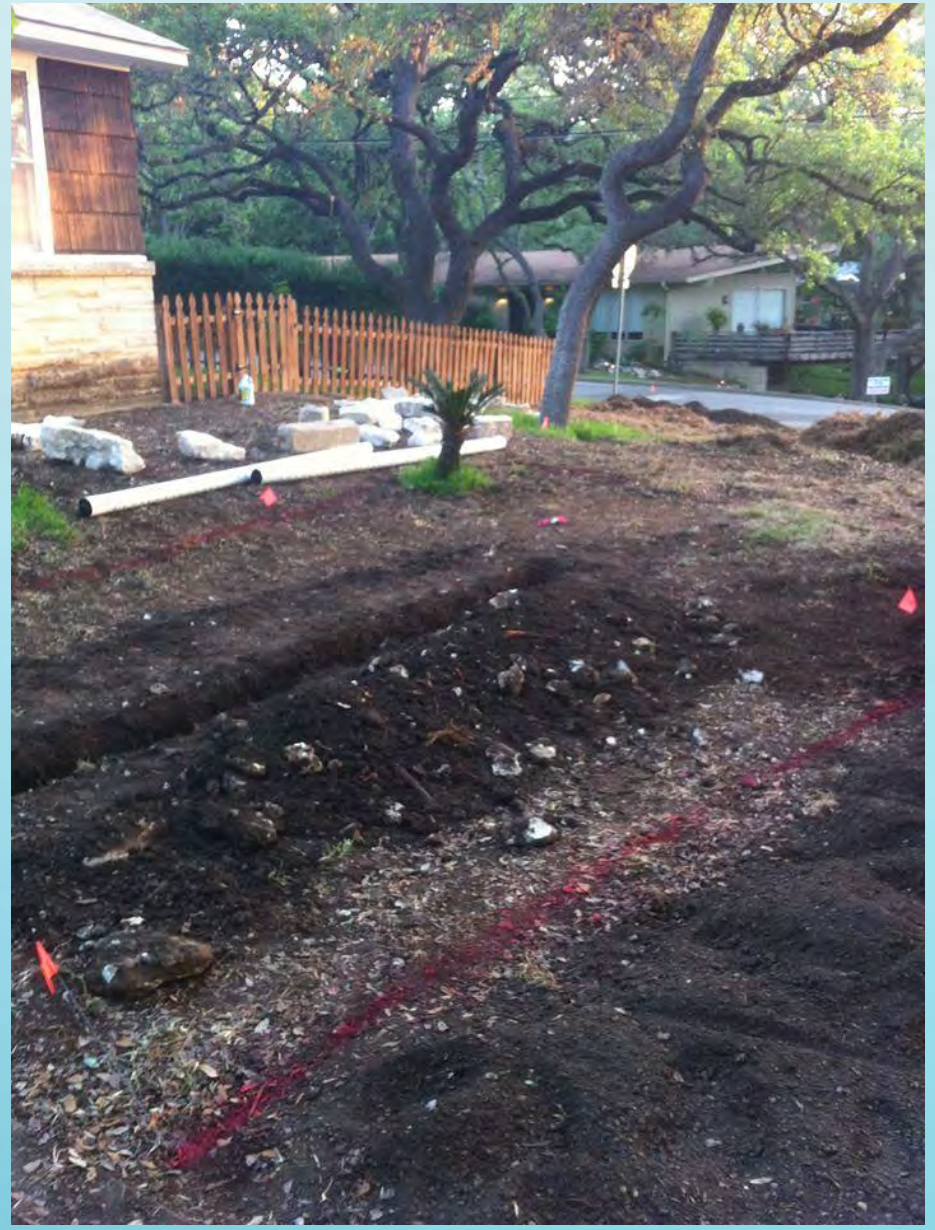
Top side system

Top side system, street view

Perennial woodland

Spring light

Overflow into infiltration trench



Infiltration trench

Buffalo basin

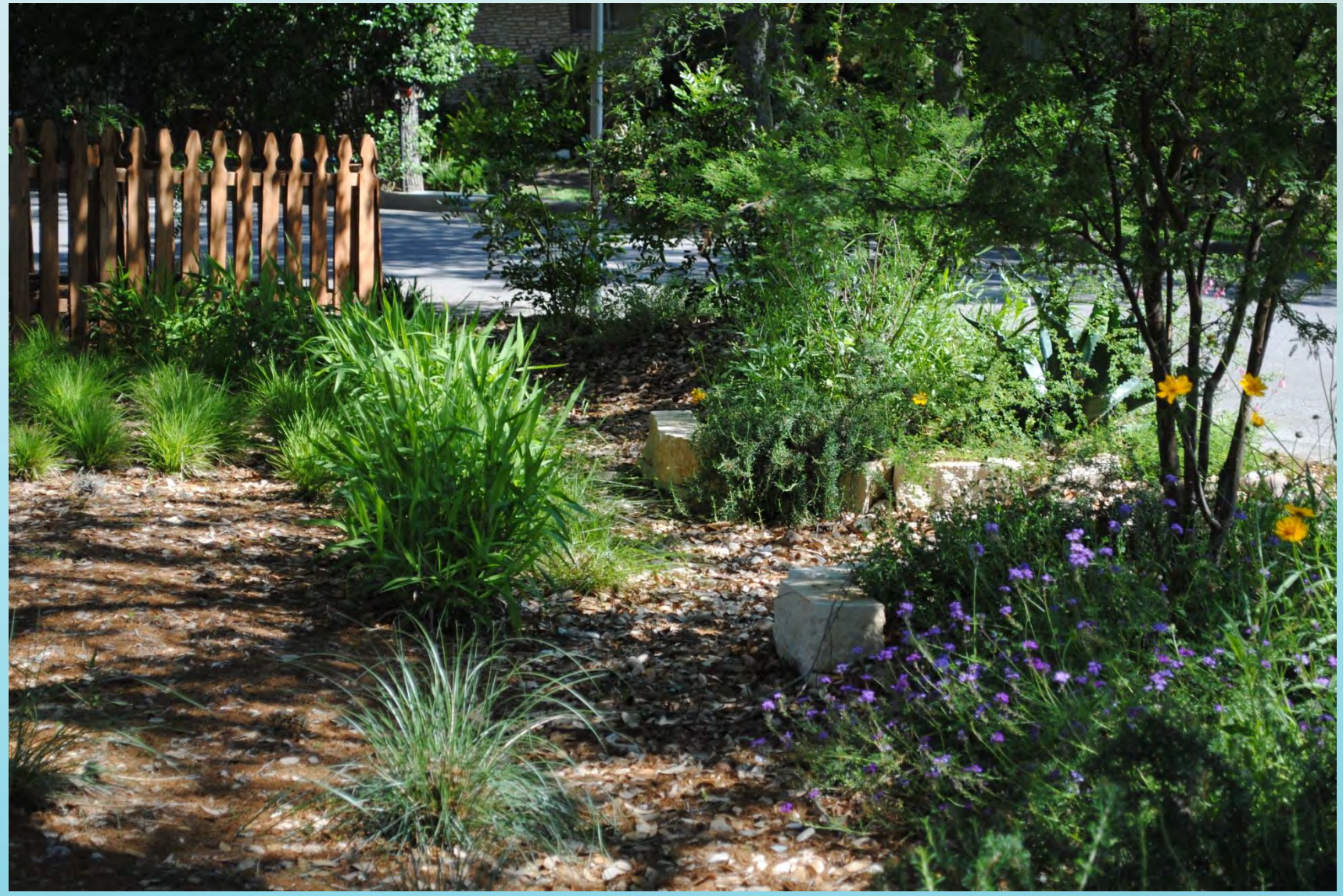
Herb and bulb Garden check dam

Check dams and cedar mulch trail

Vegetated filter strip before the spillway

Vegetated filter strip

spillway



Spillway

Some facts:

- no mortar.
- Except for the french drain and the irrigation line, all material used is natural and local
- 75% reduction of water usage: capping of unused heads, use of drips, retrofit with low flow rotor heads.
- 16 CuY of living mulch
- Berm plantings are high density to secure the berms rapidly and prevent erosion
- Multilayered plantings
- Intense soil prep for turf, 3 different turf grasses for a total of 600 sqft
- Legumes scattered throughout the design, from mountain pea, mimosa's to Huisache.
- Captures 2200 gal after a 1" rain event. The system can hold 6000 gal, close to a 3" event.
- Wildlife settled in in a matter of weeks and is as diverse as the design itself and is surprisingly well balanced: no infestations observed so far.

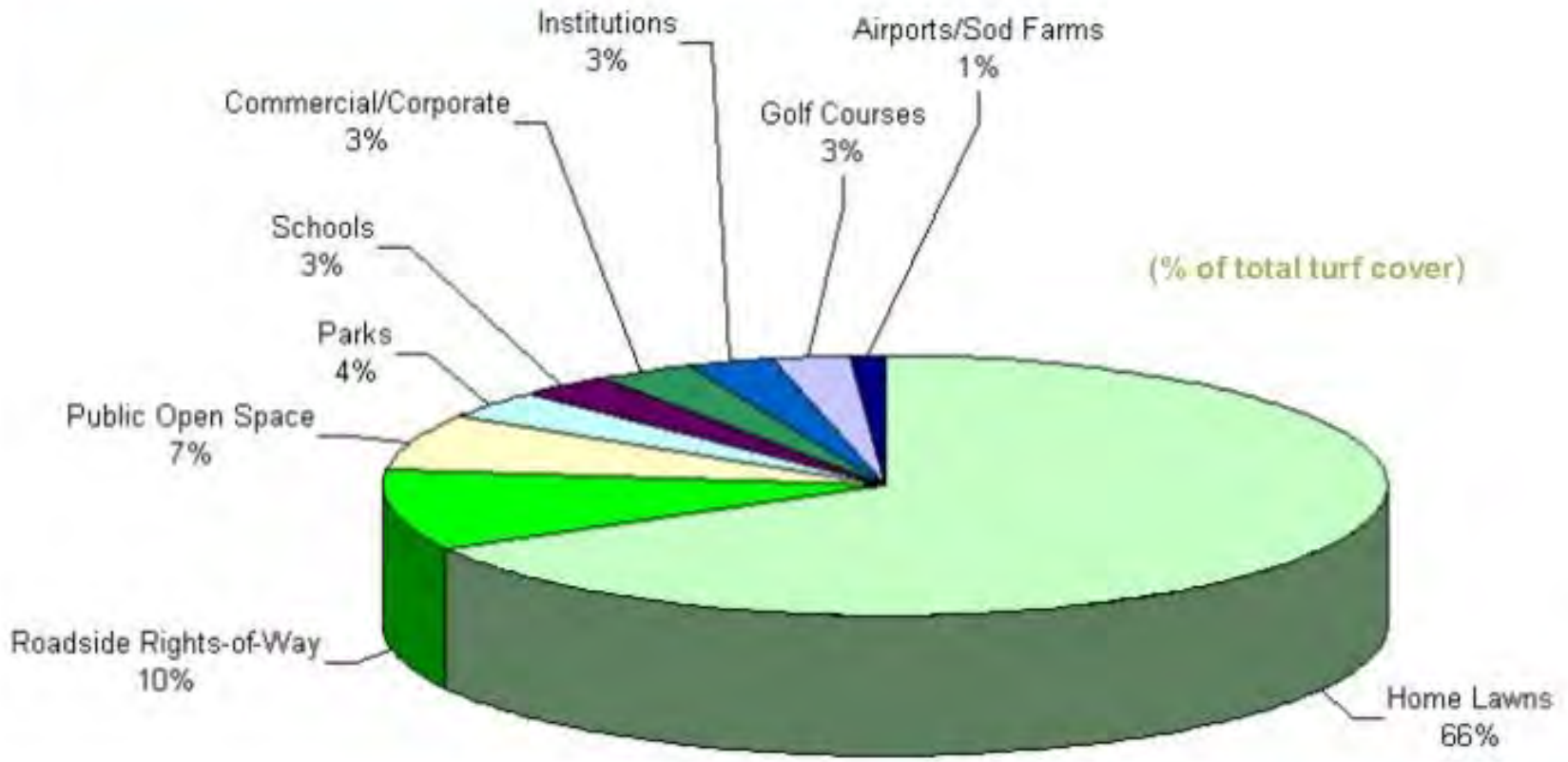
Shade trees/woody shrubs	Ornamental trees/woody shrubs/vines/cycads	Grasses/ sedges/perennial bloom
Escarpment Live oak Cedar Elm Mexican White oak Mexican Sugar Maple Flame leaf sumac (fall color) Huisache (blooming legume) American beautyberry (insect repellant leaf) Burr oak (remnant from prior owner, not recommended for this design as it is a riparian tree, not upland) Anacacho Orchid Blue giant fig Fragrant mimosa	Paw Paw Almond trees Asian Pear European pear Golden ball lead tree Arroyo sweetwood Almond verbena (perfume) Mountain Laurel Cat Claw Trailing Rosemary Coral honeysuckle Dioon (slowest plant on record, self feeding trough atmospheric nitrogen) Sago palms Ferrox Agave Ghost Plant	Bamboo Muehli Pine Muehli Scott's sedge Berkeley sedge Cherokee sedge St Augustine (in shade only) Emerald Zoysia Buffalo grass Purple verbena Blackfoot daisy 4nerve daisy Copper canyon daisy Mexican oregano Lantana (various) Root beer plant (oja santa) Turk's cap Mountain pea Angel trumpet (datura) Columbine Cedar sage Rock Rose Cedar sage (native) Various succulants and sedum Senna Skullcap Stemodia Lavender

Maintenance

- Correct grade and flow mistakes
- Keep up with bed maintenance
- Compost excess litter on site with one year turn around dry compost system
- Have fun with the herb garden
- Edibles are watered with a dripline and with condenser water caught in a rain barrel (7-10 gal/day for a 2000 sqft home.)
- Mowing is done on highest setting for the st Augustine, no mowing for the buffalo and occasional mowing for the zoysia.


share it for awareness

So what's with turf cover?
fastest growing land cover in the US!



Center for Watershed Protection

USDA Forest Service, Northeastern Area, State and Private Forestry

Heat island