San Luis Obispo County Homeowner's Guide to

Rainwater Management

Green street allows required egress for emergency vehicles while maintaining infiltration of water in this Oceano, CA ***cluster development***.

Rain chain directs water to a ***swale*** in this Atascadero, CA rain garden.

Rainwater from roof is stored in a ***cistern*** to be used for landscape irrigation.

Rain garden captures and infiltrates rainwater from a roof in Los Osos, CA. Roof downspouts discharge run-off to vegetated areas.

for

Low Impact Development

Suggested donation: $10.00

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This is the second publication in an educational series regarding water and waste applications of appropriate technology for San Luis Obispo County.

These guidelines are being developed by the San Luis Obispo Coalition of Appropriate Technology (SLO-COAT) to specifically address efforts to maintain a healthy hydrological cycle in San Luis Obispo County.

SLO-COAT is a joint effort of SLO Green Build, the San Luis Bay Chapter of the Surfrider Foundation and the Santa Lucia Chapter of the Sierra Club. The information presented is for general education purposes. Final details and construction must be developed and designed for specific site conditions; therefore SLO-COAT is hereby indemnified from any liability arising from the use of this information.

Cover images: Green road- San Luis Sustainability Group Architects, rain chain to swale- Laura Lopez Landscape Contractor, cistern- Jenny Ferguson WaterSmart Design Build, rain garden- Lawson Schaller.

San Luis Obispo County Homeowner's Guide to Rainwater Management for Low Impact Development

Appropriate technology is defined as applying technology to address problems related to energy use, the water cycle, and affordable building at the smallest and most accessible scale possible.

The water imbalances in San Luis Obispo County have become evident as many municipalities implement water rationing policies. Growth has always been naturally restrained due to the scarcity of water resources in the County. New development is often burdened with the subsequent increase in infrastructure costs. Fortunately, over the past thirty years, the research and refinement of appropriate technologies as related to water have much to offer us today.

SLO-COAT believes it is imperative that we revisit, at a local scale, the encouragement and application of appropriate technology. San Luis Obispo County is in a position to be at the forefront of these efforts to reconcile growth and environmental quality.

Application of appropriate technologies as described in this guide can improve our connection to water, maintaining a healthy hydrologic cycle. Key terms appear in bold italic and are defined in the glossary at the end of this guide. In addition to ***low impact development (LID)***, appropriate technology topics related to healthy watersheds and water cycles are:

Graywater
Rainwater Harvesting
Waterless Waste Treatment
Bioremediation Strategies

Look for more information and educational events presented by SLO-COAT on these topics. If you would like to become involved contact SLO Green Build on the internet at www.slogreenbuild.org

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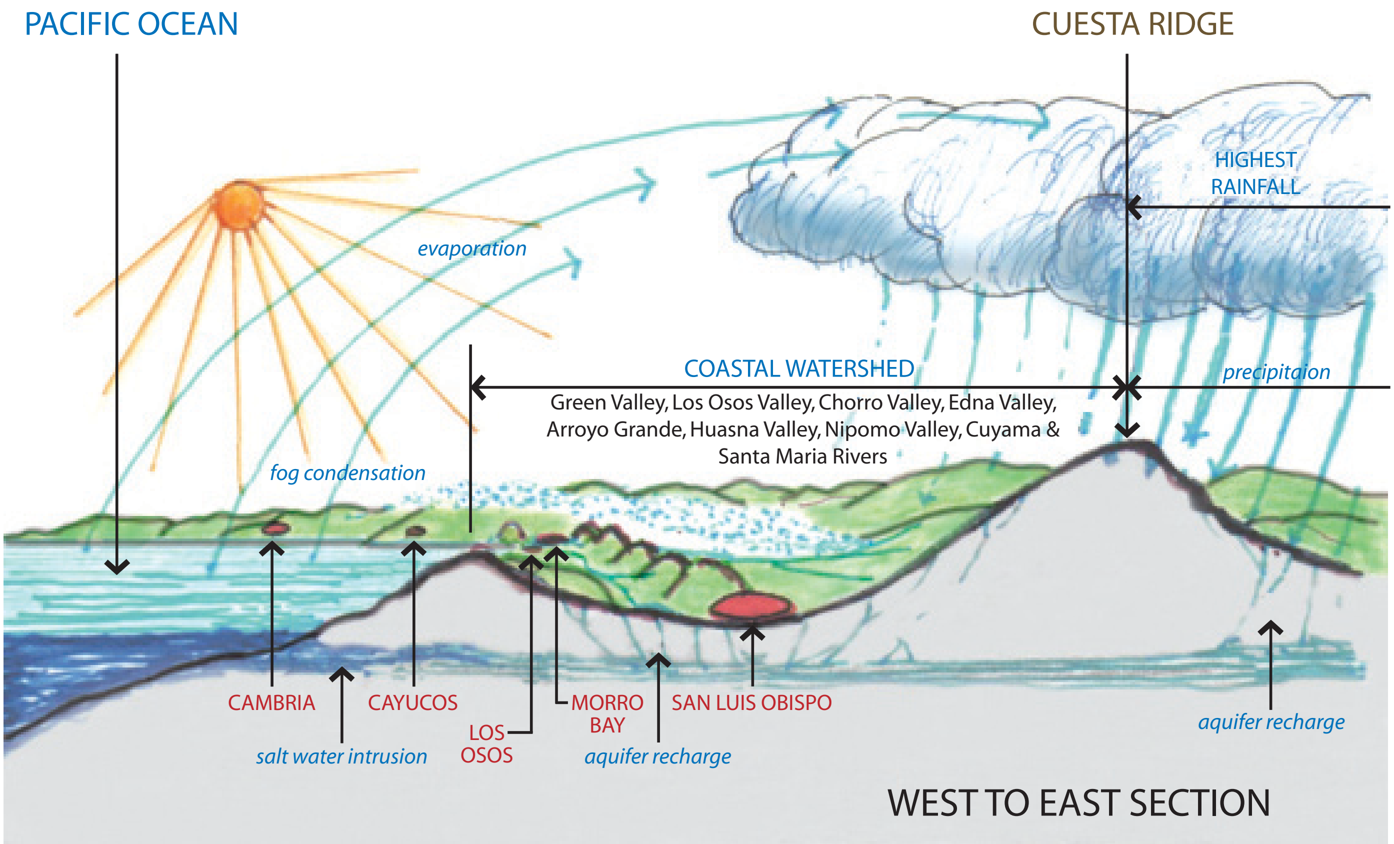


NATURAL HYDROLOGIC CYCLE

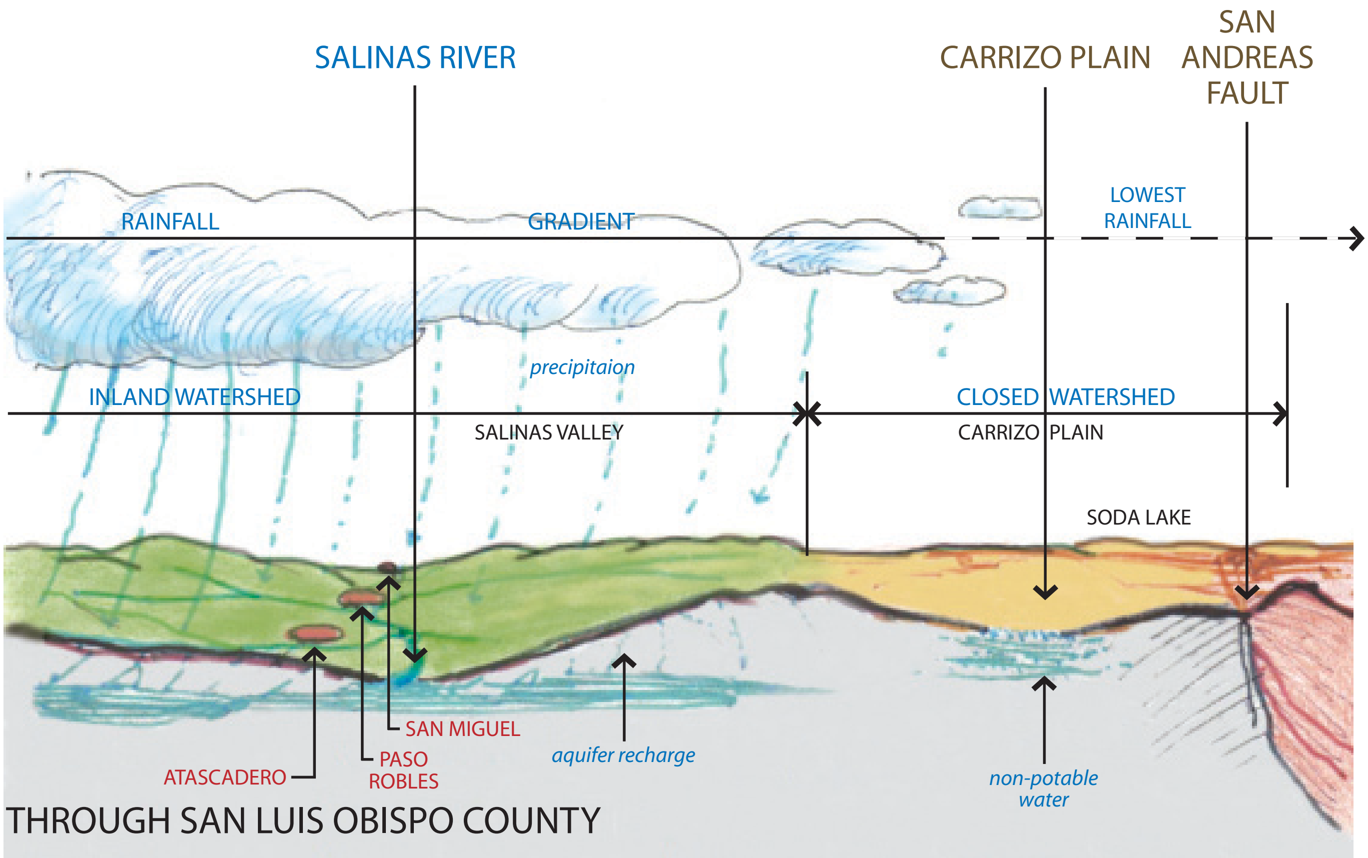
No matter where you live, you live in a ***watershed***, and are part of a hydrologic cycle. A natural ***hydrologic cycle*** and healthy watershed work hand in hand to create a clean, healthy environment that supports complex social, economic and ecological systems.

A watershed is a ***basin*** that funnels water from ridge tops to the ocean. The hydrologic cycle occurs in a watershed and provides fresh water in the form of precipitation (rain, hail, snow) and condensation (fog). Water collects in ***riparian areas*** forming creeks and streams, and ***infiltrates*** into the ground replenishing ***aquifers***. An aquifer is an underground layer of rock or soil in which ***groundwater*** resides. Aquifers can provide substantial amounts of potable water but many are overdrawn.

STORMWATER PROBLEMS IN COMMUNITIES

Runoff that leaves a site by crossing over ***impervious surfaces***, often picks up contaminates that were accumulated on that surface as a result of seemingly harmless, everyday activities such as: driving, maintaining vehicles and lawns, disposing of waste, washing cars and even walking pets. Polluted runoff may contain nutrients, pathogens, hydrocarbons, toxic organics, sediments, metals, trash and debris. Contaminates are carried to a storm drain system and are discharged into our creeks, lakes and the ocean where they can accumulate and cause problems for aquatic life and beach closures.

Traditional stormwater management practices emphasize conveyance—using street gutters, ***curbs***, pipes and canals to remove water from the developed areas as quickly as possible, engineered flood control measures—dams, dikes and levees, and detention facilities to offset the impact of development. This transfers the immediate problems downstream by increasing the amount of runoff leaving a site. Impervious surfaces are more efficient for collection and conveyance systems, but often cause flooding, ***erosion*** and ***nonpoint source pollution*** at discharge locations.



Low impact development (LID) is a way to minimize these problems and also benefit individual homeowners, renters and your community. LID techniques focus on distributing, storing, slowing, spreading and sinking rainwater within the property where it falls.

BENEFITS OF KEEPING STORMWATER ON YOUR PROPERTY

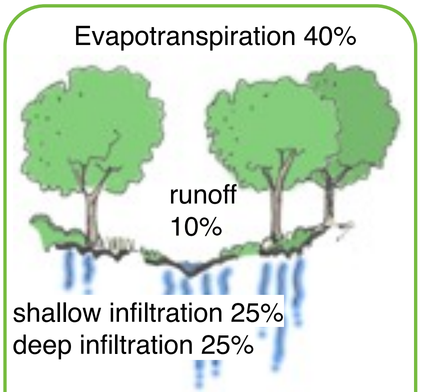
1. Reduce the water bill for your home or business
2. Capture water for passive & active landscape irrigation
3. Maintain healthy soils by flushing accumulated salts from the soil
4. Add aesthetic interest to your yard
5. Protect your community's wildlife, soils, creeks, lakes & watersheds
6. Help your community by reducing off-site flooding problems and reducing the extent of municipal stormwater infrastructure; thereby saving public funds
7. Reduce pollution from reaching the ocean
8. Recharge groundwater aquifers
9. Reduce the ***heat island effect***

WHY IS LOW IMPACT DEVELOPMENT IMPORTANT?

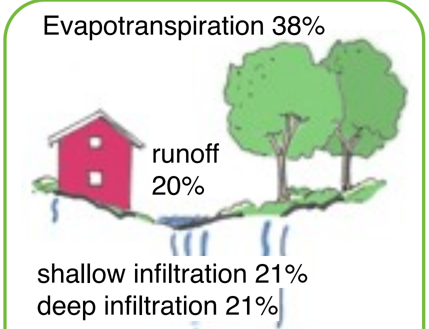
Undeveloped areas such as oak forests and grasslands serve as sponges for excess rainwater. When these areas are covered with ***impervious surfaces*** (houses, roads and parking lots, etc.) the amount of rainwater absorbed is limited. The extent of impervious surface of a site can influence how much of a rain storm is intercepted by vegetation, evaporated back into the atmosphere (***evapotranspiration***), infiltrated, or leaves the site as runoff.

The loss of infiltration from urbanization has also resulted in profound groundwater changes. An increase in impervious surfaces decreases the amount of water that is able to seep back into the ground. Reduced infiltration may result in less groundwater available to move through the soil and into stream channels and aquifers.

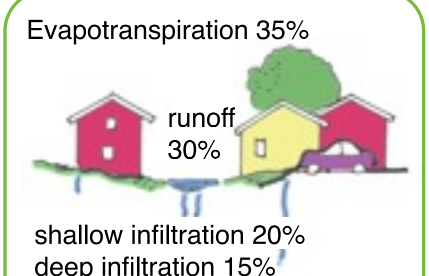
To protect surface water quality, groundwater resources, and taxpayer dollars, we should design and build using LID techniques. An increase in impervious surfaces requires larger and more costly flood control pipes and basins. These additional costs are borne by the taxpayer.



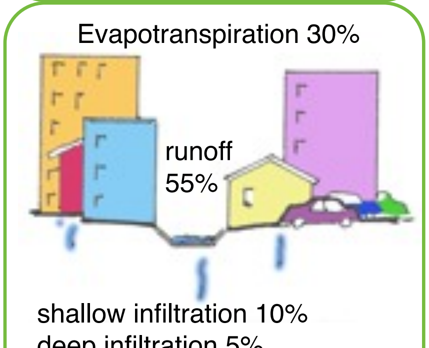
1. Natural Conditions



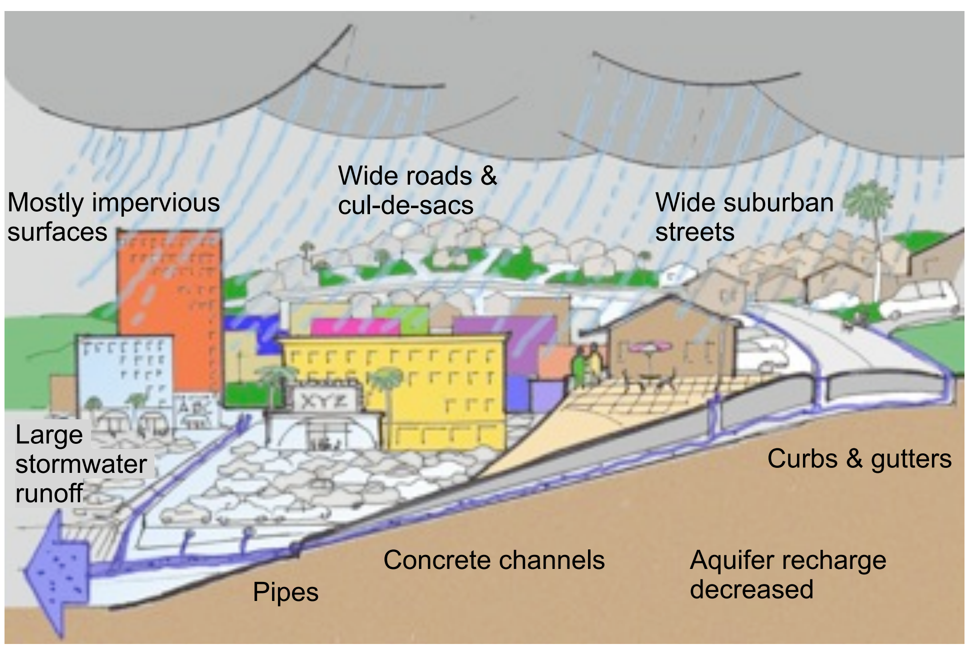
2. 10-20% Impervious Surfaces



3. 35-50% Impervious Surfaces



4. 75-100% Impervious Surfaces



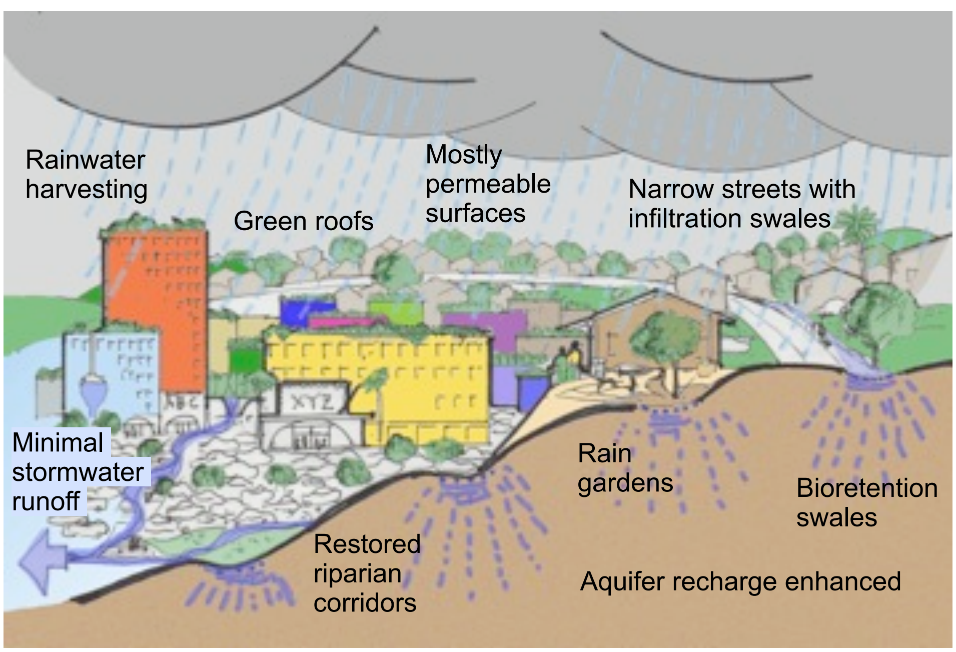
… the result is ***high impact development (HID)*** as shown above.

WHAT IS LOW IMPACT DEVELOPMENT?

LID site design and planning are based on natural land contours. LID addresses stormwater runoff by increasing ***permeable surfaces*** to slow, sink and spread runoff. These methods may include: reducing impervious surfaces, separate impervious areas, natural resource conservation, ***cluster development***, water conservation and ***xeriscaping***. Use of these residential scale techniques will allow you to meet the LID objectives:

✳ Mimic ***natural drainage*** patterns to infiltrate and treat stormwater on your site.
✳ Minimize land ***disturbance*** by avoiding soil compaction when not required for development.
✳ Make drainage a design feature which enhances your home and community.

LID TECHNIQUES		***LID FUNCTIONS***					
Recipe card- Feature		*slow runoff (increase detention)*	*allow infiltration (increase retention)*	*increase evapotran-spiration*	*provide filtration*	*water reuse & aquifer recharge*	** requires regulatory involvement*
A	*retention grading and vegetated swales*	X	X	X	X	X	X
B	*roof downspout to pervious area*	X	X	X	X	X	
C	*interceptor trees*	X	X	X	X	X	
D	*rain gardens*	X	X	X	X	X	X
E	*rain barrels & cisterns*	X				X	
F	*soil amendment*	X	X	X	X	X	
G	*permeable alternatives for driveways & patios*	X	X	X	X	X	
H	*green roofs*	X	X	X	X	X	
* Grading permits may require a drainage plan or soil studies be prepared by a licensed professional.							



Low impact development (LID) shown above.

The basic LID strategy for handling runoff is to reduce the volume and decentralize flows. This is usually best accomplished by creating a series of smaller retention and detention areas that allow localized infiltration instead of carrying stormwater runoff to remote collection areas to be treated. This is accomplished by specific LID techniques, shown in recipe cards A-H, to perform the LID functions listed above.

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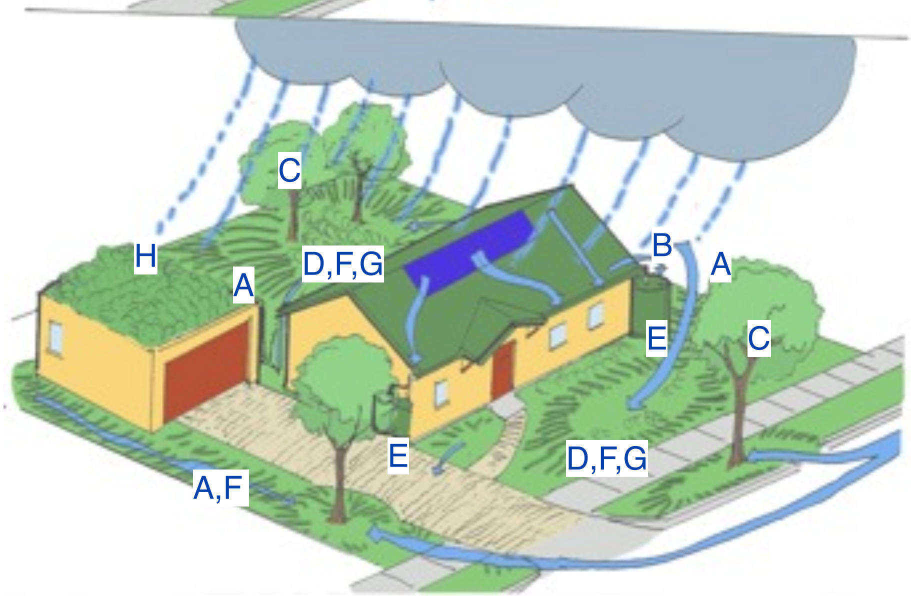
STORMWATER AS A RESOURCE

Stormwater is an important natural resource that can be used to replenish our creeks, lakes and groundwater supplies. By using stormwater as a resource and not a waste, we are protecting our community and our environment. LID mimics nature with distributed, decentralized, small scale techniques that capture, spread and infiltrate stormwater at the source in contrast with traditional storm drain systems. It is generally more efficient and cost effective to prevent hydrologic cycle imbalances rather than try to correct them after the fact.

Typical Property Without Low Impact Development:

Excessive stormwater flows into storm drains causing flooding and eroding creek banks. Pollution increases from stormwater runoff from oil drippings, lawn pesticides, fertilizer, sediments and debris, damaging aquatic habitats such as creeks, lakes and oceans. Local groundwater recharge is decreased requiring more irrigation throughout the year.



Low Impact Development improvements:

A. Vegetated swales
B. Downspout to pervious area
C. Interceptor tree
D. Rain gardens
E. Rain barrels & cisterns
F. Soil amendments
G. Permeable alternatives
H. Green roofs

* South facing roofs can be used for solar electric energy production.

LID is particularly suited for sites with ***permeable*** soils that are:

- Adjacent to or draining to wetlands, riparian areas or ***estuaries***
- Upstream of communities at flood risk
- Adjacent to open spaces

5 EASY STEPS *to incorporating LID on your property:*

1. Evaluate your site characteristics and perform calculations

Identify opportunities and constraints of your site. Calculate impervious areas and infiltration areas.

2. Test for soil absorption capacity

Complete a soils test to determine the characteristics of your soil type. This will allow you to select the most appropriate LID techniques.

3. Design your LID system

Using information from steps 1 and 2, choose from the recipe cards on pages 8-20 to design your LID system.

4. Refine & construct your design

Conduct additional research to refine your design, consult a professional if you are going to alter the drainage of your site to avoid any legal matters that may arise from affecting your neighbor's property, then collect all necessary permits, tools and equipment to begin construction.

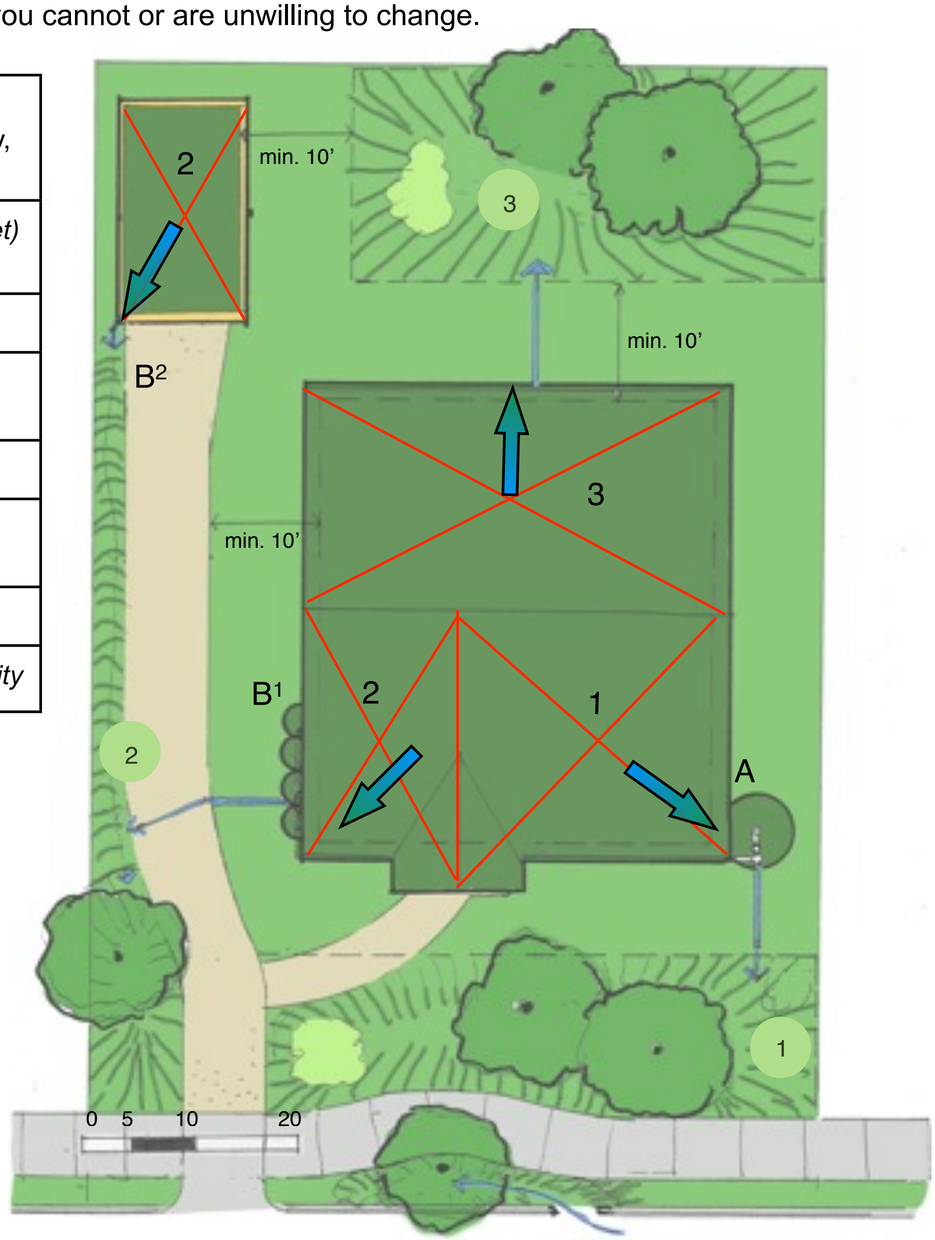
5. Maintain LID feature

LID features only function as well as they are maintained, so choose features that meet your maintenance preferences.

STEP 1: EVALUATE YOUR SITE & PERFORM CALCULATIONS

Careful consideration of your site's opportunities and constraints is necessary to determine the appropriate LID techniques. Opportunities may include natural depressions, vegetated areas and sandy soils. Constraints may include existing landscaping, utility lines, natural features such as rock outcroppings, creeks, buildings or other features you cannot or are unwilling to change.

Constraints To locate utility lines on your property, call 811 or visit www.call811.com	
Keep your distance from:	*Distance (feet)*
Buildings	*10*
Septic tanks and leach fields	*50*
Private wells	*20-100*
Groundwater contamination	*500*
High groundwater	*10*
**Depends on soil type and runoff quality*	



LEGEND - Create your site plan

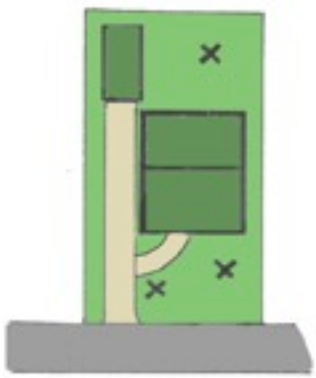
1. Imagine your site's many watersheds. Calculate the individual impervious ***tributary areas*** that will collect rainfall.
2. Number your drainage areas and show the distribution direction.
3. Calculate the absorption area for each tributary area.

You will need to do the following calculations based on your site's characteristics to develop your LID

Drainage → Absorption Area		Size	via
1	1	500 SF distributed to 700 SF	A = cistern & downspout
2	2	570 SF distributed to 700 SF	B^1= rain barrels & downspout B^2 = downspout
3	3	720 SF distributed to 860 SF	C = downspout

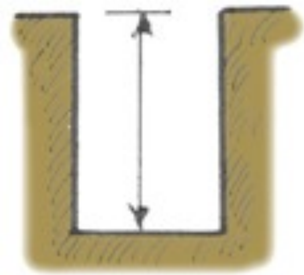
STEP 2: TEST SOIL ABSORPTION CAPACITY

Percolation is the movement of water through the soil. Measuring the percolation rate will help you know which areas are suitable for specific LID techniques. Soil percolation is used for sizing specific LID techniques shown in the recipe cards; in particular, recipe card D- rain garden on pages 12-13.



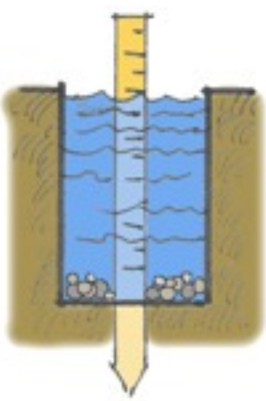
SITE PLAN

1. Choose several infiltration testing sites in the areas LID may be considered.



2. Dig holes about 2 feet deep (the proposed bottom).

3. Put about 2” of gravel in the bottom of each hole and pre-soak holes overnight.



4. Pour water into the holes at least 8”-10” above the gravel. Using a stake marked at ¼” intervals, measure water level drop at 30 minute intervals. Refill after each measurement.

You should obtain at least 12 measurements which should take at least 6 hours. The water level drop during the last 30 minute interval is the percolation rate. Convert this measurement to minutes per inch. If you have sandy soils and the water level drops faster than 6” in 25 minutes, take 12 measurements every 10 minutes. In lieu of performing this calculation, you can implement your LID feature with an overflow path designed to convey water away from the structure in a non-erosive manner. A percolation worksheet can be downloaded from www.slogreenbuild.org under news and publications- LID guide.

What is your percolation rate and soil type?		
Soil percolation results	Soil type	Recommendation
0-4 min. per inch	very fast draining soil, typically coarse ***sand*** and gravel	For areas with vegetation, added ***loam*** may help retain water in the soil and reduce irrigation needs.
5-15 min. per inch	well draining soils (ideal), typically fine or loamy sands	Suitable for low impact development techniques.
16-60 min. per inch	poor draining soils, typically loams or ***clay*** soils	Amend soil (recipe card F) using ⅓ compost material or use under-drains.
greater than 60 min. per inch	not suitable for LID without further consideration	Consult a professional to insure proper drainage.

STEP 3: DESIGN YOUR OWN LID SYSTEM

The concept of a ***treatment train*** should guide the LID design goals. An example of a treatment train is shown on the site plan on page 3. The impervious roof area labeled 1, drains via the gutter to catchment area A. Water collected in the cistern is used for irrigation during the dry season. The cistern reduces the amount of stormwater leaving the site. An overflow from the cistern is directed to absorption area 1. In a heavy storm, the rain garden will retain, filter and infiltrate stormwater to recharge the aquifer. In advanced applications, the water in the cistern could be treated with appropriate purification processes to be used for indoor uses such as toilet flushing and laundry. Filtration may be costly but could help reduce overall demands for potable water.

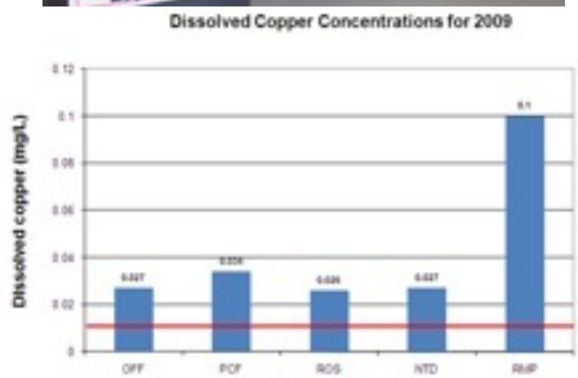
Impervious areas that convey contaminated runoff to sensitive habitats should be intercepted prior to entering the habitat. Filtration of contaminated runoff reduces the harmful down stream effects of pollutants by removing or reducing their toxicity. Filtration throughout the watershed prevents harmful ***first flushes*** of heavily contaminated runoff, see sidebar analysis of first flush locations along the Morro Bay Embarcadero.

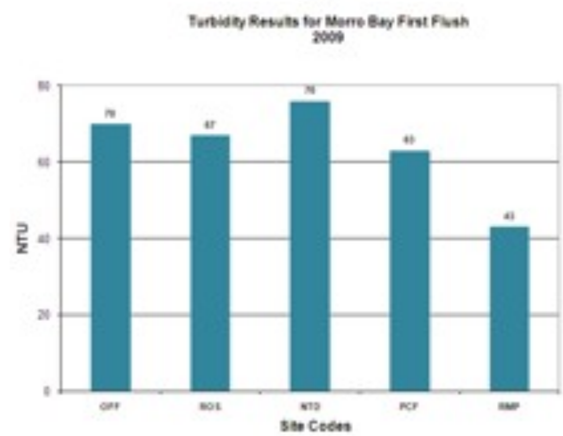
Sizing LID Practices Appropriately

LID practices need to be appropriately sized. Capturing runoff from the full rain event provides the highest environmental benefits, however if your constraints do not allow you to do this even smaller amounts of runoff capture can reduce your water bill and improve the environment. See appendix 2 for ***design storm*** data.

The recipe cards on the following pages summarize considerations related to site characteristics, limitations and maintenance. The relative rating guide on each recipe card provides additional information on complexity of design, maintenance and sustainability.

Complexity of Design, Installation or Maintenance
🛠 = Simple to 🛠 🛠 🛠 = Complex
Cost for Materials & Labor
$ = Low to $$$ = High
Sustainability (Economy, Environment, Equity)
🌍 = Low to 🌍 🌍 🌍 = High



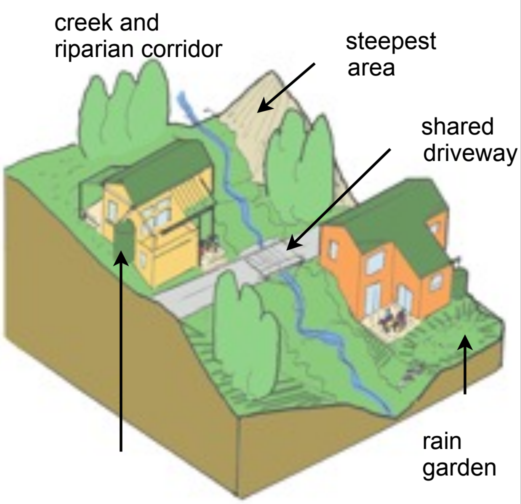


The first heavy rainfall brings a first flush of nonpoint source pollution as clearly illustrated by the outfall, samples and testing analysis conducted by the Morro Bay National Estuary Program. E. coli levels varied in 2009 from 1,223 to 7,701 MPN/100 mL. The standard for safe swimming is 235 MPN/100 mL. Treatment trains reduce the density of pollutants at first flush locations that empty directly into sensitive aquatic habitats.

Page 1 shows LID applications to a single residential lot that is relatively flat. This appendix introduces considerations for other situations such as hillside residential, multifamily housing and commercial shopping.

1. Hillside Residential

Steep topography offers a challenge. Stormwater treatment can be even more important here because of the erosion potential of development.

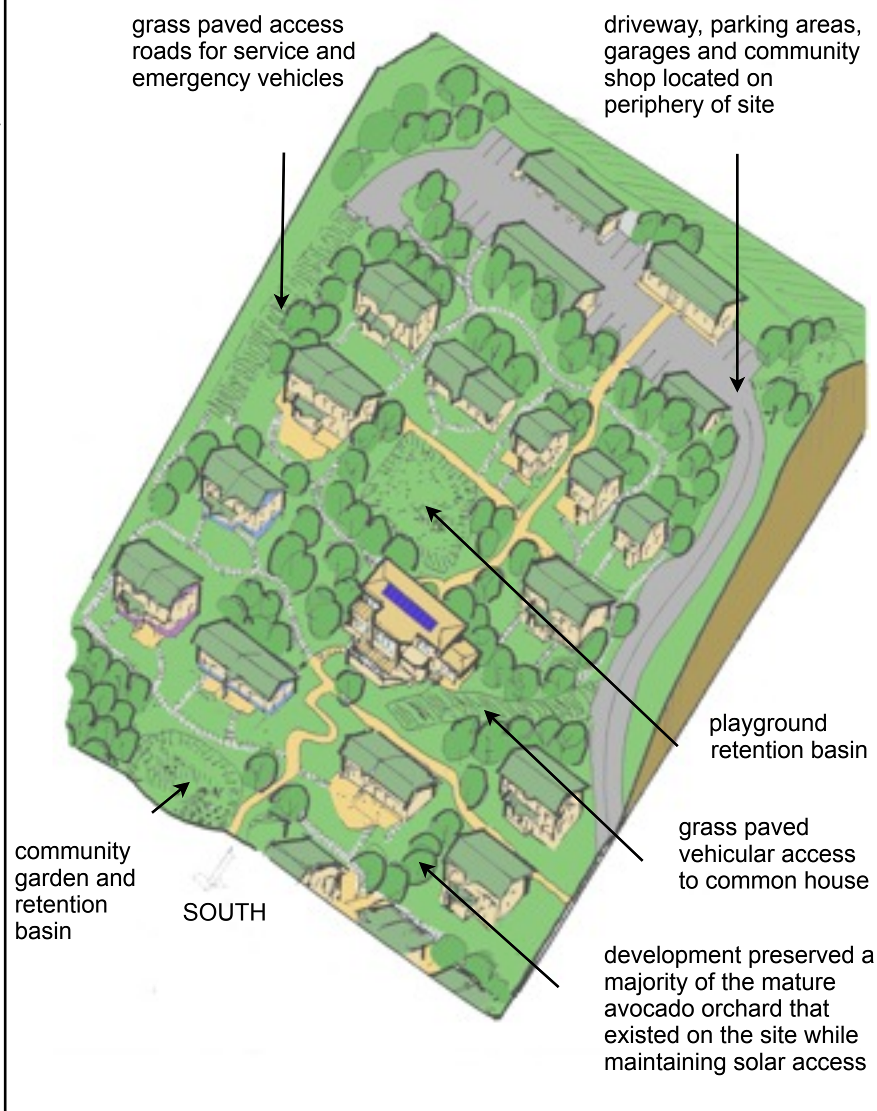


Shown is a generic example that:

- avoids the steepest part of the site
- preserves most of the existing vegetation
- aligns the building with the topography
- maintains and protects existing creek and its riparian vegetation
- utilizes pervious surfaces for decks, patios and terraces
- creates rain gardens where feasible

2. Multifamily housing

Higher density housing means less open space is available for absorption of rainwater. However, this type of building also offers greater potential for shared facilities and LID techniques such as underground cisterns that can take advantage of economies of scale.



Example shown above is of Tierra Nueva Cohousing in Oceano, CA which consists of 27 units, common house and a host of community facilities on a relatively steep five acre site.

3. Commercial

It is a matter of scale and larger roofs, more parking and paving makes handling stormwater with LID techniques even more important.

A very flat site with a high water table is dealt with by:

- using a vegetated rock swale for a detention basin that is built on two sides of the site
- connecting all downspouts into the retention facilities
- using permeable concrete paving for parking and plaza area
- curb cuts and tire stops that allow easy drainage into the swale
- extensive use of native vegetation

Example shown is Mission Community Bank in San Luis Obispo, CA

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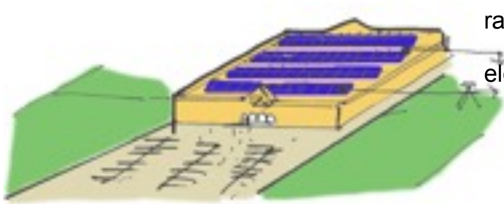
4. Commercial Retail

The huge roof area and parking of standard commercial retail offers challenging but also huge opportunities for the application and extension of low impact development techniques.

The Future

A recent study in Austin, Texas found that by using the roofs of the city's large quantity of "big box stores" for water harvesting and solar photovoltaic panels, very large economies of scale could be developed that would serve the entire city.

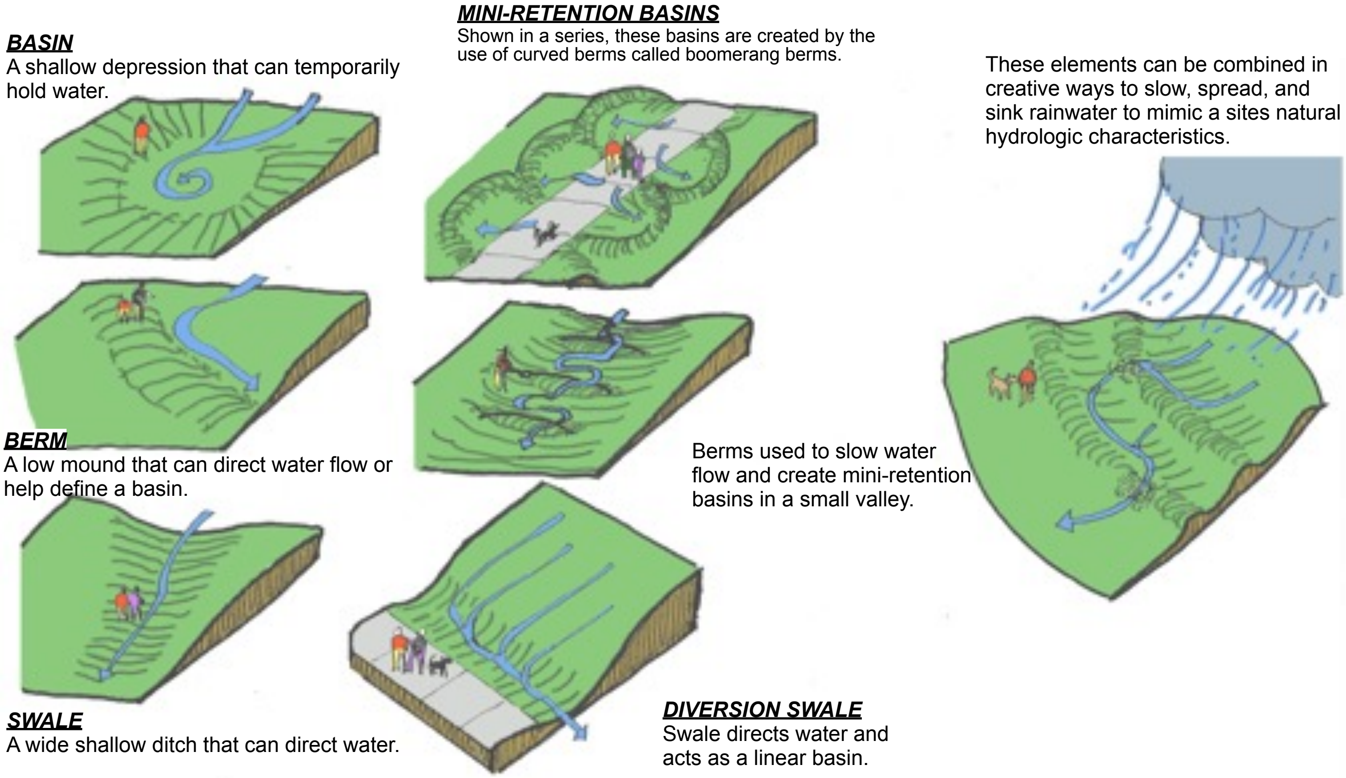


high impact development + *low impact development* + *energy harvesting on-site* = *a City wide green utility*

The result of this study showed that such a green utility could provide 17% of the city's water needs and 19% of the city's electrical needs using the roofs of the existing large commercial retail stores.

RECIPE CARD A - RETENTION GRADING & VEGETATED SWALES

SUSTAINABILTY:
COMPLEXITY:
MATERIALS COST: $



Description
This practice involves the creation of shallow depressions on gently sloped or nearly flat landscapes. The shallow depressions intercept and infiltrate small volumes of surface water directed to the depressed area. Vegetated open channels are shallow channels meant to blend into the surrounding landscape while conveying stormwater runoff short distances, typically ending at a rain garden or other detention or retention basin. This design technique should be considered in lieu of storm drain pipe at locations where storm drain pipe is proposed.

Applicability
Shallow depressions work best in clay soils. Deeper depressions are acceptable only in permeable, sandy soils. Swales should be considered on sites with ground slopes less than 4 percent.

Limitations
- Seek professional help for steep banks or in highly erodible soils.
- Ponding area should be 10 feet away from structural foundations and sidewalks.
- Consult your regulatory agency regarding grading and drainage, permits may be needed.
- Structures and pavements adjacent to vegetated swales may require a moisture barrier or flush curb to keep them from cracking.
- Pipe systems may be more appropriate on sites with steep slopes or highly erodible soils.
- Depending on the rain catchment area, a high-flow drainage system may be necessary.
- Vegetated swales are not appropriate at locations with high ground water table elevations or poor drainage. Grassed swales without underdrains need to be maintained to avoid wet areas for mosquito breeding.

Lasthenia californica, Goldfields, a native plant species thrives in the swale.

Vegetated swale San Luis Obispo County demonstration LID project in Santa Margarita.

Vegetated swale in Arroyo Grande infiltrates runoff to prevent erosion of the slope below.

Vegetated swale in San Luis Obispo County.

Design Criteria

1. Locate grading at existing low points.
2. Determine design of grading technique(s). Spillways or channels can be used to link and distribute water throughout the site.
3. Vegetate with native plantings. Shrubs and trees should be planted slightly above ponding water elevation. Grasses are generally used in ponding area. Vegetation is needed to stabilize soil and assist with infiltration and transpiration of runoff.
4. Locate vegetated swale along property boundaries along a natural grade or as a channel to direct water to a rain garden. Soil infiltration rates should be greater than ½ inch per hour for swales without an under drain. Using the applications and limitations to choose your swale location.
5. Determine the size of the swale using the rule of thumb that the total surface area of the swale should be one percent of the area that drains to the swale. If you are catching rain from 400 sq. ft. of roof then your total channel could be about 4 sq. ft. in area. Channels should be shallow and parabolic or trapezoidal in shape, and not have side slopes steeper than 1:3. Longitudinal slopes should not exceed 4 percent.
6. Layout vegetated swale with string or stakes and excavate. Check dams across the swale may be used to increase detention time, slow the velocity of runoff, and allow sediment to settle out.
7. Vegetate with short, densely grown native vegetation; diverse planting provides better habitat for birds, bees, insects, etc. than grass, but if grass is used maintain a height of 6 inches is recommended. Refer to the Plant Palette in Appendix 1.

Maintenance

- Regularly weed and mow (to 6 inches) to maintain functioning and aesthetic appeal.
- Reseed plants as necessary to fully cover bare ground and reduce erosion.
- Clear debris that may clog the channel.
- Repair and/or regrade as necessary.
- Rodents can be disruptive, repair rodent damage seasonally.

RECIPE CARD B – DIRECT DOWNSPOUTS TO PERVIOUS AREAS

SUSTAINABILTY: 🌍🌍🌍
COMPLEXITY: 🛠
MATERIALS COST: $

Commercial supermarket, Morro Bay.

Residential downspouts directed to pervious areas.

Description

Impervious areas that drain into the stormwater system are considered “connected impervious areas.” These areas can be “disconnected” by directing the runoff to a landscaped area instead. Roof tops are traditionally “connected” impervious areas well suited for “disconnection.”

Applicability

These procedures are suitable on all sites. Roof top disconnection is the easiest and is suitable for all guttered homes.

Limitations

Runoff must be discharged so that it flows at least 10 ft. away from structural foundations and only to locations where adequate area available to receive the runoff.

Design Criteria

Roofing downspouts can be redirected to a yard, garden or swale on your own property with a downspout diverter. Drip chains or scuppers can also be used to replace downspouts all together. Discharge points should be connected to other LID techniques such as vegetated swales or rain gardens.

Runoff from driveways should not drain directly to a road. Instead driveways should:

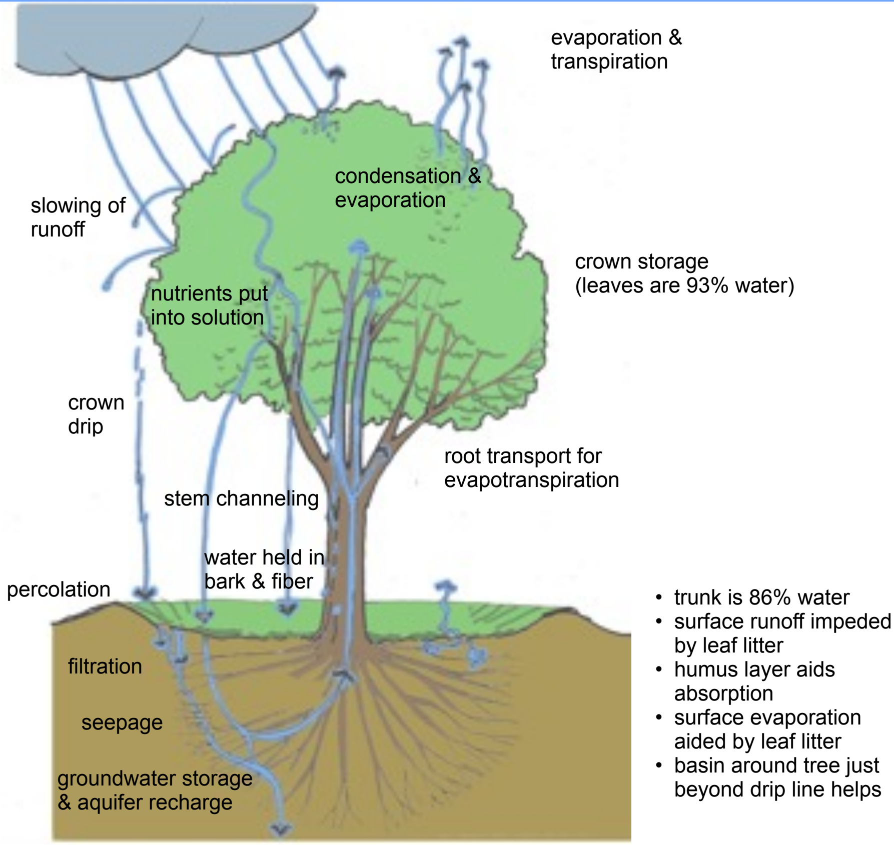
- be constructed from ***pervious*** materials, and/or
- be sloped to drain onto stabilized groundcover area, and/or
- be designed to intercept and drain runoff into a dispersion trench and adjacent vegetated area.

Maintenance

- Downspout disconnection does not require additional maintenance beyond normal gutter cleaning prior to the rainy season.
- For both downspout and driveway disconnection, discharge locations should be evaluated for erosion potential and adjusted as necessary to prevent erosion from occurring.

RECIPE CARD C - INTERCEPTOR TREES

SUSTAINABILTY:
COMPLEXITY:
MATERIALS COST: $ $



Description

Trees are effective in intercepting light storm events by temporarily capturing, storing and evaporating rainwater from their leaves, branches and trunk bark.

Applicability

Planting trees is well suited adjacent to impervious surface like driveways but can be incorporated into much of a site’s landscaped areas.

Limitations

Trees should not be planted where they will interfere with utility lines (both surface and subsurface facilities) or create a fire hazard. Certain trees should not be used as their roots are known to damage adjacent impervious hardscapes. Consider the potential impacts of tree shade on adjacent structures and landscaping, and the irrigation needs of water loving trees. Trees should not be placed where they block lines of sight at intersections or driveway approaches and should not be planted near septic, sewer or water lines. Root barriers are not recommended as they can lead to long term instability for the tree.

Design Criteria

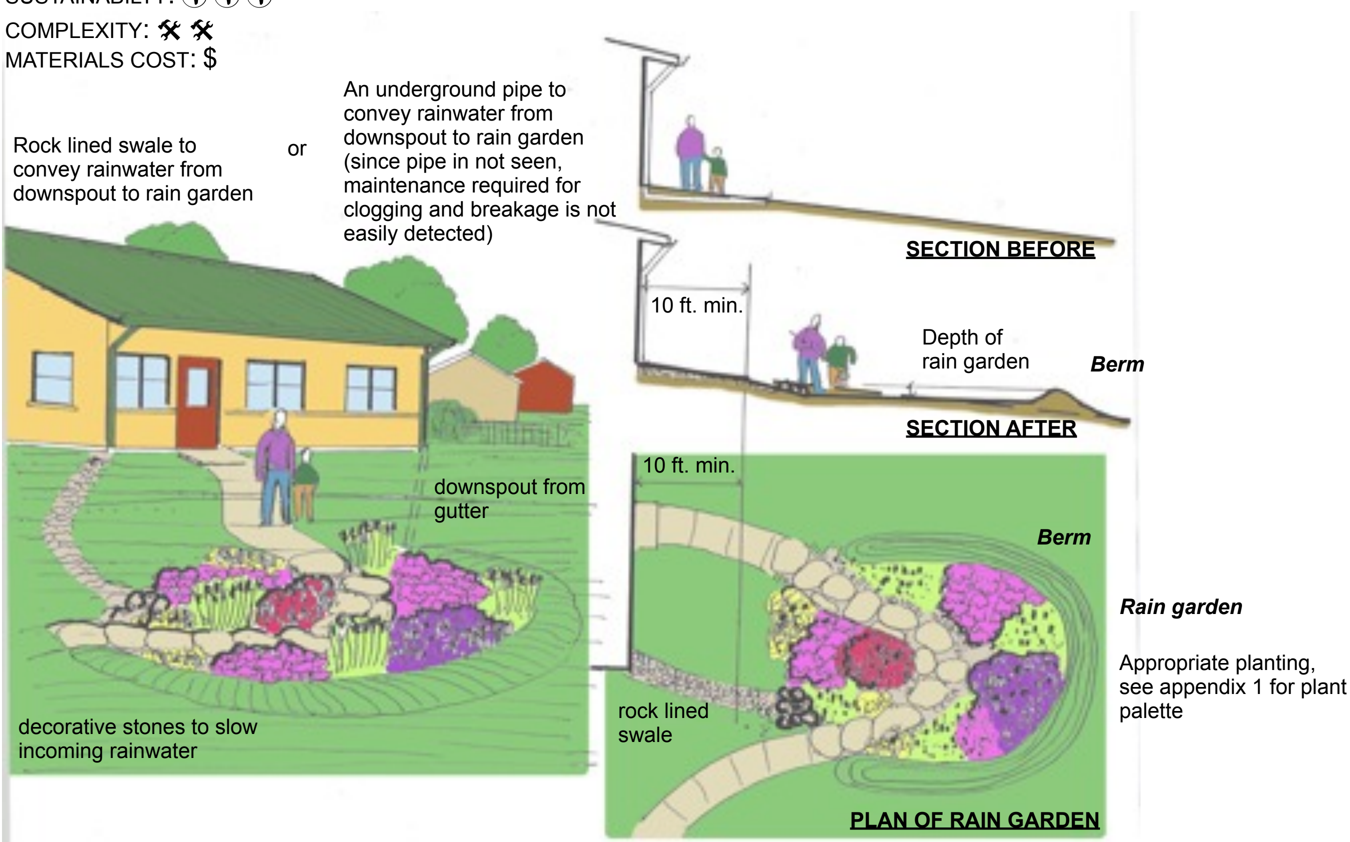
Broadleaf evergreens and conifers intercept more rainfall than deciduous species. A list of plants including trees that grow well in San Luis Obispo County is included in Appendix 1, Plant Palette. Use native or drought tolerant plants to decrease the need for supplemental irrigation.

Maintenance

- Use mulch to maintain moisture around tree roots.
- If deer are a nuisance, put mesh/wire around young tree starts.

RECIPE CARD D - RAIN GARDENS

SUSTAINABILTY: 🌍🌍🌍
COMPLEXITY: 🛠🛠
MATERIALS COST: $



Description

Rain gardens reduce the volume of stormwater runoff delivered to surface water during the more frequent, low runoff events through plant interception and transpiration and by infiltration into the soil. The soil and root systems also improve water quality. Rain gardens are made from shallow depressions. Native soil is excavated out and backfilled with soil that serves to enhance retention and degradation of contaminants in stormwater runoff. The rain garden area is heavily planted and mulched. These low spots collect rainwater during wet periods.

Applicability

- Rain gardens can be installed in most residential areas with porous soils types like ***sands*** or sandy ***loams***. Projects located in soils with infiltration rates less than 0.5-inches per hour (indirect infiltration) and 1.0-inches per hour (direct infiltration) require an under-drain.
- Rain gardens can provide attractive visual buffers from roads or neighboring homes.
- Areas that naturally collect water by gravity are ideal for rain gardens.

Limitations

- A single rain garden should not be used to catch runoff from areas of 5 acre or more because it is more likely to pond. Instead try to capture runoff in several smaller gardens encouraging infiltration.
- Rain gardens are not recommended on sites with steep slopes of 15% and greater, sites with high ground water or sites with elevated bedrock.
- Rain gardens should not be located over septic fields or leach lines, shallow utilities or within 10 feet of a building foundation.
- Rain gardens should have an overflow area that directs water safely away from the home and neighboring property, any underdrains should outlet to a safe overflow area or LID feature.

Design Criteria

1. ***Locate rain garden*** at least 10 feet from structural foundations and in areas with high infiltration that allows rain gardens to drain within 72 hours or install an under-drain.
2. ***Determine the size*** of the garden by asking yourself the following three questions:

   How much area is draining to the garden? To determine the drainage area, measure the driveway, rooftop, landscape areas with compacted soils or other impervious surfaces and note the area in square feet. To find the area of a rooftop, measure the perimeter of the building plus the overhang.

   How much space is available? Next, measure how much space is available for the rain garden. Remember that rain gardens can be placed in more than one location or built so that one drains to another.

   How much water from the drainage area will the rain garden hold? Finally, look at Table 1 to determine the surface area of the rain garden based on how much water it can hold for a given drainage area. The table gives two different columns for the rain gardens distance from the downspout. Remember that determining if your soil is well-draining or poor-draining is found by using the soil test explained on page 4. Typical rain gardens are between 4 and 8 inches deep depending on the slope (steeper slopes need deeper rain gardens) and 100 to 300 square feet in area.

Example:
Tributary area = 200 sq. ft.
Poor draining soils
Even slopes
200 sq. ft. x 0.43 = 86 sq. ft.

Therefore our example house will require a rain garden with a surface area of 86 sq. ft.

Table 1. Less than 30 feet from downspout				**More than 30 feet from downspout**
	3 – 5 in. deep	6 – 7 in. deep	8 in. deep	All depths
Well draining	0.19	0.15	0.08	0.03
Poor draining	0.43	0.32	0.10	0.10

3. ***Layout rain garden*** with string or stakes and excavate. The goal is to keep the garden level. When building on a slope, bring the down-slope up to the same height as the up-slope by cutting into the slope.

4. ***Excavated soil.*** Soil from the excavation can be used to build a small berm on the down-slope of the rain garden. It is important to enhance your soil for higher infiltration. A mix of about 65% excavated soil and 35% compost is usually good. ***Clay*** and ***silt*** soils may require greater amounts of compost. Replace the soil in the rain garden about 6 inches at a time and walk on each layer to lightly compact. Fill the soil up to a level that provides the desired ponding depth.

5. ***Get water to the rain garden*** through an open swale lined with plants or decorative rock, or through a pipe. Whatever technique is used, consider the slope and protect against erosion.

6. ***Vegetate and mulch***. Diverse, native or drought tolerant species that can withstand wet conditions should be used. Appendix 1 has information on choosing appropriate vegetation.

Maintenance

- Watering plants for the first 2 to 3 years to ensure survival and deep rooting may be necessary.
- Regularly weeding to maintain the function and aesthetic appeal.
- Renew mulch and plants as necessary to fully cover bare ground and reduce erosion.

RECIPE CARD E - RAIN BARRELS & CISTERNS

SUSTAINABILTY: 🌍 🌍 🌍
COMPLEXITY: 🛠 🛠
MATERIALS COST: $ $ $

Description

Approximately 40-60 percent of all urban water use is for irrigation. Capturing and later reusing rainwater in water barrels or cisterns reduces the volume of runoff during rain events and conserves potable water supplies. Roof runoff contains no chlorine or hard minerals. It can easily be used later for landscape irrigation or typical graywater uses. Capturing an entire rain event can provide large quantities of water.

Use these equations to determine the amount of water contributed by your roof and the amount of storage you will need to capture a full rain event.

Example: **Rain Supply/ Catchment for a 1" rain event:**

1. Drainage area x Design Capture Volume x 7.48 gallons/cf (conversion factor)
   200 sq. ft. x 1 in. (1 ft./12 in.) x 7.48 gallons/cf = 124.67 gallons/cf

Number of Barrels/Cisterns Needed

2. Rain supply (gallons)/ gallons per barrel/cistern
   124.67 (gallons/cf) /55 gallons = 2.26
   Round up to (3) 55-gallon barrels to hold each 1" rain event (see appendix 3 for rainfall data)

Barrels can come in all shapes and sizes. For the committed rainwater harvester, large above ground tanks equipped with a gravity system may be most suitable, as they use less energy and are easier to maintain. Small or multiple barrels provide less capacity for rainwater and may require more unwanted maintenance.

Applicability

The volume of roof runoff to be intercepted is directly proportional to the area of the roof. A larger roof yields more runoff.

Limitations

Roofs constructed with tar, treated cedar shakes or old asbestos shingle roofs may create too much contamination for rainwater harvesting. Runoff from roofs exposed to air borne particles originating from cement kilns, gravel quarries, crop dusting, or concentrated automobile emissions could adversely affect the rainwater quality. Rainwater for potable uses should not be harvested if it is conveyed via gutters with lead soldering, lead-based paints or stored in PVC and additional treatment is necessary to meet potable water standards. Low storage capacities will limit rainwater harvesting so that the system may not be able to provide water in a low rainfall period. Increased storage capacities add to construction and operating costs.

Design Criteria

1. Locate rain catchments at rain gutter downspouts and close to water use areas like landscaping, vegetable gardens or plumbing facilities.
2. Determine rain supply and barrels/cisterns based on the example calculations above.
3. Build or buy rain barrels. Rain barrels can be purchased or built, but they have the following common components:
   - A solid base of gravel, bricks, concrete blocks or pressure treated wood. Small rain barrels can be elevated to increase water pressure for gravity feed or placed on wheels to increase flexibility.

- 55-gallon food-grade, plastic containers are often used for small rainwater harvesting because they do not rust; however, any waterproof container can be used. Large plastic cisterns can be locally purchased with capacities in the hundreds or thousands of gallons. Any container you use should be opaque.
- A flexible window screen is used to keep mosquitos out if you don't have a solid top. This can also be used on your overflow outlet.
- Downspout adapter or diverter attaches to the downspout and directs water into the rain barrel.
- Faucet assembly allows for the attachment of a garden hose.
- Overflow assembly is essential to divert flows from large rain events away from structures once the rain barrels have reached full capacity.
- Rain barrel connection assembly increases total holding capacity with multiple containers.
- A water pump may be used with large cisterns or some small rain barrels.

4. Address overflow by directing overflows at least 10 ft. away from any adjacent structures. Verify that the overflow device is adequately sized to convey the anticipated rain events. Incorporate energy dissipaters like rocks or vegetation to eliminate erosion at the outlet.

Variations on common designs can be integrated based on your needs and site characteristics, however always follow manufacturer specifications. A little extra research will expand your knowledge of the possibilities to design a rain barrel or cistern system that works best for you.

Design considerations for cisterns:

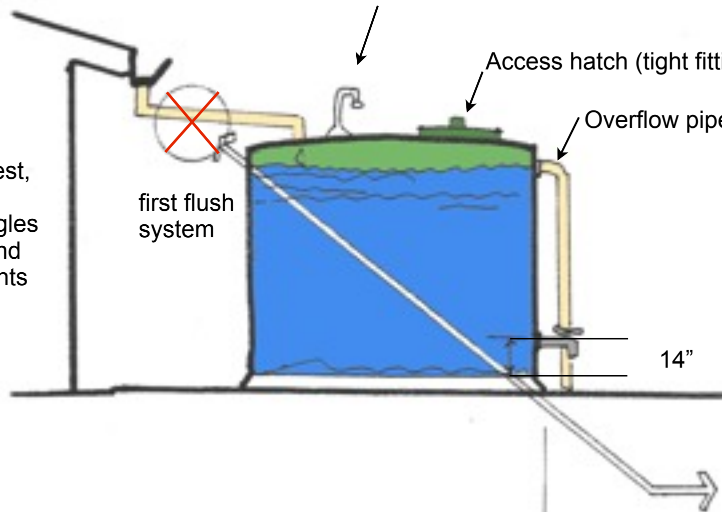
- Your City/County may have permit requirements to install large cisterns, check with your local Public Works or Building and Planning Department.
- Opaque containers will inhibit algal growth and potentially related smells.
- Tanks should be securely covered with fine-mesh screens on all inlet and outlet pipes to keep mosquitoes from entering tanks. This also protects the tanks from inadvertently trapping and drowning children and wild or domestic animals.
- Consider installing a "first flush" diverter to increase stored water quality and reduce tank maintenance needs. The first flush diverter should allow the first 10 minutes of a storm event to bypass the system.
- Installing a drain cock at the bottom of the cistern allows removal of the lowest layer of build up for maintenance.
- Rainwater collected and intended for indoor use has additional treatment requirements.
- Always contact your City or County to find out about relevant codes.
- Use for flushing toilets will require a parallel plumbing system.
- Potable uses should include filtration and disinfection to eliminate potential contamination originating from leaves, bird droppings, dust, and other natural causes.
- Route overflow runoff from cistern to a safe location in a non-erosive manner.

Maintenance

- Consider using an operations & maintenance manual.
- Regularly clean gutters to reduce the amount of debris entering rain barrels.
- Clean barrels/cistern every 1 to 2 years by removing sediments through the drain cock at the bottom or fully emptying and rinsing clean with a hose.
- Small leaks often can be repaired with aquarium caulk.

Inflow
Size gutter, downspout and inlet pipe to handle maximum rainfall event

Harvest high quality water
Steel roofs are best, tile is okay, but composition shingles are too gravely and can leach pollutants from tar.



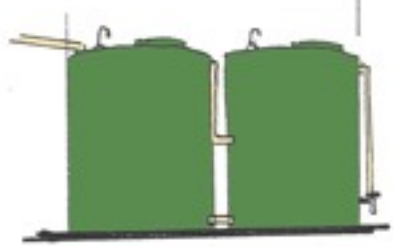
Tank should be closed to light to prevent algae growth and screened with max. ¼” mesh to prevent pests from entering the tank.

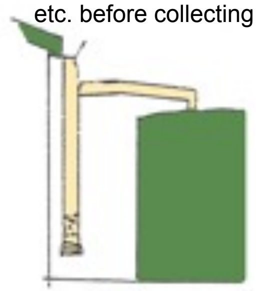
Raising outlet valve 14” prevents bottom sludge from coming out or clogging outlet.

First flush systems
Allow the first rain to wash the roof and remove debris, bird droppings, etc. before collecting rainwater.

Storage tank(s)
Steel tanks are the most common but concrete, polyethylene and ferrocement can also be used.

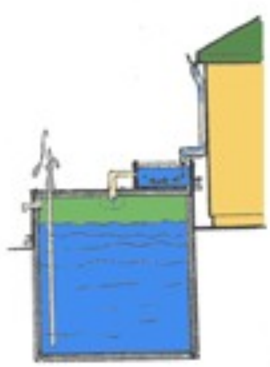
Tanks can be placed in series for expansion of capacity.



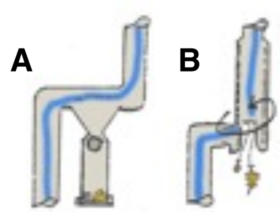


The simplest first flush system is a closed pipe before the intake. Once it fills the water goes into the tank. Annual maintenance consists of seasonally unscrewing the cap at the bottom of the pipe to flush out debris.

Below grade tanks are generally more expensive to install but can be concealed below a deck or terrace.



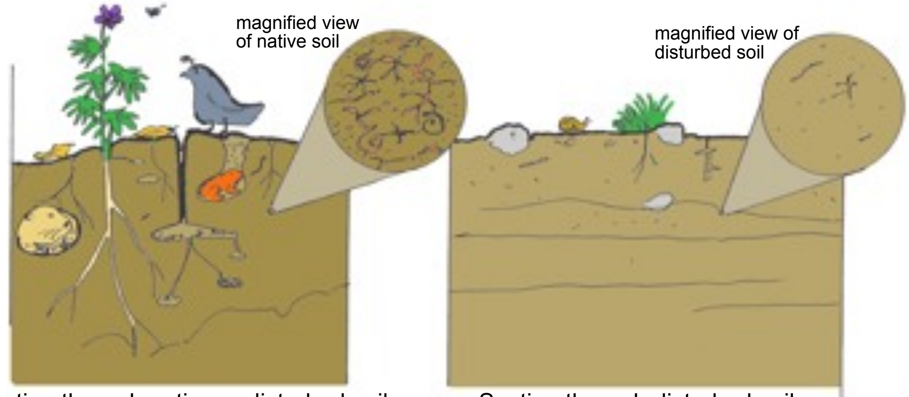
First flush can occur on a below grade tank with a small debris tank as shown here.



With the increasing popularity of cisterns, first flush accessories are now being produced. (A) A ball valve float seals off the first flush water and debris. (B) A screen and pipe cleverly designed to use centripetal force to swirl the water in such a way that debris drops out which also eliminates maintenance on the first flush system.

RECIPE CARD F - SOIL AMENDMENTS & AERATION

SUSTAINABILTY: 🌍🌍🌍
COMPLEXITY: ⚒⚒
MATERIALS COST: $



Section through native undisturbed soil   Section through disturbed soil

Description

Physical, chemical and/or biological properties of soils can be improved through the addition of soil amendments. Compost amended soils increase the soil's permeability and water holding capacity, thereby delaying and often reducing the peak stormwater runoff flow rate, and decreasing irrigation water, fertilizer and pesticide requirements.

Disruption of soil can kill most beneficial soil organisms and remove the air spaces in the soil that the aerobic organisms need to thrive. Surface plantings, fertilizer and other nutrient supplements typically only help the first few inches of soil to develop new biota. Chemical fertilizer addition can actually kill or restrict the development of this biota. The living organisms are essential for maintaining healthy soil and vegetation

Where soil impacts cannot be avoided or sterile fill is brought in, the soil organic matter can be restored through numerous materials such as compost, composted yard waste, industrial by-products and wood residuals. It is important that the materials used to improve soil quality be appropriate and beneficial to the plant cover to be established.

Applicability

These procedures are suitable for soils that have been compacted as a result of construction or previous land use and for soils where the organic quality has been compromised due to overuse of pesticides and fertilizers or an exposure to household/industrial chemicals, concentration of pet waste or extreme and unnatural temperatures.

Limitations

Aeration works best with dry to moist soils.

Design Criteria

To the extent possible,

- Ripping, spading or tilling of the soil is recommended to alleviate soil compaction, wherever the subsoil has been compacted by equipment operation. Amending existing soil mitigates sub-soil compaction when compost is incorporated to a 12 inch depth.
- The upper eight inches of existing soils should be amended to restore the soil organic matter to pre-disturbed levels.

Maintenance

Continued reduction of soil compaction and introduction of compost amendments.

RECIPE CARD G - PERMEABLE SURFACES FOR PATIOS & DRIVEWAYS

SUSTAINABILTY: 🌍
COMPLEXITY: 🛠 🛠 🛠
MATERIALS COST: $ $ $

Description

Impervious surfaces increase the amount of surface runoff and contribute to heat island and pollutant loading as stormwater runs over the impervious surface. Permeable pavement surfaces may be used to replace traditionally impervious surfaces. Examples of materials that have increased permeability include:

- Unit pavers
- Granular materials like stone or decomposed granite
- Porous concrete or porous asphalt

Applicability

These procedures are well suited for patios and driveways with flat surfaces, but can also be applied to steeper grades. Alternative patio & driveway surfaces are most cost effective in areas with native sandy soils. The ability of porous concrete and asphalt to exchange air and water makes it especially suitable for use around trees.

Limitations

Homeowners must choose a pervious surface type that provides adequate structural integrity for the intended purpose i.e. vegetated areas should not be used on surfaces frequently driven or parked on. Porous concrete or asphalt are not suitable for areas with a hard pan soils, high water table or in areas that have the potential for hazardous spills to occur on the parking surface. Sites with native clay soils require a subsurface drainage system. Avoid in areas with high sediment loads draining to the paved surface.

Design Criteria

Replace traditional patios with an alternative pervious surface like unit pavers or granular material.

Replace traditional driveways and parking surfaces with an alternative pervious surface such as:

- Paved tire paths with vegetation in the center
- Porous concrete, porous asphalt, permeable pavers, turf pave, etc. Pavers should have rigid edge systems to prevent movement of paving stones.
- Surface and stone recharge bed must be suitable for design traffic load.
- An underdrain is required for soils with limited infiltration rates.
- Terraced infiltration beds are required if porous concrete and asphalt are used on steep hills.
- A portion of the driveway can be replaced to disconnect runoff if constraints do not allow the entire driveway surface to be replaced.

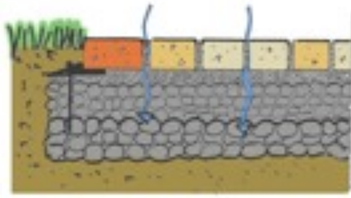
Maintenance

May require regular, manual weeding to clean out trapped sediment.

System notes:

1. Permeable interlocking concrete pavers (PICP)

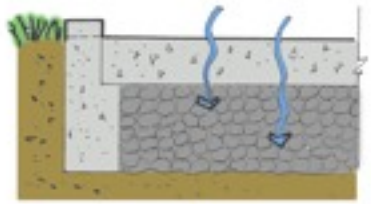
Concrete pavers with small aggregate filled joints that allow passage of water.



Highest loading capacity, aggregate in joints interlock units and help transfer loads.

2. Pervious concrete paving (PCP)

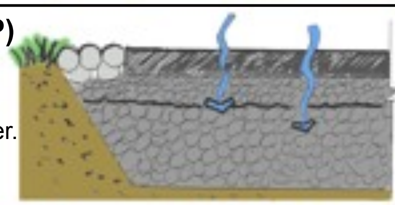
Concrete without fines (sand) allow passage of water.



Both pervious concrete and paving asphalt have slower water passage rates and may require thicker bases for water storage.

3. Porous asphalt paving (PAP)

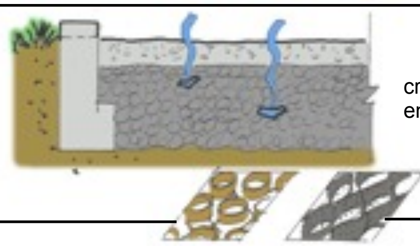
Asphalt surface allows passage of water.



Less expensive than PICP or PCP, initially can release hydrocarbons into runoff.

4. Porous composite paving

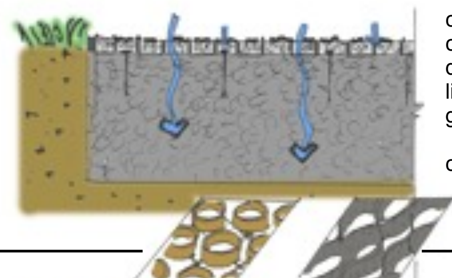
Composite consisting of ⅜" rubber granules from recycled tires plus ½" diameter gravel bonded together by moisture cured urethane.



Flexible material, good for parking lots, boat ramps and decks.

5. Cellular paving system for gravel

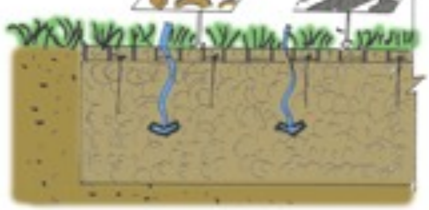
Uses mat consisting of 2" snap together cells consisting of high density polyethylene (HDPE) or high impact polypropylene (HIPP).



Provides for a porous but more stable gravel surface.

6. Cellular paving system for grass

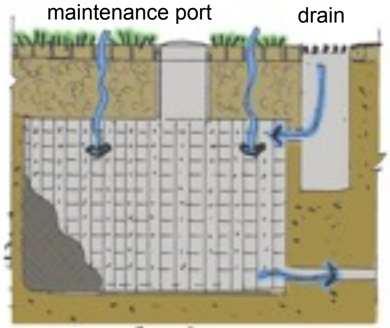
Same as above except filled with hydro-grow spread and planted with grass.



Allows for grass surface that can take large vehicular loads.

7. Cellular system for water storage under permeable paving

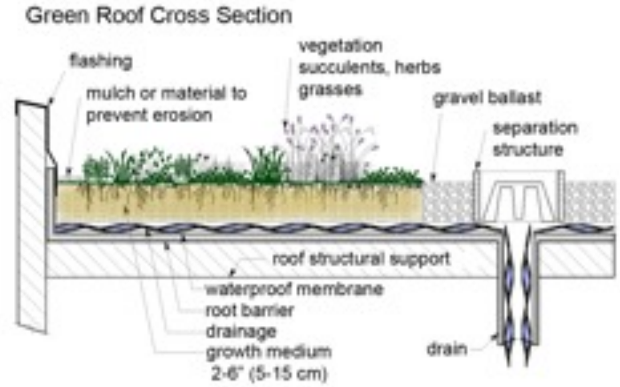
Modular tied together cellular system similar to 5 & 6 that can store water.



Allows paved area to also be a water retention area.

RECIPE CARD H – GREEN ROOFS

SUSTAINABILTY: 🌍
COMPLEXITY: 🛠 🛠 🛠
MATERIALS COST: $ $ $



Description

Vegetated roofs serve to treat stormwater pollutants, reduce runoff volumes, provide additional landscape amenity, provide acoustical control, air filtration and create urban wildlife habitat. Vegetated roofs also provide oxygen production, carbon storage, increase insulation, reduce energy for thermal conditioning and extend the expected lifetime of the roof compared to conventional roofing.

Roofs can be either extensive or intensive or vegetation can be placed in modules. Extensive: Consists of shallow (1"-6"), lightweight substrate and a few types of low-profile, low-maintenance, drought-tolerant plants. Intensive consists of thicker (8"- 48") substrate that can support a richer variety of plant material and a has more garden-like appearance. Vegetated walls are facades of steel cables that hold climbing plants away from the surface of the building.

Applicability

Can be installed on almost any building with moderate roof slopes. Effective strategies for managing stormwater at a larger scale in highly urbanized settings where rooftops comprise a large percentage of the total impervious surface.

Limitations

Installing a vegetated roof with a pitch of greater than 20 percent increases project complexity and requires supplemental anchoring. A slight pitch is preferable for efficient drainage but may not be as necessary in an arid environment. Sun exposure must be considered as both pitch and neighboring buildings may limit the amount of sunlight the vegetation receives, which can inhibit growth and the other beneficial effects of a vegetated roof. The building must have sufficient structural design to hold the load of the saturated vegetated roof. Fire safety provisions must be abided by and may affect the location and the extent of vegetated roofing that is allowed.

Design Criteria

Construction should be performed by an experienced vegetated roof specialist as waterproofing is critical. Extensive roofs utilize light-weight soil mixes to reduce loads. Native soils are usually too heavy when wet for roof usage. Structural capacity of the roof must be designed to support up the anticipated additional loads. A living non-irrigated vegetated roof is possible to maintain and will perform a stormwater benefit; however irrigation may be required during ***xeriscape*** plant establishment.

Maintenance

Installations require regular inspection and maintenance to guarantee proper functioning of any drainage or irrigation components as well as for removal of dead or diseased vegetation as needed, pruning and weeding must occur in order to maintain the appearance of the roof. Weeding and removal of dead material should be scheduled to coincide with important horticulture cycles. Intensive vegetated roofing may require more frequent inspection and maintenance. Intensive installations may also require irrigation as needed and may leak even with a waterproof membrane. Extensive installations should not be irrigated unless deemed absolutely necessary. Soils may also need to be tested for pH periodically and neutralizing agents may need to be employed as needed.

STEP 4: REFINE THE DESIGN & CONSTRUCT

Recipe cards provide the basic steps in designing and tooling-up for your LID technique however additional research on more complicated practices like rain gardens and rain barrels will benefit you in the long run.

Here is a checklist to ensure that you are using all the tools available to you in this guide.

- ☐ Estimate runoff generated by impervious surface to be captured.
- ☐ Complete percolation test and determined soil type.
- ☐ Draw scale base map of yard that included site opportunities and constraints.
- ☐ Choose LID practices in line with Steps 1 and 2 and with personal cost ranges and preferences in mind.
- ☐ Be sure to contact your local jurisdiction to learn about your areas specific drainage and grading requirements as well as when a permit is required. All LID designs shall meet local ordinances and California Building Codes.
- ☐ Complete additional research online or in the library to further refine LID design.
- ☐ Gather all tools and equipment needed for construction.

THINK LIKE A RAINDROP! SLOW IT, SPREAD IT, SINK IT!

Be sure to incorporate the following constraints & opportunities that apply to the site drawing.

Opportunities

- ☐ Natural depressions or low points
- ☐ Soil types like loams and sands that provide high infiltration rates
- ☐ Open or un-landscaped areas

Site Characteristics

- ☐ Total impervious area (Drainage area)
  ______Tributary Area
- ☐ Average annual rainfall
- ☐ Area available for LID practices
- ☐ Soil type

Constraints

- ☐ Creeks, wetlands, seeps, springs, lakes and areas within the 100-year floodplain. Includes existing drainage patterns for stormwater.
- ☐ Steep slopes, outcrops, or other geologic features.
- ☐ Difficult soil types and areas with high groundwater.
- ☐ Existing impervious surfaces, e.g., roofs, patios & sidewalks.
- ☐ Public and private wells and septic systems / leach lines
- ☐ Utility lines and easements
- ☐ Other existing infrastructure like buildings or landscaping that you do not want to change

STEP 5: MAINTAIN LID FEATURE

Maintenance is an important piece of installing low impact development techniques that ensures reduced repair costs, increased rainwater infiltration and maximum environmental benefits. Developing a maintenance log will allow you to schedule recurring maintenance requirements outlined for your specific practice and keep track of maintenance completed. Each recipe card provides maintenance guidelines.

APPENDIX 1 - PLANT PALETTE

To help protect California's remaining wild lands, it is important to avoid planting problem plants. The California Invasive Plant Council (www.cal-ipc.org) maintains a list of invasive plants causing problems in the state. Before selecting a plant for your project, search this list (available on their website) to find out the potential risk that plant may pose. Another great resource is Plant Right (www.plantright.org). This website will show you potential invasive horticulture plants in your growing region and offer alternatives to those plants. By making informed decisions about your plant selection, you can do your part to keep California wild!

Troublesome invasive plants include (1) Jubata Grass (Cortaderia jubata), (2)Scotch Broom (Cytisus scoparius), (3) Permiwinkle (Vinca major), (4) Iceplant (Carpobrotus edulis) and (5) English Ivy (Hedera helix).

Botanical Name	Common Name	Planting Zone (hydrozone)			LID Design Considerations					
		Low Zone	Mid Zone	High Zone	Small Planting Strips (<5' Wide)	Large Planting Areas (> 5' Wide)	Tolerates Prolonged Dry Periods	Requires Good Drainage	Tolerates Mowing	Tolerates Clay
GRASSES,GROUNDCOVERS,FERNS & BULBS										
Achillea millefolium	Yarrow		X	X	X	X	X		X	X
Aquilegia formosa	Western Columbine	X	X		X	X	X			
Arctostaphylos spp.	Manzanita		X	X		X	X	X		
Bothriochloa barbinodis	Cane Bluestem		X	X	X	X	X	X		
Bromus carinatus	California Brome		X	X	X	X	X			X
Calamagrostis nutkaensis	Pacific Reedgrass		X		X	X	X			X
Calochortus albus	White Fairy Lantern		X		X	X				
Carex pansa	California Meadow Sedge	X	X	X	X	X		X		
Carex praegracilis	Dune Sedge	X	X	X	X	X	X	X	X	
Carex tumulicola	Foothill Sedge	X	X	X	X	X	X		X	X
Castilleja miniata	Indian Paintbrush		X	X	X	X	X	X		
Deschampsia spp.	Hair grass		X	X	X	X	X	X		
Dudleya pulverulenta	Chalk Dudleya		X	X	X	X	X	X		
Eleocharis macrostachya	Common Spike Rush	X	X		X	X				
Eschscholzia californica	California Poppy		X	X	X	X	X			X
Festuca californica	California Fescue		X	X	X	X	X			X
Festuca idahoensis	Western Fescue	X	X	X	X	X	X			X
Fragaria chiloensis	Beach Strawberry		X		X		X	X		
Heuchera micrantha	Crevice Alum Root		X	X	X	X	X	X		
Hordeum spp.	Barley		X	X	X	X	X			X
Iris douglasiana	Douglas Iris		X	X	X	X		X		X
Juncus spp.	Rush	X	X		X	X	X			X
Lasthenia californica	California Goldfields	X	X		X	X	X			X
Lasthenia glabrata	Yellowray Goldfields	X	X		X	X	X			X
Layia platyglossa	Tidy Tips		X		X	X	X			
Leymus spp.	Wild Rye	X	X	X	X	X	X		X	X
Lilium pardalinum	Leopard Lily		X			X	X	X		
Linanthus parviflorus	Stardust		X	X	X	X	X	X		
Lupinus microcarpus var. densiflorus	Whorled Lupine		X	X	X	X	X	X		
Melica imperfecta	Coast Melic Grass		X	X	X	X	X			
Muhlenbergia rigens	Deer Grass		X	X		X	X			X
Nassella pulchra	Purple Needlegrass		X	X	X	X	X		X	X

Throughout California invasive plants are causing catastrophic changes to our last wild areas. Many of these invaders have been intentionally introduced as landscape plants, and while most garden and landscape plants cause no problems, a few become real pests as they escape from yards and developed lands to take root in wild areas.

		Planting Zone (hydrozone)			LID Design Considerations					
Botanical Name	**Common Name**	Low Zone	Mid Zone	High Zone	Small Planting Strips (<5' Wide)	Large Planting Areas (> 5' Wide)	Tolerates Prolonged Dry Periods	Requires Good Drainage	Tolerates Mowing	Tolerates Clay
GRASSES,GROUNDCOVERS,FERNS & BULBS (cont'd)										
Polystichum munitum	Sword Fern		X		X	X				X
Salvia spp.	Sage		X	X	X	X	X			X
Satureja douglasii	Yerba Buena	X	X		X					X
Scirpus spp.	Bulrush	X				X				X
Sisyrinchium bellum	Blue-Eyed Grass		X	X	X	X	X		X	X
Symphoricarpus mollis	Creeping Snowberry		X	X		X	X			
Triteleia laxa	Ithuriel's Spear		X	X	X	X	X			
VINES										
Clematis lasiantha	Chaparral Clematis		X	X		X	X	X		
Vitis californica	California Wild Grape	X	X	X	X	X	X	X		X
SHURBS										
Arctostaphylos spp.	Manzanita		X	X		X	X	X		
Baccharis pilularis	Coyote Brush			X		X	X			X
Baccharis salicifolia	Mulefat		X	X		X	X			X
Berberis aquifolium	Oregon Grape			X	X	X	X			X
Ceanothus spp.	Wild Lilac			X		X		X		X
Cornus sericea	Creek Dogwood	X	X	X		X				X
Fremontodendron californica	Flannel Bush			X		X		X		X
Garrya elliptica	Coast Silk-Tassel			X		X	X	X		X
Heteromeles arbutifolia	Toyon			X		X	X	X		X
Lupinus albifrons	Silver Bush Lupine		X	X		X	X	X		X
Myrica californica	Pacific Wax Myrtle		X	X		X				X
Rhamnus californica	Coffeeberry		X	X		X	X	X		
Ribes spp.			X	X	X	X	X			X
Rosa californica	California Wild Rose		X	X		X	X			X
Rubus ursinus	California Blackberry		X			X	X			X
Sambucus mexicana	Elderberry		X	X		X	X			X
TREES										
Acer macrophyllum	Big-Leaf Maple		X	X		X				
Aesculus californica	Buckeye			X		X	X			X
Alnus rhombifolia	White Alder		X	X		X				
Cercis occidentalis	Western Redbud		X	X		X	X	X		
Platanus racemosa	California Sycamore		X	X		X				X
Populus fremontii	Western Cottonwood		X	X		X				X
Prunus ilicifolia ssp. Lyonii	Catalina Cherry			X	X	X	X			X
Salix spp.	Willow	X	X	X		X				X
Umbellularia californica	California Bay Laurel			X		X				X

APPENDIX 2 - AVERAGE RAINFALL IN SAN LUIS OBISPO COUNTY

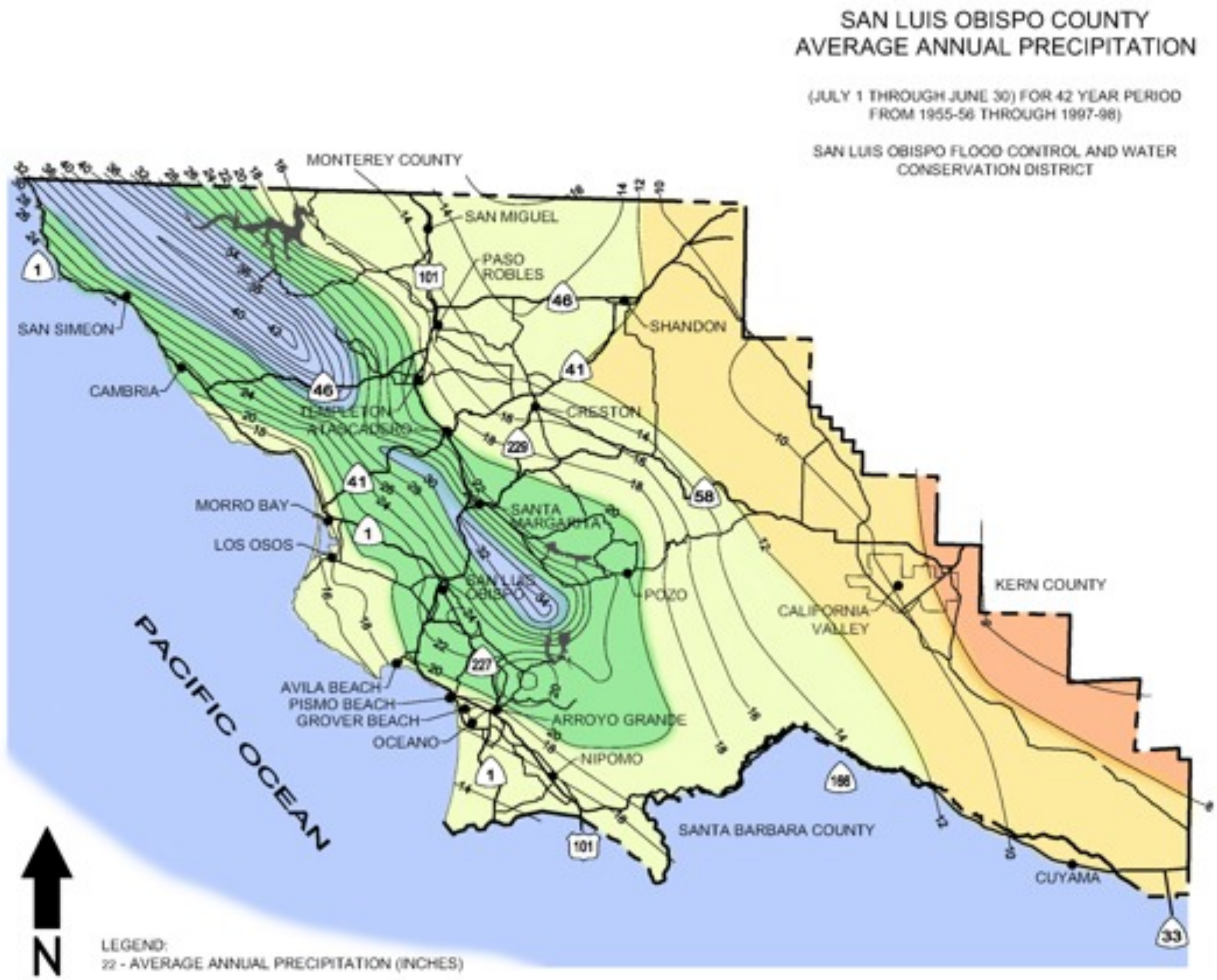


TABLE 1: ANNUAL RAINFALL < 14":

Recurrence Interval (Years)	Duration							
	10 Min	15 Min	30 Min	1 Hr	2 Hr	3 Hr	6 Hr	10 Hr
2	1.00	0.90	0.60	0.40	0.26	0.22	0.18	0.14
5	1.40	1.20	0.80	0.50	0.37	0.32	0.25	0.20
10	1.70	1.40	1.00	0.60	0.44	0.38	0.30	0.23
25	2.00	1.70	1.10	0.70	0.54	0.47	0.37	0.28
50	2.20	1.90	1.30	0.80	0.60	0.53	0.44	0.34
100	2.40	2.10	1.40	0.90	0.65	0.59	0.48	0.36

TABLE 2: ANNUAL RAINFALL 14" TO 17":

Recurrence Interval (Years)	Duration							
	10 Min	15 Min	30 Min	1 Hr	2 Hr	3 Hr	6 Hr	10 Hr
2	1.30	1.10	0.80	0.50	0.35	0.30	0.23	0.18
5	1.90	1.60	1.10	0.70	0.49	0.42	0.33	0.26
10	2.30	1.90	1.30	0.80	0.60	0.51	0.40	0.30
25	2.60	2.20	1.50	1.00	0.71	0.63	0.50	0.38
50	3.00	2.50	1.70	1.10	0.81	0.74	0.60	0.47
100	3.20	2.70	1.90	1.20	0.90	0.80	0.65	0.49

TABLE 3: ANNUAL RAINFALL 18" TO 21":

Recurrence Interval (Years)	Duration							
	10 Min	15 Min	30 Min	1 Hr	2 Hr	3 Hr	6 Hr	10 Hr
2	1.70	1.40	1.00	0.65	0.44	0.37	0.29	0.22
5	2.30	1.90	1.30	0.85	0.60	0.52	0.41	0.33
10	2.80	2.40	1.60	1.03	0.74	0.64	0.50	0.38
25	3.20	2.70	1.90	1.20	0.92	0.80	0.64	0.50
50	3.70	3.10	2.10	1.40	1.05	0.92	0.74	0.58
100	4.00	3.40	2.30	1.50	1.13	1.00	0.80	0.62

TABLE 4: ANNUAL RAINFALL 22" TO 28":

Recurrence Interval (Years)	Duration							
	10 Min	15 Min	30 Min	1 Hr	2 Hr	3 Hr	6 Hr	10 Hr
2	2.10	1.80	1.20	0.77	0.55	0.47	0.36	0.28
5	2.80	2.50	1.70	1.05	0.76	0.64	0.52	0.42
10	3.60	3.00	2.10	1.30	0.92	0.81	0.64	0.48
25	3.90	3.50	2.40	1.50	1.10	0.98	0.78	0.60
50	4.50	3.90	2.60	1.70	1.28	1.15	0.94	0.72
100	5.00	4.30	2.90	1.85	1.40	1.25	0.98	0.76

Rainfall Intensity Data
Source: San Luis Obispo County Department of Public Works dwg. #H-4 August 2006.

appropriate technology applying technology to address problems related to energy use, the water cycle and affordable building at the smallest and most accessible scale possible.

aquifer the underground layer of rock or soil in which groundwater resides. Aquifers are replenished or recharged by surface water percolating through soil. Wells are drilled into aquifers to extract water for human use.

basin a shallow depression that can temporarily hold water.

berm a low mound that can direct water flow or help define a basin.

biofilter any of a number of devices used to control pollution using living materials to filter or chemically process pollutants.

bioremediation the use of plants to extract heavy metals from contaminated soils and water, also known as phytoremediation.

bioretention a technique that uses parking lot islands, planting strips, or swales to collect and filter urban stormwater, that includes grass and sand filters, loamy soils, mulch, shallow ponding and native trees and shrubs.

catchment the smallest watershed management unit, defined as the area of a development site to its first intersection with a stream, usually as a pipe or open channel outfall.

cistern a reservoir, tank or container for storing or holding water or other liquid.

clay a stiff, sticky sedimentary material that is soft and pliable when wet and consists mainly of various silicates of aluminum. Clay particles are smaller than silt, having a diameter less than 0.0039 mm and has low permeability.

cluster development a development pattern for residential, commercial, industrial, institutional, or combination of uses, in which the uses are grouped or "clustered," rather than spread evenly throughout the parcel as in conventional lot-by-lot development. A local jurisdiction may authorize such development by permitting smaller lot sizes if a specified portion of the land is kept in permanent open space to provide natural habitat or open space uses through public or private dedication.

constructed wetland an artificial wetland system designed to mitigate the impacts of urban runoff.

curbs a concrete barrier on the margin of a road that separates vehicular and pedestrian traffic and is used to direct stormwater runoff to an inlet, protect pavement edges, and protect lawns and sidewalks from encroachment by vehicles.

design storm a rainfall event of specified duration, intensity, and return frequency (e.g., a 2 year 6 hour event) that is used to calculate runoff volume and peak discharge rate.

detention the temporary storage of storm runoff which is used to control discharge rates sufficiently to provide gravity settling of pollutants.

disturbance the act of moving, grading, tilling, clearing, taking or repositioning the natural environment's soil surfaces and/or vegetation that was previously undisturbed by man.

erosion the wearing away of land surface by wind or water. Erosion occurs naturally from weather or runoff but can be intensified by land-clearing practices related to farming, residential, commercial or industrial development, road building, or timber cutting.

estuaries a transition zone between river environments and ocean environments that are subject to both marine influences, such as tides, waves, and the influx of saline water; and riverine influences, such as flows of fresh water and sediment.

evapotranspiration the combined loss of water from a given area, occurring during a specified period of time, by evaporation from the soil surface and transpiration from plants into the atmosphere.

filter fabric a textile of relatively small mesh or pore size that is used to either allow water to pass through while keeping sediment out (permeable), or prevent both runoff and sediment from passing through (impermeable).

filter strips a vegetated area that treats sheetflow and/or interflow to remove sediment and other pollutants. Filter strips are used to treat shallow concentrated stormflows over very short contributing distances in urban areas.

filtration the process of passing a liquid or gas through a filter in order to remove solid particles.

first flush the delivery of a disproportionately large load of pollutants during the early part of storms due to the rapid runoff of accumulated pollutants. The first flush of runoff can be defined in several ways (e.g., one-half inch per impervious acre).

french drain a drainage trench filled to ground level with fragments of brick, rock, etc.

groundwater water stored underground that fills the spaces between soil particles or rock fractures. A zone underground with enough water to withdraw and use for drinking water or other purposes is called an aquifer.

habitat the specific area or environment in which a particular type of plant or animal lives. An organism's habitat must provide the basic requirements for life and should be free of harmful contaminants.

heat island effect the increase in ambient temperatures generated by heat radiating from paved surfaces exposed to sunlight.

high impact development (HID) is characterized by having a high percentage of impervious surfaces, landscaping that is mostly decorative, stormwater issues and pollution which have typically been handled by concrete curbs, pipes and canals.

hydrologic cycle describes the continuous movement of water on, above and below the surface of the Earth.

hydrology the science of the behavior of water in the atmosphere (air), on the surface of the earth, and underground.

impermeable not able to be infiltrated by water.

impervious surface any surface which cannot be effectively (easily) penetrated by water. Examples include conventional pavements, buildings, highly compacted soils, and rock outcrops.

imperviousness the level of (or percentage of) impervious surface within a development site or watershed.

infiltration the downward entry of water into the surface of the soil, as contrasted with percolation which is movement of water through soil layers.

loam soil composed of approximately equal quantities of sand, silt and clay, often with variable amounts of decayed matter.

low impact development (LID) is characterized by having a high percentage of pervious surfaces, regenerative, native or edible landscaping, water infiltration and filtration of on site pollutants and surface drainage recharges the local aquifer or is harvested for use.

management practice a method, activity, maintenance procedure, or other management practice for reducing the amount of pollution entering a water body. The term originated from the rules & regulations developed pursuant to the federal Clean Water Act (40 CFR 1 30).

natural drainage a drainage consisting of native soils such as a natural swale or topographic depression which gathers and/or conveys runoff to a permanent or intermittent watercourse or waterbody.

nonpoint source pollution pollution that enters water from dispersed and uncontrolled sources, such as rainfall or snowmelt, moving over and through the ground rather than a single, identifiable source. A nonpoint source is any source of water pollution that does not meet the legal definition of point source in section 502(14) of the Clean Water Act (e.g., agricultural practices, on site sewage disposal, automobiles, and recreational boats). While individual sources may seem insignificant, they may contribute pathogens, suspended solids, and toxicants which result in significant cumulative effects.

percolation the downward movement of water through soil layers, as contrasted with infiltration which is the entry of water into the surface of the soil.

permeable a type of soil or other material that allows passage of water or other liquid.

permeable surfaces surfaces made up of materials that allow stormwater to infiltrate the underlying soils (e.g., soil covered or vegetated areas).

pervious a soil or material that allows the passage of water or other liquid.

point source pollution a source of pollutants from a single point of conveyance, such as a pipe. For example, the discharge from a sewage treatment plant or a factory is a point source pollutant.

pollutants a chemical or other additive that adversely alters the physical, chemical, or biological properties of the environment.

permeable pavement asphalt or concrete paving material consisting of a coarse mixture cemented together with sufficient interconnected voids to provide a high rate of permeability.

rain barrel a small barrel used as a cistern that holds rainwater runoff typically from rooftops via downspouts.

rain garden a planted depression that allows rainwater runoff from impervious urban areas like roofs, driveways, walkways, parking lots and compacted lawn areas the opportunity to be absorbed.

recharge infiltration of surface water to groundwater.

retention the capacity to hold or retain liquid.

riparian area habitat found along the bank of a natural and freshwater waterway, such as a river, stream, or creek, that provides for a high density, diversity, and productivity of plant and animal species.

runoff water from sources such as rain, melted snow, agricultural or landscape irrigation that flows over the land surface.

sand loose material consisting of rock or mineral grains, especially rounded grains of quartz, between 0.05 and 2 mm in diameter and has a high permeability.

silt a sedimentary material consisting of grains or particles of disintegrated rock, smaller than sand and larger than clay. The diameter of the particles ranges from 0.0039 to 0.0625 mm. Silt is often found at the bottom of bodies of water where it accumulates slowly by settling through the water.

swale (vegetated) an open drainage channel that has been explicitly designed to detain, evaporate, and/or infiltrate the runoff associated with a storm event.

treatment train a stormwater technique in which several treatment types (filtration, infiltration, retention, evaporation) are used in conjunction with one another and are integrated into a comprehensive runoff management system.

tributary area the portion of an area contributing load to another area, the load is water in the case of watersheds.

unit pavers concrete grid and modular pavement whose spaces are filled with pervious materials such as sod, sand, or gravel.

water table the upper surface of groundwater or the level below which the soil is saturated with water. The water table indicates the uppermost extent of groundwater.

watercourse a permanent or intermittent stream or other body of water, either natural or improved, which gathers or carries surface water.

watershed (see basin) the geographic region within which water drains into a particular river, stream or body of water. A watershed includes hills, lowlands, and the body of water into which the land drains. Watershed boundaries are defined by the ridges of separating watersheds.

xeriscaping environmental design of residential, commercial and park land using various methods for minimizing the need for water use.

A ***watershed*** is a network of streams, creeks and ground water systems, which drain rainfall and other freshwater from the land into the ocean, an estuary or a river. Every square inch of land is a part of one watershed or another.

Whether you live on a farm, on the coast, in the woods or even in the desert, you live in a watershed. Everyone lives in a watershed, as all lands drain rainfall to one body of water or another. The watershed can be a source of sediment and pollution. As rainwater drains from our yards, hillsides and streets it carries pollution with it. Think twice before you dump cleaners, paint, oil and other chemicals on your yard, in the storm drain or in the street.

California Native Plant Society
San Luis Obispo Chapter
http://www.cnps-slo.org/

Hardscapes: Patios and Driveways
GreenBuildingAdvisor.com
http://www.greenbuildingadvisor.com/green-basics/hardscapes-patios-and-driveways-0

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By Texas Commission on Environmental Quality
http://rainwaterharvesting.tamu.edu/drinking/gi-366_2021994.pdf

Harvesting Rainwater for Landscape Use
By University of Arizona Cooperative Extension
http://cals.arizona.edu/pubs/water/az1344.pdf

Natural Yard Care Guide
By Seattle Public Utilities
http://www.seattle.gov/util/Services/Yard/Natural_Lawn_&_Garden_Care/Natural_Yard_Care/index.asp

Rainwater Harvesting for Drylands and Beyond
By Brad Landcaster
http://www.harvestingrainwater.com/

Rain Gardens: A How-to Manual for Homeowners
By City of San Luis Obispo
http://clean-water.uwex.edu/pubs/pdf/home.rgmanual.pdf

Rain Barrel Guide
http://www.rainbarrelguide.com/

Texas Manual on Rainwater Harvesting
By Texas Water Development Board
http://www.twdb.state.tx.us/publications/reports/RainwaterHarvestingManual_3rdedition.pdf

Slow it, Spread it. Sink it. A Homeowner's Guide to Greening Stormwater Runoff
By Resource Conservation District of Santa Cruz County
http://www.rcdsantacruz.org/media/brochures/pdf/HomeDrainageGuide.v25.pdf

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www.slogreenbuild.org
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www.arroyogrande.org

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(805) 461-5000
www.atascadero.org

Grover Beach
Community Development Department
(805) 473-4520
www.grover.org

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City of Morro Bay - Public Services
(805) 772-6569
www.morro-bay.ca.us

Paso Robles
(805) 237-3850
www.prcity.com

Pismo Beach
(805) 773-4656
www.pismobeach.org

City of San Luis Obispo
Community Development Department
(805) 781-7530
(805) 781-7274
www.ci.san-luis-obispo.ca.us

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Planning & Building
(805) 781-5600
www.sloplanning.org
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