

Resilient Rainwater | Collection **Designing Integrated Rainwater Systems For Use Inside Buildings.**

Celeste Allen Novak Architect FAIA, LEED AP



Your Land, Your Water, Your Michigan

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Rain Barrels

Rain Barrels can be ordered from the Conservation District Office or by mail. A limited supply of barrels are maintained at the District Office. If not in stock, barrels generally arrive in 2-3 weeks, depending on delivery schedules. Pick-up will be at the District Office unless notified otherwise.

See the [Order Form](#) for current prices and products available.

What Is A Rain Barrel?

A rain barrel collects and stores rainwater from roofs that would otherwise be lost to runoff and diverted to storm drains, streams and rivers.



Subsections

[What Is A Rain Barrel?](#)

[What Are The Advantages of Using A Rain Barrel?](#)

[Available Colors](#)

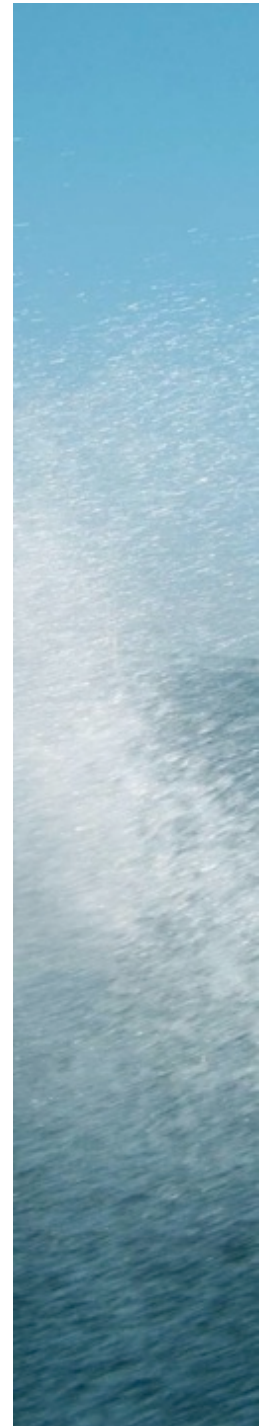
[Accessories](#)

[Common Questions](#)

Downloads

Advantages of Using Rainwater

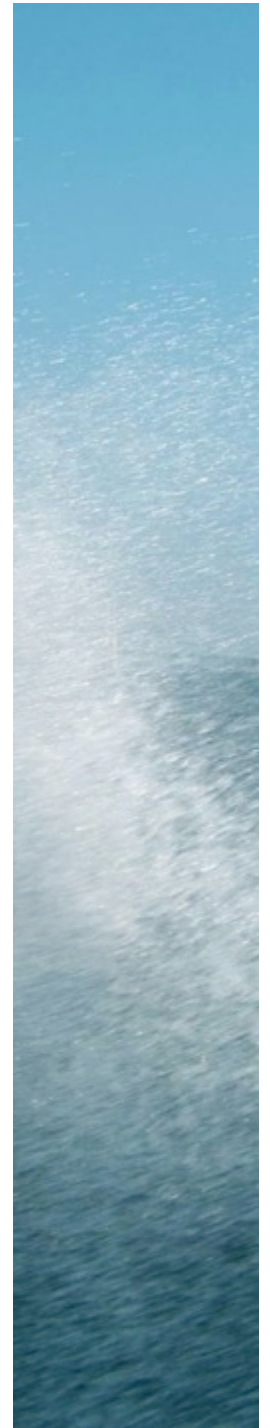
- Saves You Money
- Helps Reduce Stormwater Pollution
- Conserves Water
- Better for Plants and Gardens

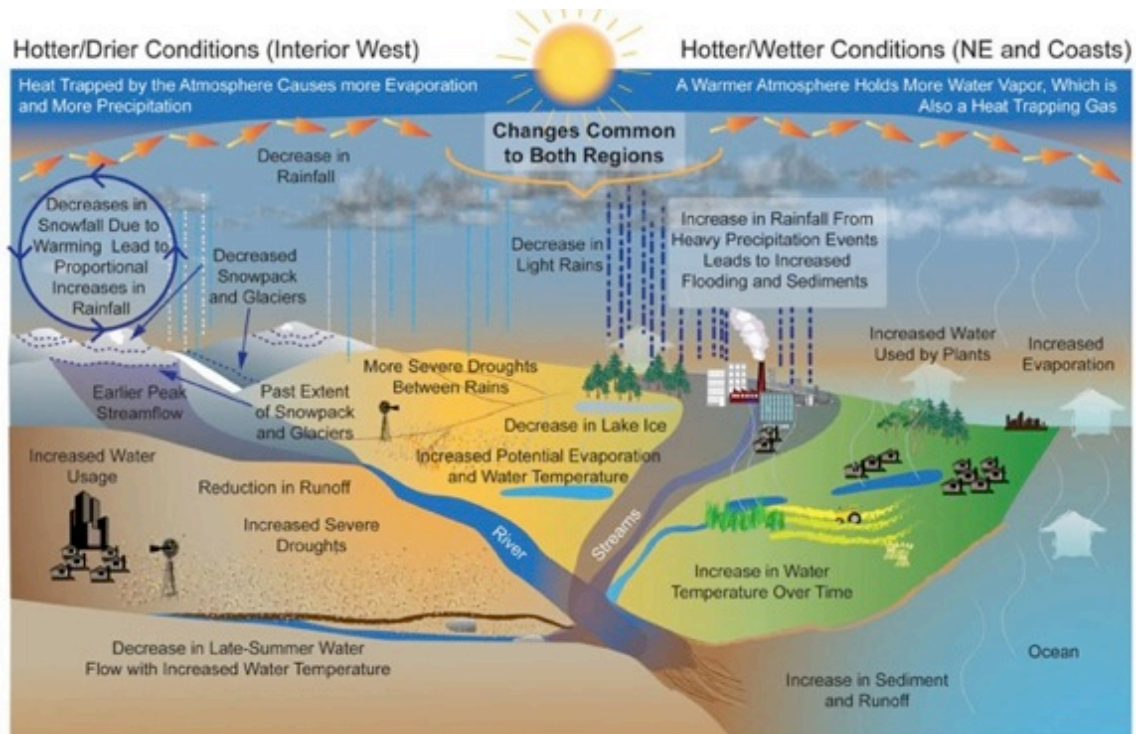




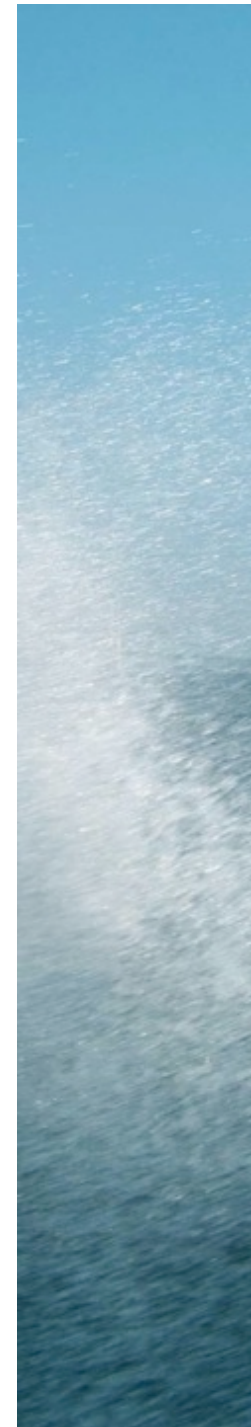
Advantages of Using Rainwater

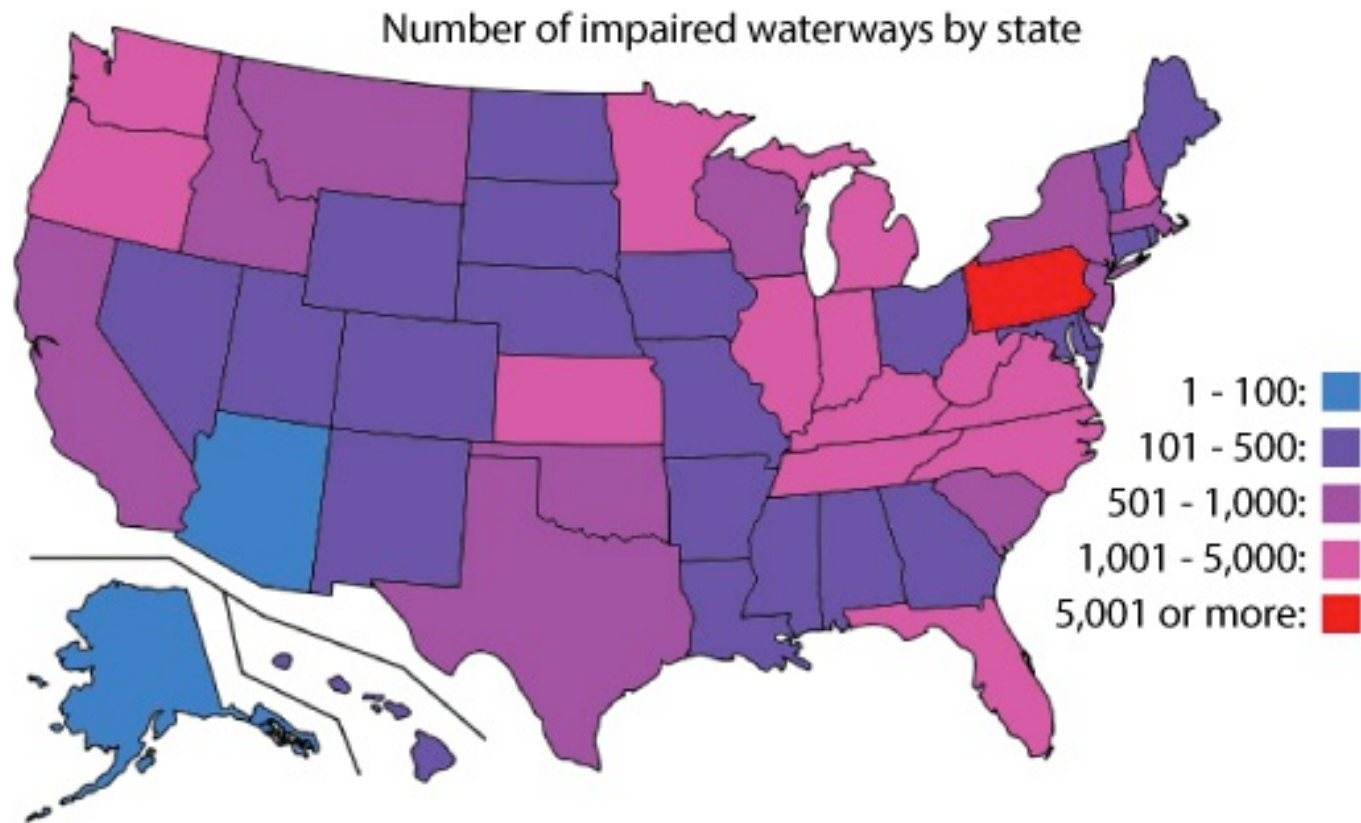
- *Pier 27 - San Francisco – 22.28 inches of rain* - KMD Architects +PLA
- Toilet Flushing (33 units)
- Urinal (13 units)
- Irrigation area: Approximately 67,000 square feet





The New Hydrologic Cycle





Planning Goals – Stormwater and The Clean Water Act

“We pay to bring water in, we pay to get rid of it, and the water that is free, we pay to channel it away as fast as possible through costly stormwater infrastructures.”

-Georgia Taxpayer, 2013

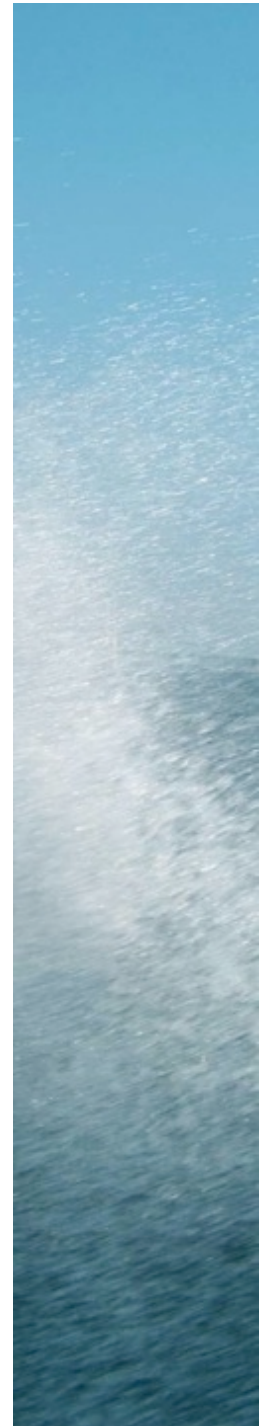
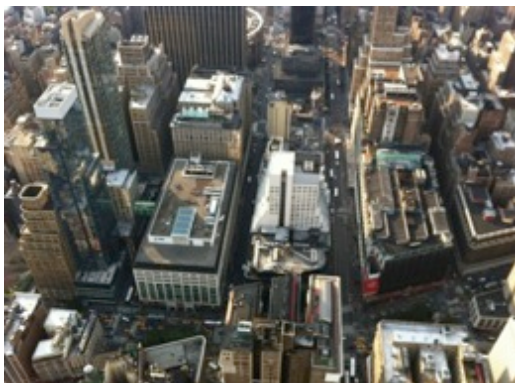




Table 2: Total Rooftop Rainfall for Eight U.S. Cities

City	Estimated 2008 Pop.	Land Area (mi ²)	Acres of Residential Roof	Acres of Non-Res. Roof	Annual Rainfall (in.)	Annual Rooftop Rainfall (Billion Gal.)	Equivalent Number of People Supplied Annually	% of Pop.
Atlanta, GA	519,000	132	4,801	4,462	47.6	11.98	291,772	56.2%
Austin, TX	743,000	252	11,151	4,426	30.2	12.78	311,249	41.9%
Chicago, IL	2,837,000	227	17,288	12,099	39.0	31.10	757,493	26.7%
Denver, CO	588,000	153	7,252	4,260	14.5	4.54	110,548	18.8%
Fort Myers, FL	68,000	22	782	624	54.5	2.08	50,660	74.7%
Kansas City, MO	476,000	314	2,315	3,874	35.1	5.90	143,666	30.2%
Madison, WI	229,000	67	-	2,491	29.5	1.99	48,566	21.2%
Washington, DC	588,000	61	1,318	7,081	39.4	8.99	218,968	37.2%

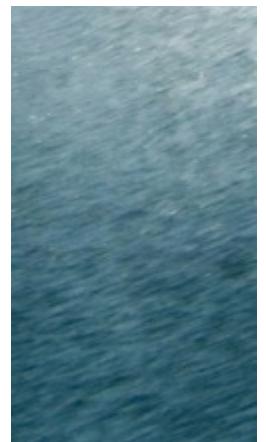
Source: Rooftop area data provided by case study cities. Rainfall data from NOAA National Climate Data Center. Population Data from Census 2000.

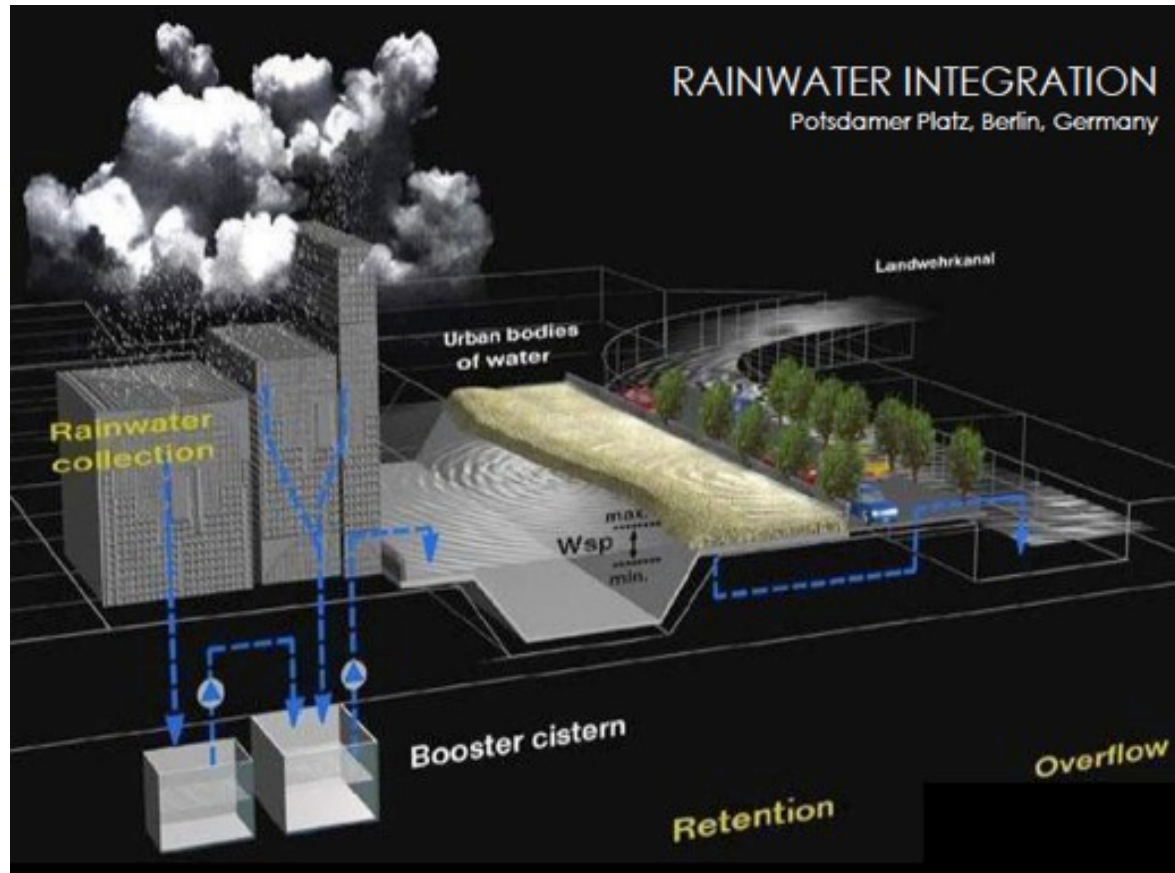


Total Rooftop Rainfall For Eight US Cities

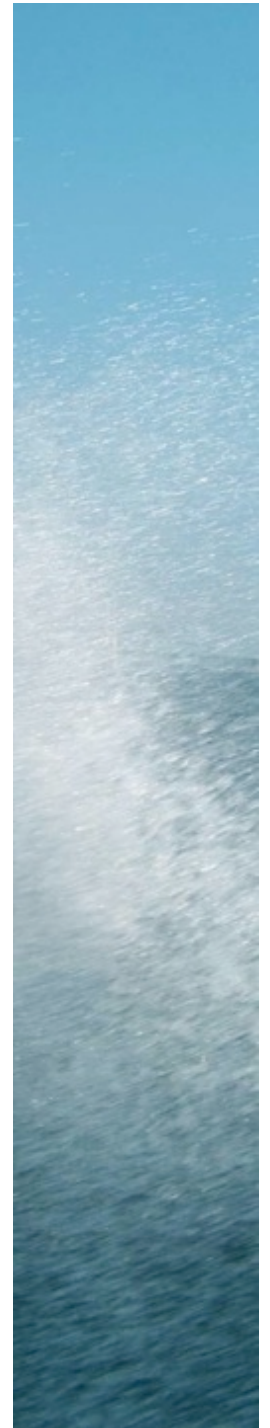
Capturing Rainwater from Rooftops: An Efficient Water Resource Management Strategy that Increases Supply and Reduces Pollution

www.nrdc.org/water/files/rooftoprainwatercapture.pdf





USE It for grey water and irrigation



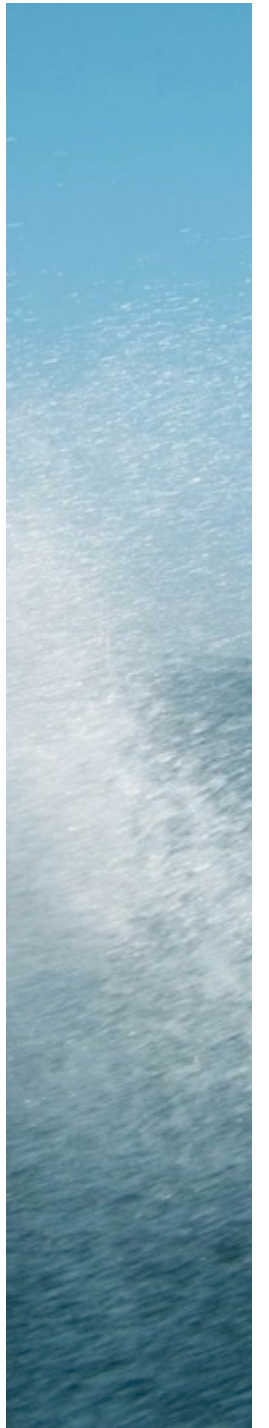
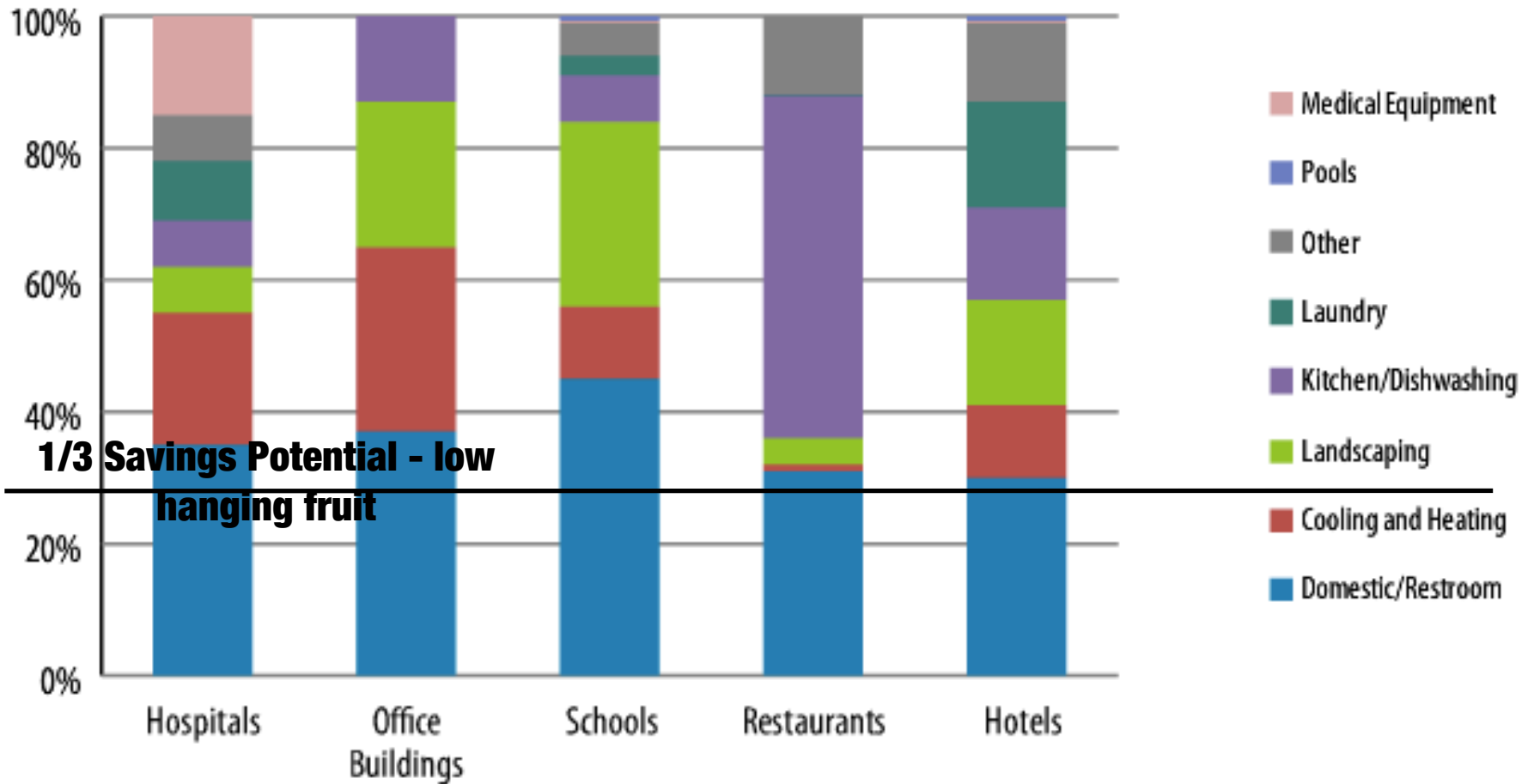
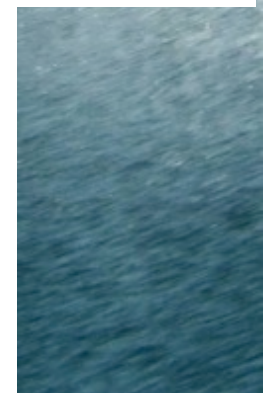


Figure 1-1. End Uses of Water in Various Types of Commercial and Institutional Facilities



Low Hanging Fruit – Water Use in Buildings

http://www.epa.gov/watersense/commercial/docs/watersense_at_work/#/10/zoomed



STATE RAINWATER | GRAYWATER HARVESTING LAWS AND LEGISLATION

9/1/2013



Record droughts and water-supply worries have served as catalysts for state legislatures to consider legislation legalizing the catchment and use of rainwater for use in households and for lawns.

There has been increased interest over the past five years in legislation allowing, defining, and clarifying when rainwater harvesting can occur. Rainwater harvesting is the act of utilizing a collection system to

use rainwater for outdoor uses, plumbing, and, in some cases, consumption. States have also passed legislation encouraging the use of Graywater. Graywater refers to the reuse of water drained from baths, showers, washing machines, and sinks (household wastewater excluding toilet wastes) for irrigation and other water conservation applications.

States must ensure water-quality standards and public health concerns are met. In some states, such as Colorado, previous water law stated that all precipitation belonged to existing water-rights owners, and that rain needed to flow to join its rightful water drainage. However, a 2007 study conducted by the Colorado Water Conservation Board and Douglas County determined that only 3 percent of rain actually reached a stream or the ground. Colorado followed-up by enacting two pieces of legislation, one allowing certain types of well owners to use rainwater and one authorizing pilot development projects.

FEATURED ITEMS

[NCSL Energy and Environment Legislation Tracking Database](#)

[Map of Rainwater Harvesting Laws](#)

[State Rainwater Harvesting and Graywater Laws and Programs](#)

[2012 Notable Rainwater Harvesting Legislation](#)

NCSL STAFF CONTACT

[Douglas Shinkle](#)

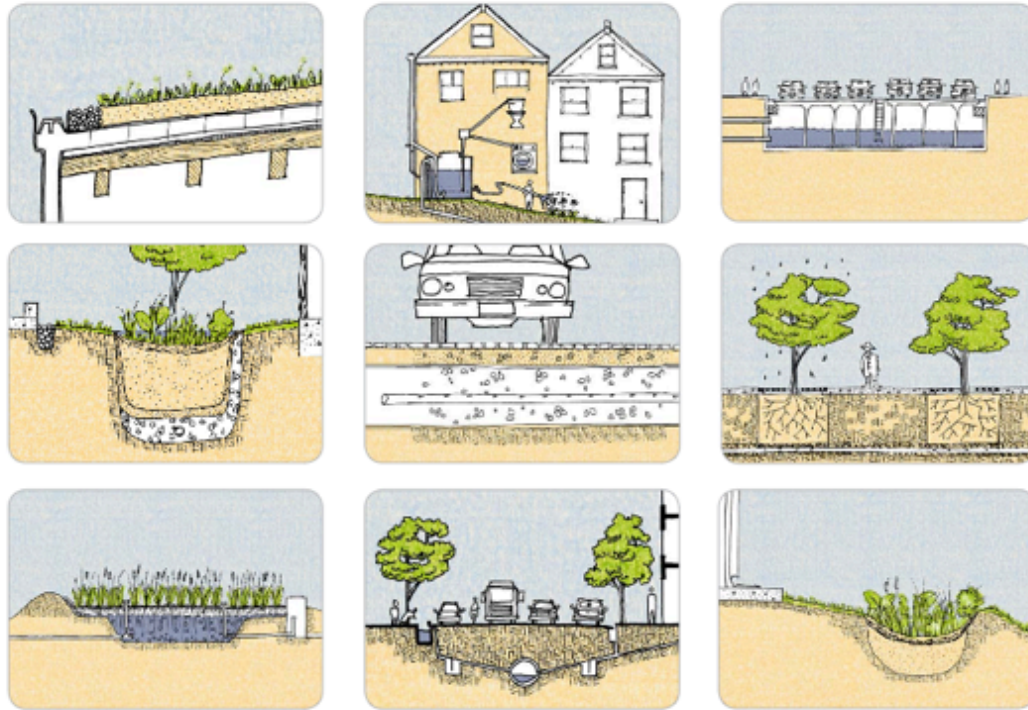
NAVIGATE

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States with Rainwater Legislation

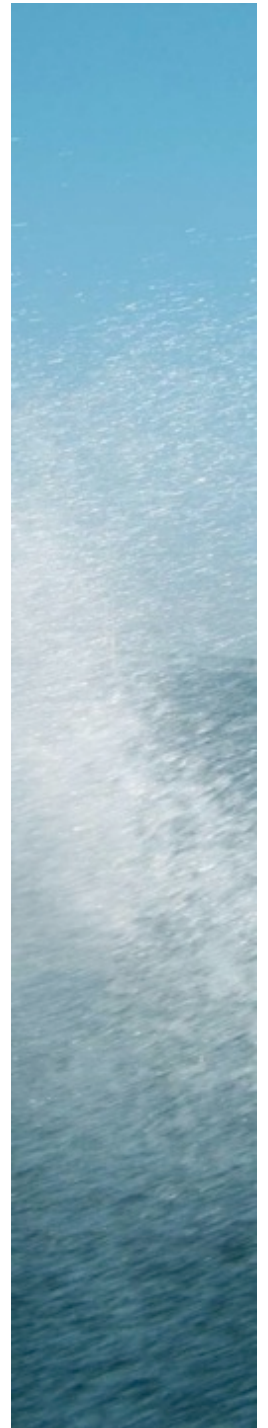
<http://www.ncsl.org/research/environment-and-natural-resources/rainwater-harvesting.aspx>



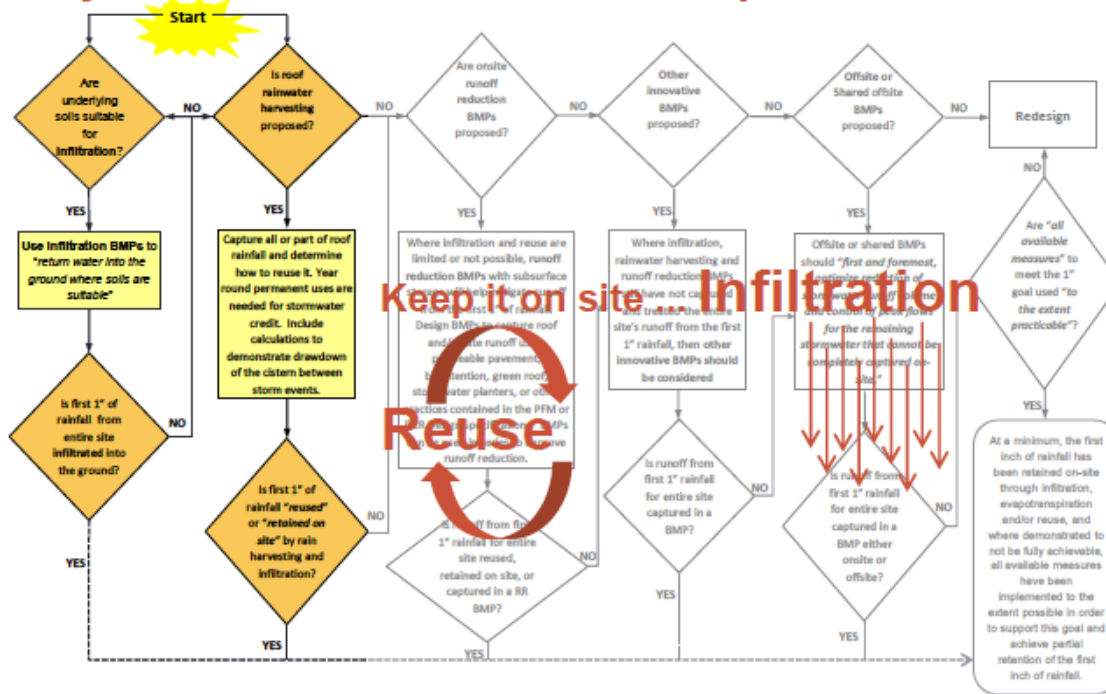
SAN FRANCISCO
stormwaterdesignguidelines

Stormwater Best Practices – San Francisco

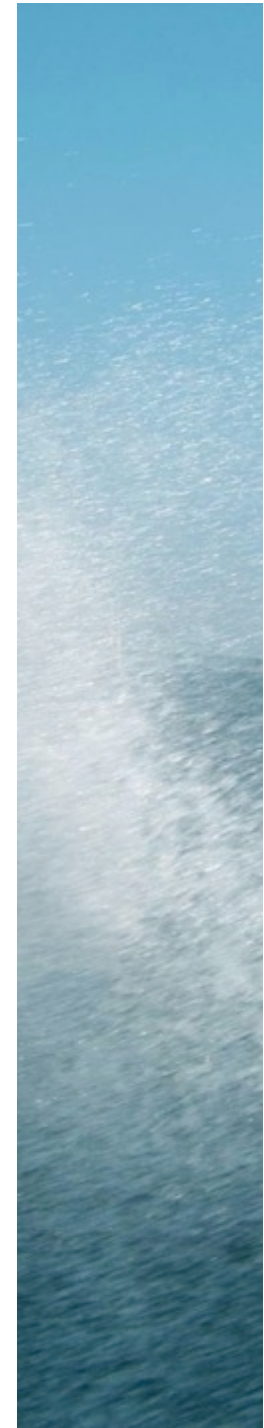
Think of stormwater as a resource, not a waste product!

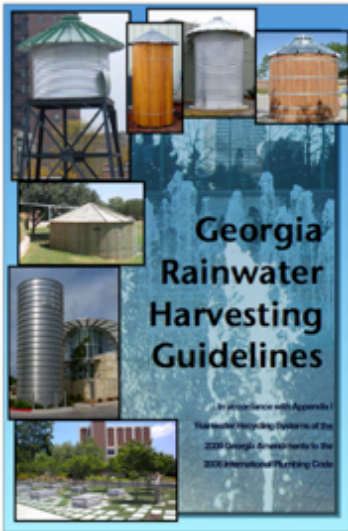


Tysons Corner Stormwater Concepts

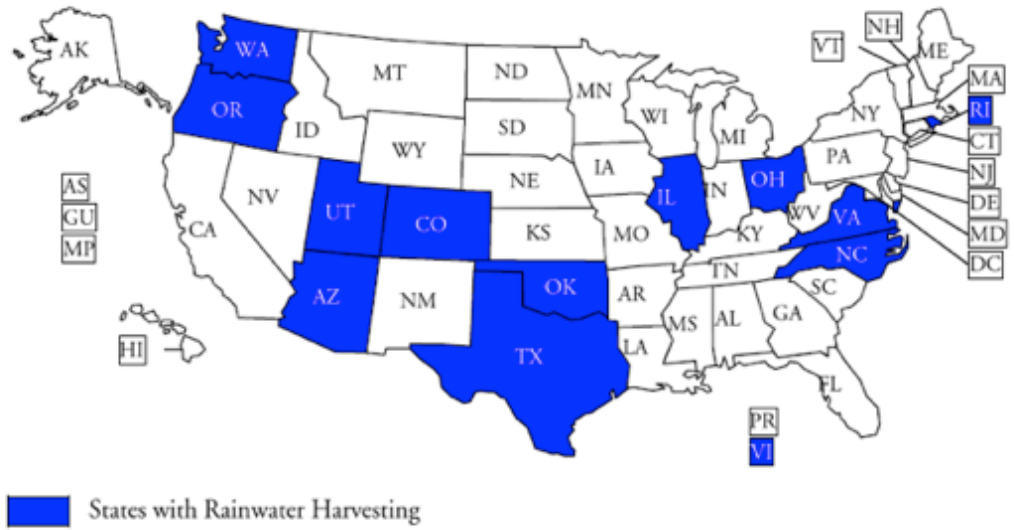


Stormwater Best Practices - Fairfax County





Map of Rainwater Harvesting Laws



overview

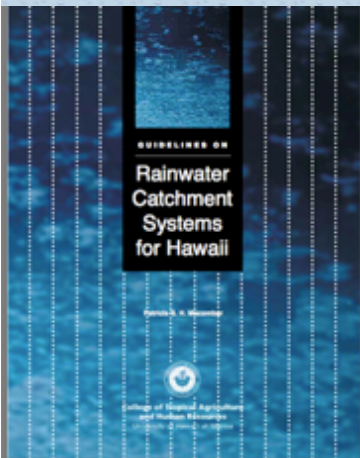
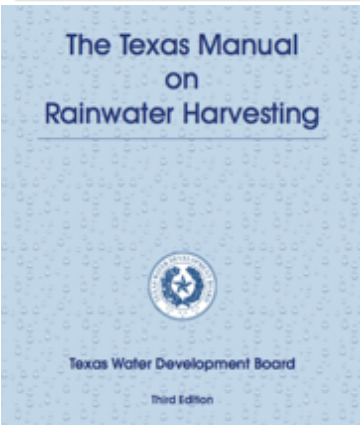
This leaflet targets any business where rainwater can be collected in sufficient volume to be re-used. It details how to quantify the volume of rainwater that can be collected and key considerations, such as water quality, when assessing options for re-use.

Reusing rainwater harvesting systems can create a variety of economic benefits, as well as reduce the risk of flooding in some areas.

It is more expensive to install rainwater harvesting systems than to install a sewerage system in urban construction.

Rainwater is ideal for many uses, including cooling systems and irrigation, as there is a lower concentration of salts to build up.

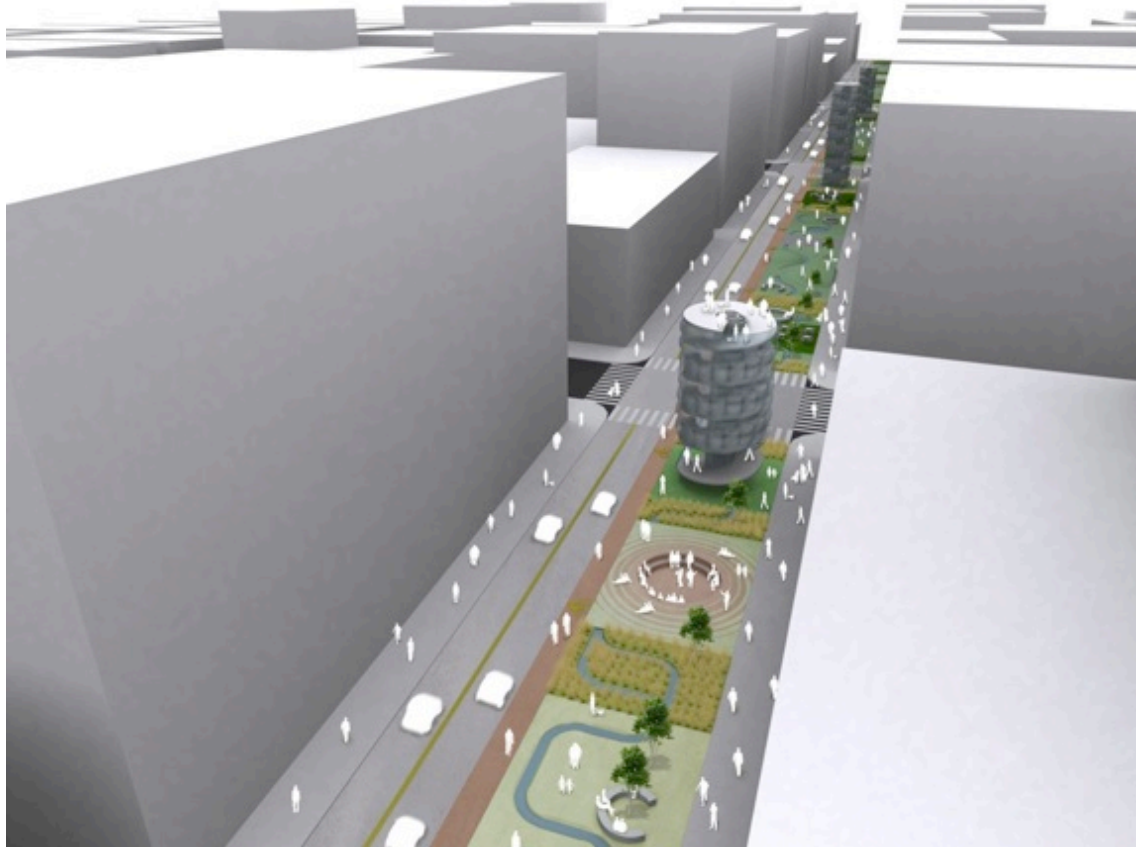
Water reuse requires treatment to a high standard, cost and space requirements will be higher than a system requiring only low quality water. Generally, the systems with the lowest lifecycle costs offer large reduction rates to reduce a constant demand of general quality water. In certain commercial installations, the capital outlay can be as short as 3 years.



Rainwater Harvesting Guidelines By State

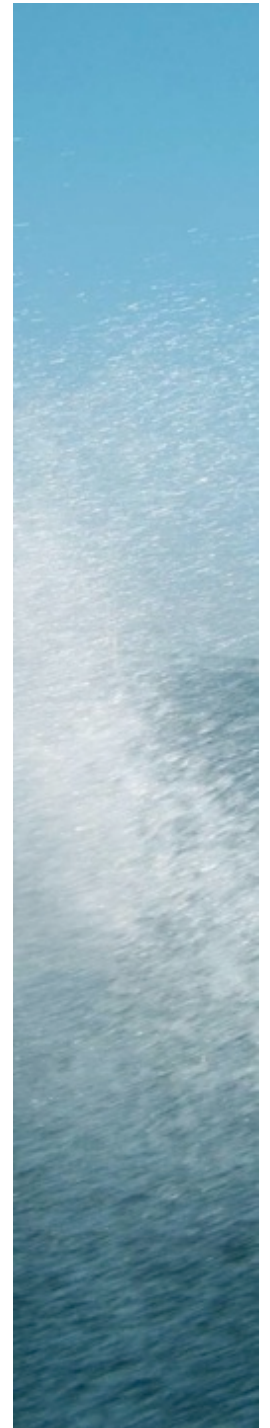


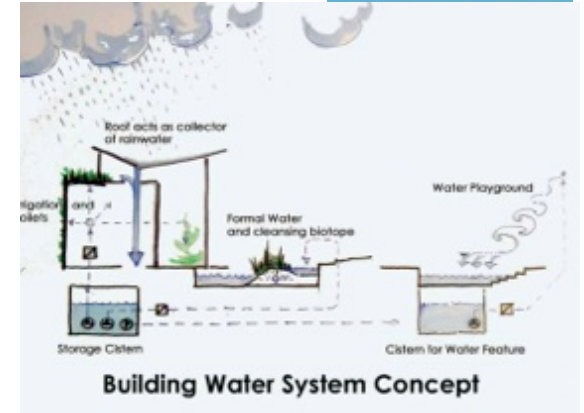
Rainwater Harvesting
Conservation, Credit, Codes, and Cost Literature Review and Case Studies



Eco Boulevard – Urban Lab

Growing Water: <http://www.urbanlab.com/urban/ecoblvd.html>





End Uses:
 Toilet Flushing
 Irrigation
 Water Features - Fountains

**QUEENS BOTANICAL
 GARDENS
 FLUSHING, NEW YORK**

COURTESY: HOK AND ATELIER DREISEITL



Todd Williams, Shooting Star Photography

End uses:

Toilet Flushing: 12 toilets and urinals
Irrigation: Approx. usage variable based on weather

**METRO INTERMODAL
TRANSIT CENTER**
AKRON, OHIO
GPD GROUP





End Uses:

Toilet Flushing: Dual flush toilets—men = 27; women = 47; waterless urinals =14

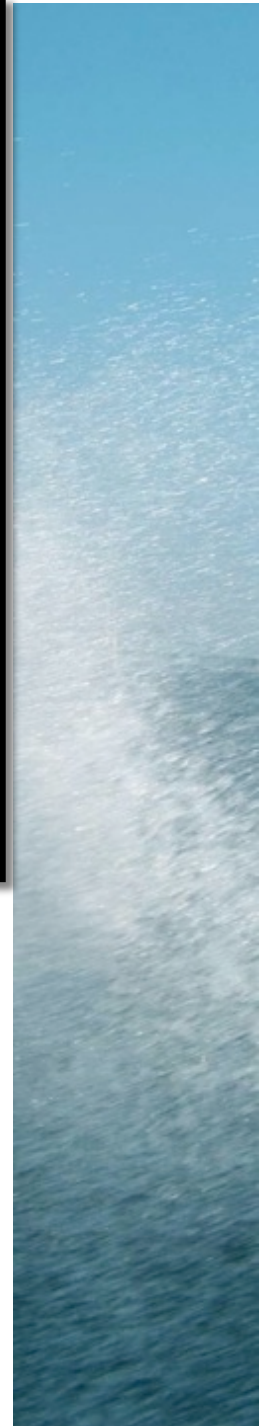
Irrigation: Native & draught-resistant plant species used, minimal irrigation provided.

Water Feature: Rainwater waterfall

**NOAA CENTER FOR WEATHER &
CLIMATE PROTECTION**

COLLEGE PARK, MARYLAND

COURTESY: HOK AND ALAN KATCHMER



Atelier Dreiseitl (Germany, China, US) Mathew & Gosh Architects (India), Perkins+Will (Canada and US), Lake Flato, SmithGroup, Quinn Evans LP3 Architects, AECOM, Integrated Architects, HOK, MSM Architects, M2 Architects, KMD Architects +PLA, GPD Group, VMDO, Waller Todd and Sandler, William McDonough and Associates. USGBC LEED, BREEAM, Living Building Challenge, Green Globes, Passive House Standards. Schools, universities, municipal buildings, animal shelters, low income housing, fire stations, grocery stores, industrial buildings, animal feedlots, offices,

Design For End Use and Reliable Maintenance

www.wiley.com/go/rainwaterharvesting

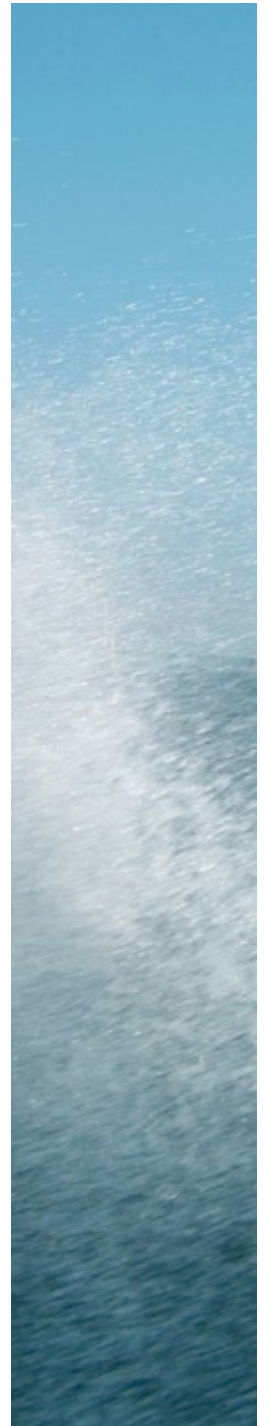


Table 8-1. Water Quality Considerations for Onsite Alternative Water Sources*

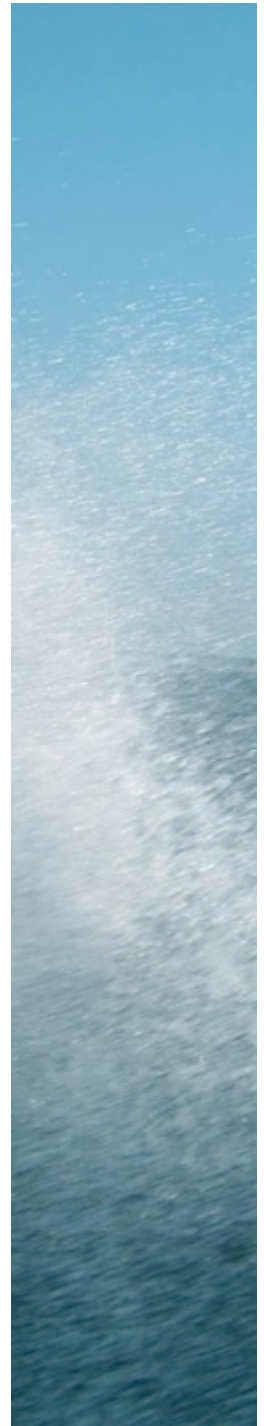
Possible Sources	Level of Water Quality Concern					
	Sediment	Total Dissolved Solids (TDS)	Hardness	Organic Biological Oxygen Demand (BOD)	Pathogens (A)	Other Considerations
Rainwater	Low/Medium	Low	Low	Low	Low	None
Stormwater	High	Depends	Low	Medium	Medium	Pesticides and fertilizers
Air Handling Condensate	Low	Low	Low	Low	Medium	May contain copper when coil cleaned
Cooling Tower Blowdown	Medium	High	High	Medium	Medium	Cooling tower treatment chemicals
Reverse Osmosis and Nanofiltration Reject Water	Low	High	High	Low	Low	High salt content
Gray Water	High	Medium	Medium	High	High	Detergents and bleach
Foundation Drain Water	Low	Depends	Depends	Medium	Medium	Similar to stormwater
<p>Note: The use of single-pass cooling water is also a possible source of clean onsite water, but facility managers should first consider eliminating single-pass cooling because of its major water-wasting potential. For that reason, it is not included in the list.</p> <p>*Key: Low: Low level of concern Medium: Medium level of concern; may need additional treatment depending on end use High: High concentrations possible and additional treatment likely Depends: Dependent upon local conditions (A): Disinfection for pathogens is recommended for all water used indoors for toilet flushing or other uses</p>						

Onsite Alternative Water Sources

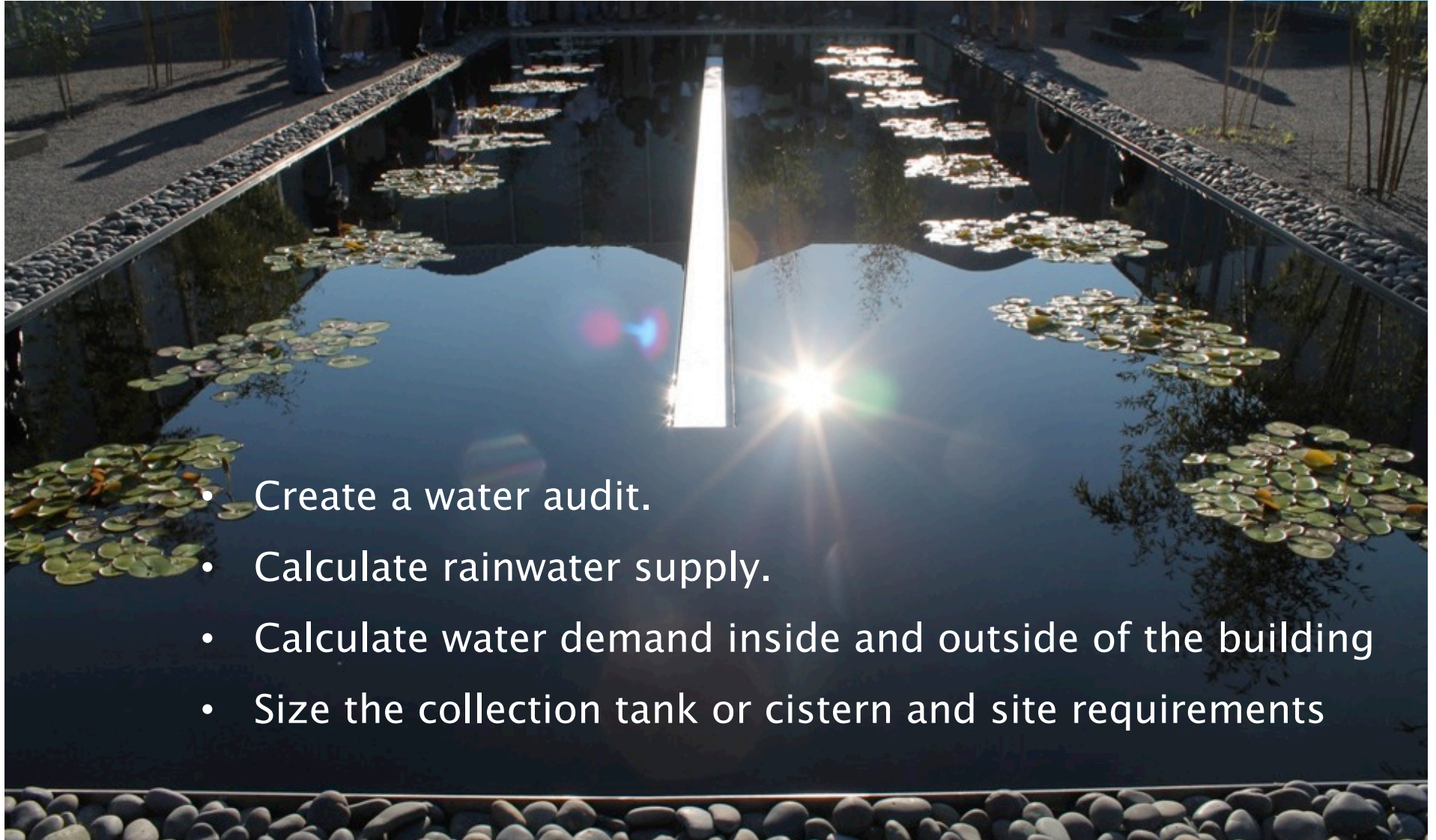
Source for Table 8-1: http://www.epa.gov/watersense/commercial/docs/watersense_at_work/#/261/zoomed

For information on Condensate Collection:

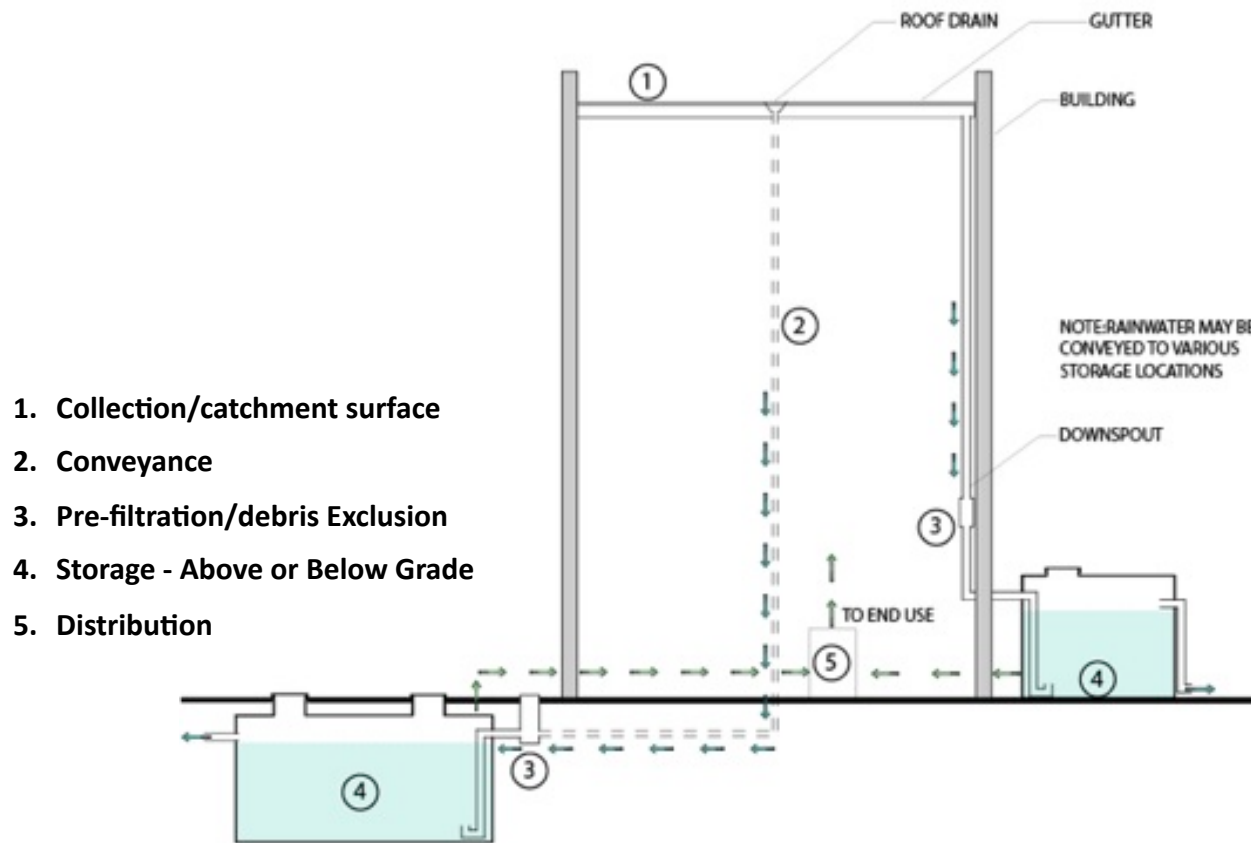
http://www.saws.org/conservation/commercial/Condensate/docs/SACCUManual_20131021.pdf



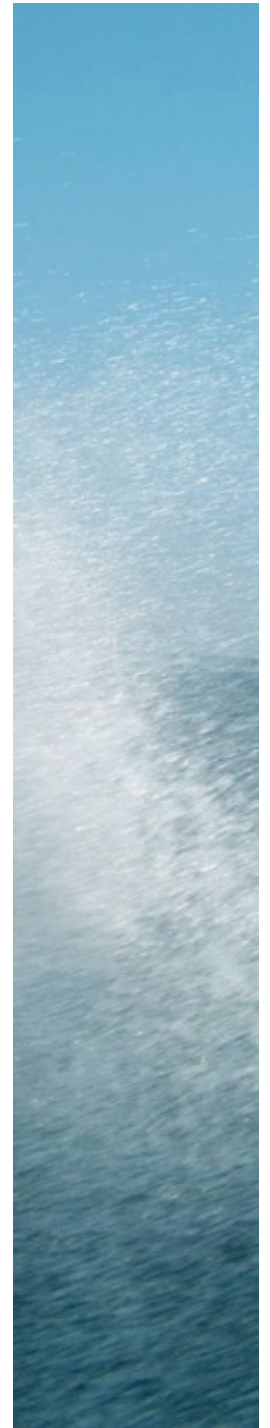
Water Balance Equation (demand = supply)



- Create a water audit.
- Calculate rainwater supply.
- Calculate water demand inside and outside of the building
- Size the collection tank or cistern and site requirements



Key Elements of A Rainwater Collection System



$$V_{\text{SUPPLY}} = A \times P \times C \times 0.623$$

where V_{SUPPLY} = volume of available water (gal)

P = annual precipitation (in)

A = collection surface area (ft²)

C = runoff coefficient (dimensionless)

Note: The value “0.623” is a conversion factor



Collection Formula

NOAA 30 year data on annual rainfall and precipitation easy to find.

$$\text{Cost}_{\text{RWH}} - \text{Cost}_{\text{MW}} = \text{ROI}$$

Where Cost_{RWH} = cost of rainwater harvesting system (\$),
 Cost_{MW} = cost of municipal water over time (\$)

OR

$$\text{Cost}_{\text{RWH}} - \text{Cost}_{\text{MW}} - \text{ED} - \text{PP} - \text{RR} - \text{SI} - \text{HT} - \text{MF} - \text{BA} - \text{MB} = \text{ROI}$$

ED = environmental degradation (\$)

PP = pollution prevention (\$)

RR = river restoration (\$)

SI = stormwater infrastructure (\$)

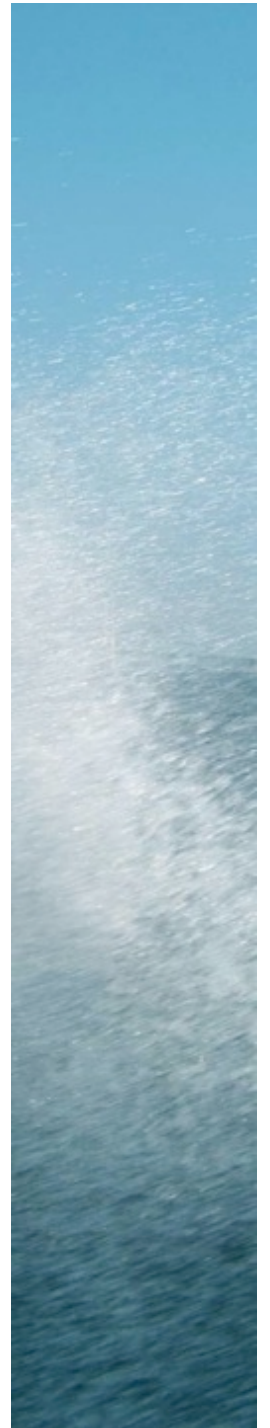
HT = increase in tax rates (\$)

MF = municipal fees (\$)

BA = increase in buildable area (\$)

MB = costs associated with market branding (\$)

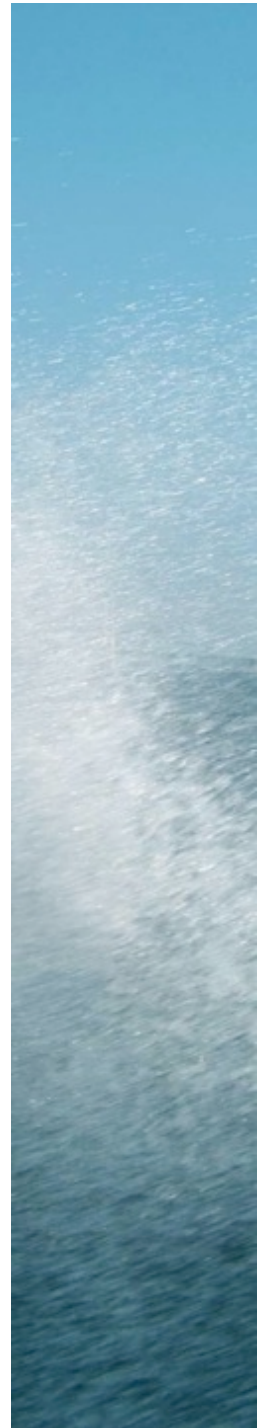
A New Return On Investment



A modern decentralized water infrastructure can include site-collected rainwater, graywater, stormwater, and blackwater systems.

- *These alternative water sources may **never** totally replace centralized systems.*
- They do help manage and store water and treat it to various levels of quality for use in buildings/sites.
- By designing the site and building as a complete system for water storage and use, designers can ***conserve water resources, save energy, and reduce the cost to community treatment facilities.***

Decentralized Water Infrastructures

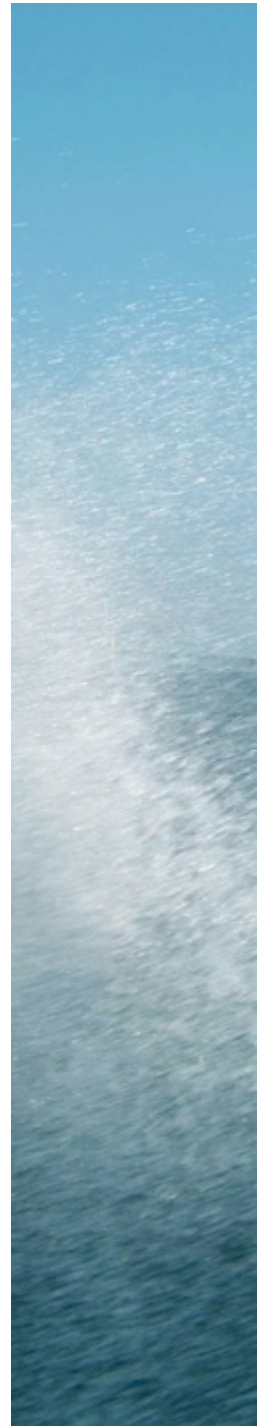


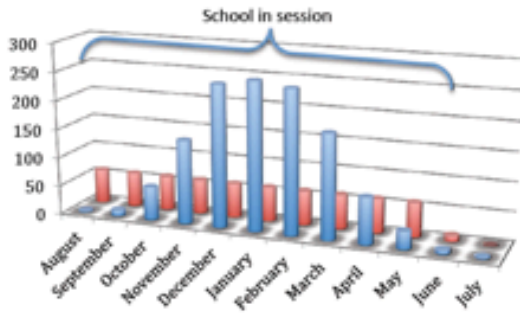
**Table E-26
Modeled Water Use per Student**

End Uses	Unit Measuring Area or Volume of Use	Area or Volume	Unit Measuring Frequency of Use	Frequency of Use	Total gal/student/day
Elementary and Middle Schools					
Irrigation ¹	irrigated acres/student	0.004	gal/acre/school day	varies	24.3
Toilet ²	gpf	3.00	visits/day	2.11	6.3
Urinal ³	gpf	1.60	visits/day	1.01	1.6
Faucet Use ⁴	gpf	0.11	flushes/day	3.12	0.3
Kitchen	gal/meal	9.91 ⁵	meals/day/student	0.4 ⁶	4.0
Other ⁷					2.0
Total					38.5
High Schools					
Irrigation ¹	irrigated acres/student	0.008	gal/acre/school day	varies	55.6
Toilet ²	gpf	3.00	visits/day	2.11	6.3
Urinal ³	gpf	1.60	visits/day	1.01	1.6
Faucet Use ⁴	gpf	0.11	flushes/day	3.12	0.3
Kitchen	gal/meal	9.91 ⁵	meals/day/student	0.4 ⁶	4.0
Other ⁷					4.0
Total					71.8
Other Schools					
Irrigation	irrigated acres/student	0.002	gal/acre/school day	varies	6.9
Toilet ⁸	gpf	3.00	visits/day	1.03	3.1
Urinal ⁹	gpf	1.60	visits/day	0.39	0.6
Faucet Use	gpf	0.11	min/day	0.96	0.1
Kitchen	gal/meal	9.91	meals/day/student	0.4	4.0
Other					1.0
Total					15.7

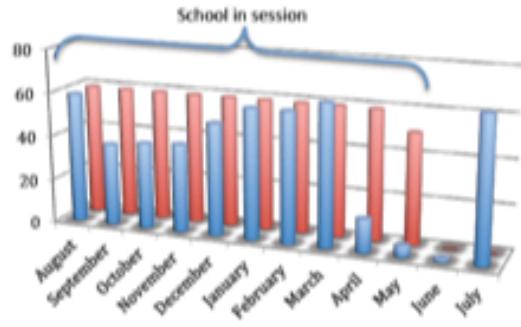
Water Use In Schools

PAC InstituteSource for many demand tables http://www.pacinst.org/wp-content/uploads/sites/21/2013/02/appendix_e3.pdf

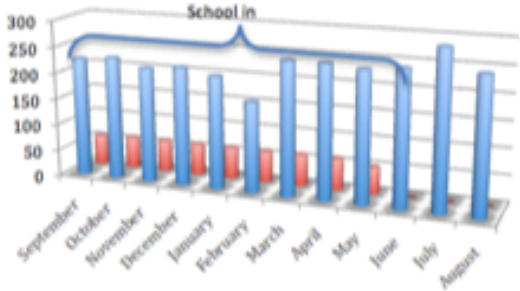




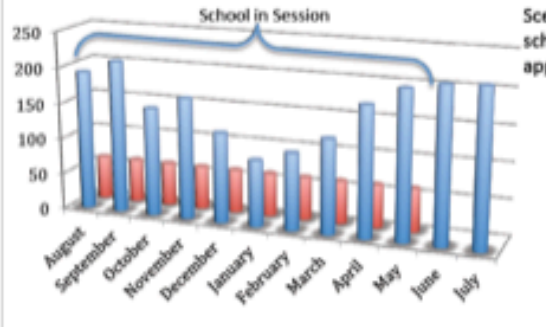
San Francisco



Phoenix

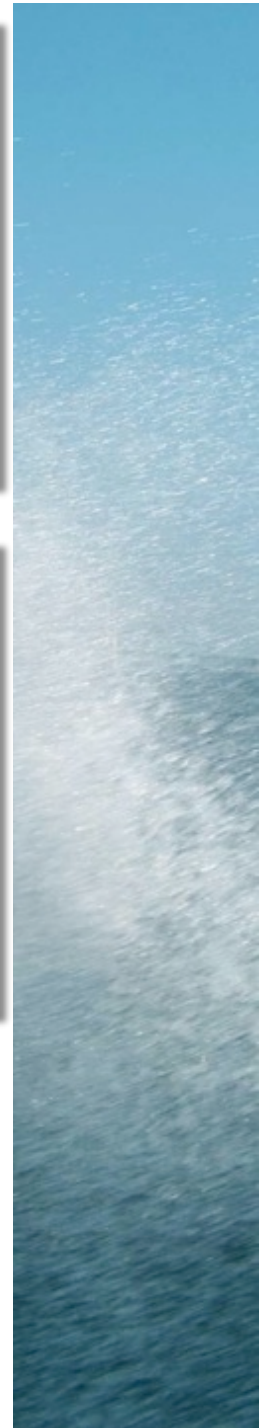


New York



Ann Arbor

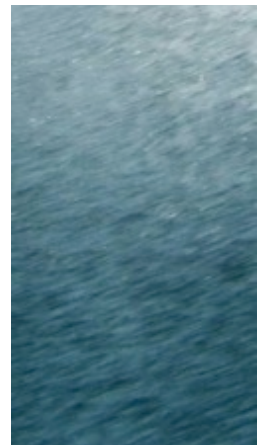
Rainwater For Similar Schools In Different Climate Zones



City	Average Annual Rainfall (inches)	Potential Annual Collection of <u>Rainwater</u> from <u>Roof</u> (gallons)	Annual Water <u>Demand</u> for <u>Toilet Flushing</u> (gallons) in <u>Typical</u> Middle School (average of 10-month school year)	Potential Annual Surplus (gallons)
Atlanta	49.71	3,038,091.27	590,000	2,448,091.27
Ann Arbor	32.81	2,005,225.803	590,000	1,415,225.80
New York	47	2,872,466.10	590,000	2,282,466.1
Phoenix	8.22	502,375.99	590,000	-87,624.01
San Francisco	20.69	1,264,496.25	590,000	674,496.25

Example: Comparison of Rainwater Collection in Five Schools

Less than a 100,000 gallon deficit. Potentially could be made up with condensate or another source such as gray water use.





Fowler Drive Elementary – Atlanta, Georgia

Even with a smaller roof than hypothetical examples, two 10,000 gallon tanks support the needs of the school with a four year payback!

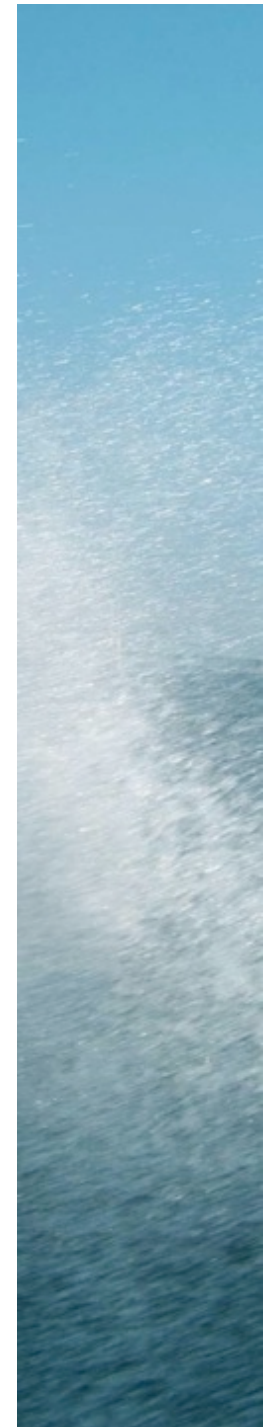
Table 1: Suggested Maintenance Procedures for Rainwater Harvesting Systems

Activity	Frequency
Keep gutters and downspouts free of leaves and other debris	O: Twice a year
Inspect and clean pre-screening, inlet filtration devices, and first flush diverters	O: Four times a year
Inspect and clean storage tank lids, paying special attention to vents and screens on inflow and outflow spigots. Check mosquito screens and patch holes or gaps immediately	O: Once a year
Inspect condition of overflow pipes, overflow filter path, and/or secondary runoff reduction practices	O: Once a year
Inspect tank for sediment buildup	I: Every third year
Clear overhanging vegetation and trees over roof surface	I: Every third year
Check integrity of backflow preventer (unless required more frequently by state or local regulations)	I: Every third year
Inspect structural integrity of tank, pump, pipe, and electrical system	I: Every third year
Replace damaged or defective system components	I: Every third year
Key: O = Owner; I = qualified third party Inspector	

Source: Virginia DCR Stormwater Design Specification No. 6 – Rainwater Harvesting

Maintenance

<http://water.epa.gov/polwaste/nps/upload/rainharvesting.pdf>

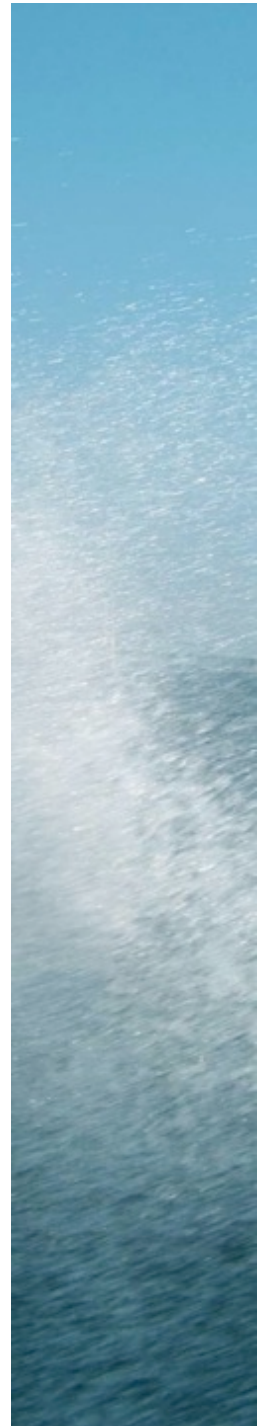


“When you are looking at setting standards for water quality you need to think about two things.

Obviously the major thing is to protect the health and safety of the end user. ... and You need to take into account the reactivity and the quality of the water so as to protect the end use device. . . .It is incumbent on us to get it right.”

*Shawn Martin,
Director of Plumbing, Mechanical and Gas (PMG) activities in the Government Relations Group,
Plumbing and Mechanical Code Developer for the International Code Council (ICC)*

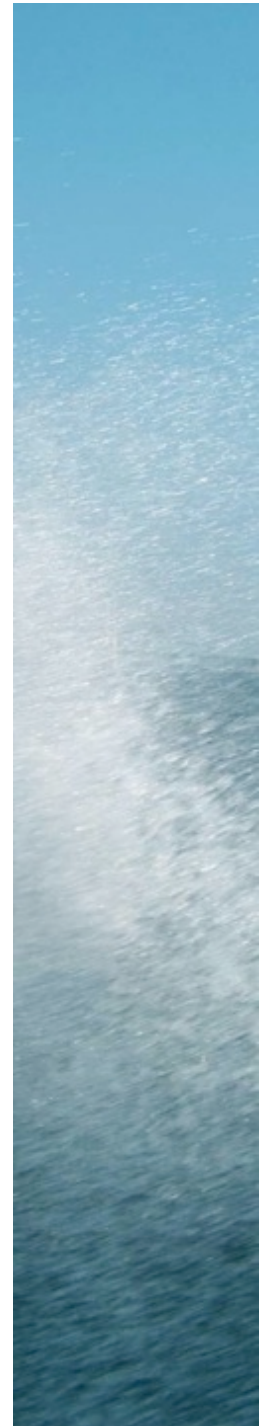
Pollution Impact



Rooftop runoff, often referred to as ‘clean runoff’ may contain pollutants, but “generally in lower concentrations and absent many of the toxics present in runoff from other impervious surfaces.” – U.S. EPA Municipal Handbook on Rainwater Harvesting Policies



Pollutants

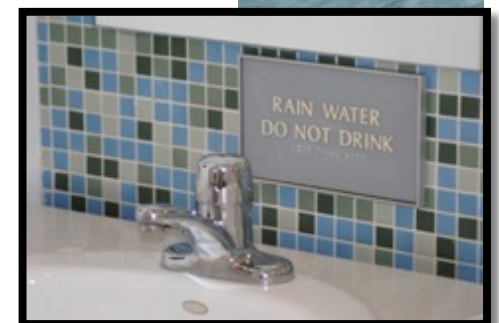


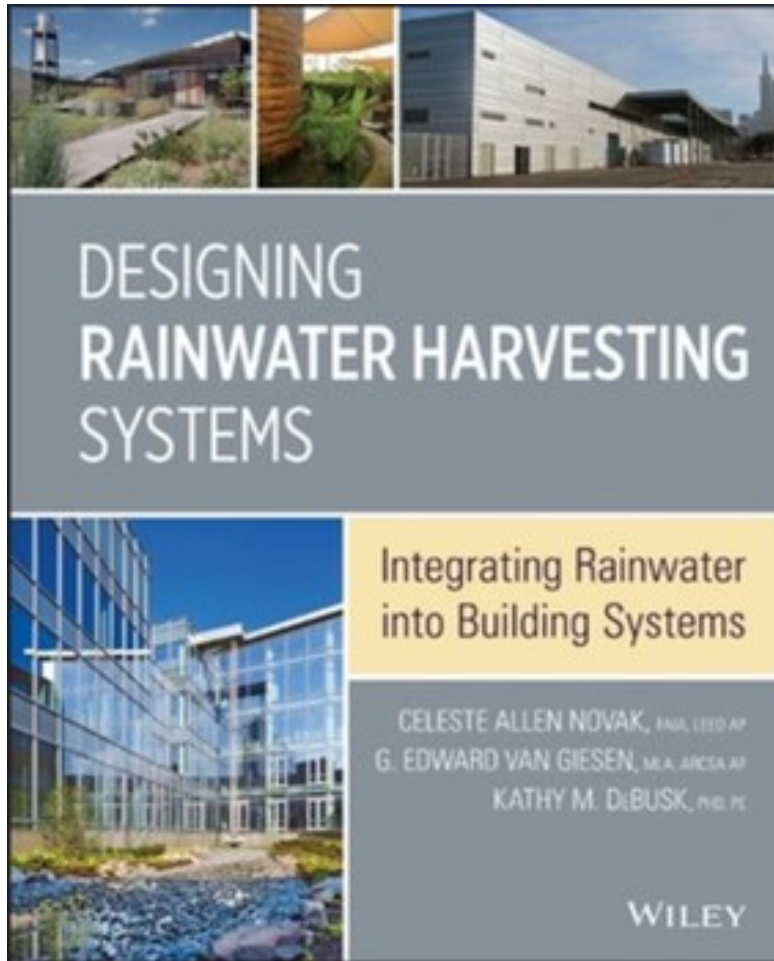
1. Adopt stormwater pollution control standards that require on-site volume retention and allow rainwater harvesting and reuse, with appropriate health and safety standards, to be used to meet that requirement, thereby creating an incentive for on-site capture.
2. Adopt standards that require or promote rainwater harvesting and/or water efficiency
3. Review building, health, and plumbing codes for barriers to capturing or reusing rainwater
4. Provide incentives for decreasing stormwater runoff and promoting water conservation
5. Require use of rainwater harvesting and reuse on all public properties

Acceptance

[Capturing Rainwater from Rooftops: An Efficient Water Resource Management Strategy that Increases Supply and Reduces Pollution](http://www.nrdc.org/water/files/rooftoprainwatercapture.pdf)

www.nrdc.org/water/files/rooftoprainwatercapture.pdf





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Resources

