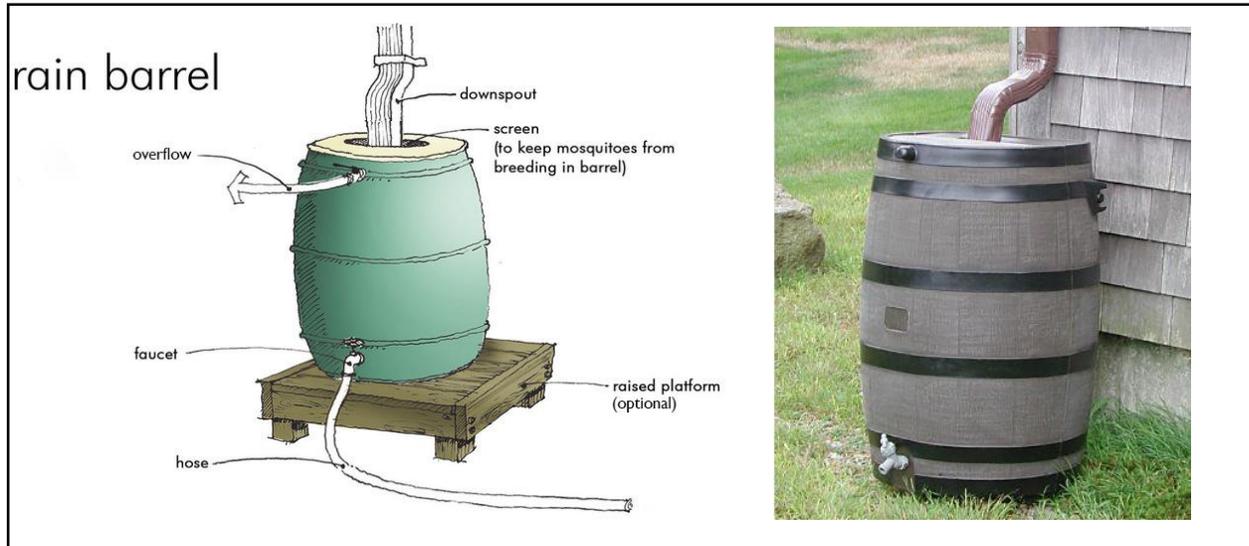


5.1 Rainwater Harvesting: Rain Barrels and Cisterns



Cisterns and Rain Barrels

Water is a valuable resource that is taken for granted most of the time. This approach to stormwater management is geared towards the homeowner that is interested in reusing stormwater for irrigation, washing cars, along with a variety of other grey water applications. Rain barrels have gained in popularity over the last few years and are available at most local home improvement stores. They provide flexibility in regards to capacity and set up. Several rain barrels can be connected in series to provide additional storage as needed. Cisterns are less flexible in regards to layout but offer larger capacity to store rainwater and can typically be buried underground or designed to blend in with the landscaping.

Advantages:

Rain barrels and cisterns not only help reduce stormwater runoff but can offer irrigation to landscapes throughout times of drought. Cisterns can be gravity fed or enhanced with a booster pump to deliver irrigation to larger areas. This SWMF is a good option if the soils on your property do not drain very well or if you are in a location where the groundwater is close to the surface.

Limitations:

Limitations to rain barrels are generally associated with storage capacity. The typical volume of a rain barrel is 55 gallons, therefore several barrels will be needed to provide adequate stormwater mitigation. Additionally, if the barrels are left open to the environment, they can become mosquito breeding grounds. Therefore, if rain barrels are the preferred mitigation technique, care should be taken to ensure mosquitoes do not have access to the stored water by installing screens on all the openings.

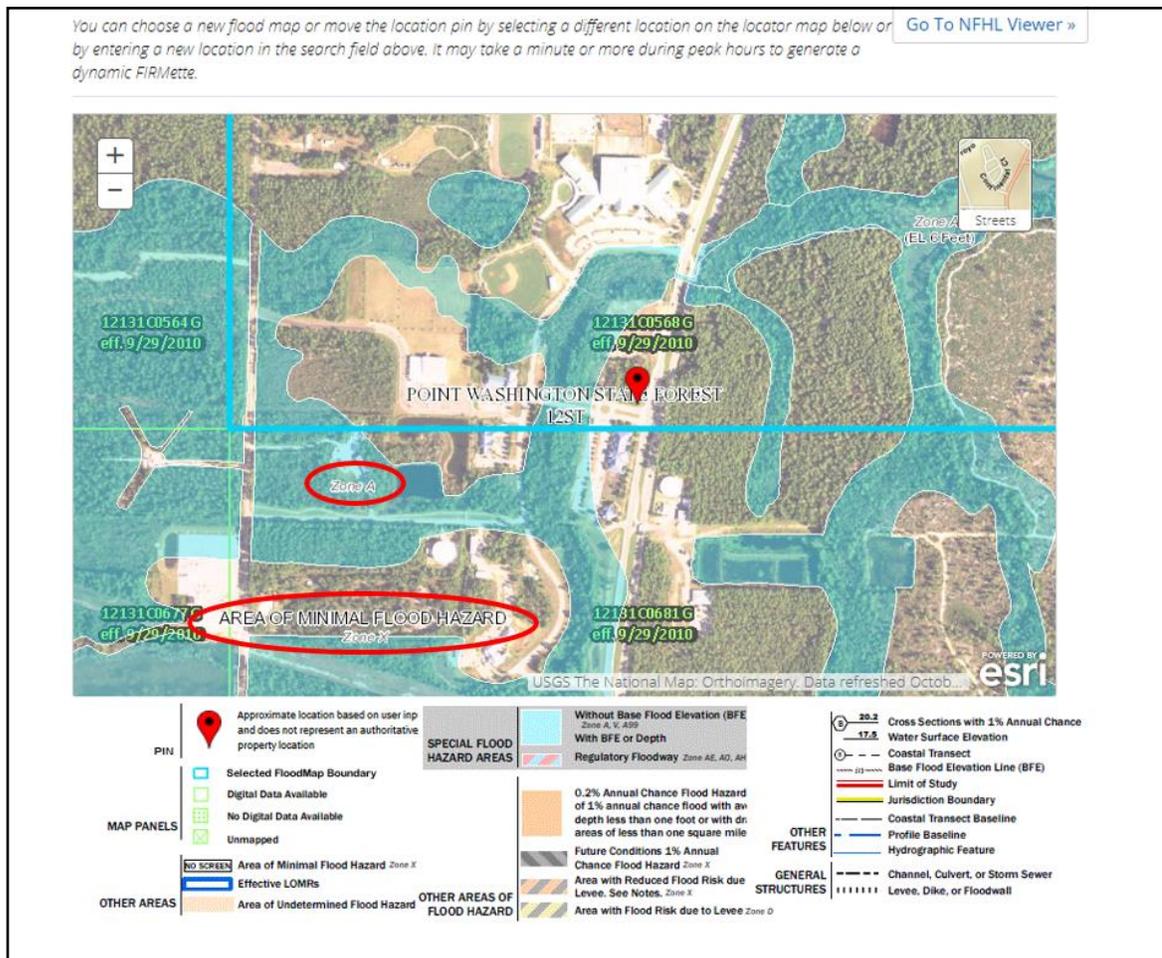
Cisterns are larger in size and can provide a storage capacity of up to several 1,000 gallons. Cisterns can be placed above or below ground. Limitations that homeowners encounter when employing cisterns are space and visual aesthetics. Regulatory requirements provided in the **LDC Chapter 4.09.15 Tanks** states that if a cistern is to be installed in a flood hazard area or will be installed below the SHGW than it will need to be anchored to prevent flotation, collapse, or lateral movement.

important

Cisterns will not be permitted in areas designated by FEMA as Zone V. To check your flood zone designation visit the FEMA Flood Map Service Center at <https://msc.fema.gov/portal/home> and enter your address in the “search” box.

The screenshot shows the FEMA Flood Map Service Center (MSC) website. The browser address bar displays <https://msc.fema.gov/portal/home>. The page features the FEMA logo and a navigation menu on the left with options: Navigation, Search, and Languages. Below the menu are links for MSC Home, MSC Search by Address, MSC Search All Products, MSC Products and Tools (including Hazus, LOMC Batch Files, and Product Availability), MSC Frequently Asked Questions (FAQs), MSC Email Subscriptions, and Contact MSC Help. The main content area is titled "FEMA Flood Map Service Center: Welcome!" and includes a search prompt "Looking for a Flood Map?". Below this is a search box with the placeholder text "Enter an address, a place, or longitude/latitude coordinates" and a "Search" button. To the right of the search box is a small map showing flood zones. Further down, there is a section "About Flood Map Service Center" which states that the MSC is the official public source for flood hazard information produced in support of the National Flood Insurance Program (NFIP). It also mentions that FEMA flood maps are continually updated and provides a link to the "Flood Hazard Mapping Updates Overview Fact Sheet". The "Announcements" section contains two notices: one regarding a delay in email subscription results and another about enhancements to dynamic maps.

The flood zone designations will be listed throughout the map.



Design Considerations:

- When determining if rain barrels or cisterns are a viable option for stormwater mitigation first calculate the required storage / treatment volume using the calculation provided in **Section 3**.
- Once you have determined the required volume, you will want to identify the optimal placement for the rain barrels or cistern.
- Rain barrels and cisterns are generally very easy to connect to existing roof gutters or other impervious areas and require very little maintenance.
- The entire set up consists of a closed container with an opening at the top that is placed under a downspout or plumbed into a rainwater collection system; a spigot is placed near the bottom of the barrel to allow the stored water to be conveyed through either a hose, pump, or watering can.
- All rain barrels should be fitted with overflow piping that will ensure that excess water is not allowed to infiltrate the soil around the foundation of a structure, such as your home.
- A typical rule of thumb for sizing a rain barrel system is for every inch of rain that falls on 1,000 square feet, approximately 600 gallons of water should be collected.⁷

⁷ City of Murfreesboro Tennessee. Rain Harvesting. Structural Stormwater Control. 2008. <http://www.murfreesborotn.gov/DocumentCenter/View/2761/Rain-Harvesting-TanksBarrels-2226-?bidId=>

- Additionally, opaque rain barrels and cisterns are recommended to keep algae from growing inside the container.

Rain Barrel Example:



Design Steps - Example:

1. First, determine the required storage treatment volume, similar to the example presented in **Section 3**.

<i>Treatment Volume Criteria</i>	<i>= Total Required Stormwater Volume (ft³)</i>
<i>Volume of 1/2 inch of rainfall over the total impervious area</i>	<i>= 421 ft³</i>

2. Then calculate how much volume a rain barrel can hold in cubic feet (ft³); for example if you install rain barrels that can hold 55 gallons (gal) the calculation would be as follows:

<i>Volume of Rain Barrel (gal)</i>	<i>*</i>	<i>Conversion from Gallons (gal) to Cubic Feet (ft³)</i>	<i>= Volume of Rain Barrel (ft³)</i>
<i>55 gal</i>	<i>*</i>	$\frac{1 \text{ ft}^3}{7.48 \text{ gal}}$	<i>= 7.35 ft³</i>

3. Determine how many rain barrels you will need by dividing the required storage by the volume of the rain barrel or cistern. If you install rain barrels that can hold 55 gallons the calculation would be as follows:

<i>Required Storage Volume</i>	<i>= Quantity of Rain Barrels Required</i>
$\frac{421 \text{ ft}^3}{7.35 \text{ ft}^3}$	<i>= 57.3</i>

Always round up to the next number, so you would need to buy 58 rain barrels. In this case, the amount of rain barrels needed would take up a lot of space to hold the required volume.

Let us look at a cistern with a 3,000-gallon capacity:

1. First determine how much volume in square feet the cistern can hold:

<i>Volume of Cistern (gal)</i>	<i>Conversion from gallons (gal) to cubic feet (ft³)</i>	<i>Volume of Cistern (ft³)</i>
3,000 gal	* $\frac{1 \text{ ft}^3}{7.48 \text{ gal}}$	= 401 ft ³

2. Then determine how many cisterns you will need:

<i>Required Storage Volume Capacity of the Rain Barrel</i>	<i>Quantity of Cisterns Required</i>
$\frac{421 \text{ ft}^3}{401 \text{ ft}^3}$	= 1.04

*Always round up to the next number, so you would need to buy two cisterns to accommodate 421 ft³. Installing one cistern and a few rain barrels would be a good option since you need just a little bit more capacity than the one cistern can provide. Cisterns come in a variety of shapes. As a general reference, a 3,000-gallon cistern is 8 feet in diameter and 8 feet in height.

To calculate how many rain barrels you would need to hold the extra stormwater you would do the following:

3. First determine how much volume capacity you will need after installing the 3,000 gallon cistern:

<i>Total Required Stormwater Volume (ft³)</i>	<i>-</i>	<i>Volume of Stormwater Collected in Cistern (ft³)</i>	<i>=</i>	<i>Stormwater Volume For Rain Barrels (ft³)</i>
421 ft ³	-	401 ft ³	=	20 ft ³

4. Then determine how many rain barrels you will need:

<i>Required Storage Volume Capacity of one Rain Barrel</i>	<i>Quantity of Rain Barrels Required</i>
$\frac{20 \text{ ft}^3}{7.35 \text{ ft}^3}$	= 2.72

Always round up to the next number, so you would need to buy three rain barrels. One cistern and three rain barrels would provide the correct amount of stormwater storage.

Another thing to consider is how much rainfall you can collect from your rooftop. The following calculations will assist you in determining the volume you can anticipate for different storm events.

1. Determine the area of your roof (keep in mind that a typical residential structure has an eave that extends approximately 1.5 feet beyond the exterior walls, therefore if you simply take the square footage of your structure you could be underestimating the volume that the rain barrel system will collect). For this example, we will use a surface area of 2,200 ft² and the one-half inch criteria presented in this technical manual.

<i>Rainfall (in)</i>	<i>Area of Roof (ft²)</i>
0.5 in	2,200 ft ²

2. Convert rainfall from inches to feet.

<i>Convert Inches (in) of Rainfall To Feet (ft) of Rainfall</i>		
0.5 in	* $\frac{1 \text{ ft}}{12 \text{ in}}$	= 0.041 ft

3. Multiply the area of the roof by the rainfall to determine the volume of rainfall anticipated from the design storm.

<i>Area of Roof (ft²) * Rainfall (ft)</i>	<i>= Volume Collected From Roof (ft³)</i>
2,200 ft ² * 0.041 ft	= 90 ft ³

4. Your roof will capture 90 ft³ of rainfall from a 2,200 ft² roof during a storm that produces one-half inch of rainfall. Now we can determine how many rain barrels we will need if we were to store all of the rainfall by converting the volume back to gallons.

<i>Volume Collected From Roof (ft³)</i>	<i>* Convert Cubic Feet (ft³) to Gallons (gal)</i>	<i>= Total Gallons Collected for a storm producing ½ in of rainfall</i>
90 ft ³	$\frac{7.48 \text{ gal}}{1 \text{ ft}^3}$	= 673 gallons

As you can see, your roof can collect a lot of rainwater. The volume collected from the rooftop of your home will depend on the approximate square feet of the roof and the rain event. The anticipated precipitation (in inches) associated with different storm events are provided in **Appendix C**.

Refer to Calculation Sheet 5.1 at the end of this section for assistance in designing rain barrels or cisterns.

Operation and Maintenance:

Operation and maintenance of rain barrels and cisterns is relatively simple. You will need to visually inspect piping associated with inflow and outflow to ensure that there are not any clogs and water is still being collected, stored, and delivered. The best time to inspect piping delivering water to the rain barrel is while it is raining. All other components can be inspected anytime. Additionally, you will need to ensure that fittings are not leaking. Check screens for holes or tears to ensure that mosquitos do not have access to the water stored in the rain barrels or cisterns.

Cistern Example:



Calculation Sheet 5.1 - Rain Barrel Design:

Only Enter Information In To The Green Boxes - All Other Boxes Are Automatically Calculated

Low Impact Development Calculation Sheet			
Owner			Line 1
Address			Line 2
Phone			Line 3
E-mail			Line 4
Parcel Identification Number			Line 5
Total Proposed Disturbed Area	_____ ac		Line 6
Proposed Impervious Area Totals			
House	_____	ft ²	Line 7
Detached Garage	_____	ft ²	Line 8
Shed	_____	ft ²	Line 9
Driveway	_____	ft ²	Line 10
Patio / Porch / Deck	_____	ft ²	Line 11
Pool	_____	ft ²	Line 12
Misc Description:	_____	ft ²	Line 13
Is Your Property In The Following Locations:			
		Yes	No
ICPAL	If "yes" see section 3.4	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Dune Lake	If "yes" see section 3.5	<input type="checkbox"/>	<input type="checkbox"/>
Near a Mosquito Control Ditch	If "yes" see section 3.6	<input type="checkbox"/>	<input type="checkbox"/>
Area Totals			
Total Impervious Area	_____	ft ²	Line 14
Total Impervious Area (acres)	_____	ac	Line 15
Total Impervious Area (acres)	= Total Area (ft ²) * (1 acre/ 43,560 ft ²)		
Total Pervious Area	_____	ac	Line 16
Total Pervious Area (ft ²)	_____	ft ²	Line 17
Total Pervious Area (acres) = Total Area (acres) - Total Impervious Area (acres)			
Next Determine the Volume Required Per the LDC Section 5.06.00			
Total Property (square feet)	_____	ft ²	Line 18

Soils Characteristics			
Depth to Seasonal High Groundwater Table	<input style="width: 100%;" type="text"/>	ft below ground surface	Line 19
Predominant Soil Type			
Predominant Soil Type	<input style="width: 100%;" type="text"/>	Value Taken From USGS Soils Survey	Line 20
Infiltration Actual K_{sat}	<input style="width: 100%;" type="text"/>	in/hr Provided in Table 3	Line 21
Design Infiltration Design K_{sat}	<input style="width: 100%;" type="text"/>	in/hr	Line 22

Stormwater Volume Requirements			
<u>0.5 in</u> Rainfall Over Disturbed Area	<input style="width: 100%;" type="text"/>	ft^3	Line 23
<u>1 in</u> Runoff Over Proposed Impervious Surface	<input style="width: 100%;" type="text"/>	ft^3	Line 24
Attenuation Volume	<input style="width: 100%;" type="text"/>	ft^3	Line 25
Required Retention Volume	<input style="width: 100%; background-color: #e0f0ff;" type="text"/>	ft^3	Line 26
Find Largest Value Between Line 23, 24, and 25 And Enter The Value On Line 26			

*****Special Circumstances Only - Verify Your Location****

Section 3.4 Stormwater Volume Requirements for ICPAL			
<u>0.5 in</u> Rainfall Over Disturbed Area	<input style="width: 100%;" type="text"/>	ft^3	Line 27
<u>1 in</u> Runoff Over Proposed Impervious Surface	<input style="width: 100%;" type="text"/>	ft^3	Line 28
Attenuation Volume	<input style="width: 100%;" type="text"/>	ft^3	Line 29
Required Retention Volume	<input style="width: 100%; background-color: #e0f0ff;" type="text"/>	ft^3	Line 30
Find Largest Value Between Line 27, 28, and 29 And Enter The Value On Line 30			

Section 3.5 Stormwater Volume Requirements for Dune Lake			
<u>0.5 in</u> Rainfall Over Disturbed Area	<input style="width: 100%;" type="text"/>	ft^3	Line 31
<u>1 in</u> Runoff Over Proposed Impervious Surface	<input style="width: 100%;" type="text"/>	ft^3	Line 32
Attenuation Volume	<input style="width: 100%;" type="text"/>	ft^3	Line 33
Required Retention Volume	<input style="width: 100%; background-color: #e0f0ff;" type="text"/>	ft^3	Line 34
Find Largest Value Between Line 31, 32, and 33 And Enter The Value On Line 34			

Section 3.6 Stormwater Volume Requirements for Mosquito Control Ditch			
<u>0.5 in</u> Rainfall Over Disturbed Area	<input style="width: 100%;" type="text"/>	ft^3	Line 35
<u>1 in</u> Runoff Over Proposed Impervious Surface	<input style="width: 100%;" type="text"/>	ft^3	Line 36
Attenuation Volume	<input style="width: 100%;" type="text"/>	ft^3	Line 37
Required Retention Volume	<input style="width: 100%; background-color: #e0f0ff;" type="text"/>	ft^3	Line 38
Find Largest Value Between Line 35, 36, and 37 And Enter The Value On Line 38			

Table 3. NRCS Soil Data

Map Unit Symbol	Map Unit Name	HSG	SHGW Elevation (SHGW)	High Water Season	Permeability Rate (Ksat)
5	Chiple sand, 5 to 8 % slopes	A	-2 feet	Dec - Apr	6 in/hr
8	Dorovan-Pamlico association, frequently flooded	B/D	0 (at surface)	Jan – Dec	0.6 in/hr
12	Foxworth sand, 0 to 5 percent slopes	A	-3.5 feet	Jun – Oct	20 in/hr
16	Kureb sand, 0 to 8 percent slopes	A	-5 feet	----	6 in/hr
17	Lakeland sand, 0 to 5 percent slopes	A	-5 feet	----	6 in/hr
18	Lakeland sand, 5 to 12 percent slopes	A	-5 feet	----	6 in/hr
19	Lakeland sand, 12 to 30 percent slopes	A	-5 feet	----	6 in/hr
21	Leon sand, 0 to 2 percent slopes	A/D	0 (at surface)	Jun – Feb	0.6 in/hr
27	Rutlege fine sand, 0 to 2 percent slopes	A/D	0 (at surface)	Dec – May	6 in/hr
30	Tifton fine sandy loam, 5 to 8 percent slopes	B	-3.5 feet	Jan – Feb	0.6 in/hr
36	Pits	-	On-site test	On-site test	On-site test
45	Dirego muck, frequently flooded	A/D	0 (at surface)	Jan – Dec	6 in/hr
49	Eglin sand, 0 to 5 percent slopes	A	-5 feet	----	6 in/hr
50	Mandarin sand, 0 to 2 percent slopes	A	-1.5 feet	Jun – Dec	0.6 in/hr
51	Bigbee loamy sand, 0 to 5 percent slopes, occasionally flooded	A	-3.5 feet	Jan – Mar	6 in/hr
53	Arents, 2 to 8 percent slopes	A	-5 feet	----	20 in/hr
54	Newhan-Corolla sands, rolling	A	-5 feet	----	20 in/hr
55	Beaches	-	0 (at surface)	----	0 in/hr
56	Kureb sand, hilly	A	-5 feet	----	6 in/hr
57	Hurricane sand, 0 to 5 percent slopes	A/D	-2 feet	Nov – Apr	6 in/hr
58	Duckston muck, frequently flooded	A/D	0 (at surface)	Jan – Dec	6 in/hr
62	Resota sand, 0 to 5 percent slopes	A	-3.5 feet	Dec – Apr	20 in/hr
63	Pickney sand, depressional	A/D	0 (at surface)	Nov – Apr	6 in/hr
64	Pamlico muck	A/D	0 (at surface)	Dec – May	0.6 in/hr
69	Floralo loamy fine sand, 2 to 5 percent slopes	C	-1.5 feet	Dec – Mar	0.06 in/hr
99	Water	-	-	-	-
100	Waters of Gulf of Mexico	-	-	-	-

Site Characteristics		
Total Disturbed Area	_____ ft ²	Line 1
Impervious Area	_____ ft ²	Line 2
Impervious Surface Ratio (ISR)	_____	Line 3
Soil Characteristics		
Soil Type - Refer to Section 2.4		Line 4
Rainfall Intensity	_____ 0.43 in/hr	Line 5
Infiltration Rate - Refer to Table 3	_____ in/hr	Line 6
Design Infiltration Rate (Divide By 2)	_____ in/hr	Line 7
Rainfall Depth	_____ 8.73 in	Line 8
Reduced Rainfall Depth	_____ in	Line 9
Attenuation Calculation		
Design Factor - Choose One Based On The ISR Calculated In Line 3	_____	Line 10
ISR Less Than 0.4	1	
ISR Between 0.4 and 0.7	1.2	
ISR Greater Than 0.7	1.4	
Design Rainfall Depth	_____ in	Line 11
Design Rainfall Depth (Conversion)	_____ ft	Line 12
Required Storage Volume	_____ ft ³	Line 13

Site Characteristics		
Total Disturbed Area	_____ ft ²	Line 1
Impervious Area	_____ ft ²	Line 2
Impervious Surface Ratio (ISR)	_____	Line 3
Soil Characteristics		
Soil Type - Refer to Section 2.4	_____	Line 4
Rainfall Intensity	_____ 0.61 in/hr	Line 5
Infiltration Rate - Refer to Table 3	_____ in/hr	Line 6
Design Infiltration Rate (Divide By 2)	_____ in/hr	Line 7
Rainfall Depth	_____ 14.7 in	Line 8
Reduced Rainfall Depth	_____ in	Line 9
Attenuation Calculation		
Design Factor - Choose One Based On The ISR Calculated In Line 3	_____	Line 10
ISR Less Than 0.4	1	
ISR Between 0.4 and 0.7	1.2	
ISR Greater Than 0.7	1.4	
Design Rainfall Depth	_____ in	Line 11
Design Rainfall Depth (Conversion)	_____ ft	Line 12
Required Storage Volume	_____ ft ³	Line 13

*****Only Enter Information In To The Green Boxes - All Other Boxes Are Automatically Calculated*****

Site Characteristics

Total Disturbed Area	_____	ft ²	Line 1
Depth To SHGW	_____	ft	Line 2
Infiltration	_____	in/hr	Line 3

Treatment Volume

Design Volume (largest value from Site Characteristics sheet)	_____	ft ³	Line 4
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Rain Barrel Design

Volume of Rain Barrel	_____	Gallons	Line 5
	_____	ft ³	Line 6
Number of Rain Barrels Required	_____		Line 7

Amount of Rainfall Collected From Your Roof

Area of House	_____	ft ²	Line 8
Design Storm	_____	in	Line 9
	_____	ft	Line 10
Rainfall Volume	_____	ft ³	Line 11

Rain Barrel Back Calculations - Multiple LID Applications

Number of Rain Barrels /Cisterns	_____		Line 12
Volume of Chosen Rain Barrel / Cistern	_____	gallons	Line 13
Total Treatment / Storage	_____	ft ³	Line 14



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