A.8 CISTERNS AND RAIN BARRELS

Location: Shavano Park Fire Station, San Antonio, Texas.

Figure A.8-1. Corrugated metal cistern.

A.8.1 DESIGN

The design of a cistern or rain barrel can be broken into an eight-step process, as Table A.8-1 describes.

Table A.8-1. Cistern/Rain barrel iterative design step process

Design step		Design component/ consideration	General specification
1	**Determine Integrated Management Practice (IMP) Treatment Volume**	Runoff calculations	Per chapter 2 of the County SUSMP, the volume of the 24-hour 85th percentile storm is required for the water quality treatment method.
2	**Determine IMP Configuration (A-78)**	Layout and site configuration	Based on volume and desired alternative uses. Incorporate next to buildings or underground. A foundation of gravel should be provided if the weight of the cistern at capacity is less than 2,000 pounds, otherwise a concrete foundation should be provided.

Design step		Design component/ consideration	General specification
3	**Select and Size Inlet Configuration (A-79)**	Conveyance type	Runoff should be conveyed to the cistern such that no backwater onto roofs occurs during the 100-year event. Two types of inlet configurations are available: Dry conveyance: Conduit freely drains to cistern with no water storage in pipe. Wet conveyance: A bend in the conduit retains water between rainfall events.
4	**Design Pretreatment Configuration (A-79)**	Inlet filter	A self-cleaning inlet filter should be provided to strain out large debris such as leaves. Some systems incorporate built-in bypass mechanisms to divert high flows.
		First flush diverter	A passive first flush diverter should be incorporated in areas with high pollutant loads to capture the first washoff of sediment, debris, and pollen during a rainfall event. First flush diverters are typically manually dewatered between events.
5	**Select and Size Appropriate Outlet and Overflow/Bypass Method (A-81)**	Low-flow outlet	An outlet should be designed to dewater the water quality storage volume to a vegetated area in 2 days minimum. The elevation of the outlet depends on the volume of water stored for alternative purposes.
		Overflow or bypass	Emergency overflow (set slightly below the inlet elevation) or bypass must be provided to route water safely out of the cistern when it reaches full capacity.
6	**Specify Cautionary Signage, Pipe Color, and Locking Features (A-82)**	Signage	Signage indicating "Caution: Reclaimed Water, Do Not Drink" must be provided anywhere cistern water is piped or at the outlets.
		Pipe color and locking features	All pipes conveying harvested rainwater should be Pantone color #512 and be labeled as "reclaimed water." All valves should feature locking features.
7	**Design for Multi-Use Benefits (A-82)**	Additional benefits	Harvested rainwater should be used to offset potable water uses, such as irrigation, toilet flushing, car washing, etc. Additionally, educational signage and aesthetically pleasing facades should be specified.
8	**Additional Design Specifications (A-82)**	Vector control	All inlets and outlets to the cistern must be covered with a 1-millimeter or smaller mesh to prevent mosquito entry/egress.
		Routing water for use	Regardless of gravity or pumped flow, adequate measures must be taken to prevent contamination of drinking water supplies.
		Makeup water supply	A makeup water supply can be provided to refill the cistern to a desired capacity when harvested water has a dedicated use.
		Cistern material	Tanks should typically be opaque to prevent algal growth.

A.8.1.1 Step 1. Determine the Volume of Water or Flow to Treat

The cistern/rain barrel must be sized to fully capture the desired or required design storm volume. Chapter 2 of the County SUSMP presents relevant sizing regulatory requirements.

A.8.1.2 Step 2. Determine IMP Configuration

Cisterns are available in numerous sizes, shapes, and materials and can be custom fit to nearly any available space. Cisterns are designed to capture runoff from elevated surfaces, such as rooftops, and must be next to structures where runoff is collected (typically a downspout or other concentrated source). Figure A.8-2 depicts the typical components of a cistern.

Cisterns must have a proper foundation to support the weight when they are at capacity. Two options exist for foundations:

- Cisterns exerting less than 2,000 pounds per square foot: The foundation should be cleared and leveled. The foundation should consist of at least 6 inches of No. 57 gravel or concrete.
- Cisterns exerting greater than 2,000 pounds per square foot: The foundation should be cleared and leveled. Concrete should be poured such that gravity flow can be maintained and the cistern can be drained to the level of the outlet valve.

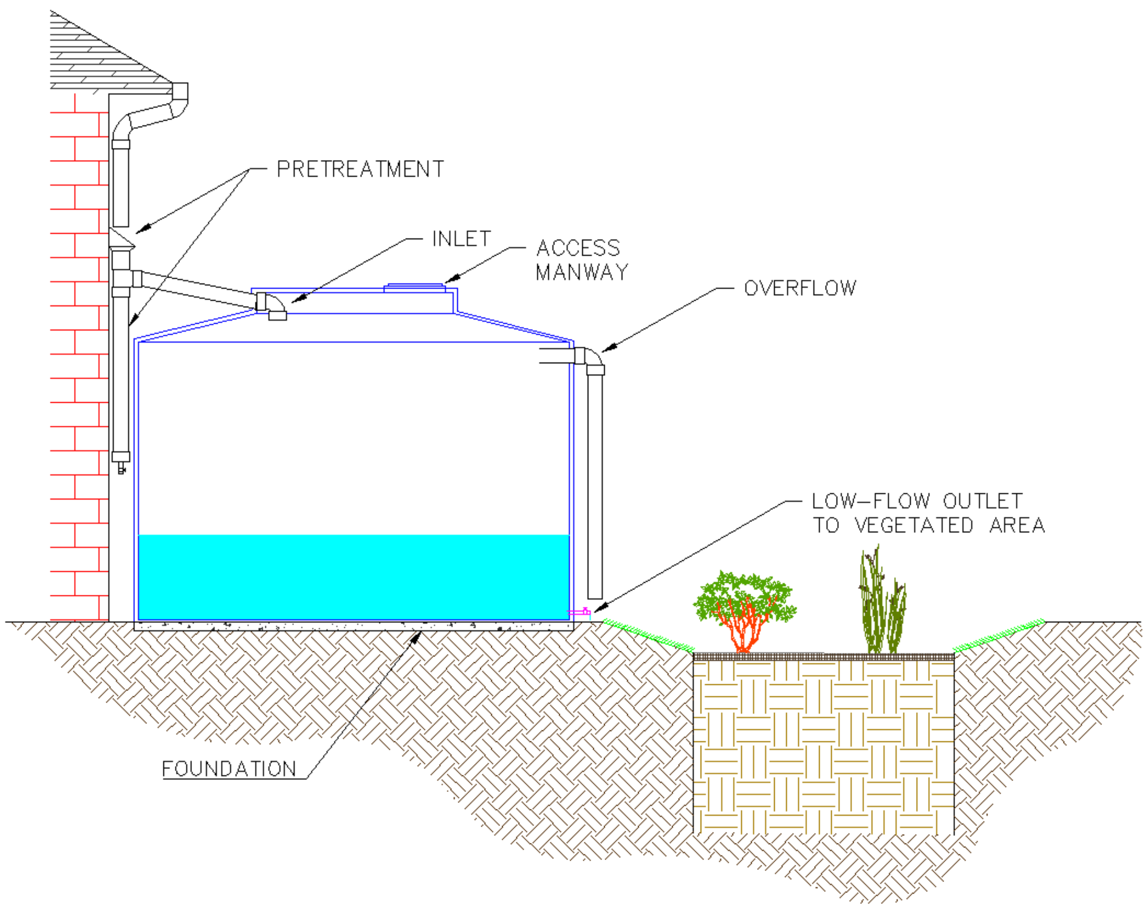


Figure A.8-2. Minimum design components of a rainwater harvesting system.

A.8.1.3 Step 3. Select and Size Inlet Configuration

Inlet connections can feature either dry or wet conveyance. The following subsections describe each configuration.

A.8.1.3.1 Dry Conveyance

Dry conveyance freely drains downspouts to the cistern without any trapped water in the inlet pipe. Connections are made through the top or side of the cistern.

Downspout pipes should be sized to convey the 100-year discharge without causing any backwater on the roof.

A.8.1.3.2 Wet Conveyance

Wet conveyance features a bend, causing water to be trapped in the inlet pipe between events. Connections are made at any point in the cistern. Inlet pipes can be buried to place the cistern further from the buildings. A drain should be installed at the lowest elevation of the downspout for dewatering and emergency maintenance.

Downspout pipes should be sized to convey the 100-year discharge without causing any backwater on the roof. Watertight connections must be used to prevent leakage.

A.8.1.4 Step 4. Design Inlet Pretreatment Configuration

Runoff must be filtered to remove debris and particles that can clog the water harvesting system. The following subsections discuss pretreatment configurations in greater detail.

A.8.1.4.1 Inlet Filter

Table A.8-2 outlines the inlet filter requirements.

Table A.8-2. Cistern inlet filter specifications

Parameter	Specification	Example
Installation location	At the gutter	
	End of the downspout	
Contributing area size filter type	< 1,500 square feet = flow through filter	
	1,500–3,000 square feet = bypass capable filter	
Self-cleaning screen	45 degrees or greater as measured from horizontal (Nel 1996)	See image above

A.8.1.4.2 First-Flush Diverter (Optional)

Installed after the inlet filter, the first-flush diverter is designed to divert an initial volume of water away from the cistern to prevent small particles from clogging the outlet. They are recommended in areas where pollen or other fine materials might not be removed by the inlet filter.

The size of the diverter is typically 4 to 6 inches in diameter, with varied lengths to adjust the captured volume. Once the diverter is full, a valve closes and water flows to the cistern. A relief valve is required to drain the diverter between events to provide capacity for the next rainfall event.

A.8.1.5 Step 5. Select and Size Appropriate Outlet and Overflow/Bypass Method

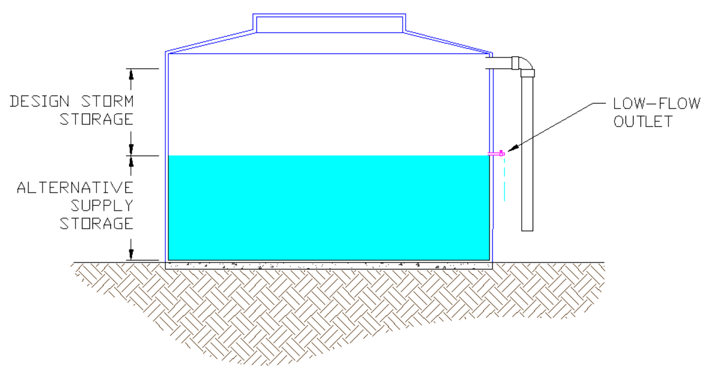
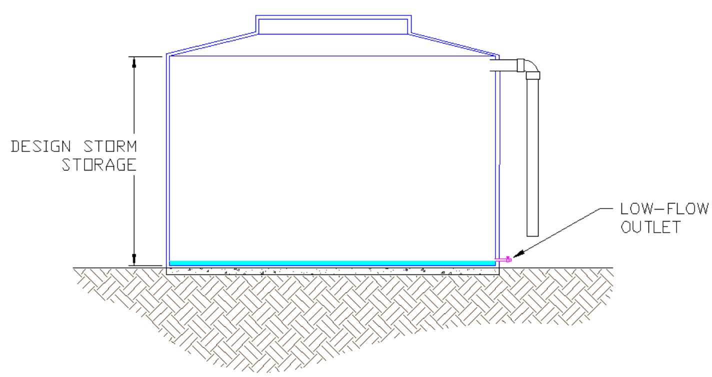
Low-flow outlets and high-flow bypass design recommendations follow in the subsequent sections.

A.8.1.5.1 Low-Flow Outlet

The outlet of the cistern should be designed to release the volume of captured runoff at a rate below the design storm inflow rate. The outlet should be directed to an infiltration integrated management practice (IMP) such as bioretention. Infiltration requirements must follow those outlined in the Bioretention section (A.1.1.2.2).

The elevation of the low-flow outlet depends on the demand for alternative water use. Table A.8-3 outlines the two alternatives for low-flow outlet placement.

Table A.8-3. Cistern water demand outlet configurations

Alternative Water Demand	Typical Uses	Outlet Location	Example Profile
High	Supplements potable or greywater supply. Uses can include irrigation, toilet flushing, and car washing.	Above half the height as measured from the bottom. Creates a permanent storage elevation.	
Low to none	Cistern acts as a stormwater management device solely.	Bottom of the cistern. Creates a dewatering device and allows for maximum storage capacity of future rain events.	

A.8.1.5.2 Overflow/Bypass

All cisterns must have an overflow for runoff volumes that exceed the capacity of the cistern. The overflow outlet should be set slightly below the inlet elevation.

All overflow and outlet volumes must be directed away from all structural foundations and areas where infiltration can have a negative impact. Overflow and bypass systems must be sized to convey the 100-year discharge without any backwater onto the roof.

A.8.1.6 Step 6. Specify Cautionary Signage, Pipe Color, and Locking Features

The International Plumbing Code specifies that clear and obvious signage must be provided when harvested rainwater is used. Signs should read: "Caution: Reclaimed Water, Do Not Drink" and should be placed where ever the water is daylighted (spouts, spigots, hoses, etc).

All pipes and hoses used to convey harvested water should be purple in color (Pantone color #512) to indicate that the water is not safe to drink. All valves must be equipped with locking features.

A.8.1.7 Step 7. Design for Multi-Use Benefits

Rainwater harvesting practices offer multi-use benefits by proving an alternative nonpotable water source while controlling runoff. Cisterns and rain barrels can be designed for multi-use benefits by doing the following:

- Providing irrigation for landscape beds and vegetated IMPs
- Offsetting nonpotable water supplies used for toilet flushing, car washing, street sweeping, and other uses (nonresidential cisterns only)
- Incorporating aesthetically pleasing colors and murals
- Incorporating creative downspout designs for low-flow practices (e.g., rain chains)
- Using signs to raise public awareness about stormwater issues

A.8.1.8 Step 8. Additional Design Specifications

The following considerations should be included in design plan notes and specifications.

A.8.1.8.1 Vector Control

Cover inlets and outlets with a 1-millimeter or smaller filter material, such as a screen or wire mesh, to prevent mosquito breeding. Inlet screens should be placed downstream of the inlet filter and first flush diverter (if installed) to prevent clogging. Overflow/bypass screens should be hinged to allow for flows to bypass during high-flow events.

A.8.1.8.2 Routing Water for Beneficial Use

Routing water for beneficial use typically has the following characteristics:

- Gravity flow or pressure flow depending on application. Pumps can be installed as submersible or external.
- Cistern pipes cannot use the same trenches as potable water.
- A 2-foot lateral separation and a 1-foot vertical separation from all potable water lines are required. The portable water line must always pass on top of the water harvesting line.

A.8.1.8.3 Supplemental Water Supply for Dedicated Use

If a cistern is used to offset nonpotable water demand, a makeup or backup water supply system is installed to maintain a minimum volume of water stored in the cistern. Multiple makeup systems are available, and the most common functions with a float and valve similar to toilet tank components. When the cistern drops to a certain level, the valve is opened, filling the tank up to the minimum stored volume. An air gap and a reduced pressure backflow device must be installed.

A.8.1.8.4 Cistern Material Specification

Rainwater harvesting tanks are typically constructed of plastic, metal, or concrete. Specified material controls the quality of runoff captured, aesthetics, configuration, installation, and cost.

A.8.2 Operations and Maintenance

Maintenance of cisterns and rain barrels is critical to the success of the system. Table A.8-4 provides a detailed list of maintenance activities.

Table A.8-4. Inspection and maintenance tasks for cisterns

Task	Frequency	Indicator maintenance is needed	Maintenance notes
Gutter and rooftop inspection	Biannually and before heavy rains	Inlet clogged with debris	Clean gutters and roof of debris that have accumulated, check for leaks.
Remove accumulated debris	Monthly	Inlet clogged with debris	Clean debris screen to allow unobstructed stormwater flow into the cistern.
Foundation inspection	Biannually	Cistern leaning or soils slumping/eroding	Check cistern for stability, anchor system if necessary.
Structure inspection	Annually	Leaks and slow draining	Check pipe, valve connections, and backflow preventers for leaks. Verify flows empty the structure within 24 to 48 hours.
Add ballast	Before any major wind-related storms	Tank is less than half-full	Add water to half full.
Miscellaneous upkeep	Annually		Make sure cistern manhole is accessible, operational, and secure.

A.8.3 References

County of San Diego. 2012. *County of San Diego SUSMP: Standard Urban Stormwater Mitigation Plan Requirements for Development Applications*. http://www.sdcounty.ca.gov/dpw/watersheds/susmp/susmppdf/susmp_manual_2012.pdf.

Nel, C. 1996. *Die ontwikkeling van 'n struktuur vie die verwydering van vaste besoedeling uit stormwateraflope*. Unpublished DTechEng thesis. Technikon Pretoria.