The Cistern Solution

A GLEE Resource for Learning how to Collect Water from the Sky

Made Possible with Funding and Support from South Florida Water Management District.

sfwmd.gov

Purpose

While hosting dozens of Rainbarrel Workshops throughout the Keys, GLEE was asked by numerous people how to build something bigger than a rainbarrel, how to collect more rainwater. People were confused by what was allowed, who to talk to and how much it would cost. Because there were too many questions, they had been paralyzed into inaction.

The Cistern Solution Manual puts all the decision making tools in your hands so that you can find the water collection method that works best for you and your space. GLEE believes that putting these tools in the right hands will greatly affect not only how much potable water we can save, but also how much stormwater runoff gets into our nearshore waters.

If you feel that we have missed something in this first edition, please let us know. The Cistern Solution is meant to be a community document – a resource that we all can use to learn from each other.

Thank you,

Alison Higgins
GLEE President
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Thank You's

GLEE would like to give a large thank you to our Duke University intern Trisha Lowe for her research, resourcefulness and patience. We couldn't have completed this without her. Thanks also to the multitude of agencies and featured Keys residents that collaborated on this document to make sure GLEE's information was correct and up to date. We look forward to maintaining our relationships with you and keeping the Cistern Solution Manual as useful to Keys residents in 10 years as it is today.

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Introduction

Taste It, Don't Waste It

Did you know that the largest water consuming activities in every household don't require potable* water? If you are like most families, you use drinking quality water to flush toilets, wash cars, and water the lawn. Rather than wasting money and diminishing water supplies, wouldn't it be nice if you could create your own source of water?

> ***Definition**: "Potable water" Water that is suitable for drinking

The truth is that most of us are blind to the abundance of water delivered to us every time it rains. By installing a rainwater harvesting* system at your home or business, you can save money and our water supply by using your roofs' water to fill common water needs.

> ***Definition**: "Rainwater Harvesting" Collecting rainwater from a roof or other surface before it reaches the ground.

Create your own Water by Harvesting it from Your Roof

Rainwater can be used for landscaping, washing vehicles, flushing toilets, washing clothes, and even as drinking water (with special treatment). Some of the benefits of using rainwater are healthier plants, monetary savings on water and sewer bills, a reduction in stormwater runoff, a reduction in pollutants and nutrients in our nearshore waters, and an over all reduced demand on our limited and shared water supply. It's also important to note that harvested water is not regulated by water restrictions, so when everyone else is forced to limit water use, you can keep your plants happy and your car clean at any time, day or night.

Rainwater "harvesting" means collecting rainwater from a roof or other surface before it reaches the ground. The rainwater is piped into a container and is stored until it can be used. The simplest and most common use of rainwater harvesting is yard/garden watering, but others have gotten more inventive and installed pressurized pumps for boat and car washing.

With the proper plumbing you can even run it into the house and use it for drinking. It is important to note that rainwater must be treated for many home uses (ex: drinking water, washing dishes, etc.) and that you will need a special backflow device to keep harvested rainwater from mixing with FKAA city water.

Anywhere you can use your roof water instead of your utility water will result in water conservation, a decrease in your water bill, provides emergency water in times of restrictions or utility contamination, and also a reduction in stormwater runoff. We'll go more in depth about rainwater harvesting methods and uses in Section 2 on page 12.

Stop Harmful Stormwater from Reaching the Reefs

Stormwater runoff is a leading cause in erosion and nearshore water pollution. Stormwater carries pollutants from our streets and nutrients from our landscaping into our shallow waters, upsetting the balance of the ecosystem. Flooding in areas with septic tanks has been shown to carry enterococcus bacteria into canals. Diverting that stormwater and saving it for later, can help the general ecology and health of our islands.

How much storm water could be diverted? Let's use Key West as an example:

Potential Runoff Diverted
(in Millions of Gallons)

Key West:	206 MG
Lower Keys:	188 MG
Marathon:	155 MG
Islamorada:	72 MG
Key Largo:	335 MG
TOTAL	**958 MG**

High volume, short duration rainstorms dump approximately 39" in Key West annually, 60% of which hits roofs. If this water was caught and stored from Key West's 6,000+ roofs they could divert an estimated 180 million+ gallons from nearshore waters. See the Runoff Chart for potential roof water savings in your region.

We're Over our Limit of Freshwater

The Florida Keys, like the rest of our world, have a limited amount of freshwater available for use. Our water supply comes from the Biscayne and Floridian Aquifers on the mainland, travelling up to 130 miles of pipe from Florida City to Key West. We are not the only ones using these aquifers either; nearly all of South Florida depends on them. Thus conserving water and becoming self sufficient is extremely important.

The Florida Keys Aqueduct Authority (FKAA) provides the logistics of pipeline plumbing, services and billing to provide this valuable liquid commodity to the Keys. Created in 1937 by the State of Florida, FKAA is the sole utility provider of potable water for all of the residents of the Florida Keys, presently serving 42,237 customers Keyswide.

Did You Know?
An estimated 25% of household water consumption goes toward non-potable uses such as landscape watering, car washing and laundry.

FKAA received a grant from South Florida Water Management in 2000 to build and operate two Reverse Osmosis (RO) desalinization plants. These RO plants were originally intended for use in the event of pipeline rupture – to produce potable water under emergency conditions only. Eight years later they are expected to be fired up many times a year to meet regular demand.

Due to the increase in demand with rising population, FKAA also opened up a new plant that takes water from the brackish Floridian aquifer, treats it, and then mixes it with the Biscayne aquifer water. There have been series of 5% water cost increases to pay for this new plant, the last of which will be implemented in October 2008. As responsible citizens, we need to help alleviate some of the pressure on our limited resources.

Currently, for residential consumption, FKAA charges a $11.97/month base facility charge, along with a flow/consumption charge that is about $5.02 per thousand gallons used, up to 6,000 gallons a month. After that 6,000 gallons, the rate increases incrementally up to nearly $10 per thousand gallons used. The Keys average household uses about 4,400 gallons a month of water.

Reduce Your Sewer Bill

As municipalized sewers are incorporated into the Keys, your monthly bills will increase since the sewage bill is based on water consumption. If you use water on your landscaping or to wash your boat or car, you will pay for it in your sewer bill, regardless of whether that water was actually treated by the sewer plant or not.

What if there was a way to offset and decrease these water-related bills?

The Cistern Solution Manual was created by GLEE to help individuals, businesses and policy makers navigate through all the questions and options for cistern creation and use here in the Florida Keys.

Read on to learn more about what you can do to save money, save water and save our islands.

The Cistern Solution

We need water to survive, but we also need to protect our resource and our islands in order to enjoy life. There are many different solutions to this problem. This manual hopes to explain the pros, cons, costs, and give examples of each. Whether you are considering adding a system to an existing home, building a new home, or even renting, you can help conserve water and have your own rainwater harvesting system.

How to use this Manual

This manual looks into four types of rainwater harvesting systems: rainbarrels, and three types of cisterns: new added on tanks, built as part of the home tanks, and septic tank to cistern conversions.

In the first section of this manual GLEE explores the common aspects of rainwater harvesting: basic components, design, permits, water quality, mosquito prevention, etc.

In the second section GLEE examines the differences of the four systems, their pro's and cons and specific design distinctions. We also provide testimonials from local keys folks who have been using these systems for many years and know firsthand how they work in the real world.

In the third section, GLEE has prepared worksheets to help you determine the costs and savings of implementing the rainwater harvesting system of your choice. We will examine upfront costs, rebate potentials as well as your return on investment after 5 years.

In the fourth and final section, GLEE has assembled example designs and additional pictures to better assist you in understanding all of the new concepts and terms that you will soon master.

It is GLEE's intent that after reading this manual, you will have a clear vision of what will work best for your space, needs and funds, and that you will have the tools to make it happen with enough time to take advantage of FKAA's Cistern Rebate pilot program. If you have additional suggestions or corrections, please let us know.

Rain Harvesting "At a Glance"

Type	Pros	Cons	Costs	Other
Rainbarrel	Cheap and easy, Modular, Transportable, Garden art	Don't hold very much water, Risk of mosquito problems	Homemade for under $45.00, Purchase from retailer $55.00 +	Link together to hold more water. Great option for renters/businesses.
Tank, Separate From House	Plug and Play, Use along with utility water for conservation/lower water bill, Easily used for non-potable water	Space needed, Additional plumbing for potable uses, White/clear tanks sometimes breed algae, Backflow device if hooked up to utility; Need building permits	Can be built on site or purchased from retailer, Cost depends on size/materials, Smaller tanks can be bought as cheap as $250	Many different sizes/materials available to fit your needs- rough cost correlation of ~ $1-$2.50/gallon for storage tank size
Tank, Part of House	Structural integrity, Plumbing can be as complicated or simple as desired, Climate buffer	Backflow device if hooked up to utility, Need building permits	Vary on size, materials, and installer. See case studies; call an expert for a quote, or search online for pre-made units.	Every new home built in the Keys should have a cistern! Old ROGO system gave points for cisterns, Green Team looking into incentives
Septic Tank Conversion	Already on site, No new space taken up, No need to destroy old septic tank, Recycling, Costs	Must get variance, Involved process	~ $800	With the conversion to municipal centralized system- reuse your tank for good!

Section 1 - General Information

Choosing Your System

Although collected rainwater is often believed to be for non-potable uses only, it can also be used as drinking water with the proper treatment. What you need to do to set up your system will depend greatly on what you decide you want to use it for.

For outdoor uses, such as landscaping or garden watering, car or boat washing, or pond or pool filling, no extra filtration or water quality tests are necessary. This is the easiest and cheapest option.

If you want to connect your rainwater harvesting system for in-house needs, there are two possibilities, both with different standards of filtration and testing:

- Non-potable uses: Toilets and laundry.
- Potable uses: Drinking, cooking, dish washing, bathing and sinks.

Sizing Your System

Determining the correct size cistern needed depends on estimated water needs, rainfall and roof area.

Estimating Water Needs

Average Total Daily Water Use per person ranges from 50 to 150 gallons of Water. If you only want to use rainwater for landscaping uses, a rainbarrel, septic tank conversion, or a small cistern between 50 and 250 gallon capacity may be enough for your needs.

If you want to use your rainwater in house, there are two possibilities, both with different required standards:

- Non-potable uses: Toilets and laundry.
- Potable uses: Drinking, cooking, dish washing, bathing and sinks.

Approximating Annual Rainfall

The Keys typically receive between 35-44 inches of rainfall per year. Use the following regional rainfall list to find the average precipitation level in your area.

Calculating Harvest by Roof Area:

A roof is capable of harvesting roughly 600 gallons per 1,000 square feet of roof per inch of rain. You can turn to page 28 of this manual to calculate how much water you can harvest from your roof right now.

Average Annual Rainfall:	
Key West:	39”
Lower Keys:	43”
Marathon:	44”
Islamorada:	45”
Key Largo:	45”

Understanding your System

All rainwater harvesting systems can be divided into four basic components:

1. The water collection system, which consists of the roof, gutter and downspout;
2. The filter, which keeps debris from the roof and gutters from entering the tank;
3. The water storage structure, (rainbarrel, above ground cistern, septic conversion), built out of plastic, concrete, metal, or fiberglass; and
4. The treatment system (for potable uses), which consists of additional plumbing and filtration systems.

The EPA states that cisterns should be constructed of non-toxic materials that make it watertight Also, to keep children out, its access cover should be lockable, relatively heavy, and at least two inches above the surface. The piping for the cistern should include a drain for cleaning, an overflow, and an intake to the system pump. To prevent insects, animals, and debris from getting into the cistern the drain and overflow should to be

screened. A free-flowing drain line with and isolation valve should be located at the bottom of the cistern. The intake to the system should be six inches above the floor and screened to prevent contamination. Though this manual was specifically for public water systems, it includes valuable information, and can be found at the following website: (**Guidance Manual for Conducting Sanitary Surveys of Public Water Systems, April 1999**).

Permitting your System

Cisterns are not prohibited by any federal, state or local statutes or codes, and all local building departments allow their construction, with the proper permits. Rainbarrels do not need permits.

The proper building permits must be obtained before cistern work begins:

- Residential cistern permits **are** required (fees range from about $75-$150)
- Plumbing permits *might* be required if you are going to use the water in house.

Therefore, you need to consult with an engineering firm to draft plans for a cistern that fits into your needs and your home, and they will be sure that all building codes for your area are met and can assist you with the permitting process. It is advised that you contact your local building department for further information.

You can find a list of building departments and their contact information in Appendix B on page 31.

Separating Water Supplies

There is a potential for rainwater getting into the utility pipeline if a cisterned house connects its water source into the utility's system. Therefore, a backflow device is required by the State of Florida for homes that have both cistern and utility plumbing, to prevent mixing of water sources. This backflow device is part of the new water meters, but your home may not have been updated yet. Be sure to contact FKAA to find out. If you do not currently have the correct meter, they will install the new meter for free. (Note: The backflow device used to cost the customer ~$1,000, but is now supplied and installed for free by FKAA, at the time of print)

You can reach FKAA at: 305-296-2454

Protecting Against Mosquitoes

It is important to take the necessary measures to avoid increasing the mosquito population in the Keys. There are many preventative products available on the market. All rainwater harvesting systems should have screens to prevent debris, animals, and mosquitoes from getting into the tank and pipes, and if there are any holes or gaps they should be covered. These measures will keep mosquitoes away! You will read later in our case studies about several different homeowners in the Keys who have never experienced mosquito problems by following these preventative measures.

If mosquito larvae does get established in non-potable cistern water, "Bt" (larvae specific bacteria that prevent them from eating) and Gambusia (larvae eating fish) are available from the Florida Keys Mosquito Control District and will clear up a mosquito larvae infestation. Do not put Bt or Gambusia into a potable system.

You can reach the Florida Keys Mosquito Control District at: 305-292-7190

Drinking From Your System

Although most rainwater systems are used for "non-potable water," with minor treatment rainwater collected in cisterns can be used as drinking water. Benefits of using rainwater instead of utility water to drink are that it is softer, as it contains fewer chemicals to begin with. Also, it provides a sense of security during hurricane season as you know that even if the mainland pipe leaks or is disconnected, you still have a water supply. Think of how often "boil water" alerts occur- with harvested rainwater you control the quality! The main downside of a potable system is that it is up to you and only you to keep it well maintained by cleaning your cisterns, changing your filters and testing your water periodically.

If the ultimate use is drinking water, care must be taken through the whole system to avoid leaching from poorly chosen materials. In this regard, a metal roof is the best roofing material, with white being the best color to combine low leaching potential and high reflectivity (for energy efficiency of the building), while asphalt shingles are the most problematic because of the high likelihood of contaminants. In between are compromise materials such as concrete, with the potential for mildew, and clay tiles that can also harbor mildew and have the disadvantage of building-envelope heating due to their darker color

Like well water, cistern water is not regulated, however, for your own safety you should take measures to be sure your water is quality. The EPA sets limits (primary and secondary standards) for drinking water contaminants.

White metal roof with wide gutters and splash shields ensure that you maximize collection and your rainwater stays as pure as possible.

Primary standards protect public health by limiting the levels of contaminants in drinking water (See Appendix X). Secondary standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.

It is strongly suggested that rainwater for potable uses have a filtration system. Chlorination, micron filters, charcoal filters, ultraviolet systems, and reverse osmosis systems are all possible methods of filtration, and can be combined for your needs. From the Local Spotlight case studies in Section 3 (pg 20) you will see many different types of filtration systems in use, each with its own pros and cons.

Water quality testing can be done for less than $140, the price ranges on the company and the extensiveness of the tests. It is recommended that you find a company which tests all of the EPA limits, and after the installation and hook up of your cistern have the water (post-treatment) tested to ensure your filtration system is working and adequate.

Testing the Quality of Your System

Rainwater for non-potable and potable uses is not currently regulated by the State of Florida (*at the time of print*). However, if you are considering potable water, it is highly suggested that your water should comply with the same standards that FKAA water is held to (Appendix A). Generally, a basic filtration system will meet all set standards, but periodic testing will ensure that you are better safe than sorry.

Testing kits can be purchased for less than $140. The process is easy and merely requires you to collect a small amount of water from your faucet and send it away to the testing company. The company will return the results compared with EPA limits.

Budgeting for Your System

Costs of rainwater harvesting systems vary by type and size, but still have some general rules of thumb for estimating costs. When evaluating the cost of a rainwater harvesting system, do not be discouraged by a seemingly high "upfront" cost. Since harvesting your water generally lowers or even eliminates your water bills and sewer bills, long term savings should be evaluated alongside the upfront cost. You are purchasing years' worth of water at once, instead of paying it in monthly bills.

Taking advantage of the current FKAA Cistern Rebate pilot project (while funds last) will be a major benefit to your project. After you've read Sections 1 and 2 and decided which system works best for your space and needs, use the Section 3 worksheets on page 28 and 29 to estimate your costs and savings.

Rainbarrels
A rainbarrel only costs about $42.00 to make. They can also be purchased online for a range of prices ($55-$250) depending on size, type, and materials it is made of.

Pre-Made Tanks
Cistern tanks and rainbarrels can be purchased through retailers or built on the site. For cistern tanks, purchased pre-made tanks roughly have a correlation of about $1 cost per gallon of storage.

Built Cisterns
As of print, concrete cisterns, built on site, cost about $2.50 per gallon of storage. This is an increase due to the increase in cement prices, and may have changed further depending on material costs at the time of manufacturing.

Septic Conversions
The first septic conversion in the keys cost 80¢ per gallon, a price mirrored by the many other converters since.

"I've never found anyone who thought their cistern was too large. Put it another way, when it overflows, most folks wish their cistern was larger. So… I've found that the calculations usually boil down to budget and space. Make it as large as your budget and space will allow." - John Hammerstrom

Section 2 – Rainwater Harvesting, By Type

Rainbarrels

Every home in the Keys could easily have a rainbarrel. Rainbarrels can come in several different types and sizes and have been set up to collect water from roofs and dripping air conditioning units. Homes that have guttering systems can easily be adapted to funnel water into the barrels. If your home does not have gutters yet, rainbarrels can be set up to collect rainfall from a corner of your roof. This is an especially good option for those who cannot afford to install a cistern or who may be renting and cannot add a permanent structure to the lot.

Do It Yourself: $49

Online, Basic: $130

Online, High End: $230

Uses

Any small-scale water consumption need that does not require potable water can be serviced by a rainbarrel system. Landscaping and garden watering is the most common use. Some rainbarrel owners have installed timers on their barrels in order to do their watering in the recommended early morning hours. Rainbarrel water can also be used to fill fish ponds and aquaria (Rain water is a lot softer due to the lack of chlorine and a lower pH, which is better for aquatic creatures). Some rainbarrel owners have use their water to wash cars and boats with the addition of a small pressurized pump to the outflow.

Water Collection

You can collect approximately a half gallon of water per square foot of roof area during a 1-inch rainfall. In order to collect ***all*** of this water you would need a large cistern. (To find out how many gallons you could harvest from your roof, visit worksheet #1 on page 28)

The biggest downside of rainbarrels is that they really don't hold much water and can become full within a matter of minutes during a moderate rainfall. Many people have reported becoming acutely aware of "wasted" water when their barrel runneth over.

Multiple rain barrels can be linked together to store more rainwater, but is still unlikely to have the capacity or quality needed to do more than water plants and wash boats and cars. Multiple barrels also multiply your chances of breeding mosquitoes because you have increased entrances as well.

Materials
Most rain barrels found in the Keys were made from 55-gallon plastic drums that were used to ship food grade items like concentrated juice or olive oil. Some can have a distinct odor from their previous contents and might need to be rinsed with a very low concentration of bleach before use. The plastic on rainbarrels can easily be painted plainly to blend in with your house, or decoratively, as a form of garden art.

Design and Permitting
Rainwater does not need to be filtered for outdoor use. Remember, that although straight roofwater is great for plants because of the lack of chlorine and a lower pH level than utility water, it is not readily fit for human consumption.

As water runs off of a catchment area, it can pick up debris such as leaves, bird droppings or chemical agents from your roofing materials, but these are not harmful to plants. A simple screening wire-mesh, or a gutter guard, can be used to keep out leaf debris or insects. That is all the filtration necessary. The screen mesh can be located where the water enters the conveyance system (gutter) or at the tank opening.

Rainbarrels tend to be the least well sealed of the water harvesting methods. If you have a tight fit where the downspout enters the barrel you should have no problems with mosquitoes. If you have small gaps or holes fill them with caulk or window screen. There are products (such as mosquito donuts) available from Florida Keys Mosquito Control that will prevent or clear up mosquito larvae.


Screen filters out debris and keeps mosquitoes out.

A large upside to rainbarrels is that they do not require permits or tie downs. When empty, they are very transportable, so if there is a hurricane coming you can easily bring an empty barrel inside.

Cost
Rainbarrels can also be purchased online for a range of prices depending on size, type, and materials. A rainbarrel only costs about $42.00 to make. The following websites have great information on how to build and customize your own rainbarrels.

FKAA - Build Your Own Rain Barrel
SWFWMD: Make-a-rain-barrel (Includes video)

Maintenance
A small amount of debris will get through the mesh screen and settle in to the bottom of the barrel, so it is a good idea from time to time to clean the tank to avoid a large buildup of debris that can clog your spigot.

Tanks - Separate from the House

If you have already built your home and wish to retrofit it with a cistern, this section is for you! Pre-made cisterns can be purchased from a multitude of retailers, and in many different materials, sizes, and shapes to best fit your needs.

Uses

Because of the range of volumes available, a large enough cistern can provide all of your annual water needs. It is important to decide what use you want first (outside only, in house non-potable, or in-house potable), then determine the volume of water needed to fulfill those needs, then size your system.

Water Collection

The keys residents we interviewed that live year round off of their water collected in separate tanks have capacities ranging from 3,000 to 20,000. With an range of annual rainfall from 35-40 inches per year, the possible amount of water collected on a 1,500 square foot house ranges between 26,000 to 30,000 gallons. With an average water use of 50 gallons a day, the typical Keys resident would only need 18,250 gallons for all of their water needs for the entire year. And because rainfall and water use happen throughout the year, you wouldn't need an 18,250 gallon capacity cistern.

This Big Torch Key home has a standard plastic cistern attached to their gutters.

Materials

Tanks can be built on site of concrete or similar material. It is important to use a licensed professional registered with the county or city for this, as well as make sure you are meeting the building codes and have the appropriate permit for your region. Cisterns built as additions to a home will vary depending on what they are to be used for and what your property is like.

If you buy a pre-made plastic or similar material tank, be aware that the clear and white colored tanks allow algae growth. To prevent this, we suggest purchasing a darker colored, such as green or black, tank that is UV resistant. Or, place the tank inside the garage or a storage room, or build a storage unit around it, so that no part of it is in direct sunlight.

This historic cement cistern has supplied the Matheson House in Key West for many years.

Design and Permitting

Adding on a larger system requires a lot more space than a rainbarrel, either beside your home, or underneath a stilted home. Cisterns can be buried underground, but this too takes a lot of time and effort.

Although hooking a cistern to your in-home plumbing is easy, these add-on tanks require different permits and filter systems depending on the use desired (potable versus non-potable). If you intend to use the water inside your home, the experts (engineers, plumbers, contractors who are registered with the state or local building departments) will not only make sure you have the correct plumbing and filtration systems, but also secure the necessary permits to do the job.

As the volume of a cistern increases, so do the safety precautions. Since a gallon of water weighs about 8 pounds, even a small 150 gallon cistern can put 1,200lbs of stress on your foundation when full. Conversely, an empty tank can float like a boat in hurricane surge, potentially causing a lot of damage. It is necessary to consult with experts to ensure your placement site is secure.

Cost
The cost of retrofitting a home with a cistern is more than if you were to have built the home and cistern together, but remember that you are buying all the water that the cistern will gather upfront, instead of paying for it in your monthly utility bill.

The cost is roughly 1$ per gallon of storage, but because this is a wide market, and the tanks have uses not just in the Keys but on farms and other places across the nation, with a little shopping around, you can find a tank to fit your needs, and budget. Some reputable manufacturers, just to name a few, include Chem-Tainer, Plastic Mart and Ace Roto-Mold and the tanks are sold through numerous distributors. These tanks are easy to hook up to collect the rainwater for landscaping or other non-potable uses. Remember that potable uses require extra filters.


Concrete "Red Cross" house, 1937

Maintenance
With regular maintenance, few problems exist.

Tanks - Part of House

For new homes, the option is available to have a cistern incorporated into the design of the home. This is by far the most popular type of cistern in the Keys, and is ideal for many reasons. Structurally, since the cistern is part of the home, it is very secure and highly unlikely to be destroyed or contaminated even during hurricanes. The cistern can also be planned so that it does not take up valuable space like the add-on cisterns can. It is also possible that, just as living on a coastal area keeps the climate moderate, having a giant tank of water below your house will help cool your home, since it takes much longer for the water temperature to rise even when air temperatures rise. In this way, the cistern acts as a climate buffer. As with all rainwater catchment systems, a great benefit of this water is that it is "soft" water, and even when treated, uses far less chemicals than utility water.


This 16,000 gallon cistern is found on No Name Key.

Uses (Same as for Ad-On Cisterns)
Because of the range of volumes available, a large enough cistern can provide all of your annual water needs. It is important to decide what use you want first (outside only, in house non-potable, or in-house potable), then determine the volume of water needed to fulfill those needs, then size your system.

Water Collection (Same as for Ad-on Cisterns)
Tanks that are part of the house tend to be larger because they can take advantage of the house's entire footprint. With an range of annual rainfall from 35-40 inches per year, the possible amount of water collected on a 1,500 square foot house ranges between 26,000 to 30,000 gallons. With an average water use of 50 gallons a day, the typical Keys resident would only need 18,250 gallons for all of their water needs for the entire year. And because rainfall and water use happen throughout the year, you wouldn't need an 18,250 gallon capacity cistern.

Materials

Tanks that are part of the house are usually reinforced concrete.

Design and Permitting
However, the downside to integrating a cistern in with the home is only that it can be done for new homes. You must also be sure to obtain the proper building permits for this construction. Again, use a licensed and registered contractor, engineering firm, plumber, or other professional in the field. Information on building codes is in Appendix B.

Cost
Also, for Monroe County, the cost a permit is about $50 less when the cistern is included in the design of the home than when the cistern is a separate structure.

Septic Conversions

Currently, homes in the Keys that have individual septic systems are being converted to centralized municipal systems to meet with state mandated sewage requirements. Until recently, this meant that old septic tanks had to be abandoned and destroyed. However, thanks to the hard work of Fran and Mali Wagner, Keys locals who saw potential in these old septic tanks, you can now convert an old tank to a cistern for non-potable uses.

This process is a great alternative, as you save the money and time it would cost to destroy the old tank, and any money and time spent to convert to a cistern will have a great pay off as you decrease your water and sewer bills. With the proper cleaning and maintenance, your septic tank can become a source for landscaping and other non-potable water, taking pressure off our limited utility supplied potable water supply. Let us remind you again that during times of water restrictions, collected rainwater is exempt from those restrictions.

Uses
Converted Septic Tanks are for non-potable uses only, such as landscape watering and boat or car washing. (in home non potable?). The Wagner's worked with the State Department of Health to make this process possible. The DOH's requirements as well as step by step instructions are found in Appendix C.

Water Collection
Septic tanks range in size from 800 to 3000 gallons, and therefore cannot store all the water from your roof. However, even the smallest size is highly likely to meet all of your landscaping needs.

Materials
Most septic tanks are concrete, and a few are made out of fiberglass. There are two main types of individual septic systems here in the Keys. The newer systems are generally Aerobic, and older systems are typically Anaerobic. The older anaerobic systems have a single tank with drainage field(s) while the newer aerobic systems have two or three tanks, the first tank being filled with air to supply oxygen to bacteria that break down the sewage. Both types can be converted to cisterns, and the basic steps for the older tank systems are below. The newer systems require a few additional steps, found in more detail on page 35 in Appendix C.

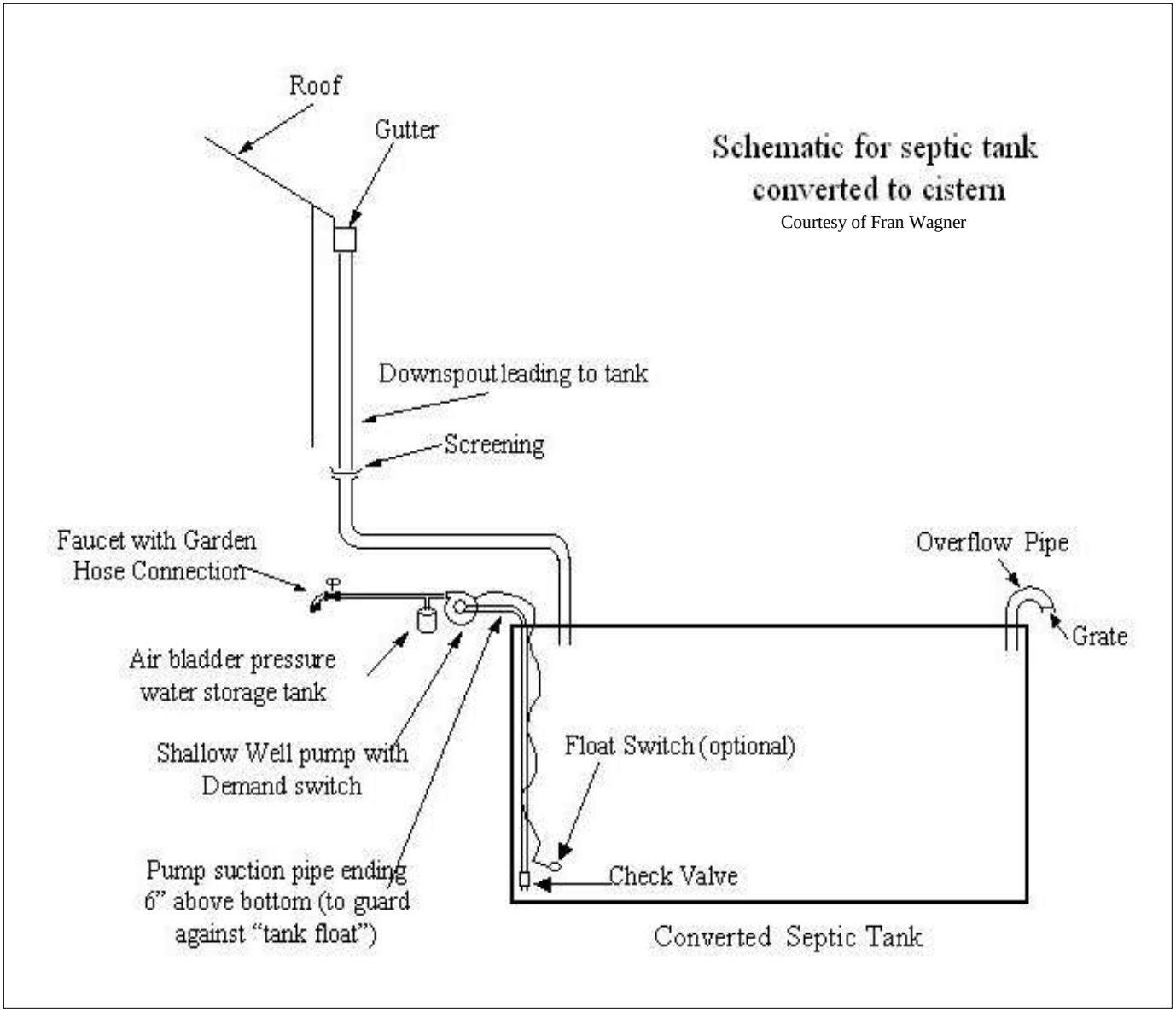
Design and Permitting
Septic to cistern conversions are great because the tank is already in place and does not require the additional space an add-on cistern does.

The basic steps for converting a septic tank:

1. Obtain the proper variance from the Department of Health.
2. Have the septic tank pumped out and pressure cleaned.
3. Connect the roof gutter downspout(s) to fill the tank.
4. Connect an overflow pipe to the cistern tank
5. Allow the cistern tank to fill and add chlorine bleach.
6. Mount a pump with pressure tank in a convenient location and supply power to it.
7. Connect an intake suction pipe from the cistern tank to the pump
8. Connect an output pipe from the pump (pressure tank) to a garden faucet
9. At any time several months after step 4 the Department of Health should be called to test the water. This is required to receive the DOH certificate of approval.
10. An optional float switch can be installed to prevent dry pump operation when tank is near empty.

Cost

Estimated at 80¢ a gallon (does not include installation of gutters, if needed)



Section 3 – Local Examples

The Oldest House Museum in Key West sits on a large cistern.

History of Conch Conservation

Prior to 1942 Keys' residents sustained themselves with water from the sky and a few underground wells. Nearly every home and business had its own cistern system. These cisterns, which are essentially storage tanks, and can be under- or above- ground, provided freshwater to the residents.

Merili McCoy, 4th generation Conch, remembered growing up knowing the worth of water:

"*My first cistern experiences were the bath rules in our house. No reason why four kids couldn't use one tub of water. I was the only girl and the oldest, so I got in first. A great respect for water and the conservation of it was imprinted on us at a very early age*."

The Lighthouse grounds are fed by a 6,000 gallon cistern.

Plans for a new naval facility in Key West with an estimated water need of 75,000 gallons/day prompted a change in how we relate to our water supply. Since it was believed that the roof of the barracks couldn't collect enough water for the 7 floors of navy personnel living underneath it, funding partnerships between Federal, State, and Municipal entities were needed to come up with a new source. The resulting new 130-mile pipeline from Florida City provided cheap water with relatively few people to share it amongst.

During the years that followed, more and more Conchs shifted their water use away from cisterns, increasingly relying on mainland water. Only in the event of droughts or pipeline ruptures were these personal water savings tapped into, the owner displaying a cistern sign in their yard to proclaim their personal resiliency and respite from the rationed water use laws (McCoy, personal communication, September 8, 2002). Residents were actually encouraged to destroy their cisterns - so they would break the concrete caps that covered them and fill the tanks with trash and dirt. Many Key West residents have discovered these old cisterns, filled with plants and debris.

Trap doors gave access to the large cistern under Fort Zachary Taylor.

Present Uses of Historic Cisterns

In the sixty years since the pipeline was put in place, the Keys' population has boomed, and residents have stopped collecting or conserving water entirely and now have to share it with 7 million others in South Florida. Only a few of the original cisterns remain intact. Some of these cisterns have been converted to pools, bathrooms and restaurant seating, but most sit abandoned, in shambles of disrepair.

The Key West Lighthouse Museum is one place in the Keys where the original cistern still remains intact. Bender and Associates architecture firm restored the 6,000 gallon cistern on site, and it is still in working order, hooked up to the landscape watering system. The cistern features a wooden gable roof, like many of the old cisterns did.

Fort Zachary Taylor, hides beneath it a secret from the past, one that the Navy should have taken note of. The entire fort had cisterns built below it, a very important feature when you are being built out in seawater. These cisterns had to support the entire Fort, for long periods of time, since the occupants were usually cut off from outside contact and resources. Today, if you tour through the barracks, you will notice four hatches in each room; these lift up to revel cisterns, two per barrack, each about 6 feet deep and approximately 50 by 15 feet.

Local Spotlight #1: 3,000 Gallon Plastic Cistern, Apart from House

Steve and Jackie Grasley are almost finished building their completely off grid home in Marathon. They have no utility water, electricity, or septic, but their home doesn't seem any different than other Keys homes. In fact, during our interview, in early August, the air conditioning was not yet on, but the inside of the home was still quite comfortable, due to good planning. Mr. Grasley is an engineer, and was formerly a co-owner of SALT (Sea Air Land Technologies), and now runs his own company Solaria Design and Consulting.

The couple lived on a boat for 15 years, so they understand the importance of water conservation. When it came time to move to dry land, they decided that their sole source of water would be the sky. They have a 3,000 gallon polyethylene cistern, ordered from manufacturer Chem-Tainer. To prevent algae growth, as well as keep the system from being an eyesore, the cistern is located in one corner of the garage. The tank is about eight and a half feet in diameter and stands seven feet tall.

The Grasley's use about 150 gallons of water a week, far less than the 700 gallons a week the average Keys' couple uses. But, they aren't depriving themselves of anything. They do at least three loads of laundry a week, but are smart in how they wash dishes, take showers, and use their precious water. Their roof is about 2,500 square feet, and so their tank has the capacity to collect ~65,000 gallons over the course of a year- more than they can use!

The Grasley's have designed and incorporated some interesting features into their rainwater harvesting system. For one, they have what is called a "pre-wash" tank, where the first 30 gallons of rainfall collect. It only takes about 4 seconds to fill up, but it greatly decreases the amount of dirt and debris heading towards the cistern. They have a set up of four different filters, one of which is only used for drinking water. First, before the water reaches the pump, there is a prescreen to keep out large debris. Then there is a cloth filter which removes everything larger than 5 microns. Next comes an activated charcoal filter that will remove particles large than half a micron. And, for drinking water, there are two parallel running "superfilters", which remove particles .1 micron and larger, heavy metals, and even viruses.

Once a year, Mr. Grasley can climb into the tank to vacuum out any dirt that has gathered in the tank. He also suggests developing a "cleaning system" to provide its own maintenance to the tank: a $50 pump, with another cloth 5 micron filter, to pump the water through once a year. The Grasley's system was incorporated into the design of their home, and Mr. Grasley especially wanted to be sure it was not unsightly, so a very streamlined design was done.

To prepare for hurricanes, heavy steel cables anchor the tank into the ground- note that this is something that must be engineered and does require a permit, but it's worth it when you consider the damage a floating tank can do.

The tank cost close to $1,600 delivered, when purchased a few years ago. Today, Mr. Grasley estimates the same tank would cost closer to $3,000, as a reflection of the increased cost of materials. The first three filters must be changed out about every three months, and the superfilters are changed every six months. The replacement filters cost about $10, with the exception of the superfilters, which run closer to $80.

Overall, the system cost around $3,000 to purchase and install, the pumps were about $300, the filter systems about $50 each, and the superfilter system was $400, plus the cost of the tank.

The Grasley's home features more interesting "green" concepts than we have room to print, so stay tuned for GLEE's next Green Homes Tour, when you can see it for yourself.

Local Spotlight #2: 13,000 Gallon Concrete Tank, Apart from House

Karen and Ike Beal in Key Largo use a 13,000 gallon cistern for all their freshwater needs, and a brackish well for flushing toilets. The Beals depend almost entirely on their cistern and the rain from the sky, though their plumbing does allow the house to run off the well with a few lever switches, but they have never had to do this.

Only once in 25 years have they ever run out of water, and then they had the fire department bring in a few hundred gallons. The tank usually runs down to about 2,000 gallons around May or June, and it is then that the Beals clean the two tanks in preparation for the coming rains. They are also very careful with how they use their water- being a two person household they typically use between 500 and 700 gallons of water a month. They only water their garden once a week, let the rain wash their cars, and Mrs. Beal doesn't allow guests to help her "clean up" since they "run the faucet like crazy thinking they are helping."

Their cistern was built in 1985, and was incorporated into the plans for their home. The only real difference in the design of their home and a home without a cistern is a small adaptation in the gutter system for the intake system. The cistern tank itself is separate from the house, and is made of reinforced concrete. It is fifteen feet wide, thirty feet long and six feet high. There are two chambers separated by a baffle (basically a short wall) with a spill-over at the top, and the entire tank has ThuroGuard coating inside. The two chambers allow for easier maintenance, since all the water can be drained into one chamber in order to clean out the other.

To prevent a mosquito problem, the Beals have screen vents and a P trap type of intake. In order to prep for hurricanes, they take the intake system down. If the water is low they pump it all into one take for easy access via siphon- which is how they managed after Hurricane Andrew when there was no electricity to run the pump. Mrs. Beal jokes they figured they could use the cistern as a hurricane shelter- pump the water into one tank for use, unhook the intake system (so they don't get flooded in), and set up camp in the second chamber.

They have a sediment filter on the shallow well pump that leads to the house and a Reverse Osmosis system under the kitchen sink. The Reverse Osmosis (RO) system purifies the water for drinking and cooking, just to make sure everything is OK. The initial cost for the system is only about $150, and can be purchased at Home Depot or Lowes, among other places. The RO system filters the water through membranes, then the filtered water goes to a special tank, which is accessed through its own lever and spigot in the kitchen sink. The Beals also test the water quality pre-RO just to be safe, using tests from a mail away company.

Aside from cleaning the tanks right before the rainy season, little maintenance and treatment is required. The Beals keep the gutters clean and the intake pipes in good shape, and add chlorine to the tank about three times a year, especially after a large rain.

Because Beals perform all their own maintenance and treatment, their system is quite economical. The cistern structure cost them $4,000 to build, and the plumbing was no different from a traditional home, so required no additional costs. The RO filters are replaced every year, which costs about $150, and the shallow well pump must be replaced every 3 or 4 years, at a cost of around $250.

The Beals enjoy their water, and are happy they did not have to pay $8,000 to hook up to the Aqueduct when they "didn't have the money." Relying on a cistern has made them more aware of their usage and weather patterns. Another plus- they don't have to use restrictions for watering plants.

Concerns for the Beals, and most systems like theirs, are that if a system fails and they loose the water in the tank, things could get a bit difficult. But by having two chambers, much of this problem is eliminated- if one tank cracks or is contaminated, the other tank can still be operational.

Local Spotlight #3: 16,500 Gallon Concrete Tank, Apart From House

Mick and Alicia Putney live on No Name Key, an island with no provided utility water. This is not a problem for the Putney's - their 16,500 gallon cistern provides more than enough water year-round. They hired Perry Wallace Contractor to build the custom reinforced concrete cistern along side the house during the construction of their home. They have no other source of water.

The Putney's don't make any extra effort to "conserve water" in their opinion, and use close to the keys average of 700 gallons a month, amounting to less than 35,000 gallons a year. They do practice xeriscaping, which is the term for practical landscaping that uses native, drought-resistant plants so there is no outside watering.

The cistern fills to overflow during the rainy season, so there is no way of knowing how much might have been collected. The Putney's have never been short of water. In fact, the lowest the cistern has ever been in 16 years was 25% (about 4,000 gallons) after four months of absolutely no rain.

The Putney's cistern is sealed and closed, so it creates no mosquito problem.

To protect the cistern pump and on "general principle" all the water is run from the cistern through a 20 micron household filter, this removes particles larger than 20 microns. For drinking, they run the water through an additional 5 micron filter coupled with a reverse osmosis filter and a final 5 micron carbon filter. This then removes all particles larger than 5 microns, and the RO filter further purifies the water. But Mr. Putney notes that "some of our neighbors drink the water directly from their cisterns, and none of them are dead." The filtered drinking water is delivered through a separate pipe to each sink or washbasin.

The only maintenance is the filter systems. The initial 20 micron filter is replaced every 2 or 3 months, the first 5 micron filter every six months, the final carbon filter once a year, and the reverse osmosis filter lasts several years. If the cistern ever gets low enough, Mr. Putney will clean the silt out of the bottom (like Hammerstrom and Beal do); but so far that hasn't happened.

In 1992 the cistern itself cost around $16,000. The gutters and piping cost another $2,000 or so, and the filter system cost around $500 not including the piping to deliver the filtered water throughout the house. After that initial cost, the only other cost is the filters, perhaps $75 a year.

Mr. Putney points out the importance of conservation in a world becoming desperately short of fresh water. Cisterns were the original source of water in the Keys, and these locals feel it should be again. It is, in Mr. Putney's words, "ridiculous" to import water 130 miles from the mainland, when we are surrounded by this resource. The Putney's also enjoy independence: they have water when hurricanes shut down regular supplies and freedom from water rationing during crises. Another pro to this cistern system is "a feeling that we are doing the right thing." And, probably what appeals to most of us, in the long run, with rising water costs, harvesting rainwater will save money.

The only downside the Putney's see in using rainwater instead of utility hook up is that they do not have enough water to maintain a large lawn- but they are quick to point out this isn't something they even want, as it isn't appropriate to the Keys anyways.

The Putney's 16,500 gallon cistern (in the foreground, right) has never run out of water.

Local Spotlight #4: 20,000 Gallon Concrete Tank, Apart from House

Tim Chapman and Charlene Hall have been building their Big Torch Key home over the last several years, piece by piece, and recently finished their approximately 20,000 gallon whole house cistern. They, like their neighbors in this area of Big Torch, have no utility water hook up, and could, living very conservatively, live off a full tank for nearly a year.

The cistern is made of "reinforced concrete" and located underneath their stilt home. The couple worked with architect Glenn Gray (of Big Pine Key) to design their system, and the final result is a two tank cistern with an overflow and separate uptake pipes to prevent contamination, decrease loss in case of a leak, and allow for easier cleaning and maintenance.

After consulting with a gutter installer, they decided to use 6 inch gutters instead of 5 inch, due to the pitch of their 2500 square foot roof, to maximize the amount of water collected. In landscaping the property, they also placed the taller trees farther away from the roof so that excess debris would not get into their gutters.

To decrease the amount of debris that enters their cistern pre-filtration, Chapman has a "rockguard" which is an extension of the gutter system so that the first few gallons of water, and the dirt and rocks washing off the roof, gather in this holding pipe before water heads to the cistern. Then there are three filters for their system. The first is a stainless steel screen on the pickup to keep out large sediments, and it is integrated into the check valve. After going through the pressure tank, the water is treated in a dust and rust filter. Finally, the rainwater travels through an activated charcoal filter. The last two filters need to be replaced about once a year. Chapman and Hall are considering adding another activated charcoal filter underneath the kitchen sink for drinking water when the house is complete. The cost of the system was about $20,000, and the entire piping/pump/pressure tank/filtration system cost close to a grand.

The couple took hurricanes into account in the design. The cistern foundation is three feet underground, on top of the caprock, to ensure a sturdy foundation. To prevent the cistern from shifting in case of high wind or water, augers root the cistern to the caprock foundation. Also, Mr. Chapman insisted that the bottom and sides of the cistern be made thicker than what was required. To keep the system well maintained, Chapman makes sure they keep the filters changed, the gutters clean, and clean out the tanks as needed. To prepare for a storm, the pressure tank is strapped down, and the hatches on the top of the cistern will be locked shut. They also unplug their pump, wrap the motor in a garbage bag and tie it down to minimize salt exposure.

The best part of having this system, Chapmen says is the control you have, over the quality of water, the use of your water (especially during times of restrictions), and after the initial cost, no water bills. On the downside, which he still sees as a benefit, you're running your own water plant so you need to know how to keep it maintained, or else hire someone to do it.

Tim waters his native landscaping with the overflow of his 20,000 gallon concrete tank (in background)

Local Spotlight #5: 10,000 Gallon Concrete Tank, Part of House

John Hammerstrom and Diane Marshall are Key Largo locals whose cistern was built during the construction of their home. The cistern is part of a storeroom on the ground floor foundation slab, underneath the living spaces, and is made of reinforced concrete. Mr. Hammerstrom did his own research on the subject, consulted with other cistern owners, and established the construction specifications for the general contractor to build.

The cistern itself is roughly 10,000 gallons, providing 7,500 gallons of useable rainwater storage. Hammerstrom and Marshall's cistern has a "weighted float" level-indication system, 1 hp jet pump, 80 gallon pressure tank and triple filtration system.

Seven and a half inches of rain will fill the cistern. Since a roof is capable of harvesting roughly 600 gallons per 1,000 square feet of roof per inch of rain, Hammerstrom and Marshall's ~1,700 square foot roof delivers ~1,000 gallons of rainwater per each inch of rain. Roughly 35,000 gallons of water falls on their roof annually. During the rainy season, the tank frequently fills to capacity, and the excess is wasted as overflow. Mr. Hammerstrom estimated that of the 35,000 gallons that falls on the roof annually, they use 25,000 gallons, with the remaining 10,000 gallons overflowing during the rainy season.

Since rainwater is much more pure to start with than any ground water or surface water (because ground water can pick up any water-soluble contaminants), and because of care taken at every opportunity to either clean the rainwater or at least not impart contaminants, their potable water far exceeds all drinking water standards. Because of the allowable contaminants in utility water and the required chemical treatment, he feels that utility water cannot compete for quality with rainwater.

Since their harvested rainwater is of extremely high quality (see Appendix A), this household conserves their cistern water for potable uses such as cooking, drinking water, and personal uses, and only use it for non-potable uses when it is plentiful. Because they are tied into FKAA with a Reduced Pressure Zone (RPZ) valve, they are able to use utility water for washing vehicles, landscape irrigation, and toilet flushing in times of drought. Their design has three subsystems, so it is possible to select either rainwater or utility water as a source, depending on the quantity of top-priority rainwater and the probability of replenishing rains.

Because they can switch to utility water during the driest times, they have never run out of rainwater. Typically, they will shift most consumtion to utility water near the end of the dry season around March and April, reserving the purified rainwater solely for cooking and drinking at one faucet in the kitchen. They remain in that configuration until June when the rains return, and from June until November use purified rainwater for all potable uses and utility water for others.

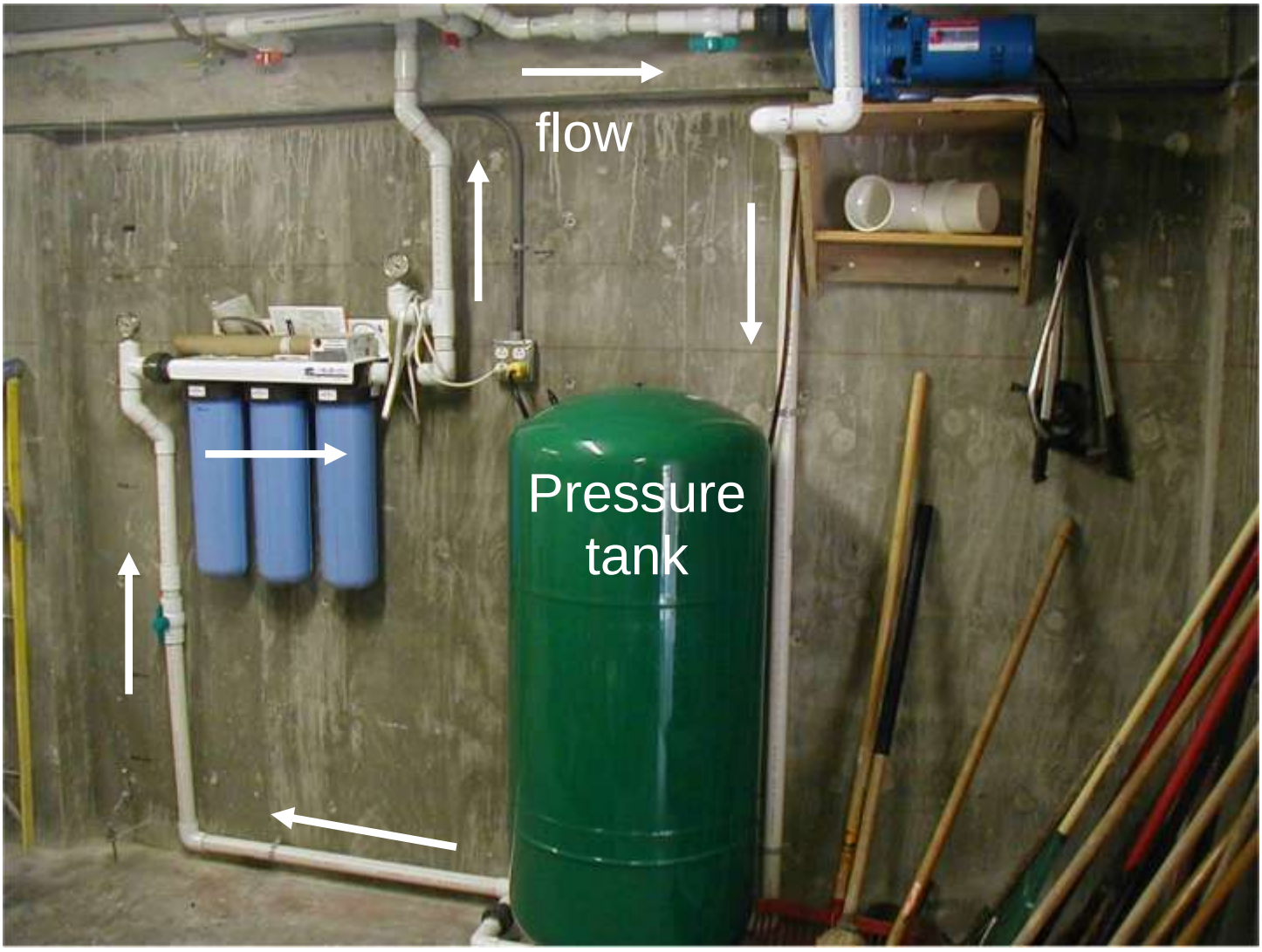
If confronted with an extended drought, Hammerstrom estimates a whole tank would last up to four months. In a crisis, however, extremely conservative use would mean the rainwater would last the whole year.

While the low contaminant metal roof, lack of tree overhangs, screens and roof washers remove the bulk of contaminants, Hammerstrom and Marshall use a Pura Big Boy 20" filtration system to purify their harvested water. It employs a 1-micron sediment filter, a carbon block and an ultraviolet chamber. Once a year, Mr. Hammerstrom inspects one side of the tank

(there is a divider so that inspection can be done without an empty tank), then the other. It is vacuumed out with a wet/dry vacuum to remove the slight “dust” sediment that collects over the year. He also changes the sediment filter every three months, the carbon block every six months, and the ultraviolet light once a year. To avoid a mosquito problem, all openings are screened or otherwise blocked. Nothing special needs to be done to prepare for storms. Mr. Hammerstrom notes that the associated rain is a welcome event, even though the wind is not.

The initial cost of the cistern was about $12,000. The filtration system cost roughly $800. Annual filter changes total to about $250. Hammerstrom also points out that because the upfront costs are high, the cost of the purified rainwater decreases each year. His rainwater has cost roughly 6 cents per gallon in the six years he has collected rainwater, and next year, because the only expected costs are the $250 filters, that will decrease to 5 cents per gallon.

Mr. Hammerstrom enjoys the fact that his rainwater harvesting system decreases stormwater runoff, makes good use of a free and plentiful resource, provides secure on-site water during emergencies, and - with rising utility water costs - has a steadily increasing investment value. The couple finds harvesting and consuming rainwater is definitely worth the time, effort and cost involved.



Local Spotlight #6: 1,000 Gallon Septic Tank Conversion

The Wagner's converted their concrete septic tank, which came with their home, to a cistern for less than $800.00. The only thing the Wagner's changed on their home was the addition of gutters to direct the water to the tank (not included in total estimated cost) They use the septic tank turned cistern for all landscaping uses, and use utility water for everything inside their home. Their new "cistern" holds 1,000 gallons, and takes about 4 inches of rain to fill.

Since the water is drawn from a suction pipe located six inches from the bottom of the tank, the water level must stay above this level. The Wagner's have never run out of water since they only use it for their landscaping and usually only draw from it during the dry season. The tank fills approximately three times a year, so it is estimated that the Wagner's use less than 3,000 gallons a year from their system.

After the initial conversion treatments, no treatment is required since the water is going to non-potable uses outside their home. To prevent a mosquito problem the tank is covered and the overflow has a screen. This tank helps the Wagner's conserve water, keep a nice lawn even during restrictions, and provide chlorine-free water for fragile plant life. The only set back is the initial cost- but don't forget you're saving on having to destroy and remove an abandoned tank (between $200-$300), as well as saving water and thus money! Fran Wagner points out that though the DOH procedures may seem tedious, they are not. The steps are very straightforward, and only have to be done once. And, since the life of the tank is about 100 years, the result that comes from converting instead of destroying a useful concrete tank already on site, is well worth it.

Step by step instructions on how to complete a Septic to Cistern Conversion can be found on page 32.

Section 4 – Evaluations

Once you have read through sections 1 and 2 to choose the rainwater harvesting system you desire, use these worksheets to estimate your potential costs and savings.

How Much Rainwater Can You Collect?

#1		X	.5	=	
	Square feet of roof (or sq. feet of home)	Multiplied by	Gallons of water per sq. ft	Equals	Gallons saved with 1” of rain
		X	**Key West: 39” Lower Keys: 43” Marathon: 44” Islamorada: 45” Key Largo: 45”**	=	
	Gallons saved with 1” of rain	Multiplied by	Average Keys rainfall	Equals	Gallons saved per year

How Much Can You Save Annually?

#2		X	0.007	=	
	Gallons saved per year	Multiplied by	Average household cost per gallon	Equals	Cost savings per year

How Much Might Your System Cost?

#3		X	.	=	
	Estimated Cistern Volume (Gallons)	Multiplied by	$1.00 for plastic $2.50 for cement	Equals	Estimated Upfront Cost

How Much Money Might Your System Save You?

#4		X	0.007	=	
	Estimated Cistern Volume (Gallons)	Multiplied by	Cost per gallon of water	Equals	Total Annual Savings Possible

How Much of a Rebate Can You Get?

#5		X		=	
	Estimated Cistern Volume (Gallons)	Multiplied by	Rebate amount per gallon of water	Equals	Total Rebate Possible

Estimated Short Term Cost

#6		--		--		=	
	Estimated Upfront Cost (#3)	Minus	Total Rebate Possible (#5)	Minus	1st Year Water Savings (#4)	Equals	

Estimated 5 Year Cost

#7		--		--		=	
	Short Term Cost (#6)	Minus	4 more Years of Water Savings (#4 X 4)	Minus	5 years of Sewer Bill Savings (if known and applicable)	Equals	5 Year Cost

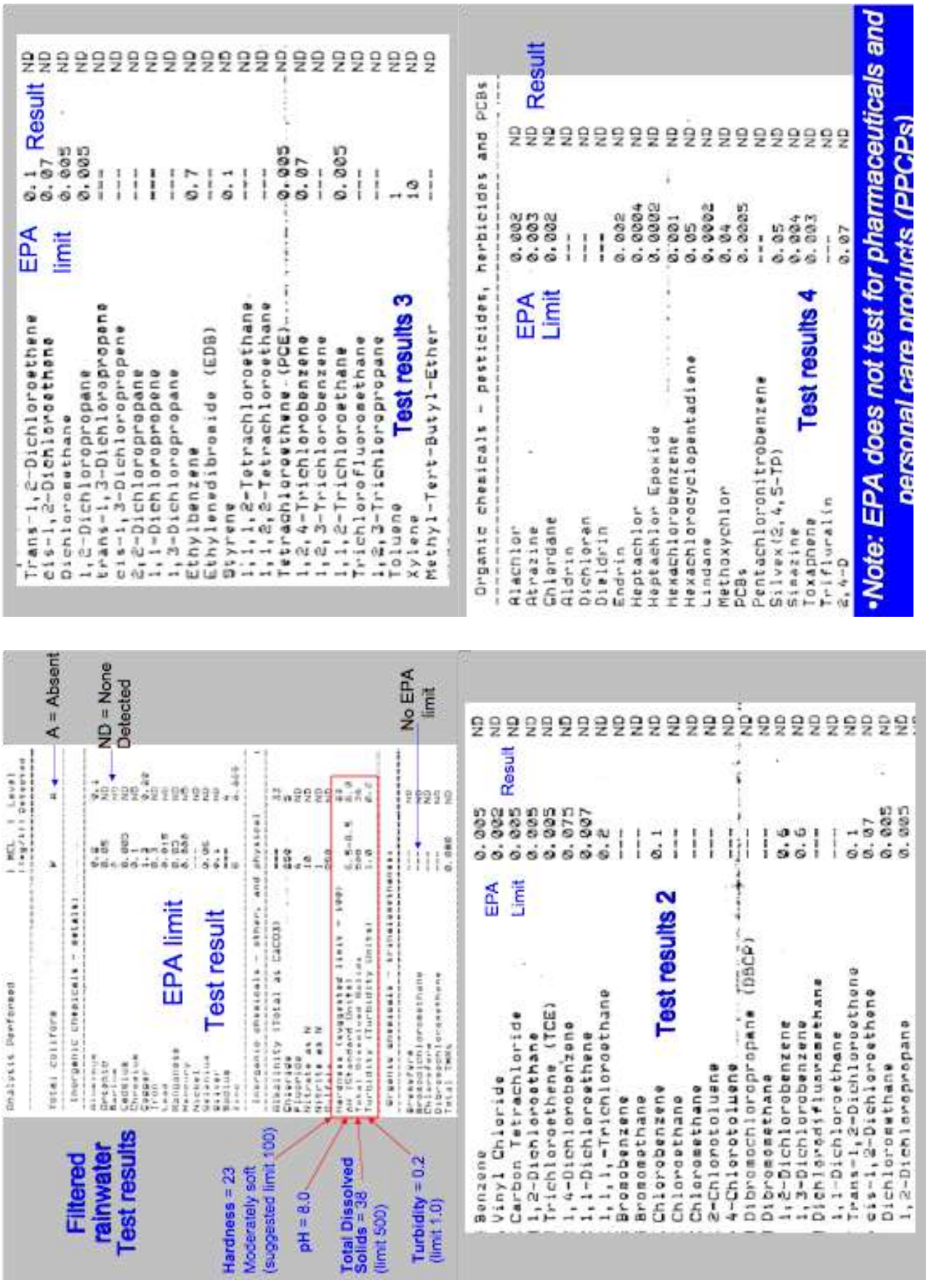
FKAA Wastewater Rates

Section 5 – Appendices

Appendix A: Hammerstrom's EPA Water Quality Test Results
Appendix B: Building Codes, Rules, and Recommendations
Appendix C: Septic Tank To Cistern Conversions
Appendix D: Guidelines for Gutters and Downspouts

Appendix A: Hammerstrom's EPA Water Quality Test Results

("ND": Nothing Detected)



Appendix B: Building Codes, Rules, and Recommendations

Cisterns in the Florida Keys are reviewed on a case by case basis, but for Marathon and Monroe County, we were able to find specific permit fees. A building permit will be required, no matter where you live, so for further information contact your local building department. You can apply for a builder/owner permit, in which you must still have a certified, registered engineer stamped designs, but you will be building the bulk of your system. Or you can get your permitting through an engineering firm or contractor, who will be installing your system. Contact your building department to determine what steps you need to take.

Marathon: 9805 Overseas Highway Phone: (305) 743-0033

Cisterns:	
Minimum Fee	$ 75.00
Residential	$ 100.00
Commercial (non-potable water only): For each 1,000 gallon capacity or fractional part thereof	$ 10.00

Monroe County: Marathon Government Center, 2798 Overseas Highway Suite 330, Marathon

Marathon Phone	Plantation Key Phone	Stock Island Phone
(305) 289-2501	(305) 852-7100	(305) 295-3990

Courtesy of Harry Kostic:

a. Residential (designed as part of home) 100.00
b. Commercial (non-potable water only):
   i. For each 1000-gallon capacity or fractional part thereof 10.00
c. Minimum Fee 150.00

- For a residential cistern that is added on, an additional $50 review fee will total the fees to $150.
- Specific regulations: An above ground cistern must be anchored to withstand 150 mph exposure winds, and cannot be in the setback. Anything that is constructed on site or could be hazardous in the event of a storm must be anchored and permitted. (When in doubt, call the authorities!)
-

Key West: 604 Simonton St (305) 809-3956

(Courtesy of Derwood Stewart):
Specific information is unavailable. Key West will regulate cisterns on a case by case basis, in accordance with the State of Florida Building Code, which has very limited regulation for residential cisterns, most notably the importance of preventing backflow, which is prevented by the backflow device from FKAA. No cisterns have been built in Key West at least 7 years, so if you are interested in either restoring your existing cistern or building a new cistern, the building department suggests you make an appointment for a consultation on local codes and statutes, and they will review your initial ideas and plans and suggest any improvements. This will save you time and money before you hire an engineer or contractor to officially design your system.

No info for Islamorada, Layton or Key Colony Beach as of printing.

Appendix C: Septic Tank To Cistern Conversions

(Courtesy of Bobbi Sleighter from Florida Department of Health)

(Step by Step Instructions Provided on Page X)

REQUIREMENTS: (AFTER VARIANCE APPROVAL)

1. The applicant shall obtain a system abandonment permit from the County Health Department. The permit application shall specify the intended use of the septic tank.
2. The activities related to abandoning the onsite sewage treatment and disposal system shall not create a sanitary nuisance.
3. The septic tank shall be disconnected from the drainfield and from the building sewer pipe.
4. All work to disconnect, clean and sanitize the septic tank shall be conducted by a registered septic tank contractor or a state-licensed Plumber or by the owner of the owner-occupied single family residence being served by the septic tank
5. All septage, wash water, and other liquids removed from the tank shall be removed and handled as septage (64E-6.010) by a DOH-licensed disposal service and disposed of at a DEP-regulated wastewater treatment facility.
6. The health department shall inspect the tank once it is disconnected, emptied, cleaned, disinfected and filled with water. The inspection shall determine that:
    a. the tank has been disconnected from the drainfield and the building sewer
    b. the tank is full of water within 12 inches from the top of the tank
    c. the clarity of the water is such that a Secchi disk is visible at the bottom of the tank
    d. the pH of the water in the tank is between 6.0 and 8.0
    e. the free chlorine residual of the water in the tank is <1.0ppm
    f. the total coliform count <1000 per 100 ml
    g. the fecal coliform count is <200 per 100 ml
    h. no sanitary nuisance condition exists on the property related to the abandonment activities
7. While one inspection is included in the abandonment permit fee, The applicant shall pay a reinspection fee (64-E-6.0302(I), FAC) for any additional inspection visits necessary until all of the criteria in #6 are met and final approval of the abandonment is granted by the county health department.
8. The applicant shall be responsible for all required laboratory fees. All sampling shall be conducted by county health department staff during the final inspection.
9. The abandonment permit shall be valid for 18 months. The septic tank shall be properly abandoned within 90 days after connection to the sanitary sewer.
10. The tank shall not be connected to any irrigation components nor the water used for irrigation purposes until final approval of the abandonment has been granted by the county health department
11. Upon final approval of the abandonment, use of the tank or the drainfield for sewage storage, treatment or disposal is prohibited and constitutes a nuisance injurious to health as defined by Chapter a.386.041, FS
12. Upon final approval of the abandonment, the water collected in the tank shall be utilized for non-potable, irrigation purposes only.

WARNING: Working in and around an open septic tank can be dangerous. Activities related to the cleaning and disinfection of the septic tank could expose the workers to hazards related to confined workspaces, methane gas, aerosolized pathogens, collapsing tanks and other hazards.

The applicant and workers are advised to seek advice from OSHA or experts in occupational safety before undertaking this work.

Additionally, the applicant is advised to have the tank inspected by a civil engineer or other person qualified to evaluate the condition of the tank and its suitability for the intended use.

This variance, as approved, applies only to those sections of the law or rules referenced above. This variance in no way exempts compliance with other state and local regulations. This variance will expire one year from the date of this letter unless an onsite sewage treatment and disposal system construction permit is issued by the county health department, in which case the variance will run concurrent with the system construction permit.

If you have any questions please call Ed Williams, Bureau of Onside Sewage Programs, at (850) 245-4070.

Details for Septic Conversion

Step by Step Details for Converting an Abandoned Residential Septic Tank to a Cistern to Collect and Store Rain Water for Landscape Irrigation

By Fran Wagner

Although these procedures seem tedious, they are not. They are very straightforward and, what's more, they only have to be done once. The gratifying result is that instead of destroying a completely useful concrete tank already on location, that tank is put to excellent use. And that use will continue to produce benefits for the life of the tank, which should be about 100 years.

1. At sometime during the sewer project, before the house is connected to the new sewer system, the owner must obtain a variance from the Department of Health (DOH) to allow the old septic tank to be converted to a cistern. The fee for this will include an inspection by the DOH of the water in the new cistern to assure that it is not contaminated. The chlorine bleach described in step 5 will make sure that the water is properly disinfected.

2. After the septic tank is no longer in use and the house sewer pipe is connected to the municipal system, the septic tank should be pumped empty by a certified septic pumping contractor. Most such contractors have a pressure washer and fresh water supply on their truck. Ask the contractor to thoroughly clean the inside of the tank and then to pump out the wash water.

3. If roof gutters do not exist they must be installed. Connect the downspout(s) to 3" PVC pipe that is routed to the now unused septic tank. We will call it a cistern tank from now on. Usually the 3" pipe can be connected to the stub which remains of what was the old fill pipe running from the house. It is a good idea

(though not necessary) to have a piece of 1/8" mesh screen material at a suitable location in the path from the gutter to the cistern. This will catch any debris which is flushed from the roof during the initial minutes of a rainstorm.

4. Connect an overflow pipe to the top of the cistern. This is usually a couple of 3" PVC 90 degree elbows which allow overflow water out of the cistern if it is full and it is still raining. Install some sort of grate or screen to prevent rodent and mosquito access to the cistern. It is also desirable to put some sort of splash basin or gravel field to reduce erosion at that point and to guide the overflow in a desired direction.

5. The tank is now able to collect rainwater. After it is about three quarter full, add 3 - 4 gallons of chlorine bleach. The best is ordinary plain (unscented) bleach. When the tank is full, add another gallon or two of bleach. These amounts of chlorine are more than is necessary for a very large tank (more than 1500 gallons. Most septic tanks are 1000 gallons or less in volume. The chlorine will totally disinfect the tank by killing any remaining bacteria even those that are in the pores of the concrete walls, while slowly dissipating.

6. The best type of pump to use to pump the rainwater from the cistern to a garden hose bib faucet is called a "shallow well" pump. Most of these are supplied with a pressure tank that holds from one to about five gallons of water. Basically the pump draws water from the cistern and fills the pressure tank to about 40 – 50 psi. If the hose is turned on, the pressure in the tank forces water out the hose. As the water is used from the pressure tank, when the pressure drops by about 5 – 10 psi, a pressure demand switch automatically turns on the pump to refill the pressure tank. The pressure tank keeps the pump from running constantly and provides fairly constant pressure. Such pump/tank combinations can be purchased from Home Depot or at substantial savings on the Internet from discounters such as "Harbor Freight Tools".

   The pump should be mounted off the ground (remember Wilma). Such pumps run on regular 115V household power. Have a GFI receptacle installed in a weathertight box near the pump and have a switch installed in the circuit to be able to disable the pump if needed.

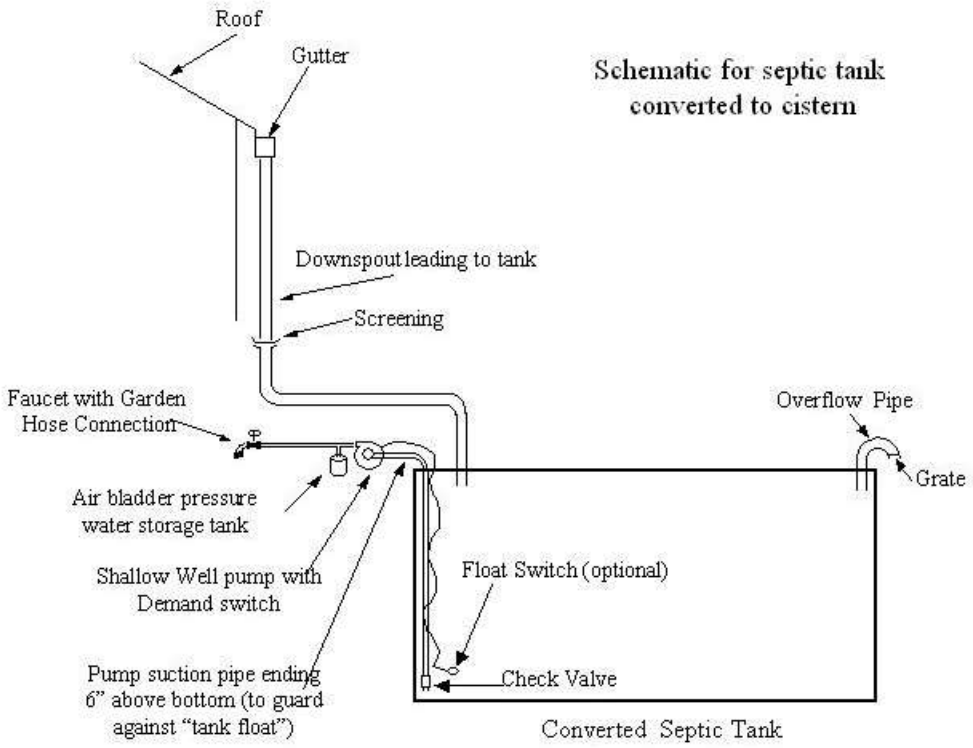
7. Connect a PVC pipe from the cistern to the intake of the pump. Usually a 1" pipe is used. If the pump intake fitting is larger, use a reducer to get to 1". If the pump intake fitting is smaller then use pipe of the same size as the fitting. The pipe should have a check valve installed near the end in the bottom of the cistern. The end of the suction pipe should be above the bottom of the cistern by about 6 – 8 inches to allow that much water to remain in the cistern. This will help weigh down the cistern tank and keep any groundwater pressure from "floating" it, that is raising it partially out of the ground.

8. Connect a PVC pipe from the pump outlet to a suitable location for a garden faucet. A 1/2" pipe is sufficient. If the pump output fitting is larger then 1/2" then the proper reducer should be used. The pump can supply several garden faucets. If several are required, they can be branched off the main output pipe from the pump and all can be serviced with 1/2" pipe.

9. In step 5, the cistern was allowed to fill and was chlorinated to kill any remaining bacteria. At any time that the chlorine level has dissipated to the level allowed by the DOH, (this level was less than 1 ppm at the time of the Wagner's write up – it may have changed so check with the DOH) they should be called to test the cistern water. This only has to be done once. The chlorine level can be easily tested by a common swimming pool test kit which is either available from a neighbor with a pool or from Home Depot for less than $10. In addition to the chlorine level, the DOH requires certain parameters to be met for water clarity and for bacterial content. These should be no problem with rainwater.

10. An optional submerged float switch can be installed into the pump circuit. This will shut down the pump if the water level falls below the float switch setting. This prevents the pump from running when the cistern is almost empty and the pump cannot pump water. This damages some pumps.

The following diagram shows the conversion:



Additional procedures required for an aerobic septic tank:

An aerobic septic system usually consists of 2 or 3 separate tanks. The tanks are made of concrete or fiberglass. There may also be aerobic systems which consist of one fiberglass tank. I am only familiar with the concrete aerobic system and this write-up only deals with that type.

The first tank is the one most easily converted to a cistern. The other tank(s), which are filled with filter sand, are best left full and abandoned as is. Check with the DOH to see if any additional procedures are required for these tanks such as the addition of any gravel to "top" them off, etc.

The first tank usually has several chambers separated by internal concrete walls. The walls have openings either at the top or bottom to allow flow from one chamber to the next. The first chamber is a "settling" chamber which allows solids to settle and for the remaining liquid to flow into the second chamber via an opening near the top of the separating wall. This first chamber has the solid waste products pumped out every 3-6 years by a septic contractor while the system is in use as a septic tank. The second chamber is for pretreatment of the liquid waste by bacteria, which require air to do their job. The air pump that supplies this air will be discarded when converting to a cistern. Sometimes the second chamber also has a type of plastic grate to trap lightweight floating material that makes its way through the separating wall opening. This grate should also be discarded after the tank is cleaned out. Usually there is a small third chamber, which is fed bacteria-treated liquid from the second chamber via an opening at the bottom of the wall which separates these two chambers. From the top of this third chamber, the treated liquid flows to the second tank for further filtering.

The complication of the aerobic design as far as cistern conversion goes is that the first and second chambers are connected via an opening near the top of the wall that separates them. While the treatment process for septic waste necessitates this, it unfortunately separates the chambers for cistern use. If cistern water is drawn from the first chamber, the water in the other two chambers cannot flow into the first chamber and thus is not available to the pump.

What is required is that a hole be punched in the separating wall near its bottom to connect the chambers. Someone experienced in its use can do this with a jackhammer with a long probe. Although the concrete tank outer walls are quite strong, some care should be taken when jack hammering the interior separating wall to prevent any cracks in the outer tank wall. Alternatively, a portion of the separating wall can be totally broken down by a jackhammer. None of this jackhammer work has to be smoothed or finished off in any way. The only purpose is to create an opening for water to flow between chambers 1 and 2. Since the wall between chambers 2 and 3 already has an opening at the bottom, the final overall result will be that all three chambers will be connected via openings near the bottom of the tank in effect making it one tank.

An alternative to opening the wall, which separates the first and second chamber, is to only use the second and third chamber as the cistern. The first chamber is usually about one quarter of the total tank in volume. Normally such septic tanks are about 1000 gallons in total volume so that this alternative would reduce the cistern capacity to about 750 gallons.

Remember that even in this case, this doesn't mean that only 750 gallons are saved per year. The cistern will be cycled several times per year as water is used for garden irrigation and then replaced by rain. In practice, an amount of water about three times the capacity of the cistern can be saved each year.

A final word about the other tank(s) of the aerobic system. If desired, they can be emptied of the filter sand they contain and can also be used as cisterns. This can be done at the same time as the first tank is converted, or at some later time. In fact this is true for any septic tanks which were abandoned in the past and filled with sand or gravel. Any of them can be "resurrected" and converted as long as they were not crushed or had holes punched into them in any way.

There is however a complication in that there is no easy way to get the sand out. Some of these tanks are designed so that the entire top can be removed, some not. If the entire top comes off, a small backhoe can remove the sand. There have been some Keys residents who have had these tanks emptied by hand labor, but that is expensive and not very pleasant. However if such a tank is emptied then it will make a fine cistern especially since there are no chambers in these tanks to complicate matters. The simplest procedure at this point is to make two separate cisterns with duplicate pumps etc. where each one is filled from part of the roof. Alternatively it is possible to hook the two tanks together with a submersible sump pump arrangement where several float switches direct the second tank to pump into the first tank when appropriate. In this way there results a two tank cistern arrangement which functions as one large cistern of about 2000 gallon capacity.

In those septic systems which consist of three tanks (these are the newest ones mandated by Monroe county) the third tank can be used in the same way as the second one.

Appendix D: Guidelines for Gutters and Downspouts

Gutters and downspouts for distributing rainwater should be the correct size, durable, attractive and well-suited to buildings on which they are used. Because specifications depend on gutter type and special considerations such as snow load or roof construction, you should consult a company specializing in gutter design and installation for product advice.

General guidelines for selecting and installing gutters include:

- Select gutters at least 5 inches wide.
- Select gutters made from galvanized steel (29 gauge minimum) or aluminum (.025 inch minimum).
- To enhance flow, slope sectional gutters 1/16 inch per 1 foot of gutter; slope seamless gutters 1/16 inch per 10 feet.
- Use expansion joints at connections for straight runs exceeding 40 feet.
- Keep the front of the gutter 1/2 inch lower than the back.
- Provide gutter hangers at least every 3 feet.
- Select elbows with 45, 60, 75 or 90 degree angles, as needed.

General guidelines for selecting and installing downspouts include:

- Space downspouts from 20 to 50 feet apart.
- Provide 1 square inch of downspout area for every 100 square feet of roof area. (A 2-inch-by-3-inch downspout will accommodate 600 to 700 square feet; a 3- inch-by-4-inch downspout will accommodate up to 1,200 square feet.)
- Do not exceed 45-degree angle bends.
- Select downspout configuration (square, round or corrugated round) depending on your needs.
- Use 4-inch-diameter pipes to convey water to storage containers or filters.

Appendix E: Additional Pictures