Common Single Dwelling Water Supply Systems in the Appalachian Coalfields

In the rural sections of the Appalachian coalfield region many residents utilize a domestic well or a developed spring as their primary source of water. A few residents employ rooftop collection systems to provide water where a well or spring source are not possible or are inadequate. Many of these systems while not perfect generally provide an acceptable amount of water which is of satisfactory quality. This guide sheet is designed to acquaint the reader with how the systems are frequently constructed and operated. In several cases, examples of recommended construction are provided.

Wells

Wells in this region are commonly between 100 and 200 feet deep depending on the general topographic location (valley bottom, hillside or hilltop). Valley bottom wells tend to be relatively shallow compared to those located on the hilltops. Hillside wells tend to be to depths in between valley bottom and hill top wells. Domestic water wells are drilled deep enough to access adequate water-bearing fractures. In some cases, the wells need to be much deeper than 200 feet in order to access sufficient quantity or quality.

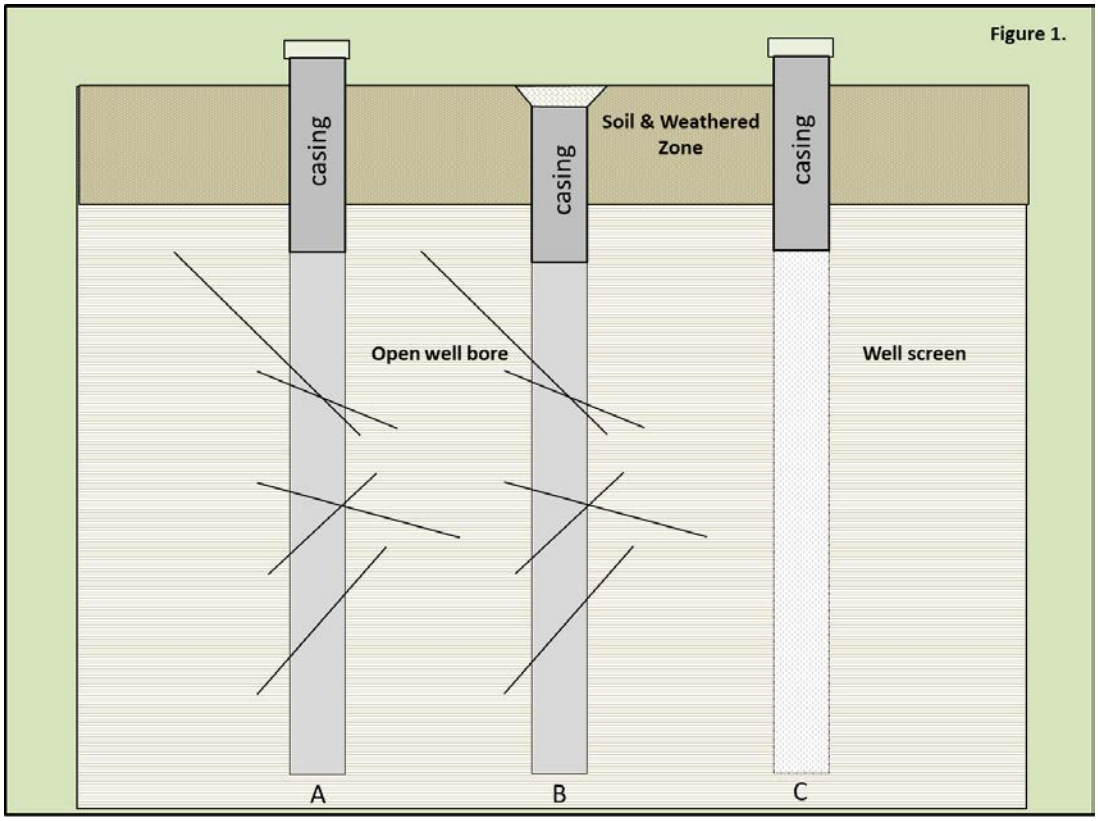
Throughout much of the Appalachian Plateaus, the majority of ground-water movement through and storage in undisturbed strata is via the secondary permeability and porosity formed by fractures in the rock. The sedimentary rocks throughout much of the Appalachian Plateau tend to be highly cemented and well indurated; thus primary porosity and permeability are very low and their influence on the ground-water flow regime is negligible. At shallow depths, generally less than 150 feet, fractures were created in large part by stress-relief (release) forces. Stress-relief forces are generated by rock mass removal from natural erosion processes over time (Ferguson, 1967; 1974; Ferguson and Hamel, 1981). Stress-relief fractures tend to be mostly vertical or near vertical along the hillsides paralleling the main valleys and horizontal bedding-plane separations become common approaching the valley bottoms (Wyrick and Borchers, 1981). Ground water flows from the hilltops and hillsides down toward the adjacent streams in a quasi-stair-step fashion. The frequency and aperture size of stress-relief fractures tend to decrease with increasing depth (Wright, 1985; Hawkins and others, 1996); so, most of the ground-water flow in this region is limited primarily to the upper 150 feet.

Frequently, highest yielding fractures are encountered in the upper 50 feet however the wells are commonly drilled another 75 to 150 feet. The additional well bore is used an in-well reservoir. An average well in the Appalachian Region yields between one and three gallons per minute (gpm) in actuality. Usage demand is often closer to five gpm. So, in-well storage (a reservoir) is required to allow the well to produce enough water for the residence during peak demand periods. The combined yield of the water-bearing fractures and the well hole storage capacity may allow marginally-yielding wells to suffice as a water source.

Commonly wells in the Appalachian Region are open borehole construction with a single 20-foot length of steel or PVC casing from the surface (Figure 1A). Casing is installed to span the soil/weathered zone horizon into the solid bedrock in order to minimize this upper unconsolidated material entering the well bore. Less frequently concrete will be used to grout the casing in place, further seal off the unconsolidated material, and preclude the rapid inflow of surface water around the casing and into the well bore. Rarely a concrete apron is poured around the top of the casing to divert water away from the well.

The casings of older wells of this region were often either originally set below the ground surface or were cut off below the surface. So, the top of the well is buried (Figure 1B). Occasionally, the home is built over top of the well. These configurations are problematic in several ways. For buried well heads, water and soil can enter the well bore by a less than tight seal at the top of the casing. Also, it is not rare for wells of this region to have appreciable concentrations of methane naturally or induced by anthropogenic activities. Buried well heads inhibit the venting of the methane and can facilitate the introduction of fugitive methane into the dwelling via the plumbing. Where the home is built directly over top of well, fugitive methane can directly enter the home. Gorody (2012) noted that up to 60 percent of wells in the United States may have detectable concentrations of methane.

In some portions of the region, a significant portion of the strata are comprised of claystones and other clay-rich rich units that are fairly soft and incompetent. In these areas, the well bores are prone to collapse from the frequent wetting and drying, weathering, vibration, and a plethora of other factors. In these cases, a well screen or perforated casing is installed to support the integrity of the bore (Figure 1C).



Some recommendations for well construction are shown on Figure 2. This is just one of several acceptable scenarios; there can be several variations and additional aspects that are not shown. The casing should stick up at least 12 inches above the ground surface. There should be an upside down U-shaped vent with a screen to inhibit the introduction of bugs and other foreign items. The cap can be bolted on or have a locking mechanism. The casing should extend through the soil and poorly consolidated weathered zone into solid rock. The casing should be grouted to secure it in place, seal off the unconsolidated zone, and inhibit the infiltration of surface water alongside the casing down into the well bore. The pump should be set about 5 feet off of the bottom to allow space for the buildup of

sediment over time. Otherwise the pump's intake can become clogged or water circulation around the pump motor will be inhibited which can cause the pump motor to burn up.

The pitless adapter should be located well below the frost line for the area to prevent the water line from freezing. Figure 3 is a broad frost line map for the lower 48 states of the U.S. This map is a general guideline, so it is suggested that you may also want to obtain a depth recommendation from local competent well installation professionals in your area.

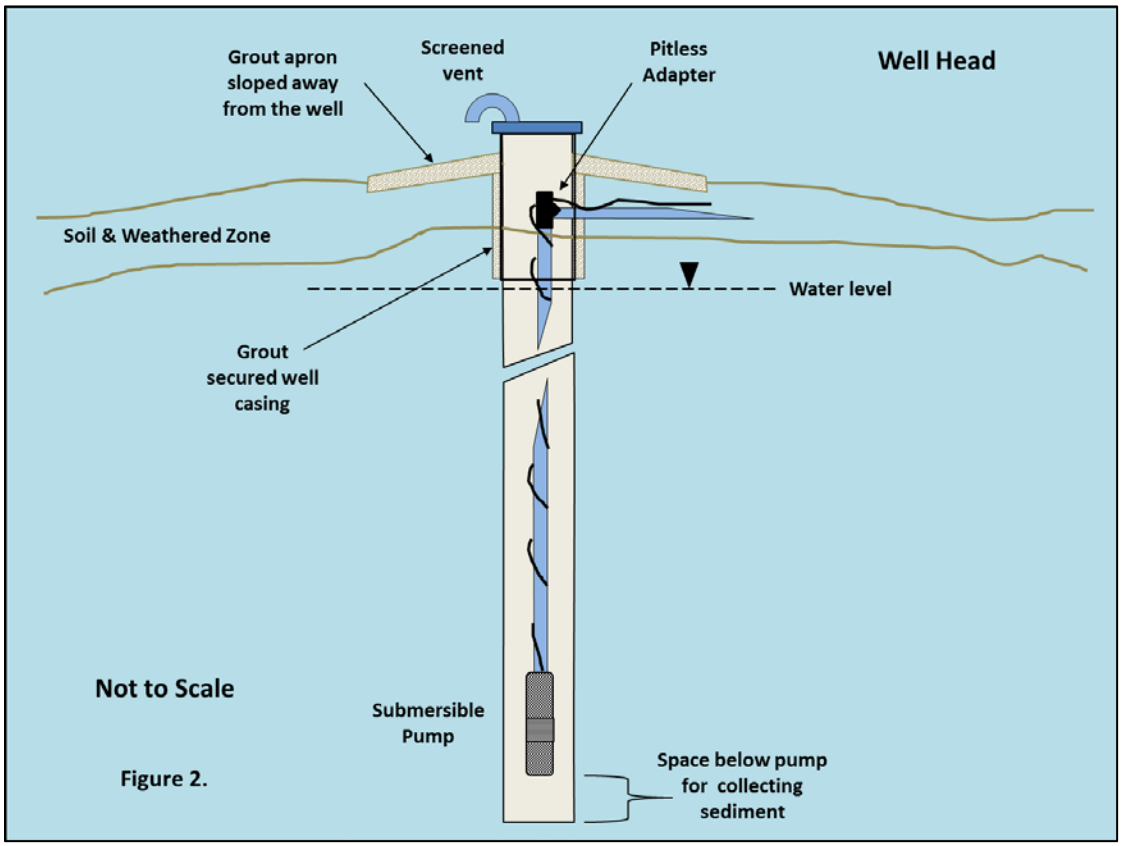


Figure 2.

Water drawn from shallow wells often is pumped to the home via a jet pump located at the surface. Where the water level is no more than 25 to 28 feet below the surface, a single line jet pump will pull the water up using suction (Figure 4). However, water levels deeper than 28 feet will lose suction and fail. Single line jet pumps are frequently employed for shallow hand-dug wells and valley bottom wells adjacent to streams where the water table is close to the surface.

Water in deeper wells can be withdrawn with a two-pipe jet pump. This type of system uses high pressure water that passes through an ejector into a venturi which in turn pulls water up through a pipe that is open below the water table (Figure 5). The water then flows up to the surface where a portion of it is sent to the pressure tank and the rest is returned to the pressure line circuit.

Low-yielding wells often have to be adapted or the system augmented to facilitate them to provide sufficient quantities of water. Wells that yield too little water during peak demand periods can be coupled with cisterns or large holding tanks. For some of these set ups, well water is pumped to the cistern for a prescribed intervals throughout the day and night. With this set up, the cistern can be

receiving water even when water is not being used. This will allow the creation of a sufficient reserve. For other set ups the well pump is wired to high and low water switches which turn it on and off, respectively. For either of the two aforementioned systems, once the cistern is completely full, a secondary switch is commonly installed to prevent further pumping until water is withdrawn from the cistern. These scenarios are engineered to preclude the pump motor from burning up if the well is dewatered and the water column drops below the intake. A secondary pump is installed in the cistern to provide water under pressure to the residence.

Springs

In hilly and mountainous terrain of the Appalachian region, contact or cropline springs are commonly located along the hillsides. Depending on the elevation of the spring, the water, once collected, can be gravity fed to the dwelling. Because these shallow-sourced springs are highly correlated to the seasons and antecedent precipitation, a springbox reservoir is used to collect and store enough water to meet the demands of daily use. A spring with a discharge rate of 1 gpm will produce 1,440 gallons of water per day. This is ample water for most single family dwellings. A single family dwelling requires between 50 and 75 gallons per day per person (EPA, 1982).

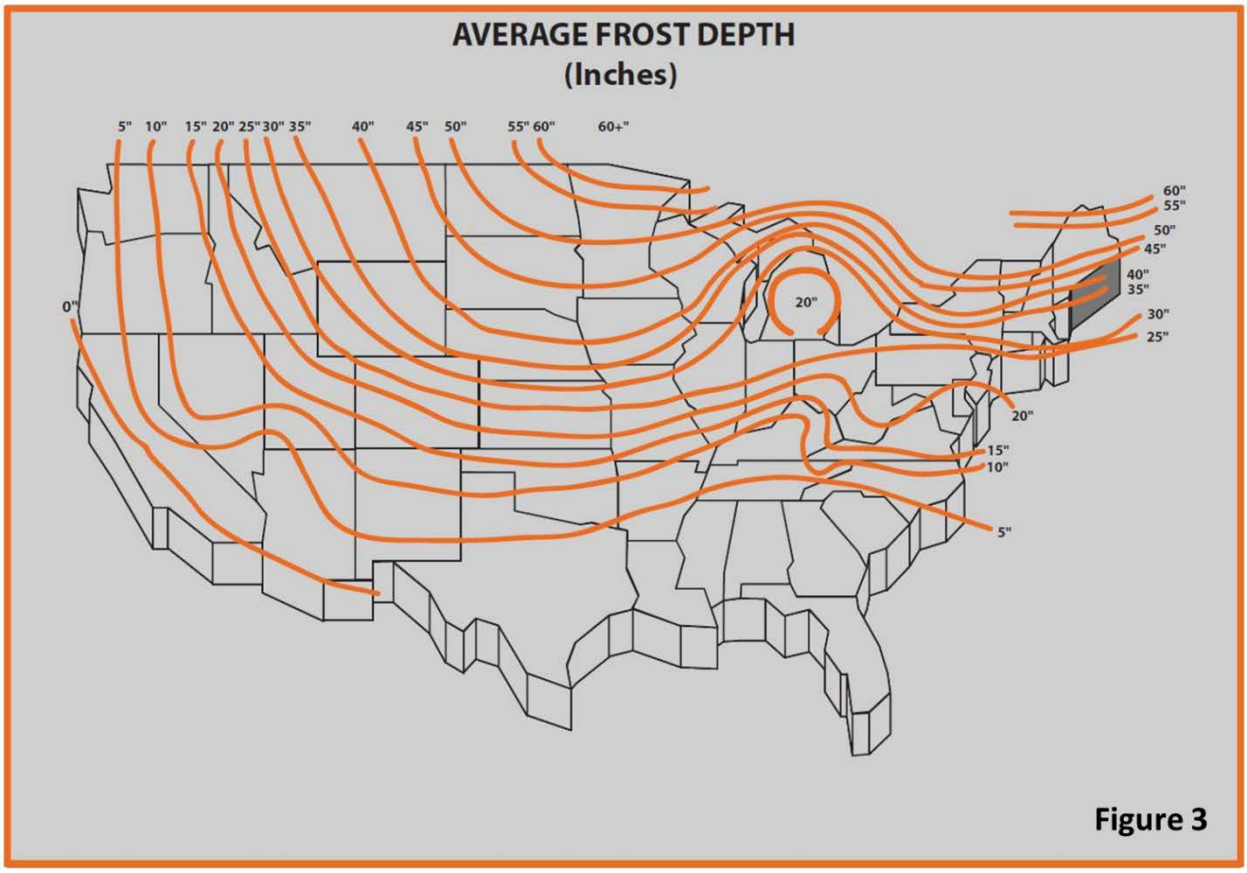


Figure 3

The spring collection system commonly used in this region is shown on Figure 6. The spring is piped to a springbox which is often made of cast high density polyethylene, concrete, or built from masonry materials (i.e. block or brick). An overflow port is situated near the top of the box and an access port for the water that is piped to the home is situated a few inches off of the bottom. The portion of the box below the access port is used to capture and retain any sediment. The box is covered to preclude

animals, bugs, and airborne debris entering the box. While less than perfect, this spring collection system configuration is generally adequate to meet the needs of the resident. However, these systems are often poorly maintained and can begin to lose their efficiency over time. With time, water tends start bypassing the collection configuration or the box itself begins to leak. Installation of a disinfection system between the springbox and points of use is highly recommended.

Figure 7 is an example of commonly recommended construction of a springbox collection system. The clean out system along with the larger size, and locked access are significant differences between this and the commonly-constructed springboxes. There is also a screen over the end of the overflow pipe to prevent access to insects and small animals. Figure 8 illustrates the recommended method to collect the water at the spring source itself. The cutoff wall acts like a subsurface dam to hold the water back so it will effectively enter the perforated pipe and be channeled to the springbox. Most systems are not nearly this elaborate, but still function well enough to provide adequate water to the home.

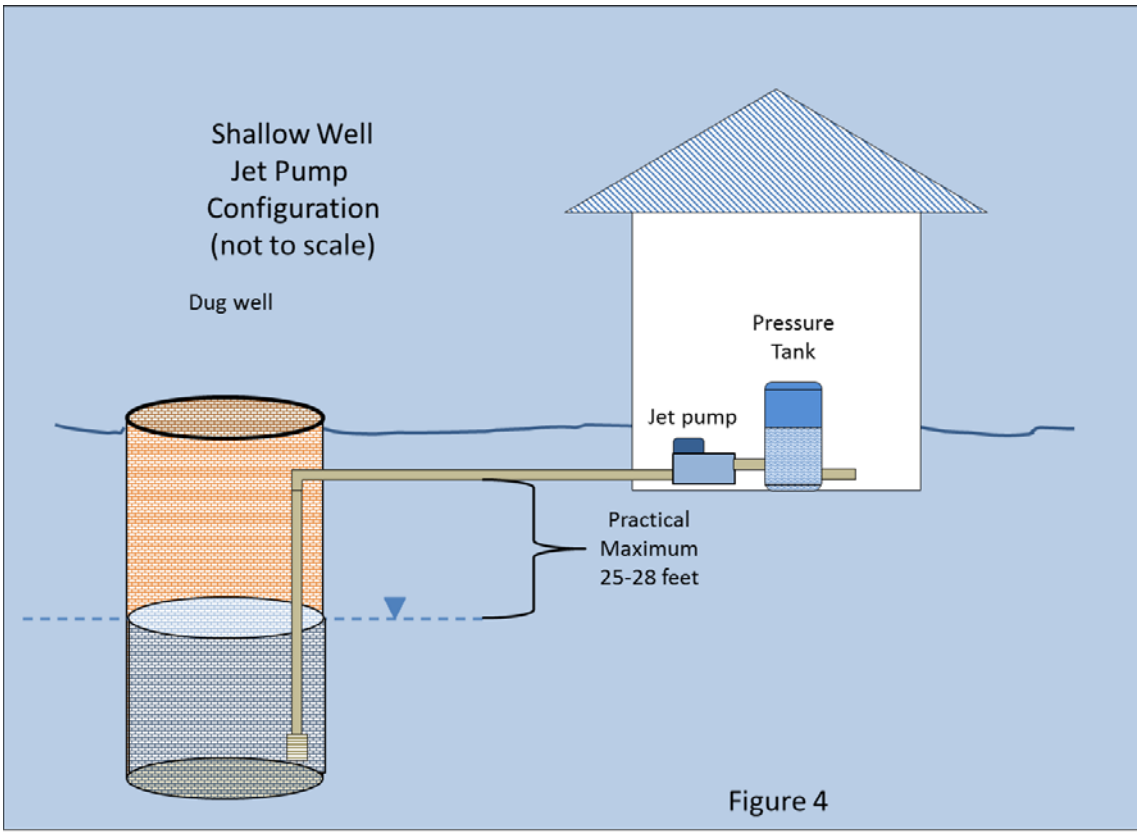


Figure 4

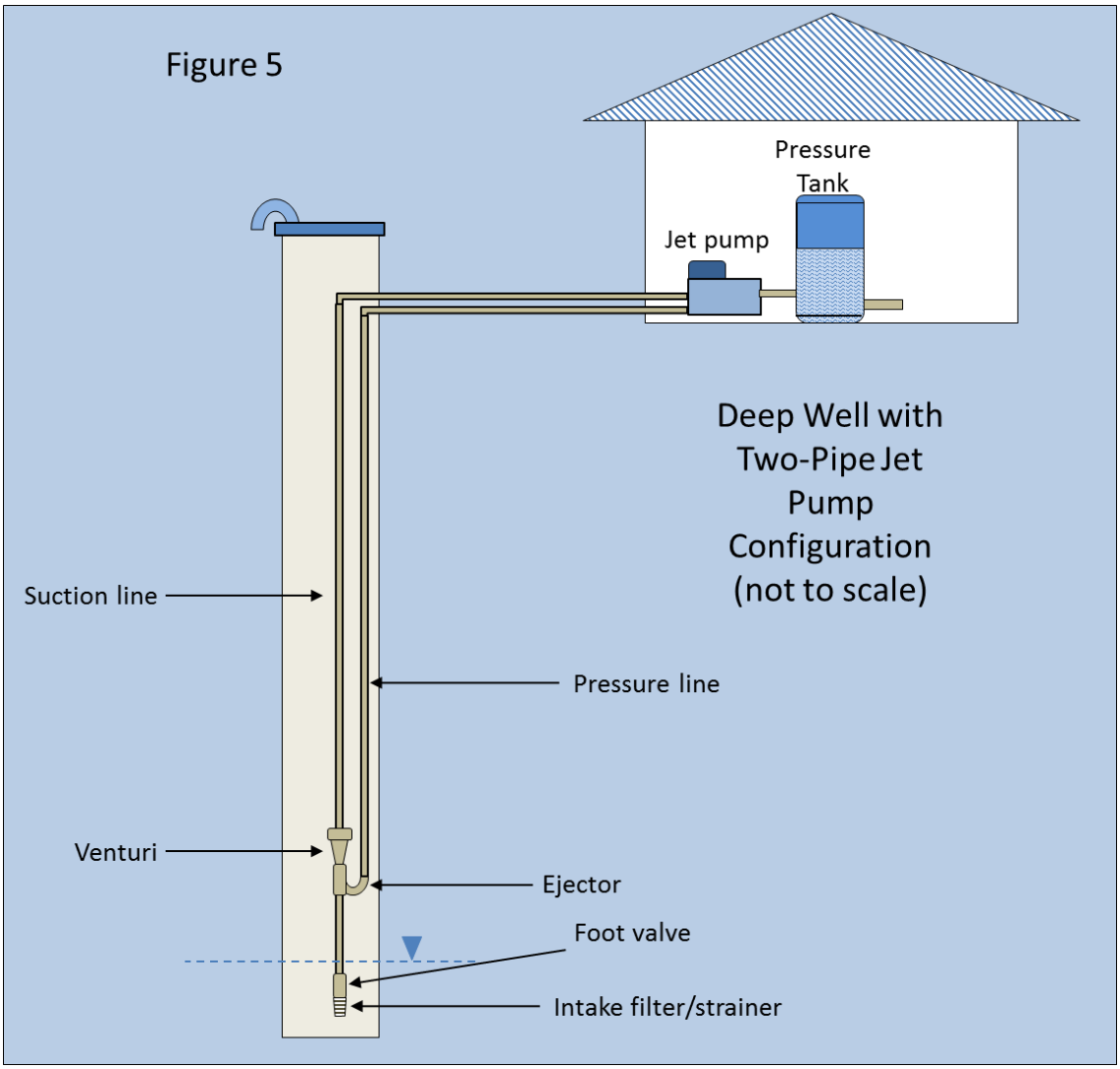
Rooftop Water Collection Systems

Rooftop water collection (harvesting) systems while not very common can provide adequate water supplies depending on the size of the collection area, annual rainfall amounts, and obviously the actual usage (Figures 9 and 10). Bear-in-mind, there are some states and portions of the country where rooftop water collection is heavily restricted or not permitted at all because of the limited amounts of precipitation and water in general. Colorado has probably the strictest water-rights laws governing rooftop harvesting of precipitation. Conversely, other states, such as Virginia, have promoted rooftop water harvesting by use of tax credits.

The basic components of a rooftop water collection system include a large surface area by which to collect and channel the water to a desired location, a filtering system to remove the larger impurities, and a reservoir to hold the water until needed. Additionally, a disinfection system is usually needed to kill any bacteria and other microorganisms.

A total of 12 inches of rain on to a 10-foot by 10-foot section (100 ft^2) of roof top will yield 748 gallons of water. The calculations for this determination are shown below.

10 ft. X 10 ft. = 100 ft^2
1 cubic foot = 7.481 gallons
12 inches (1 ft.) of rain works out to 100 ft^2 X 1 ft. = 100 ft^3
100 ft^3 X 7.481 gallons/ft^3 = 748 gallons



The average size roof for a middle income home is estimated at 40 ft. by 60 ft. or 2,400 ft^2 (Ask.com, 2014). So, in a region where the average annual precipitation is 44 inches, it is possible to collect nearly 66,000 gallons per year. As mentioned previously, water usage in a single family dwelling is between 50 and 75 gallons per day per person (EPA, 1983). If the home has four inhabitants, the water usage would

be between 200 and 300 gallons per day or 73,000 and 110,000 gallons per year. What this means for the inhabitants is that an auxiliary source of water will be required to make up the difference between what can be harvested and what will be used. Commonly, water is hauled in and added to the storage system.

Figures 9 and 10 are two examples of rooftop collection systems. In general terms, the rooftop water is channeled from the roof to the downspout. The water from the downspout passes through some type of filtering system before it is collected in a cistern or storage tank. The water is then pumped into the home for use. It is recommended to have the water pass through some sort of disinfection system between cistern and the points of use. Chlorination and ultraviolet disinfection devises are the most commonly methods employed.

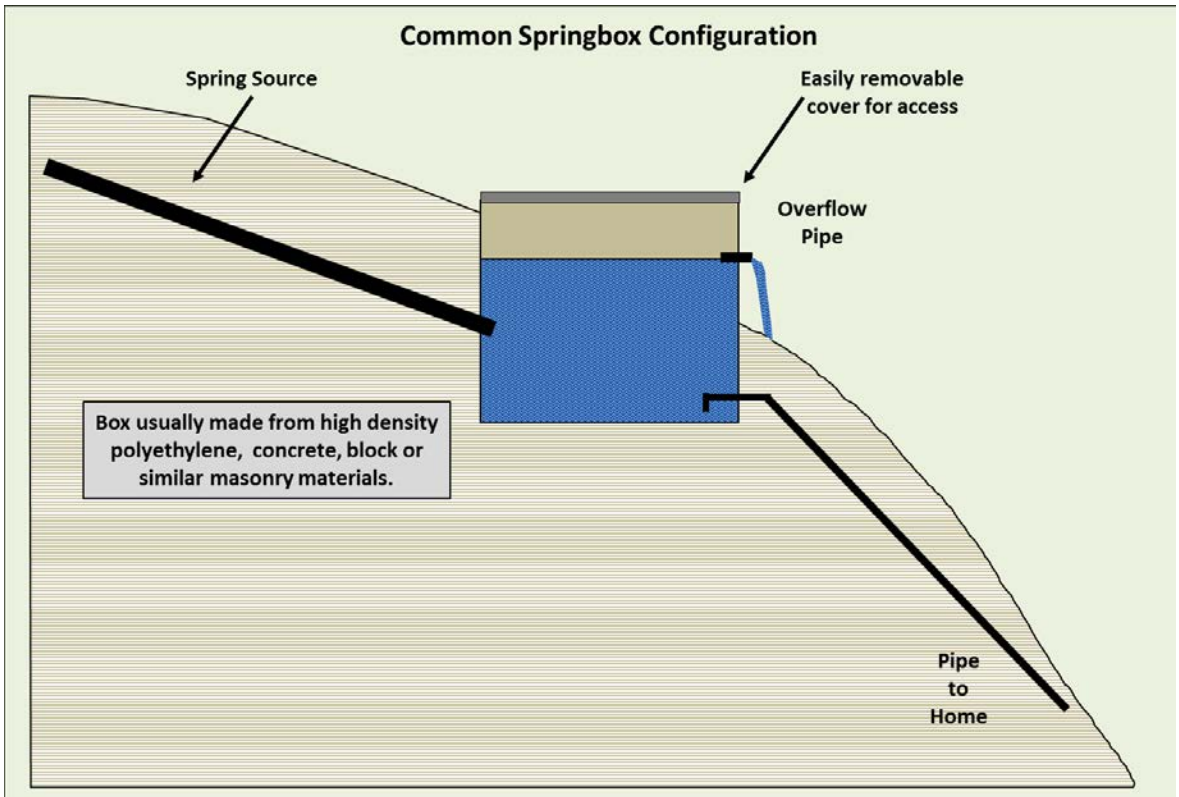


Figure 6.

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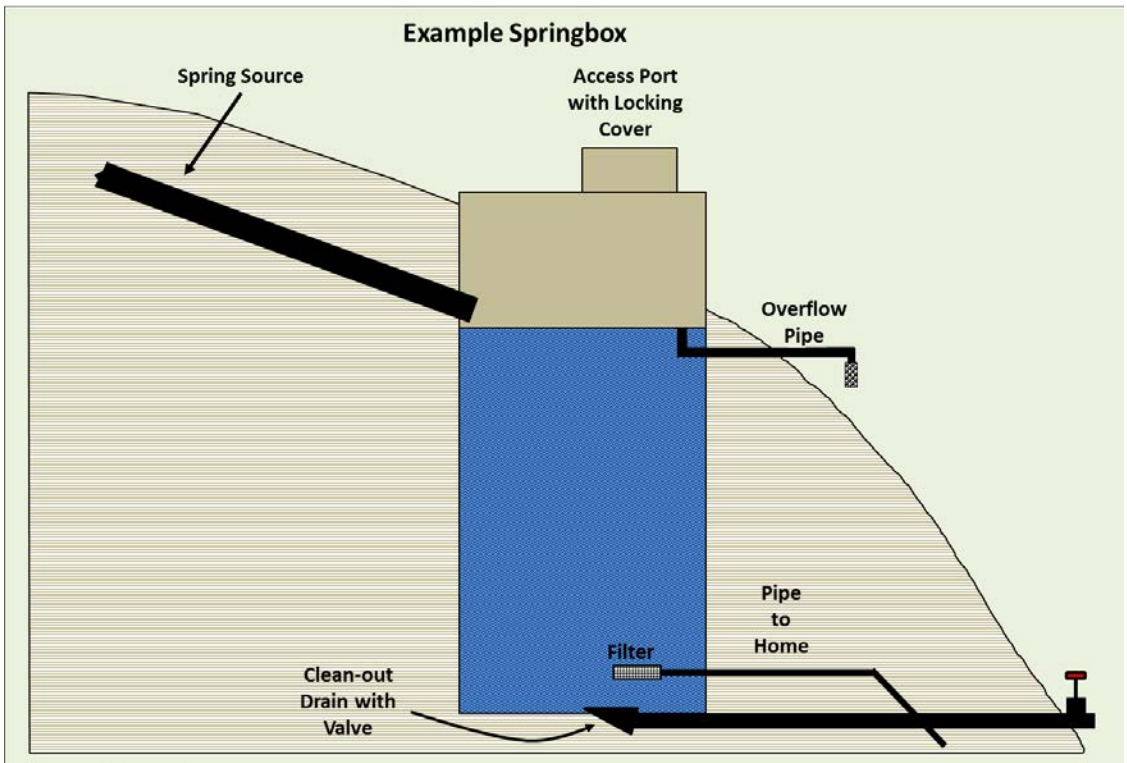

Figure 7.

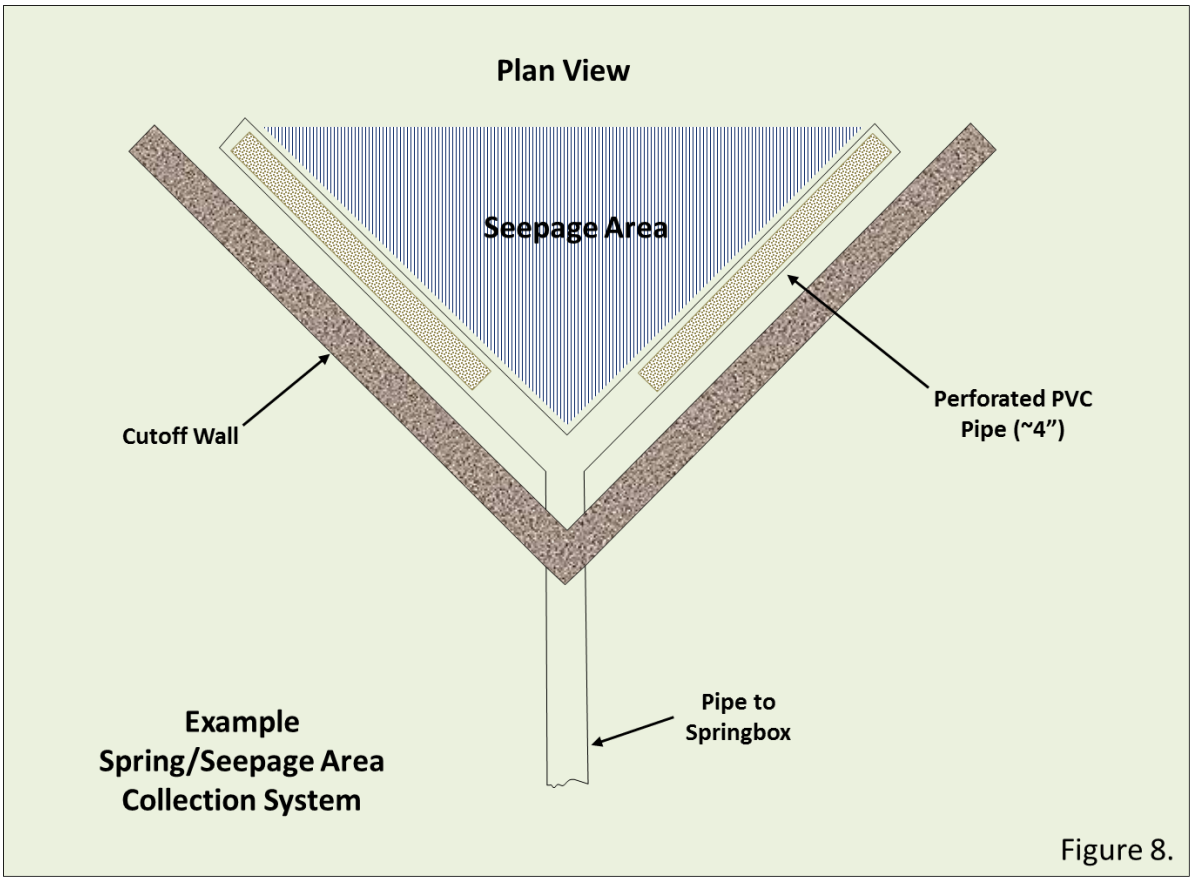

Figure 8.

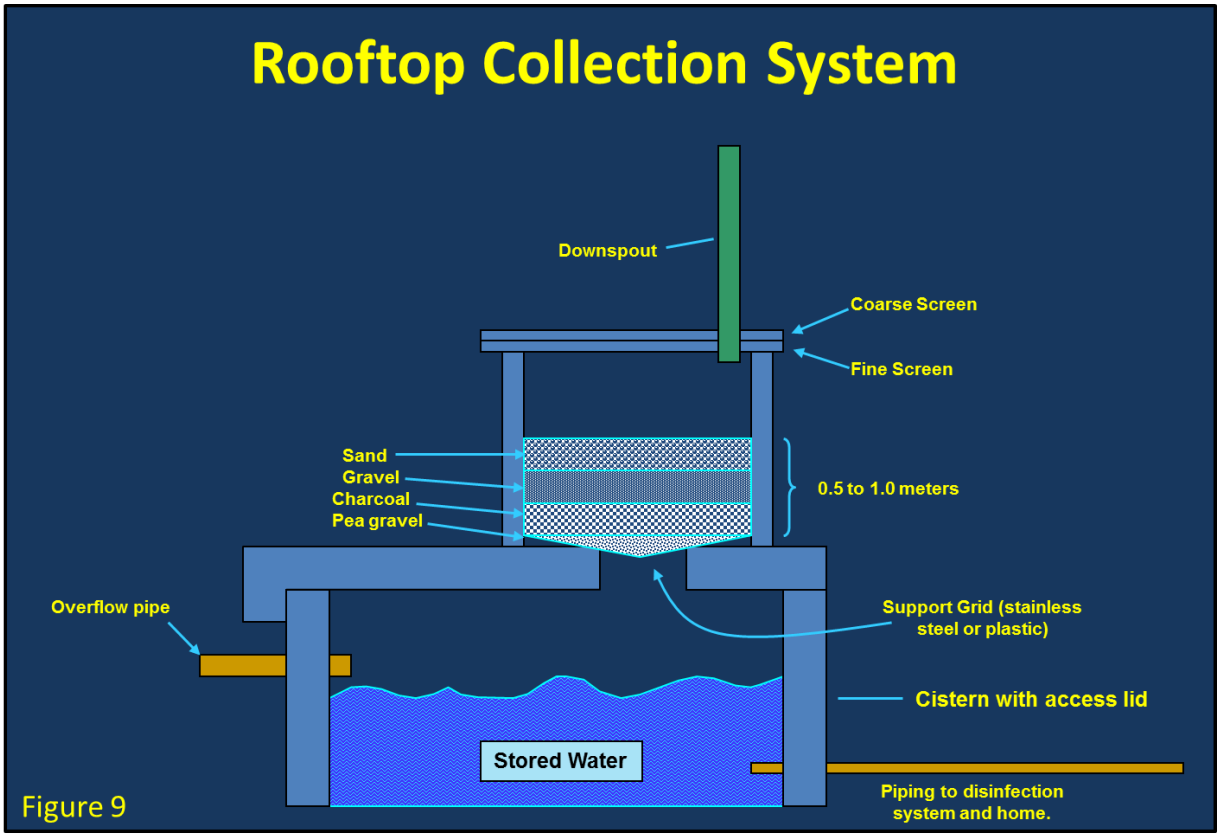

Figure 9

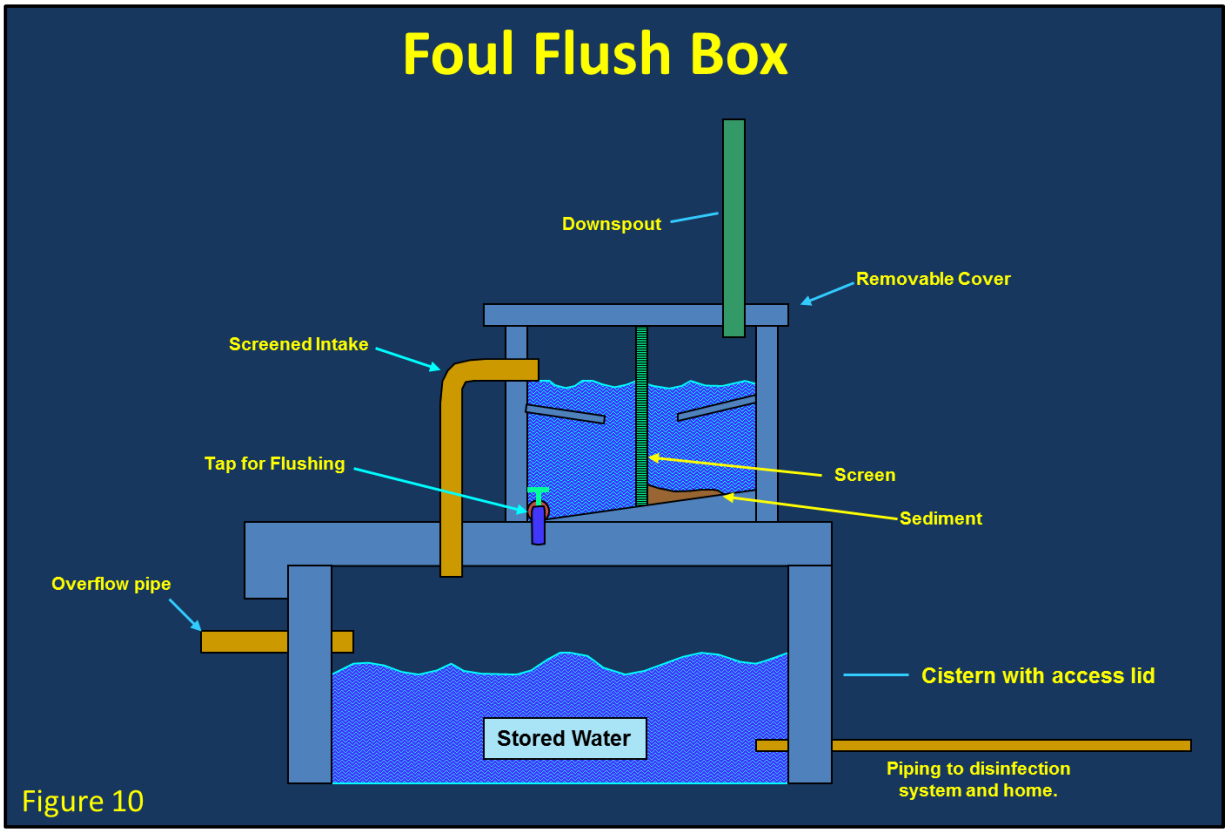
Foul Flush Box
Downspout
Removable Cover
Screened Intake
Tap for Flushing
Screen
Sediment
Overflow pipe
Cistern with access lid
Stored Water
Piping to disinfection system and home.

Figure 10