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Graywater Irrigation: Disposal or Beneficial Re-Use?

WaterSmart Innovations
October 5-7, 2011

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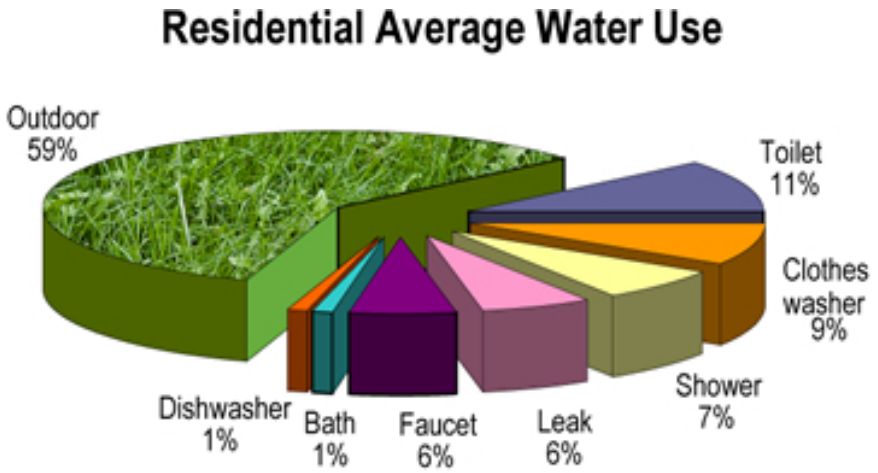
Irrigation present the greatest opportunity for saving water in a residential household

- While indoor consumption can be reduced significantly, outdoor use has the biggest potential for reducing household consumption overall



Source: American Water Works Association Research Foundation, End Uses of Water

Introduction

Sending 15 gallons of graywater into a mulch basin for a fruit tree every day isn't saving 15 gallons per day.

In most areas it is only saving less than 5 gallons – the rest is wasted.

...And, the 5 gallons saved is only saved if the fruit tree was previously irrigated with potable water.

...If the tree is an addition to the garden, no potable water has been saved.

Yet this practice is encouraged by many State codes.

This presentation examines graywater irrigation and the impact code development has on practical graywater irrigation.

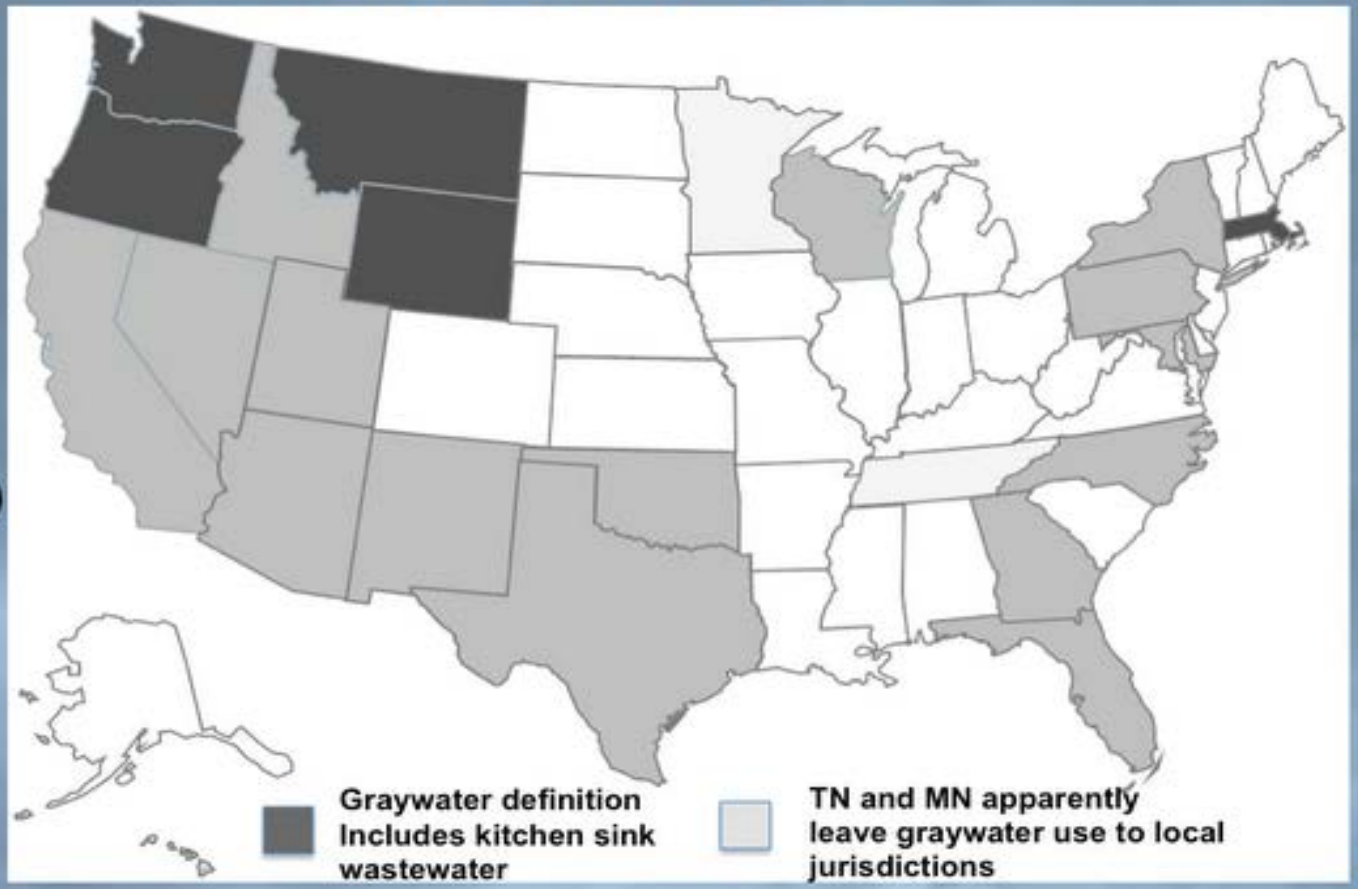
Overview

- Graywater codes vary enormously
- Terminology is inconsistent / confusing
- Back to basics: Beneficial Reuse or Disposal?
  - What is graywater?
  - Capillary irrigation
  - What area can be irrigated?
  - How does this compare with disposal?
  - How can we irrigate?
  - What is the risk / reward profile?
  - Comparison of code examples to risk profile

Geography of Graywater

States with Graywater Programs

- Arizona
- California
- Georgia
- Hawaii
- Idaho
- Maryland
- Massachusetts
- Nevada
- New Mexico
- New York
- Pennsylvania (?)
- Texas
- Utah
- Wisconsin
- Washington
- Montana
- Oregon
- Wyoming
- North Carolina
- Florida
- Oklahoma



Countries Actively Promoting Graywater Reuse

Australia, Canada, China, Germany, India, Israel, Jordan, Korea, South Africa

Image by Todd Jarvis, Salem OR http://rainbowwatercoalition.blogspot.com/

Untreated Graywater Codes

- Vary enormously across the US
- Low complexity codes e.g.
  - Arizona – no permit required, sub surface irrigation
  - Wyoming – no permit required, untreated graywater can be irrigated above the surface if contact minimized
- Medium complexity codes e.g.
  - California – permits required for waste plumbing changes and / or pumped systems
  - Washington – subsurface is minimum of 2 inches below soil surface, unless mulch basins
- High complexity codes e.g.
  - Utah – minimum 6" sub soil surface irrigation (disposal rather than beneficial reuse)
  - North Carolina – bucket reuse only, but only in declared drought
- What is Surface / Sub Surface?
  - Surface is poorly defined. Top of soil or top of soil covering (mulch / decomposed granite)
  - Disposal legacy codes impacting new code development, requiring lengthy & confusing prescriptive text .
  - ICC Green Code as an example
  - Common acceptance (most US States and other Countries) is a 2" covering of the irrigation layer. Covering can be soil or other material e.g. mulch
- Effect of code complexity / permit process
  - Simple codes / permits: graywater reuse compliance is good, built to regulations
  - Difficult codes / permits: near zero compliance, population does it anyway, but with poor reuse efficiency and elevated risk

What is the Purpose of the Graywater Code (irrigation)?

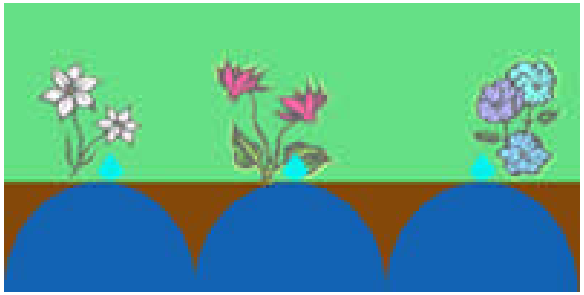
- **Assumption**: New code development **aim** is to reduce potable water demand by replacing potable irrigation with graywater irrigation
  - use of Mulch Basins encourages fruit tree planting instead of irrigating existing garden spaces
  - Where existing potable irrigation systems remain in place, potable water consumption likely to rise rather than fall
- Many codes encouraging this approach by multi tiered rules
  - code is not meeting the initial aim
  - More on this later

Graywater Basics

- Graywater Recap
  - Shower, Bath, Hand basins, Laundry water,
    Kitchen water (after grease trap, permitted in some states)
- Graywater Volume
  - 20 to 45 gallons per day, per person
  - 20 gallons in LEEDs home, personally conservation aware
  - 45 gallons in typical Tucson home.
    - 2004 Average Usage by Month (Feb) = 6,732 gallons
    - Rule of thumb = 60% of winter usage = reusable graywater
    - 4040 gallons per month (45 gallons assuming av. 3 people per home)

Traditional Irrigation

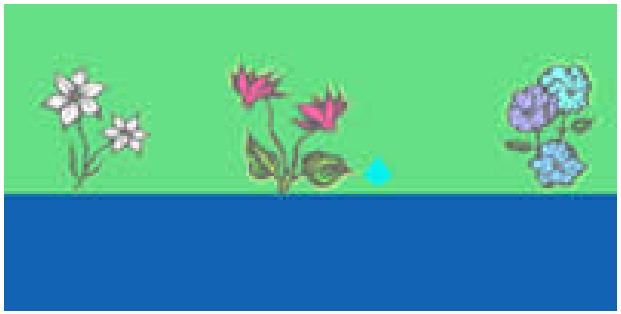
- Traditional Irrigation (potable water)
  - Twice a week
  - Wet / Dry soil profile
  - Hydrophobic soil
  - Irrigate plants directly
  - 70% efficiency (30% loss), significant gravity effect, pulling water into subsoil.



  - Promotion of tap root growth instead of lateral root development.
  - Commercial growers moving to daily / 2nd day irrigation to improve efficiency (near 100%)

Graywater Capillary Effect

- Graywater **generated daily, irrigated daily**
  - Moist soil attracts water
  - Water moves sideways, instead of downwards
  - Creates a moist layer within soil profile
  - Organic component in soil will assist water movement
  - Surface covering to prevent evaporation essential (mulch, or decomposed granite in windy areas)
  - **Water the soil, NOT the plant.**
  - 90% + irrigation efficiency
  - Soaps / detergents assist further by breaking down water surface tension
  - **Less effective when water is applied deep subsoil (6" or more) if subsoil is sandy or has limited bio matter.**



- **Commercial Growers moving away from infrequent deep irrigation to frequent light irrigation (increased yield, decreased potable water consumption)**

Capillary Effect & Plant Growth

- Promotes lateral root growth
  - Moisture kept in the nutrient rich zone
  - Less tap root growth
  - **30-50% greater plant growth because roots are in a nutrient rich soil zone**
  - Take care with fertilizer when planting
  - Often met with initial disbelief in Tucson!

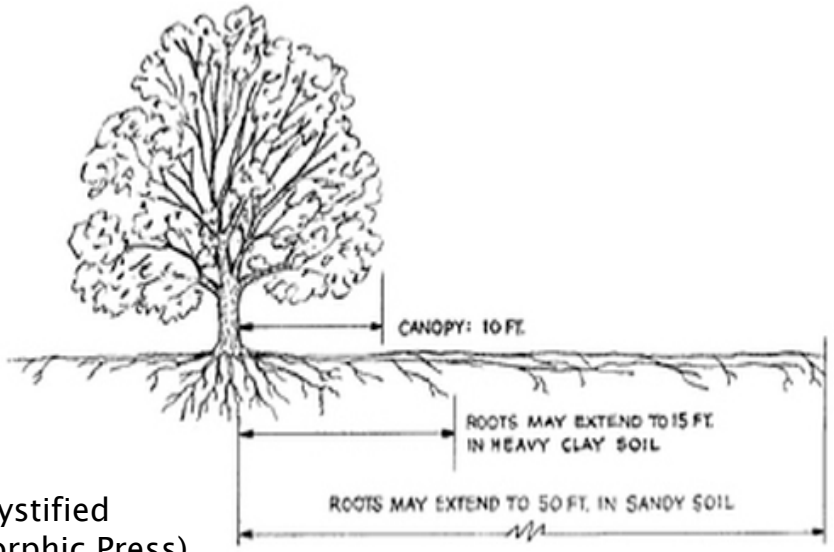


Diagram from Roots Demystified by Robert Kourik (Metamorphic Press)

Determining Optimal Irrigation

- Evapo Transpiration Rate
  - Reference value is how much water is required to grow Alfalfa (typically per month)
    - Plant coefficients (0.13 VL, 0.26L, 0.45M, 0.65H, Apple 0.81)
  - Often listed in inches per month
  - Working backwards with graywater
    - we know how much water we have – what area will it cover?

Irrigation Area Calculation

- Based on 90+% Irrigation efficiency (capillary irrigation)
- A = G / ((ET-R)*Px0.62 x 1.1)
  - A = Irrigation Area (square feet)
  - G = total graywater (gallons) per day
  - ET = Monthly Evapotranspiration rate (alfalfa)
  - R = Monthly rainfall
  - P = Plant irrigation coefficient
  - 0.62 = factor to convert inches per month to gallons per month per sq ft (144 cubic inches per sq ft per inch of rain / 231 cubic inches per gallon)
  - 1.1 = irrigation efficiency factor.

Irrigation Area (90% efficiency) & Minimum Irrigation (disposal) Area

Region	Tucson	Los Angeles	Seattle
Eto	10.5”	6.5”	4”
Summer Rainfall	0.2”	0”	0”
People	4	4	4
Graywater per person, per day	45 Gallons	35 Gallons	35 Gallons
Plant Coefficient	0.26 (low water)	0.35 (low/medium)	0.45 (medium)
Irrigation Area	2,950 sq ft	2,875 sq ft	3,422 sq ft
Minimum Irrigation Area (California)	**120 gallons per 100 sq ft per day**	**180 gallons 6 x 45 gpd = 270 gpd**	**225 sq ft**

Soil Effects

- Counter intuitively, soil type does not affect the optimal irrigation area
  - ET calculation determines the correct amount of irrigation for plant growth without adding a hydraulic loading to the soil
  - Hydraulic loading will increase during a non growing season, however the size of the irrigation field is 10 x the size of the minimum disposal area defined within codes
- Soil type does affect the density of irrigation points required to achieve consistent soil moisture profile
  - Sandy soil requires more irrigation points than a heavy clay soil
  - Consider using soil amendments to the top soil for either sandy or heavy clay soils.
- Soil testing
  - First reaction of Soil Engineers is often to require soil testing in the code
  - In every case, if the soil can support plant life, and the irrigation system is designed from an Evapotranspiration perspective, a soil test is redundant.

    The beneficial irrigation area is always larger than the minimum disposal / hydraulic loading code requirement.

Beneficial Reuse & Disposal in one location

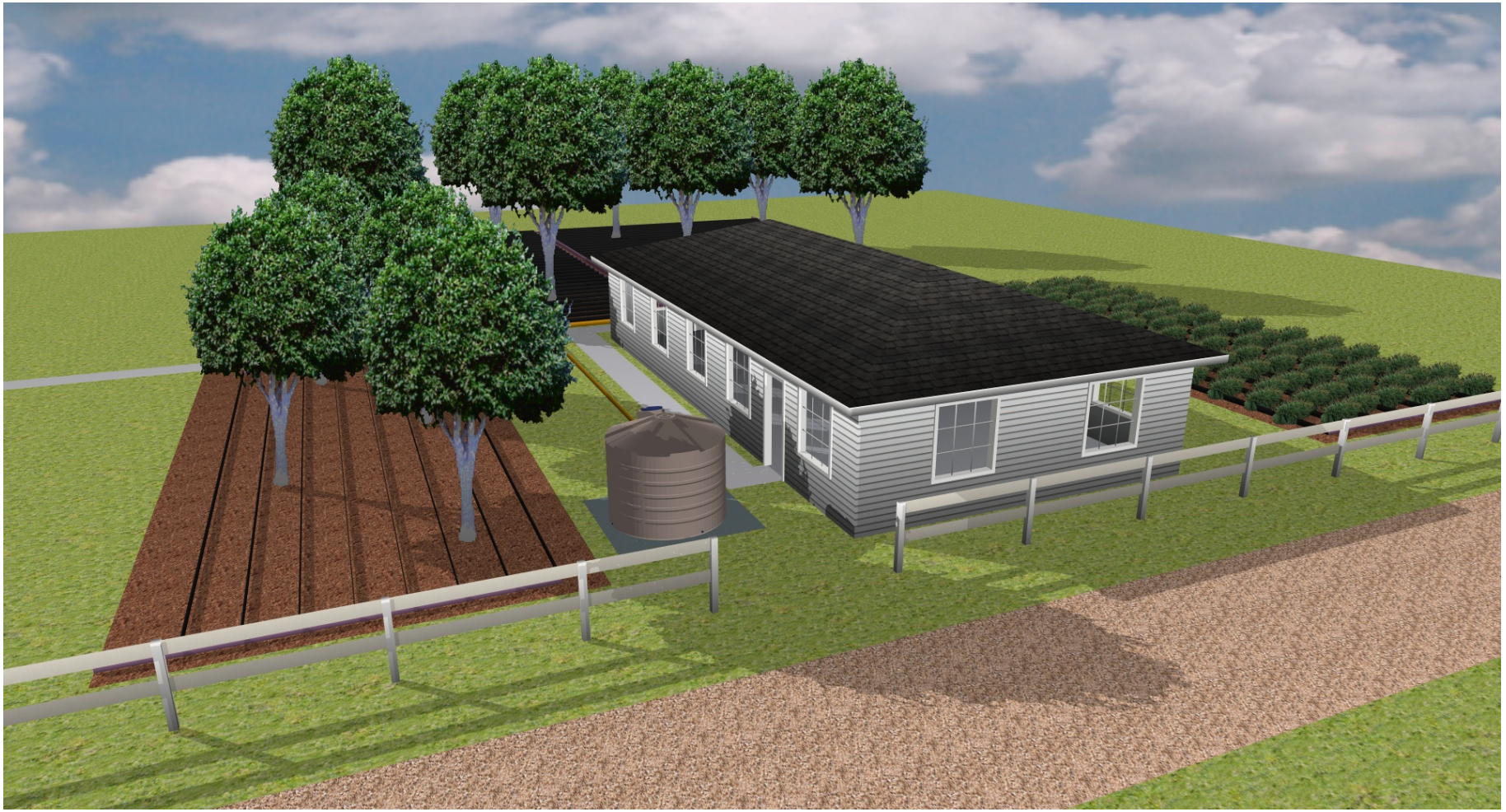
- Summer irrigation vs. Winter disposal
  - Example, California Conservation Corps Laundry, SLO
  - Goal is to replace off site waste treatment with onsite beneficial use in summer, onsite disposal in winter

    - 1,000 gallons laundry waste per day, expensive treatment costs
    - Apple Orchard, plant coefficient = 0.81
    - Summer ETo = 6.5", winter = 1.8" (supplied by rainfall)

    - Disposal rate (CA) max is 120 gallons per 100 square feet day
      - i.e. 1,000 sq ft disposal area required, will be planted with native grasses / reeds
    - Orchard size approx 8,000 square feet.

    - rule of thumb is 10% of beneficial area is far more than sufficient for a disposal area
      - Note: A Caliche or heavy clay soil barrier will require a large disposal area.

CCC Laundry

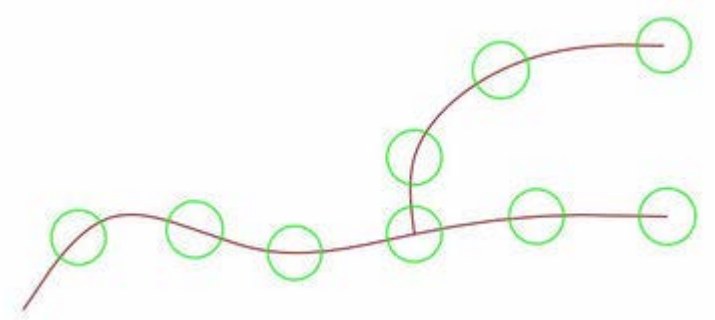


*Not all plants / trees shown

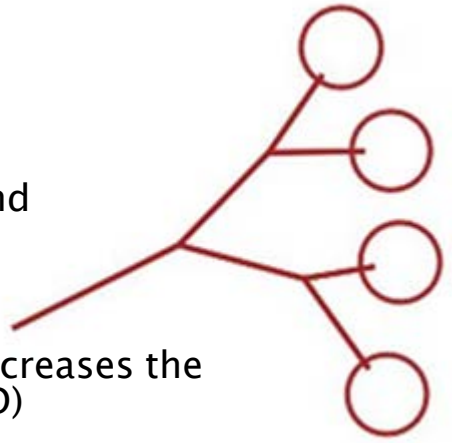
Common Irrigation Methods recognised by Codes

Mulch Basins

- Laundry to Landscape (L2L)
  - In most cases 10 basins or less
  - A mulch basin for a tree is typically about 4 feet in diameter, or 12.6 sq ft. The total irrigated area with 10 mulch basins will be 126 sq ft.
  - In CA, the ET area for mature orange trees is 250 sq ft, and for low water use plants 850 sq ft
  - Irrigation efficiency generally 30% or less



- Branched Drain
  - In most cases 8 basins or less (100 sq ft)
  - In CA the ET area for mature orange trees is 600 sq ft, and for low water use 2,500 sq ft
  - Irrigation efficiency generally 5% – 20%
  - Large volumes of water into mulch basins significantly increases the risk of overflow, flooding and human contact (L2L and BD)



Assumptions: 4 people, 1 washing machine use per day (L2L); L2L = laundry only, BD = laundry & Showers

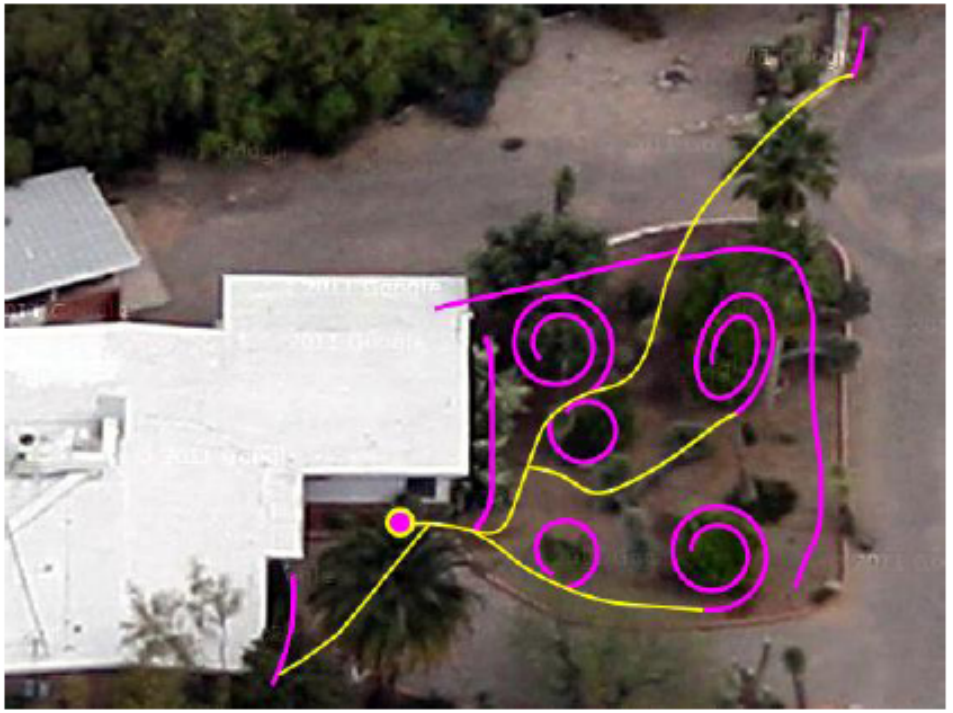
Irrigation Methods (cont.)

- **Dripperline / Distributed Emitters**

- Gravity or Pumped (site dependant)
- Laundry and Showers (4 People)
- Covers entire ET calculated area, at 90% efficiency
- Unlimited number of emitters, but generally 600 outlets for a 7,000 sq ft lot with 4 people.


3/4" Supply Tube
1/2" Garden Dripperline
(2 GPH, 40 mesh filtration)

Location:	**Tucson, AZ**
Daily graywater volume:	200 GPD
Irrigation Area (combined):	3,000 sq ft
Total Dripper Line:	450’
Irrigation system labor:	4 hours
Plumbing labor:	8 hours
Approx installed cost:	$1,900
Annual water savings:	100,000 G



This home is located in the Tucson foothills. With 2 adults and 3 children in the house, a total of 200 gallons of graywater was available for re-use. The existing plumbing was modified to divert bath, shower and laundry water into an IrriGRAY pumping station.

After being pumped through a 40 mesh filter, the greywater is distributed through 450 built-in emitters across three zones.

The purple lines indicate the position of IrriGRAY dripperline, and the yellow lines indicate mainline distribution.

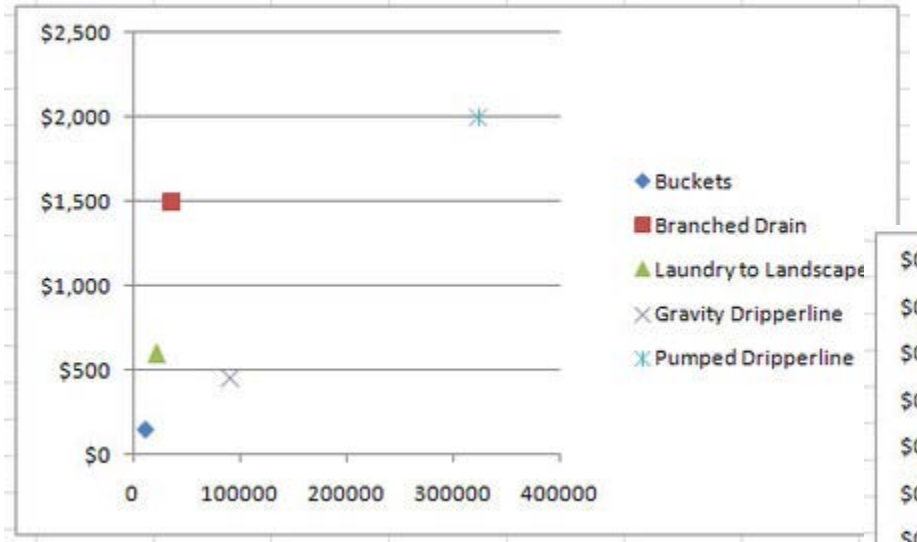
The main garden planting is a mix of very low water use native plants (cacti), medium water use privacy screening, and high water use trees (three citrus and one olive).

Pumped or Passive?

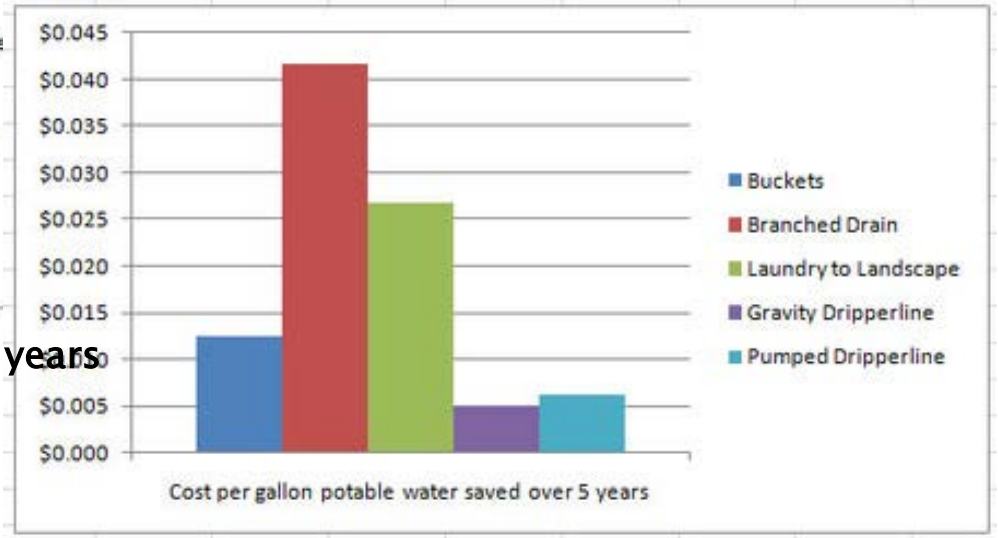
- Pumped systems ensure even irrigation across all areas of the property
  - The Power Consumption Myth dispelled:
    - A pumped system typically consumes 0.2 Kwh per day, or about $7 per year
    - This power usage is less than the power required to deliver water to your home
    - On site pumped reuse requires 10% of the power used by SNWA to treat and re-use graywater
- Passive is possible with only 6" of head pressure
  - Flow rate of 1gpm per 150' of dripperline
  - Will require a surge tank – may require a permit in California – subject to interpretation of code by the local county

Irrigation Efficiencies – ROI

- Insufficient time to explain the calculations
- http://www.thegreywaterguide.com/irrigation-efficiency.html
- Costs include installation



Cost vs. Gallons of Potable Water saved over 5 years



Cost per gallons of water saved over 5 years use

Back to the Codes

- If the aim of a code is to reduce potable water consumption and protect public safety; then:
  - Encourage high efficiency reuse, and remove existing potable water reticulation
  - Encourage distributed irrigation to avoid creation of a small number of graywater 'hotspots' in the garden
- Instead, State such as CA and WA encourage 'hotspots', and discourage distributed, efficient irrigation
  - Multi Tiered approach, emitter based systems require permits
  - Due to the high labor installation requirements for L2L and / or Branched Drain, likely that cheap inefficient and polluting products will appear in stores, creating more issues

Wyoming Code

Chapter 3, Section 8 – Permit by Rule Greywater Added – Policy 11.1

Greywater defined:
Household wastewater which has not been contaminated by toilet discharge (blackwater). Greywater includes wastewater from baths, showers, bathroom wash basins, clothes washing machines, sinks (including kitchen sinks) and laundry tubs.

Greywater re-use systems that match the following conditions will be permitted on a "permit by rule" system as described in chapter 16 of
the State of Wyoming Water and Wastewater Rules. That is to say that no application for a permit or fee is required if all the following conditions are met:

1. Human contact with the greywater will be minimal.
2. Water which has been used to wash diapers or similarly soiled or infectious garments is not allowed into the greywater system
   unless the greywater system is designed to prevent human or animal contact.
3. Greywater does not come in direct contact with or adversely impact surface or groundwater.
4. The potable water system must be isolated from the greywater system by the appropriate backflow methods and devices.
5. Greywater does not leave the property on which it is generated without written, legally recorded, permission from all land owners affected.
6. Water which contains hazardous materials cannot be disposed of in a greywater system.
7. Greywater sprayed into the air for irrigation or other purposes during high wind conditions cannot come into contact with humans, domestic animals or the edible portion of food crops during normal operation.
8. The application of greywater minimizes the pooling of water on the ground surface.
9. Greywater holding tanks, if used, shall be covered or otherwise protected from access by mosquitoes, children, animals, or other life forms.
10. The volume of greywater produced does not exceed an average of 2000 gallons per day.
11. In addition, at least one of the following conditions must also be met:

(a) The greywater system has been constructed to allow diversion of the flow to the black water disposal system, and the blackwater system (septic tank, sewer, etcetera) is sized adequately for both greywater and blackwater or:

(b) The greywater system has been constructed to allow diversion of the flow to a secondary greywater disposal system, and the second greywater system is constructed and operated within the guidelines defined above. The secondary system shall be designed and operated in such a manner that extended freezing temperatures will not cause failure. This option is required when a traditional blackwater disposal system is not present, such as when an incinerating toilet or composting toilet is utilized.
Greywater systems that do not meet the above criteria shall submit a permit application to the State of Wyoming Department of Environmental Quality to be evaluated on an individual basis.

Note : the Washington State code is approximately 15 pages long!

Graywater Irrigation Examples (temperate climate)

Concluding Comments

- The water conservation community should take care to review all options available, without necessarily taking a lead from the code for their area.
- If your local codes are restrictive, or encourage inefficient methods while discouraging best practice, discuss why with your regulators.
- Water is an increasingly scare resource, we all need to take ownership of the code development process.

No other product teaches the value of water like a Hughie!

The Hughie Sink makes it easy to re-use water from the Kitchen, Laundry and Bathroom.

Simply collect the water in the Hughie, carry out to the garden and pull the plug, watering your favorite plants.

Because the Hughie is so simple to use, **the whole family learns how much water is used in daily activities**, and how most of this water normally goes down the drain.

This **active learning results in water savings across the home**:

- Shorter showers
- Less faucet use
- Decreased garden irrigation