Cisterns for Stormwater Detention, Rainwater Storage, and Re-Use

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- Sustainable Design
- International Development

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INTRODUCTION

Global Warming and the case for conservation

- Global warming is underway and the effects are being felt locally
- Almost everywhere in the Cascades, snowpack has declined markedly since 1950.
- Nearly every glacier in the Cascades and Olympics has retreated during the past 50-150 years in response to warming.
- For a warming of +4.1°F, which could occur as early as the 2040's (but probably not until later in the century), October through March runoff increases by about 25% and April through September about 25% and decreases by 21%

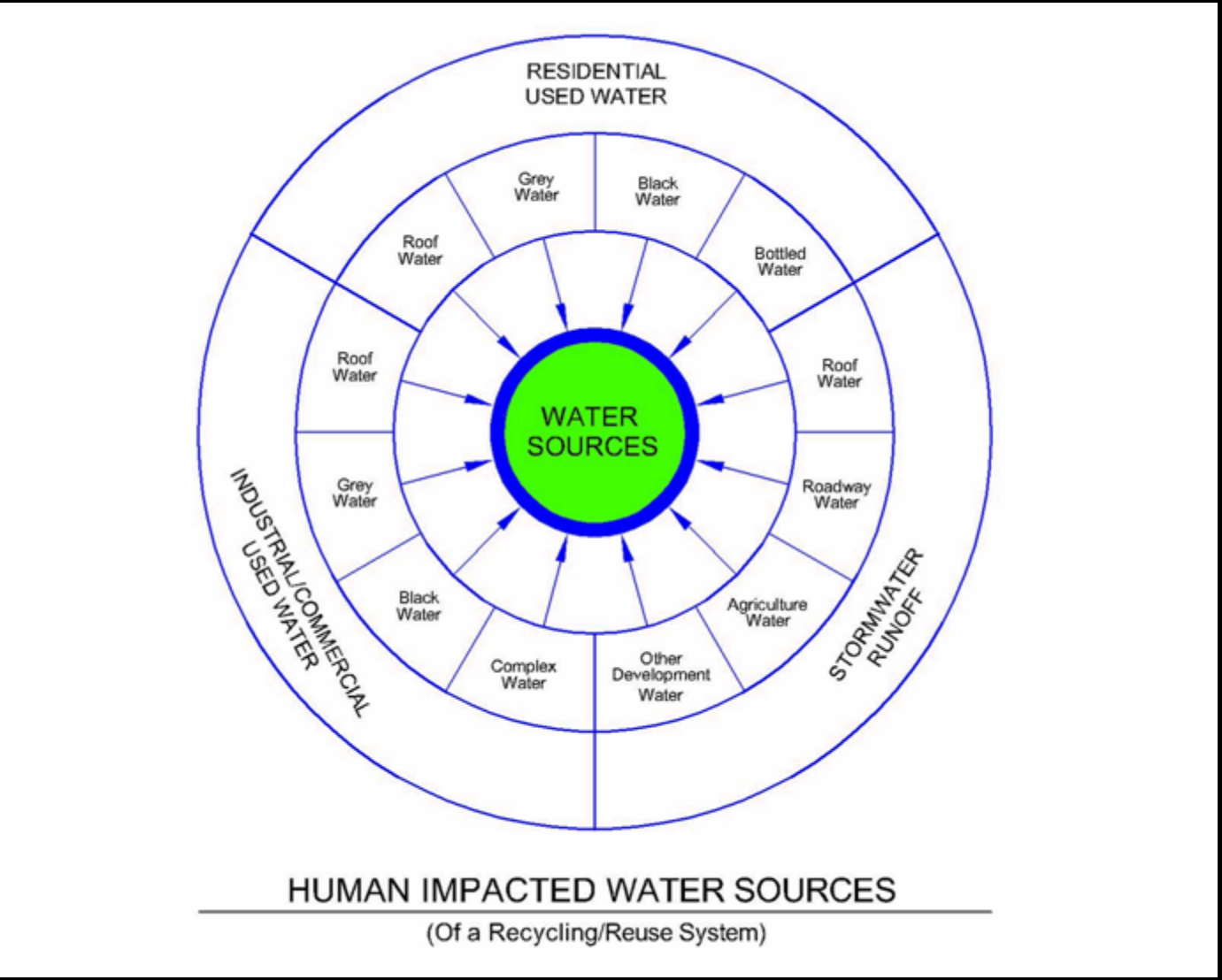
Lyman Glacier, North Cascades

Tolt Reservoir

Source: Puget Sound Action Team & The Climate Impacts Group, University of Washington

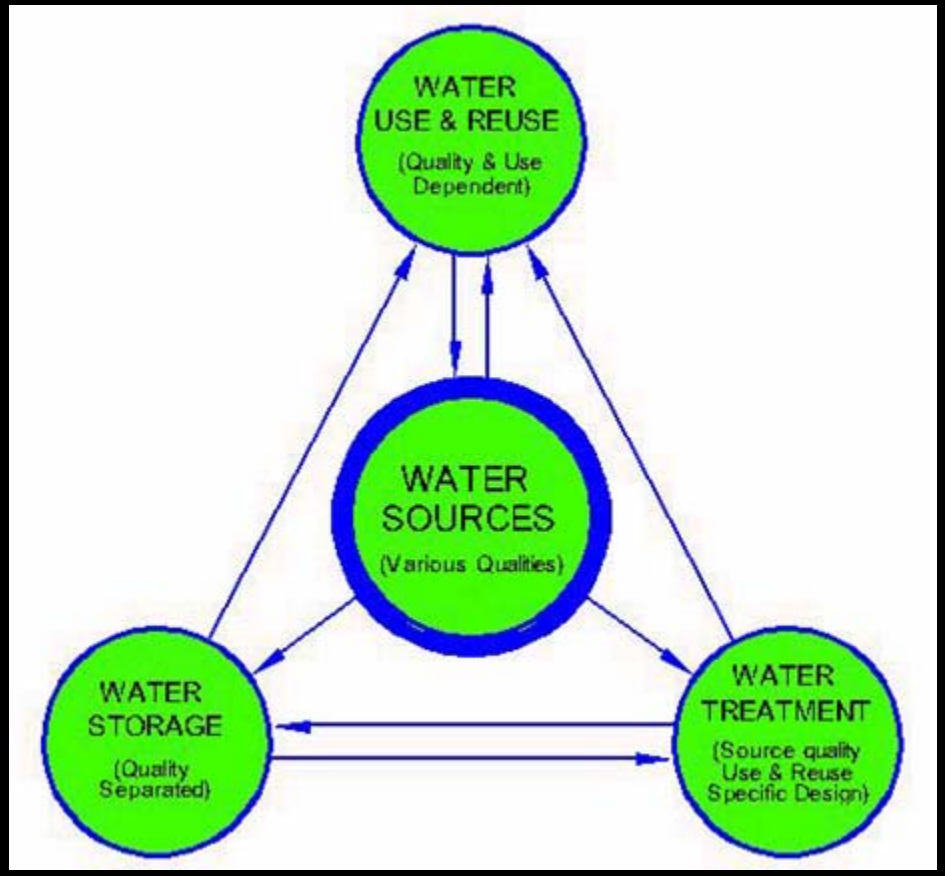
SYSTEMS THINKING

All Water is a Potential Source...



SYSTEMS THINKING

Water Management vs. Water Supply...



SYSTEMS THINKING

Potential Water Sources – Semantics are Important

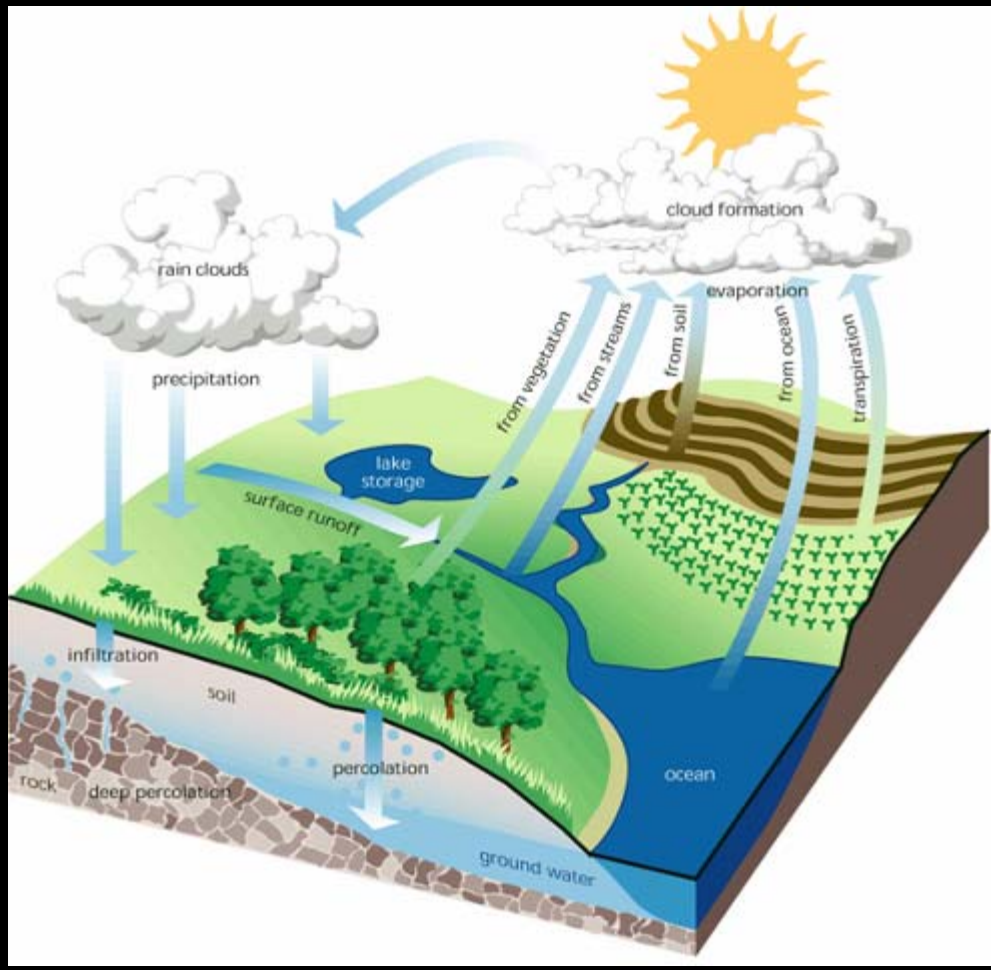
Water Resources Defined

- Potable Water (Drinking)
- Stormwater (General rainwater run-off from sites)
- “Waste”water (An out-dated term; all types of water are considered resources)
  - Blackwater (Toilet water)
  - Greywater (Sinks, showers, laundry, etc.)
  - Combined Water (Blackwater & greywater)
- Rainwater (Roof run-off)
- Reclaimed Water (Treated “waste”water)

RAINWATER HARVESTING
Introduction

<u>Opportunities</u>

- Rainwater is a clean water source available at the site
- Delivered at no cost
- Initial treatment provided by a very effective large scale distillation process
- Can reduce potable water demand and/or reduce stormwater run-off and address CSO problems
- Global warming is going to decrease water supply (*and as a result increase its cost in the future)*



The hydrologic cycle

RAINWATER HARVESTING
Introduction

Challenges

- Storage costs can challenge the cost-effectiveness of rainwater systems
- Current water prices are relatively low and do not justify much in the way of water conservation
  - *Conservation utility incentives may be available)*
  - *Seattle is better than most jurisdictions with its rate structure*
- The issue of Water Rights is currently unresolved legislatively
- Other regulatory issues can be a challenge for some jurisdictions, particularly with potable usage and with cross-connection

(more on regulatory issues later on in the presentation)

The Cedar River Reservoir

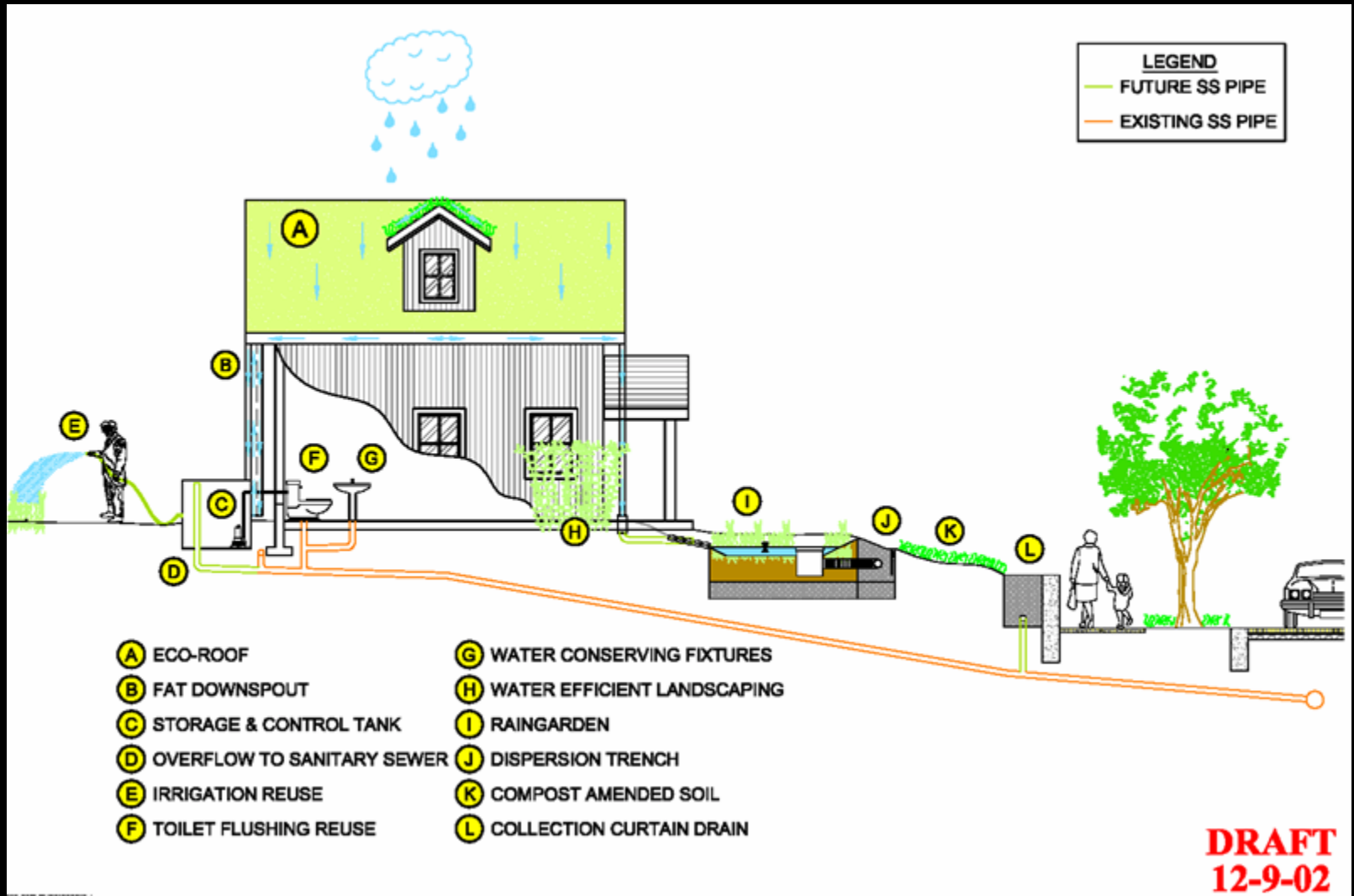
RAINWATER HARVESTING
Introduction

- Rainwater collection should be considered as part of a system, not in isolation, rainwater harvesting is not the whole solution to conservation, other strategies include
  - Conserving fixtures
  - Drought tolerant landscaping
  - Efficient irrigations systems
  - Behaviors
- Be opportunistic, find places to provide storage on projects (parking garages, bridge abutments, under patios, etc.)

Underground parking garage

RAINWATER HARVESTING

As part of overall Low-Impact Development (LID) and water conservation design



WATER EFFICIENCY

Water Conserving Fixtures

Drought Tolerant Landscaping

Washing Machines

Waterless Urinals

Composting Toilets

Drip Irrigation

Low Flow Shower and sink Fixtures

Dual Flush Toilets

RAINWATER HARVESTING
Introduction

- In many areas rainwater harvesting is commonplace
- Many jurisdictions support or require Rainwater Harvesting
  - States of Texas, California, Hawaii allow rainwater catchment
  - City of Portland, Oregon allows rainwater catchment
  - San Juan County, Washington permits rainwater catchment systems for new construction
  - Jefferson County, Washington allows rainwater catchment if salt water intrusion is present
  - Bermuda and US Virgin Islands require the use of cisterns in all new construction
  - In rural Australia rainwater catchment is very common

A cistern in Australia

A cistern in the Virgin Islands

RAINWATER HARVESTING

Introduction

- In this brief talk we are covering two topics with competing needs...
  - Rainwater Re-use cisterns for water conservation *(tries to make tank full)*
  - Stormwater detention cisterns for flow-control during storms *(tries to make tank empty)*
- Hybrid systems are possible, but they require seasonal changes in operation in this climate *(The City of Seattle has allowed the use of detention for rainwater storage in some cases...)*

RAINWATER HARVESTING

Water Rights - Statewide

- The State of Washington retains the right to all “waters of the State” as a natural resource held in common for the public good
- A water right is required to use any water
- There is no exemption for rainwater as there is for a well (5,000 gpd)
- Different jurisdictions handle this issue in different ways (i.e. San Juan County)
- Dept. of Ecology (DOE) administers water rights in WA
- DOE’s policy is to NOT actively enforce water rights on small rainwater systems, BUT if asked they will comply with the law.

RAINWATER HARVESTING

Water Rights - Seattle

- Seattle Rainwater Harvesting Homepage: http://www.seattle.gov/util/Services/Yard/Natural_Lawn_&_Garden_Care/Rain_Water_Harvesting/SPU03_001901.asp
- CSO areas vs. non-CSO areas
- The City of Seattle is actively promoting rainwater harvesting for non-potable uses
- The City of Seattle is not requiring water right permits for these systems
- There is a new permit application for pressurized systems (does not apply to gravity irrigation systems): www.metrokc.gov/health/plumbing/documents/Rainwater-Harvesting.doc

RAINWATER HARVESTING

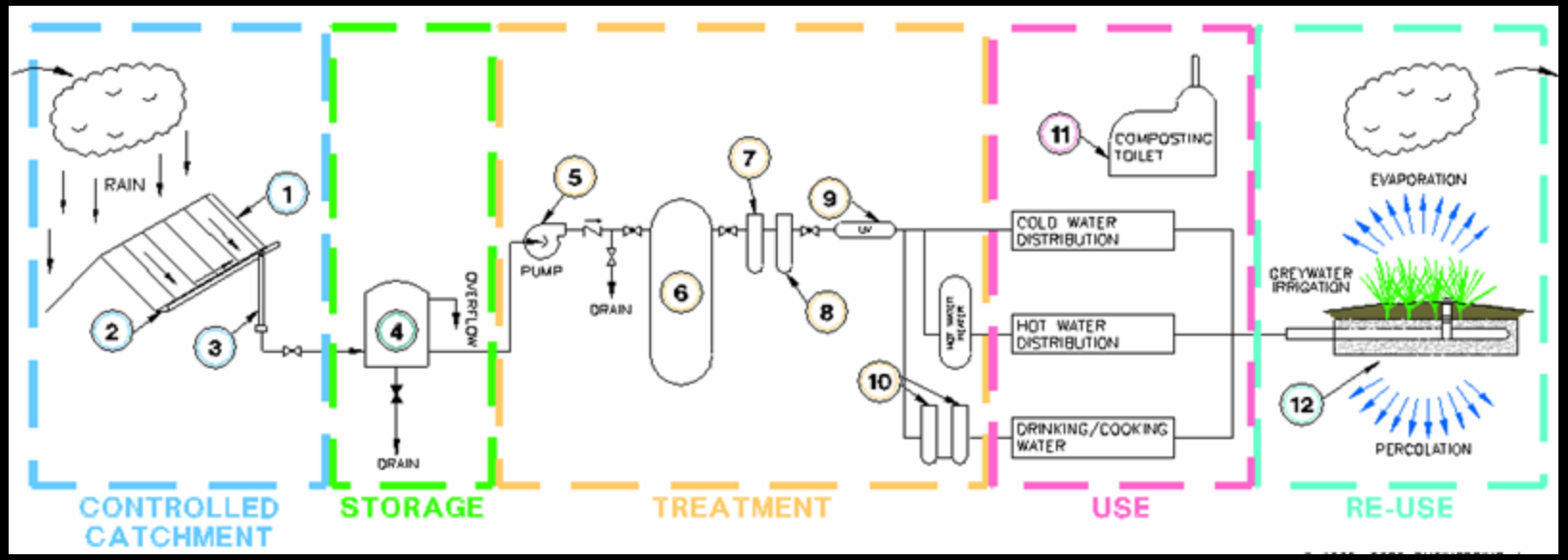
Major System Types

- Irrigation
- Toilet Flushing
- Potable
- Industrial
- Stormwater / CSO Control
- Hybrids of the above
- Each has pros and cons and the cost effectiveness of each type depends on site specific conditions and project goals

RAINWATER HARVESTING

Major System Components

- Catchment
- Pre-Treatment
- Storage
- Treatment
- Distribution/Use
- Back-up / Cross Connection
- Re-Use
- O&M and Education



RAINWATER HARVESTING

Component Design: Catchment Area

- Controlled catchment area
  - Roofs only for potable water systems (no augmenting with surface water)
  - Roofing materials, flashing, adhesives very important for potable systems
  - Ideally standing seam metal roofs
  - Source control on particulates
  - Irrigation and toilet flush systems could include some surface water or non standard roof water but aesthetic issues can arise (i.e. Seattle city hall)
- Course Pre-Treatment
  - ¼” leaf screens
  - 1/16” bug screens, self-cleaning

Standing seam metal roof

Self cleaning course pre-treatment screen

RAINWATER HARVESTING
Component Design: Storage

- Cistern Storage Tank Types
  - Underground Concrete (CIP, or Pre-Cast)
  - Underground Fiberglass
  - Partial Bury Plastic
  - Above Ground Plastic
  - Above Ground other (recycled stainless steel, etc.)
  - A portion of a below grade structure / basement
- Structural Considerations (geotechnical, seismic, etc.)

RAINWATER HARVESTING

Component Design: Catchment and Storage

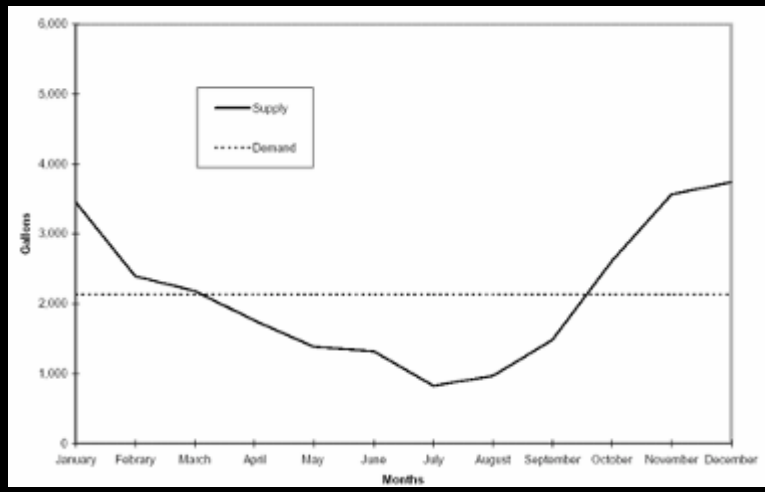
Many types of tanks are available

$0.50/gal - $4-6/gal.

RAINWATER HARVESTING

System Design: Sizing for Potable Use

- Supply
  - Catchment Area
  - Historic monthly rainfall data
  - Select design water year total rainfall as drier than 90% of all years on record
  - Apply this total rainfall to the average monthly rainfall distribution
- Demand
  - Estimate potable uses based on typical per capita daily uses values plus engineering judgment
- Size Storage and Conveyance
  - Mass balance on total storage volume
  - Pumping capacity for peak demand
  - Safety factor (say 90 days min.)



Typical supply and demand graph

RAINWATER HARVESTING

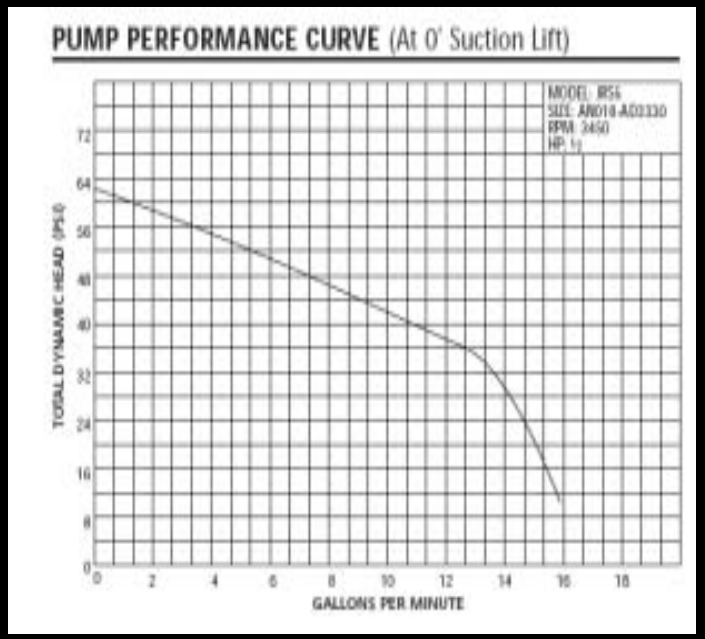
System Design: Sizing for Irrigation and Toilet Flushing

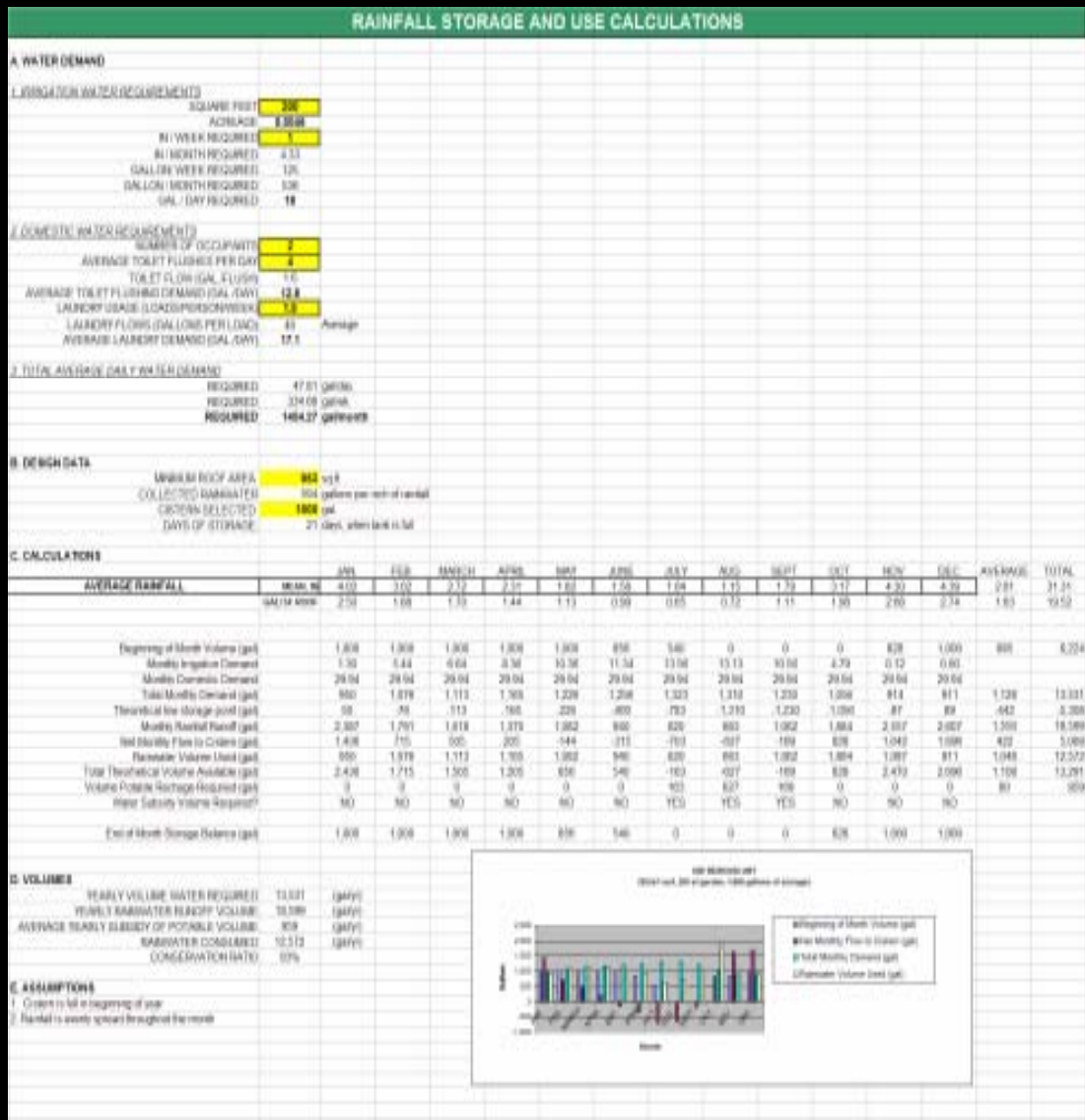
- Supply
  - Determine the conservation goal of the client (i.e. how much water do you want to save)
  - Look at catchment area and historic rainfall just like the potable system but probably base the supply on the average rainfall
- Demand
  - Determine irrigation needs of the vegetation to be irrigated (0.25” – 1” per week?)
  - Factor in the efficiency of the irrigation method (i.e. drip irrigation vs. soaker hose vs. sprinklers)
  - Estimate WC demand (use conserving fixture)
- Size Storage and Conveyance
  - Mass balance on total storage volume
  - Pumping capacity
  - Typically limited by volume available or budget

Drip Irrigation

RAINWATER HARVESTING

System Design: Typical mass balance sizing spreadsheet and typical pump curve





RAINWATER HARVESTING

Component Design: Pumping and Conveyance

Shallow Well Jet Pump

Pressure Tanks

Combination pressure tank and pump systems

Variable Speed Pumps

Commercial pumping system

RAINWATER HARVESTING
System Design: Treatment

- Potable Systems
  - Meet drinking water standards and regulations
  - 20 micron
  - 5 micron
  - Disinfection (typically UV)
  - Point of use filter for taste and odor issues (if present) or if source control is an issue (i.e. retrofit on a house with an asphalt comp. roof
- Irrigation Systems
  - Sediment filter to protect equipment
- Toilet Flush Systems
  - Sediment filter to protect equipment
  - Ozone for aesthetic considerations (i.e. color) may be needed

RAINWATER HARVESTING

Component Design: Treatment

Sand Filters

Cartridge Filters

Cartridge Filters

Point of Use
Sink Filters

Point of Use
Shower Filter

UV Disinfection Unit

RAINWATER HARVESTING

System Design: Cross-Connection / back-flow

- Necessary when a potable system is connected to the system for back-up (i.e. city water)
- Prevents back-siphonage of the rainwater into the potable system
- Code requirement
- Often the primary concern for regulators
- RP devices and other backflow preventors require a special permit and annual inspection and testing

An air gap between rainwater cistern and potable back-up

RAINWATER HARVESTING

Component Design: Cross-Connection / back-flow

6” Air gap (at King Street Center)

Double check valve backflow assembly

Reduced pressure principle backflow assembly

RAINWATER HARVESTING

Component Design: Overflow and Release

- Per local stormwater management code
- Re-Use (conservation) system design assumes tank is full and therefore storm is un-detained
- Therefore another retention/detention Best Management Practice (BMP) may be required (same as what would be required of a downspout)
- Prefer Low-Impact Development (LID) BMP's
- Stormwater cisterns are the BMP....

RAINWATER HARVESTING

Local Rainwater Projects

- Some local Public Buildings with Toilet Flush and Irrigation Systems
  - King Street Center (re-use for toilet flushing)
  - Seattle Central Library (re-use for irrigation)
  - Seattle City Hall (retrofit for irrigation and fountain) (under construction)
  - Carkeek Park Environmental Education Center
  - Portland State University dorm (toilet flushing)
  - Others...

RAINWATER HARVESTING

Commercial Hybrid Example Project

Bayview Corner Public Restroom Building – Rainwater Collection for toilet flushing

- Serves a Farmers Market and Plant Nursery
- Combines other strategies to be essentially “off the water grid”

RAINWATER HARVESTING

Residential Potable Water Example Project

Swinomish Indian Reservation, Skagit County, WA, built 1999

- Rainwater as sole source of potable water
- 1,600 sf metal roof, 5,600 gal. Storage, 2 people, 20/5 micron cartridge filtration, 1/0.5 micron carbon at taps, UV disinfection
- Composting toilets & small greywater re-use system

RAINWATER HARVESTING

Residential Potable Water Example Project

RAINWATER HARVESTING

Residential Non-Potable Water Example Project

Private Residence, Seattle, WA, built 2003

- Rainwater for non-potable uses (toilet flushing and irrigation)
- Cistern tank is the patio
- City water back-up
- Many green building strategies
- Simple 20 micron filtration
- http://www.sensiblehouse.org/prc_rainwater.htm

RAINWATER HARVESTING

Residential Non-Potable Water Example Project

The cistern is the patio...

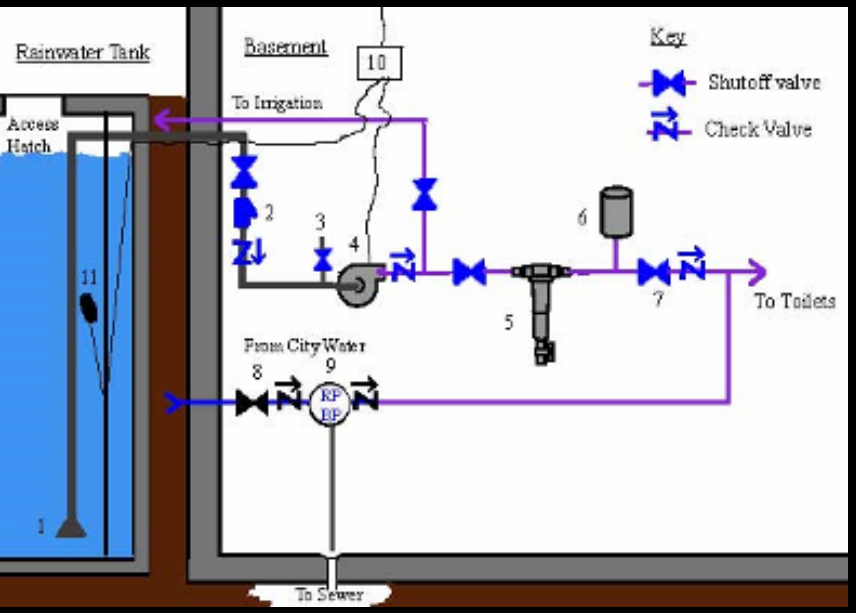
In-line downspout screens...

Inside the cistern:

RAINWATER HARVESTING

Residential Non-Potable Water Example Project

The schematic diagram...



In the basement...

RAINWATER HARVESTING

Multi-Unit Residential Non-Potable Water Example Project

14-Units Zero Net Energy, Lopez Island, WA
(Under Construction Now)

- Rainwater for non-potable uses
  (toilet flushing, clothes washers, and irrigation)
- 34,000 gallon central cistern
- Water System back-up
- Many green building strategies
- 5 micron sand filter filtration
- Water Right Acquired

ADDITIONAL INFORMATION

ARCSA

American Rainwater Catchment Systems Association (ARCSA)

www.arcsa-usa.org

RAINWATER HARVESTING

Community Scale Non-Potable Water Example Project

Nine Homes, Lummi Island, WA, built 2004/2005

- Saltwater intrusion issues on islands
- Rainwater for non-potable uses (toilet flushing, clothes washing, and irrigation)
- Cisterns are recycled food oil tanks
- Small community water system back-up
- Conservation was a requirement of the platting due to capacity of typical exempt well
- Simple 20 micron filtration
- http://www.lummiislandclt.org/projects/

RAINWATER HARVESTING

Community Scale Non-Potable Water Example Project

THANK YOU…

Questions

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