Rainwater & Greywater Challenges

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Introduction and History

Today we will be learning...

• Background and Feasibility Discussions
• Review of Sizing Equations and Calculating Use
• In-depth Look at Reclaim Systems
• Case Studies and Questions
Why do we do it?

- 97.5% of all water on earth is salt water, leaving only 2.5% as fresh water.

- Nearly 70% of that fresh water is frozen in the icecaps of Antarctica and Greenland; most of the remainder is present as soil moisture, or lies in deep underground aquifers as groundwater and is not accessible to human use.

- < 1% of the world's fresh water (~0.007% of all water on earth) is accessible for direct human use. This water is found in lakes, rivers, reservoirs and shallow underground sources. Only this small amount of the world’s water is regularly renewed by rain and snow melt runoff thus making it available on a sustainable basis.
Where Has This Technology Evolved From
## Water Recovery Definitions

### Greywater
Untreated wastewater that has not come into contact with black water (sewage). Greywater includes used water from bathtubs, showers, lavatories, and clothes washing machines.

### Reclaimed Water
A catch all term for most clear water systems as well as cooling tower. Reclaim water on an individual project level encompasses:
1. **Clear water**
2. **Fire protection**
3. **Process water**
4. **Cooling tower water**

### Harvested Rainwater
Rainwater that is conveyed from a building catchment surface. There are two types:
1. **Rainwater**
2. **Stormwater**
Anatomy of Water Reclaim Systems
Sizing and Feasibility
It is not determined by Return on Investment (ROI). Why?
The first step is to identify the water source as this will dictate how to size the system.
For rainwater and stormwater systems, sizing is a matter of computation. For other sources, empirical and use data dictate available water.
Sizing Calculations: Sizing Calculations Rainwater and Stormwater

Supply (gallons) = Feet of Rainfall \times 0.65 \times \text{Catchment Area (sq. ft)} \times \text{Runoff Coefficient}

Vertical catchment areas are multiplied by 0.5. (you can only collect water from 2 sides of any structure during a rain event).

In addition to the above, the supply is multiplied by any losses due to catchment surface filtration.
## Material Impact on Losses—Runoff Coefficients

<table>
<thead>
<tr>
<th>Material</th>
<th>Max.</th>
<th>Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roof</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal, gravel, asphalt, shingle, fiberglass, mineral paper</td>
<td>0.95</td>
<td>0.90</td>
</tr>
<tr>
<td><strong>Paving</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete, asphalt</td>
<td>1.00</td>
<td>0.90</td>
</tr>
<tr>
<td><strong>Gravel</strong></td>
<td>0.70</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Soil</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flat, bare</td>
<td>0.75</td>
<td>0.20</td>
</tr>
<tr>
<td>Flat, with vegetation</td>
<td>0.60</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>Lawn</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flat, sandy soil</td>
<td>0.10</td>
<td>0.05</td>
</tr>
<tr>
<td>Flat, heavy soil</td>
<td>0.17</td>
<td>0.13</td>
</tr>
</tbody>
</table>
Rain Catchment Surface (Roof / Conveyance) Determining the Amount of Rain Fall Available.

To determine rainwater density, use at least 7+ years of monthly data. A good reference is: www.worldclimate.com
Cold Weather Systems

Cold Weather System Effects

- The reclaim water availability and flow rates
- Requires any tanks or equipment to be buried below the frost line and heat traced
Empirical Sizing of Reclaim Water Sources

- Reverse Osmosis Reject Water ➔ Determined by rate of generation and time of use throughout the day

- HVAC and Cooling tower condensate ➔ Determined by square footage of units

- Cooling tower blow down ➔ Based on use and relative conductivity levels of feed water to tower as well as evaporation rate

- Greywater ➔ Based on occupancy and is generally a low figure for usable water sources

Competing water sources to rainwater and stormwater systems will dominate the reclaim water source.
Overall 3% of water used in a building is suitable for greywater reclaim.
Water Demand Sizing

The majority of non-residential rainwater systems are designed to feed three main non-potable water demands.

• Flushing Fixtures
• Irrigation
• Cooling Towers

Using rainwater for industrial use, lab use, and especially cooling towers, can be difficult. Generally speaking, these water demands will use water volumes in excess of what can be collected using rainwater alone. These demands are generally supplemented with rainwater in addition to other reclaimed water sources.
Common Reclaim Water Uses

Non-potable Demands Include:

- Building washing/power washing
- Cooling towers
- Fire suppression
- Household cleaning
- Industrial processing
- Landscape irrigation
- Laundry washing
- Pool/pond filling
- Toilet flushing
- Vehicle washing

Potable Demands Include:

- Drinking water
- Cooking
- Bathing
- Dish washing
Sizing Calculations Cont. Flushing Fixtures

Flushing fixture water use is determined by several factors:

- Building occupancy
- Determine the number of male and female occupants of the building
- Days of use

<table>
<thead>
<tr>
<th>Fixture Type</th>
<th>Consumption</th>
<th>Daily Uses</th>
<th>Duration</th>
<th>Occupants</th>
<th>Daily Water Use (gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.28 gpf toilet - male (gallons per flush)</td>
<td>1.28</td>
<td>1</td>
<td>1</td>
<td>XX</td>
<td>XX</td>
</tr>
<tr>
<td>1.28 gpf toilet - female (gallons per flush)</td>
<td>1.28</td>
<td>3</td>
<td>1</td>
<td>XX</td>
<td>XX</td>
</tr>
<tr>
<td>0.5 gpf urinal - male (gallons per flush)</td>
<td>0.5</td>
<td>2</td>
<td>1</td>
<td>XX</td>
<td>XX</td>
</tr>
</tbody>
</table>

Total Daily Volume

Monthly Days of Use

Total Monthly Usage
Sizing Calculations: Irrigation Demand

Demand (gallons) = Evapotranspiration × Plant Factor × Irrigated Area

Irrigation Demand
Evapotranspiration is defined as the process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants.
## Plant Use Coefficients

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Water Use</td>
<td>0.20</td>
</tr>
<tr>
<td>Medium Water Use</td>
<td>0.50</td>
</tr>
<tr>
<td>High Water Use</td>
<td>0.75</td>
</tr>
</tbody>
</table>
Cistern

A cistern is either above ground outside or more commonly buried. It is occasionally located indoors for smaller applications.

Common materials of the cistern include:

- Thermoplastics
- Fiberglass
- Concrete
- Metal
- Wood
## Cistern Material Selection is Important

<table>
<thead>
<tr>
<th>Material</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermoplastics</td>
<td>Needs pigment ratio UV stabilization</td>
</tr>
<tr>
<td></td>
<td>Best for indoor use</td>
</tr>
<tr>
<td>Fiberglass</td>
<td>Loss of customizable geometry</td>
</tr>
<tr>
<td></td>
<td>Best for underground burial</td>
</tr>
<tr>
<td>Concrete</td>
<td>Loss of water from absorption and generally high bacteria growth potential</td>
</tr>
<tr>
<td></td>
<td>due to surface area</td>
</tr>
<tr>
<td>Metal</td>
<td>Generally poor choice due to leaching of contaminants and color</td>
</tr>
<tr>
<td></td>
<td>Not a recommended material</td>
</tr>
<tr>
<td>Wood</td>
<td>Expensive, generally high bacteria growth potential due to surface area</td>
</tr>
<tr>
<td></td>
<td>Best for outside use and small applications</td>
</tr>
</tbody>
</table>
Cistern Sizing: Two Schools of Thought

Minimum Size
Minimum system size is for the volume to equal a two day supply of the daily water requirements.

Maximum Size
To maximize captured rainfall, the cistern should be sized for the volume of water required to meet the water requirements over the longest drought period.

Practical Considerations of Sizing
• Allowed Footprint
• Cost

Pitfalls (Over/Under Sizing)
• Under sizing leads to waste of collected rainfall and more city water use
• Over sizing leads to stagnation and increased project cost
What is in my Water??
Is it Raining?

- Rainwater is one of the cleanest water sources available
- Hardness and sodium content is essentially zero
- Slightly acidic in nature due to dissolved CO2 and nitrates
- Contains on average 2-20 ppm TDS (compared to municipal water supplies which contain on average 100-800 ppm TDS)
As Soon As It Is Captured and Stored It Is Not Clean.
Common Sources of Rainwater/Stormwater Contamination

- Metals
- Organics
- Bacteria/Disease
- Turbidity
- Color
Understanding the Sources of Rainwater and Stormwater Contamination

- Geography—where is the system located?
- Catchment surface elevation?
- What is the area near the catchment surface—industry, agriculture, metropolitan, etc.?
- Material of construction—roofing material, downpipes, etc.?
# Sources Of Contamination: Disease

<table>
<thead>
<tr>
<th>Disease</th>
<th>Bacteria Name</th>
<th>Where it comes from</th>
<th>Method of water contamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listeriosis</td>
<td>Listeria monocytogenes</td>
<td>Fecal matter of infected animals, which can contaminate drinking water supplies and soil</td>
<td>Rodents leave droppings on roof or in catchment systems</td>
</tr>
<tr>
<td>Leptospirosis</td>
<td>Leptospira interrogans</td>
<td>Urine of infected mammals</td>
<td>Rodents urinate on roof or in catchment system</td>
</tr>
<tr>
<td>Campylobacteriosis</td>
<td>Campylobacter jejuni</td>
<td>Fecal matter of animals, domestic and feral; particularly carried by birds, domestic and wild</td>
<td>Birds or rats leave droppings on roof or in catchment system</td>
</tr>
<tr>
<td>Salmonellosis</td>
<td>Salmonella gastroenteriti</td>
<td>Fecal matter of animals, including birds and reptiles</td>
<td>Birds or geckos leave droppings on roof or in catchment system</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>Escherichia coli</td>
<td>The fecal matter of all animals, but types pathogenic to humans are mostly found in human and cattle feces</td>
<td>Getting this disease via your water system is unlikely</td>
</tr>
<tr>
<td>Enteritis necroticans</td>
<td>Clostridium perfingens</td>
<td>Fecal matter of animals, domestic and feral</td>
<td>Animals leave droppings on roof or in catchment system</td>
</tr>
</tbody>
</table>
### Sources Of Contamination: Pathogens and Other Diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Common Name</th>
<th>Where it comes from</th>
<th>Method of water contamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giardiasis</td>
<td>Giardia lamblia</td>
<td>In the fecal matter of infected animals</td>
<td>Infected animals leave droppings on roof or in catchment systems</td>
</tr>
<tr>
<td>Toxoplasmosis</td>
<td>Toxoplasma gondii</td>
<td>In cat, rodent, and other animal feces; also, contaminated soil</td>
<td>Infected animals leave droppings on roof; wind blows soil with eggs into the water</td>
</tr>
<tr>
<td>Cryptosporidiosis</td>
<td></td>
<td>In the fecal matter of animals, but mice and birds are not believed to be carrying the human pathogen species</td>
<td>Infected animals leave droppings on roof or in catchment system</td>
</tr>
<tr>
<td>Hantavirus pulmonary syndrome</td>
<td>Sin nombre virus</td>
<td>Wild rodents and maybe other small mammals</td>
<td>From building materials that contain rodent feces, urine, or saliva that wash into your tank</td>
</tr>
<tr>
<td>Alveolar hydatid</td>
<td>Echinococcus multilocularis (a tapeworm)</td>
<td>In cat, rodent, and other animal feces</td>
<td>Infected animals leaving droppings on your roof, or wind blowing soil with eggs into the water</td>
</tr>
</tbody>
</table>
No effluent guidelines or criteria exist for Rainwater and Stormwater Harvesting.
## Sources of Contaminates Greywater

<table>
<thead>
<tr>
<th>Greywater source</th>
<th>Possible contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic clothes washer</td>
<td>Suspended solids (dirt, lint), organic material, oil and grease, sodium, nitrates and phosphates (from detergent), increased salinity and pH, bleach</td>
</tr>
<tr>
<td>Automatic dishwasher</td>
<td>Organic material and suspended solids (from food), bacteria, increased salinity and pH, fat, oil and grease, detergent</td>
</tr>
<tr>
<td>Bathtub and shower</td>
<td>Bacteria, hair, organic material and suspended solids (skin, particles, lint), oil and grease, soap and detergent residue</td>
</tr>
<tr>
<td>Sinks, including kitchen¹</td>
<td>Bacteria, organic matter and suspended solids (food particles), fat, oil and grease, soap and detergent residue</td>
</tr>
</tbody>
</table>

(2)
## Range of Contaminates Greywater

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Greywater range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended solids</td>
<td>mg/L</td>
<td>45–330</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>22–200</td>
</tr>
<tr>
<td>BOD₃</td>
<td>mg/L</td>
<td>90–290</td>
</tr>
<tr>
<td>Nitrite</td>
<td>mg/L</td>
<td>&lt; 0.1–0.8</td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/L</td>
<td>&lt; 0.1–25.4</td>
</tr>
<tr>
<td>Total Kjeldahl nitrogen</td>
<td>mg/L</td>
<td>2.1–31.5</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>mg/L</td>
<td>0.6–27.3</td>
</tr>
<tr>
<td>Sulfate</td>
<td>mg/L</td>
<td>7.9–110</td>
</tr>
<tr>
<td>pH</td>
<td>–</td>
<td>6.6–8.7</td>
</tr>
<tr>
<td>Conductivity</td>
<td>mS/cm</td>
<td>325–1140</td>
</tr>
<tr>
<td>Sodium</td>
<td>mg/L</td>
<td>29–230</td>
</tr>
</tbody>
</table>
Range of Contaminates Greywater Continued

<table>
<thead>
<tr>
<th>Source of water</th>
<th>Number of faecal coliforms (cfu/100 mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bath, shower and washing machine with baby diapers</td>
<td>$10^4$–$10^6$</td>
</tr>
<tr>
<td>Bathing and shower</td>
<td>$6 \times 10^3$</td>
</tr>
<tr>
<td>Washing machine, bathroom sink, shower and kitchen sink</td>
<td>$3.44 \times 10^6$</td>
</tr>
<tr>
<td>Washing machine (with children)</td>
<td>$2.6 \times 10^4$–$8.45 \times 10^5$</td>
</tr>
<tr>
<td>Washing machine (without children)</td>
<td>$7 \times 10^1$–$2.9 \times 10^4$</td>
</tr>
<tr>
<td>Shower and hand basin</td>
<td>$1.5^2 \times 10^2$–$3.5 \times 10^4$</td>
</tr>
<tr>
<td>Shower and bath</td>
<td>$10^1$–$5 \times 10^3$</td>
</tr>
</tbody>
</table>
Guidelines for Greywater Use

Table 2-5 Summary of NSF Standard 350 Effluent Criteria for individual classifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Class R</th>
<th></th>
<th>Class C</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test Average</td>
<td>Single Sample Maximum</td>
<td>Test Average</td>
<td>Single Sample Maximum</td>
</tr>
<tr>
<td>CBOD₅ (mg/L)</td>
<td>10</td>
<td>25</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>10</td>
<td>30</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>5</td>
<td>10</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>E. coli (MPN/100 mL)</td>
<td>14</td>
<td>240</td>
<td>2.2</td>
<td>200</td>
</tr>
<tr>
<td>pH (SU)</td>
<td>6.0 – 9.0</td>
<td>NA¹</td>
<td>6.0 – 9.0</td>
<td>NA</td>
</tr>
<tr>
<td>Storage vessel disinfection (mg/L)³</td>
<td>≥ 0.5 – ≤ 2.5</td>
<td>NA</td>
<td>≥ 0.5 – ≤ 2.5</td>
<td>NA</td>
</tr>
<tr>
<td>Color</td>
<td>MR³</td>
<td>NA</td>
<td>MR</td>
<td>NA</td>
</tr>
<tr>
<td>Odor</td>
<td>Nonoffensive</td>
<td>NA</td>
<td>Nonoffensive</td>
<td>NA</td>
</tr>
<tr>
<td>Oily film and foam</td>
<td>Nondetectable</td>
<td>Nondetectable</td>
<td>Nondetectable</td>
<td>Nondetectable</td>
</tr>
<tr>
<td>Energy consumption</td>
<td>MR</td>
<td>NA</td>
<td>MR</td>
<td>NA</td>
</tr>
</tbody>
</table>

¹ NA: not applicable
² Calculated as geometric mean
³ As total chlorine; other disinfectants can be used
⁴ MR: Measured reported only
Water Treatment Begins…

…Right At the Catchment Surface

Common Roof Treatment Includes:

• First Flush Devices
• Gutter Guards
• Siphonic Water Filters
Reclaim Water System

Treatment System Overview

- Particulate Filtration
- Disinfection
- Additional Treatment
- Dye Injection
- Building Pressurization

2 Typical Systems

Direct Storage
- Typical for smaller systems, lower flows and tighter foot prints

Cistern Storage
- Typical for higher flow systems
Direct Storage Design Basics For Reclaim Water

Rainwater → Rainwater Tank → Treatment → Point of Use
Cistern Storage Design Basics For Reclaim Water

Rainwater → Rainwater Tank → Treatment → Treated Water Storage Tank → Point of Use
Filtration-Mechanical

The first step of the treatment system is designed to remove particulate that could be detrimental to flushing fixtures and irrigation nozzles. Typical filtration is to the 10 micron range.

**Filtration Options**

**Bag/Cartridge Filtration**
- Typical of low flow systems
- Always duplexed for redundancy
- Filtration differential pressure alarms included
- Filtration automatic switch-over is an option

**Back-Flushable Filters**
- Typical of high flow systems (150 gpm+)
- Spin disk Technology (individual pods sized for a portion of the flow rate)
- Backwash water is kept to a minimum to reduce water consumption
Filtration-Carbon Filter and Other Resin Treatment

Carbon Filters

Activated carbon is a micro porous inert carbon with a large internal surface. Organic molecules from liquids or gases can be adsorbed on this surface. Adsorption is the natural phenomenon in which molecules from the gas or liquid phase are attached to the surface of the solid.

Carbon Filter removal targets:

- Aromatic Solvents
- Chlorinated Aromatics
- Chloramines
- Some large chain hydrocarbons (oils)
- Can improve taste of water
Sanitization-Primary Types

Two Primary Types of Sanitization Methods

Radiation Sanitization:

254nm UV, size dependent upon flow rate

Benefits:
- Instantaneous treatment
- No chemical handling
- Safe for irrigation or chemical sensitive equipment (i.e. cooling towers)

Disadvantages:
- No residual disinfection
Sanitization-Primary Types

Chemical Sanitization:
Sodium hypochlorite (liquid or pellet feed) or ozone

Benefits:
- Residual disinfection

Disadvantages:
- Residence time required to be effective
- Not usable for irrigation or chemical sensitive equipment
- Maintenance personal required to handle chemical
- Does not kill Giardia and Cryptosporidium
Legionella bacteria occurs naturally in lakes, water sources and subsoil water. There, they do not constitute a hazard to people. However, in unsuitably designed water systems, they may multiply rapidly and thus become a health risk. They thrive in hot water recirculation loops and thus should be a concern to warm rainwater harvesting systems.

Positively charged copper and silver ions travel within the water system to penetrate the bio-film. These ionic particles bind themselves to negatively charged micro-organisms like Legionella. This disrupts the overall cell metabolism, thus causing cellular lysis.

Disadvantages:
- May leave residual ion contamination in the water stream
Rainwater, due to contact with atmospheric gases such as carbon dioxide and sulfur dioxide, is predominantly acidic. This effect will cause leaching problems in metal plumbing treatment systems.

Generally, pH adjustment is one way treatment, either through contact with Calcite based filters or through chemical injection, such as a weak base or bicarbonate.

<table>
<thead>
<tr>
<th>The pH Scale</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic (Alkaline)</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Neutral</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Acidic</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Oven cleaner</td>
<td></td>
</tr>
<tr>
<td>Hair Remover</td>
<td></td>
</tr>
<tr>
<td>Soap</td>
<td></td>
</tr>
<tr>
<td>Bleach</td>
<td></td>
</tr>
<tr>
<td>Sea Water</td>
<td></td>
</tr>
<tr>
<td>Pure Water</td>
<td></td>
</tr>
<tr>
<td>Urine</td>
<td></td>
</tr>
<tr>
<td>Acid Rain</td>
<td></td>
</tr>
<tr>
<td>Tomato Juice</td>
<td></td>
</tr>
<tr>
<td>Orange Juice</td>
<td></td>
</tr>
<tr>
<td>Lemon Juice</td>
<td></td>
</tr>
<tr>
<td>Stomach Acid</td>
<td></td>
</tr>
</tbody>
</table>
Non-potable Water Identification

Electronic Dye Metering Pump
Reclaimed water can be injected with a non-toxic blue dye as required by local plumbing codes to easily identify as a non-potable source.

Pigmented Piping
All piping systems utilized in the treatment system as well as the building feed system, need to be colored purple to identify them as a non-potable source.
Combination Source Water Reclaim Systems

Rainwater is only one of many sources of reclaim water that can be utilized in a building. Often, when using reclaim water for uses other than flushing fixtures and irrigation, the water requirements will exceed the rain water supply. In this case other surfaces and water sources can be used. These include:

- Parking lot or surface area runoff
- Cooling tower blow down and HVAC condensate
- Reverse Osmosis reject water
- Greywater systems

Each of these sources can provide a higher volume or more consistent water supply. These sources however do carry additional contamination issues that need to be addressed in the treatment.

Caution: Once an alternate water source is utilized in the system, it tends to dominate the water supply. As such, dilution can not be used as a treatment solution.
Water Reclaim Systems

Reclaim water sources utilize many similar treatment systems to rainwater including:

- Particulate Filtration
- Sanitization (both chemical and radiation)
- pH Adjustment
- Resin Treatment (carbon, magnesium green sand, etc.)
- Legionella removal
Combination Source Water Reclaim System Separation

In addition to standard rainwater contamination, these sources possess additional contaminants.

<table>
<thead>
<tr>
<th>Source</th>
<th>Contamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking Lots</td>
<td>• Higher bacteria and debris load on system&lt;br&gt;• Oil and emulsion contamination</td>
</tr>
<tr>
<td>Cooling Tower Blowdown</td>
<td>• Very high mineral content (TDS)&lt;br&gt;• Possible scaling concerns</td>
</tr>
<tr>
<td>HVAC Condensate</td>
<td>• Relatively clean water source</td>
</tr>
<tr>
<td>RO Reject Water</td>
<td>• Very high mineral content (TDS)&lt;br&gt;• Possible scaling concerns</td>
</tr>
<tr>
<td>Graywater</td>
<td>• Very high bacteria and debris load on system&lt;br&gt;• Chemical contamination of water&lt;br&gt;(soaps, detergents, other species from carbon unit wash down)</td>
</tr>
</tbody>
</table>
Combination Source Water Reclaim Systems

In addition to standard rainwater treatment devices, these utilize additional treatment options to address specific contamination.

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Treatment Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking Lots</td>
<td>• Higher UV treatment doses, combined with secondary chemical treatment&lt;br&gt;• Requires oil and emulsion separation</td>
</tr>
<tr>
<td>Cooling Tower Blowdown</td>
<td>• Membrane filtration to remove TDS&lt;br&gt;• Descaling agents&lt;br&gt;• pH Adjustment</td>
</tr>
<tr>
<td>HVAC Condensate</td>
<td>• Requires no additional treatment</td>
</tr>
<tr>
<td>RO Reject Water</td>
<td>• Membrane filtration to remove TDS&lt;br&gt;• Descaling agents</td>
</tr>
<tr>
<td>Graywater</td>
<td>• Higher UV treatment doses, combined with secondary chemical treatment&lt;br&gt;• May require oil and emulsion separation&lt;br&gt;• Slow sand filtration&lt;br&gt;• Requires chemical removal (chemical destruct or oxidation)&lt;br&gt;• Possible membrane treatment</td>
</tr>
</tbody>
</table>
Oil Separation

Rainwater collected from parking lot surfaces, or used in car wash facilities, will contain both free and potentially emulsified oil. Free floating oil can be removed efficiently using coalescing media. Low levels of oil are removable with organic clay or charcoal filtration (in the PPM range).

The spent oil will be collected and needs to be disposed of as a waste product.
Oil Separation Emulsification

Emulsification is a chemical term used to classify the mixing of one or more immiscible liquids into a dispersed pattern.

This can occur in the presence of an emulsification agent which stabilizes the emulsion. Common emulsification agents seen in reclaim systems are surfactants.
Oil Separation-Emulsification Breaker

Emulsification breakers are chemical additives injected, or more commonly, resins designed to destabilize the emulsion.
The process of anti-scaling involves the removal of metal contamination most often in the form of hardness or calcium contamination. Anti-Scaling can be done in several different ways.

- Membrane filters such as RO can be used to remove scaling agents.
- Numerous anti-scaling agents are available on the market.
- Water Softeners can be used to specifically target calcium and hardness.
- New technology is focusing on magnetic water treatment although this has come under scrutiny as to its overall effectiveness.
Membrane Filtration In Water Treatment

Membrane filtration can serve two main purposes in the context of water treatment.

- Water filtration
- Volume reduction

There are two main types of membrane filters utilized in reclaim water treatment.

**Ultra filters** are semipermeable membranes that under hydrostatic pressure, retain suspended solids and high molecular weight species.
Membrane Filtration In Water Treatment

**Reverse osmosis** occurs when water pressure applied to the concentrated side forces the process of osmosis into reverse. Under enough pressure, pure water is “squeezed” through the membrane from the concentrated side to the dilute side. Salts dissolved in the water as well as charged ions, are repelled by the RO membrane. The rejected impurities on the concentrated side of the membrane are washed away in a stream of wastewater.
Standard multi-media or sand filters are designed for high throughput use where the entire media bed is utilized for treatment and there is a rapid backwash process.

On the contrary, slow sand filters utilize a bed media similar to a normal multi-media filter but also have another layer of treatment which is referred to as Shmutzdecke or bio-sand filter.

*Shmutzdecke* is what makes a slow sand filter unique. It is the top layer of the bed which forms a gelatinous material in the form of bacteria, fungus, enzymes and protozoa, essentially creating a beneficial living environment. Harmful bacteria and pathogens are destroyed while organics are absorbed and metabolized. Because of this, slow sand filters are common in potable and greywater system designs. These filters are not backwashed but must be cleaned every few years as the flow rate capacity will be reduced due to the continuing growth of the Shmutzdecke.
To Summarize Combination Source Water Reclaim

Rainwater is only one of many sources of reclaim water that can be utilized in a building. There are several other predominant water reclaim sources:

- Parking lot or surface area runoff
- Cooling tower blow down and HVAC condensate
- Reverse Osmosis reject water
- Greywater systems

It is important upfront in a project to know what water sources are going to be used in the system. Many advanced options require pilot testing and there is not a “one size fits all” system. Every reclaim water system is unique.
Questions

Problem 1:

A five story building on a college campus near Allentown, PA wants to install a rainwater reclaim system to supplement water for a greenhouse located on the roof. The roof itself is green roof. The greenhouse will utilize misters to distribute the water within the greenhouse.

What treatment is required for use?

Problem 2:

A residential high rise in NYC wants to use stormwater runoff from the parking garage to supplement it’s cooling tower demand. The top of the garage is open to the atmosphere and the ground level cannot be used due to the gravity flow height limitations.

What treatment is required?
Questions

Problem 3:
A large corporate campus wants to use storm runoff from its multiple acre grounds as well as a local artificial pond for irrigation and flushing fixtures in two new buildings it is constructing on the campus.

What treatment is required?

Problem 4:
A new 5 star hotel in Mexico City which has limited water rights, needs to use storm runoff from its parking garage and rainwater from the roof in combination with its greywater from each hotel room to feed its flushing fixtures and cooling tower.

What treatment is required?
Problem 1:

An elementary school in Northern Alabama (Appalachian Mountain area) wants to install a rainwater reclaim system for flushing fixtures. The school is a single level and is located near a rural forest area with overhanging trees.

What treatment is required for use?

Answer:

• Cistern First Flush Device
• Vortex Filters
• Particulate Filtration
• Sanitization Radiation
Problem 2:

A five story building on a college campus near Allentown, PA wants to install a rainwater reclaim system to supplement water for a greenhouse located on the roof. The roof itself is a green roof. The greenhouse will utilize misters to distribute the water within the greenhouse.

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Answer:

- Cistern First Flush Device
- Vortex Filters
- Particulate Filtration
- Sanitization Radiation
- Resin Treatment (carbon, magnesium green sand, etc.)
- pH Adjustment
Problem 3:

A large corporate campus wants to use a storm runoff from its multiple acre grounds (which includes parking lots) as well as a local artificial pond for cooling towers and flushing fixtures in two new buildings it is constructing on the campus. What treatment is required?

Answer:

- Oil Removal
- Oil emulsion separation
- Particulate Filtration
- Sanitization Radiation
- Descaling
- Legionella removal
Problem 4:
A new 5 star hotel in Mexico City which has limited water rights, needs to use storm runoff from its parking garage and rainwater from the roof in combination with its greywater from each hotel room to feed its flushing fixtures and cooling tower.

What treatment is required?

Answer:
- Grey Water Pre-treatment
- Chemical Sanitization
- Reverse Osmosis
- Oil Removal
- Oil emulsion separation
- Particulate Filtration
- Sanitization Radiation
References


Thank You.

Any Questions?

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