This presentation premiered at WaterSmart Innovations

watersmartinnovations.com

Designing Water Harvesting Systems

to Maximize Total Water Savings

Session T-1329

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wahaso
WATER HARVESTING SOLUTIONS

What is "Water Harvesting"?

Water Harvesting *is the collection, cleaning, storage and reuse of onsite water sources for non-potable uses to reduce the consumption of municipal potable water.*

The Harvesting Opportunity in Commercial Properties

Evaporative Cooling Tower
1,500,000 gallons annually

Toilet flushing
500,000 gallons annually

Landscape irrigation 750,000 gallons annually

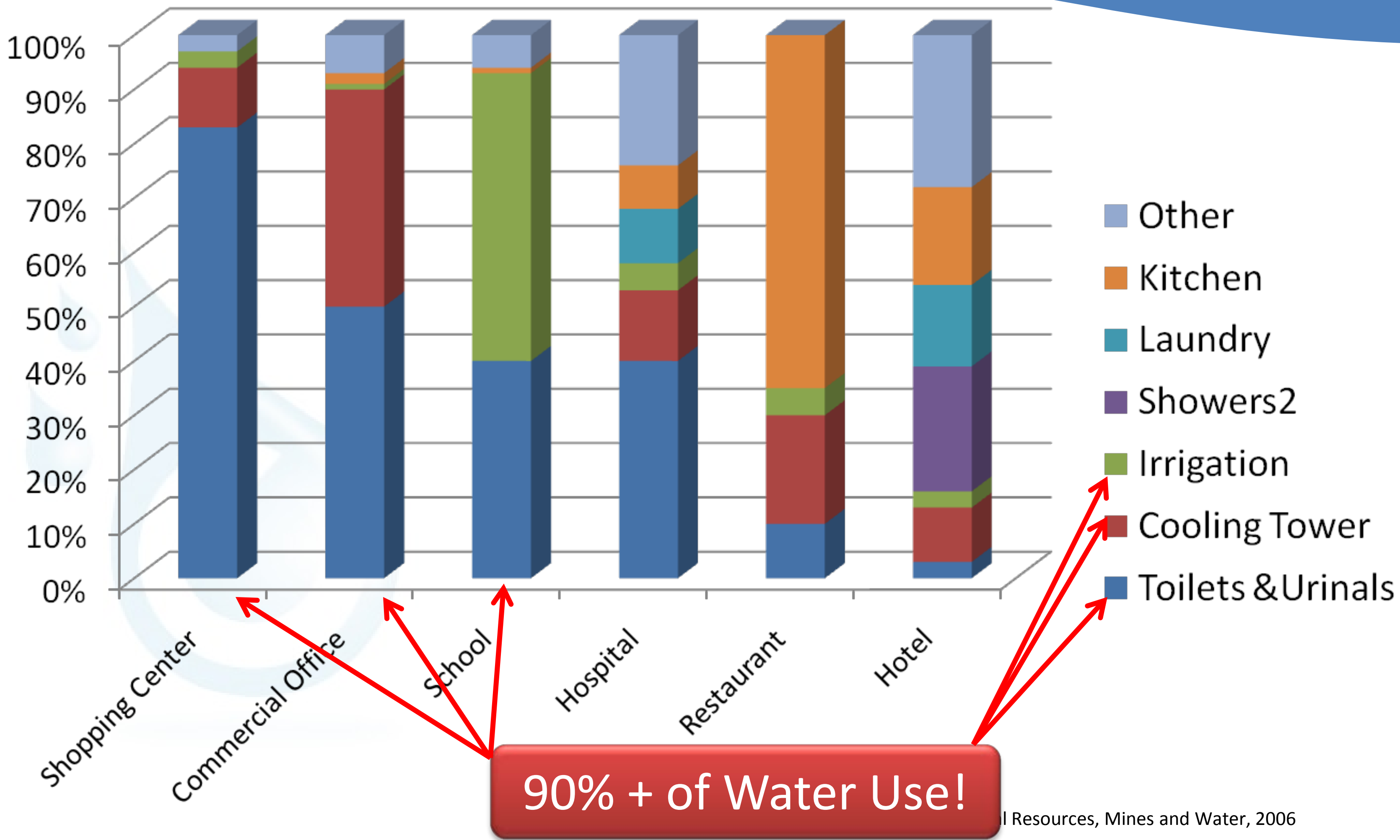
Rooftop rainwater 500,000 gallons annually

Cooling coil condensation
400,000 gallons annually

Parking lot rainwater
2,000,000 gallons annually

1-5 Million Gallon Opportunity Per Year

Most Water Use in Commercial Buildings can be Replaced with Harvested Rainwater and Stormwater



l Resources, Mines and Water, 2006

System Design Objectives

- Make a significant and meaningful impact on reducing the amount of municipal water use
- Match a system to meet the unique characteristics of the building
- Ensure that the water is safe for storage & application
- Keep the system as simple as possible
- Keep the system cost-per-gallon saved as low as possible

Maximize the System Value By Focusing on its Efficiency

High Efficiency Means:

Achieving the highest possible percentage of municipal water replaced with non-potable water

With the least cost system

Strategies for an Efficient System

- *Identify* and *quantify* all potential sources and uses of on-site water for reuse.
- Look at total supply and demand – but also their seasonality to balance the two.
- Design a system for the most-contaminated water source
- Optimize the cistern size
- Identify options and their relative cost & benefit
- Create metrics and goals for the system

The Most Efficient Systems Often Capture Multiple Sources for Multiple Uses

Potential Sources

- Rooftop rainwater
- Cooling condensate
- Surface stormwater
- Greywater from showers, sinks, washers
- Steam condensate
- Groundwater ejectors
- Process wastewater

Potential Uses

- Landscape irrigation
- Toilet flushing
- Cooling tower “make-up”
- Vehicle washing
- Boiler “make-up”
- Washing machines

Each Source Has Different Variables & Process Considerations

Best Retrofit Opportunities

Increasing Contaminants and Processing

Sources	Definition	Quantifying Variables
Condensate	From cooling system blower units or steam systems	Total cooling capacity, average humidity, seasonality
Groundwater	From below-grade sumps (around basements)	Ground permeability, springs, seasonality
R/O Discharge	Effluent discharge from R/O system (20-35%)	Average % discharge X total R/O processed, source quality
Rainwater	From roofs and above-ground collectors	Roof square footage, historic rainfall for location
Reclaimed Water	Municipally-treated sewage for reuse	GPM available, color/odor
Stormwater	From ground surfaces – Parking lots, run-off	Square footage by hardscape/ softscapes/parking, rain history
Greywater, Gray Water	Untreated waste water "gently used" in showers, sinks, processes	Number occupants, # showers, # hand washes

Each Use Has Different Variables

Best Retrofit Opportunities

Most Common to Least Common Application

Uses	Variables for Quantifying Demand
Irrigation	Square footage irrigated, plant types, soil types, seasonality, location
Toilet Flushing	Number of occupants, flushes per person per day, GPF, toilet/urinal flush ratio
Cooling Tower Make-Up	Total cooling load, seasonality, location, average humidity, cycles per blow-down
Boiler Make-Up	Total heating load, HVAC expert estimate or historical data.
Vehicle Wash	Number of vehicles per day, gallons per vehicle wash
Miscellaneous	Varies – Washing machine supply, R/O supply

Consider Seasonality of Sources & Uses in Balancing a System

	Warm Weather	Cool Weather	Non-Seasonal
Sources	Rainwater +	Rainwater -	Greywater
	Stormwater +	Stormwater-	Groundwater
	Cooling Condensate	Steam Condensate	Reclaimed Water
			R/O Discharge
Uses	Irrigation	Boiler Make-Up	Toilet Flushing
	Cooling Tower M/U	Humidifier Make-Up	Laundry
			Vehicle Wash

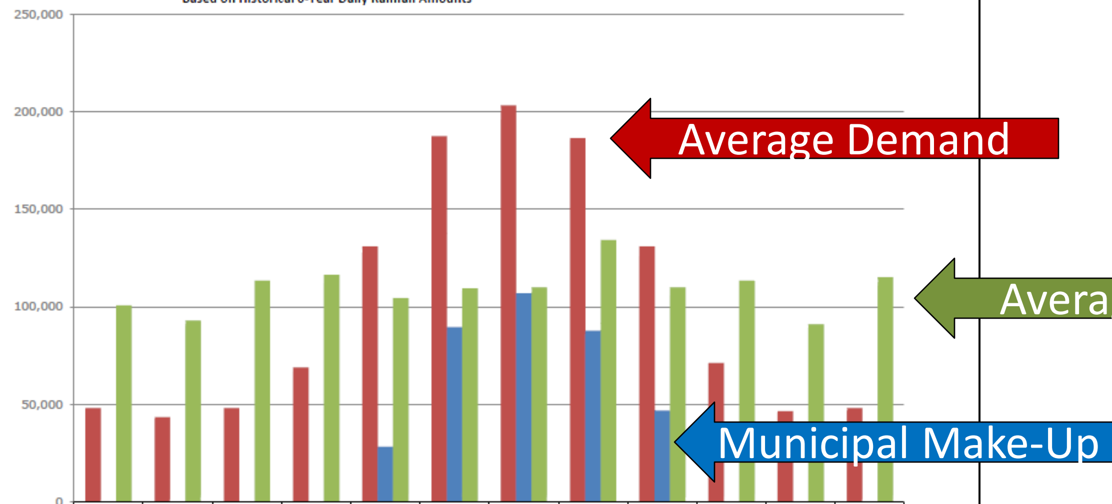
Evaluate Monthly Supply & Demand → Optimize Total Annual Savings

Projected Annual Averages Based On Past Six Years of Actual Daily Rainfall

Total Supply	Total Demand	Harvested Gallons Used	Municipal Gallons Used	Total Days Requiring Municipal Make-Up
1,311,799	1,213,949	854,438	359,511	69

Projected Monthly Supply & Demand

Based on Historical 6-Year Daily Rainfall Amounts



	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Estimated Average Demand	48,089	43,435	48,089	68,968	131,018	187,566	203,357	186,635	130,967	71,200	46,538	48,089
Estimated Municipal Make-up Required	0	0	0	0	28,245	89,692	106,957	87,797	46,820	0	0	0
Estimated Average Supply	100,734	92,987	113,562	116,409	104,496	109,424	110,063	134,290	110,045	113,452	91,081	115,258

Revisit Supply Options to Balance Supply & Demand

% of Total Demand Met

Each Year

2007	76.0%
2008	70.4%
2009	73.8%
2010	62.1%
2011	73.0%
2012	68.5%

6 Year Average

70.6%

Maximize This Number

Supply refers to all of the potential non-potable water that can be harvested. Table-3 breaks down the total municipal gallons into monthly segments. This is helpful in discovering seasonal shortfalls in the system.

Cistern Modeling Identifies Optimal Rainwater Storage Capacity

Different cistern size options are modeled using six years of daily rainfall history for the location

Cistern Size	% of Total Demand Met	Non-Potable Gallons Used	Gallons Change from Previous Increment	Rain Event Size Capable of Being Handled (inches):
5,000	52.45%	227,422	-	2/5
10,000	71.40%	309,612	82,190	4/5
15,000	81.21%	352,163	42,551	1 1/5
20,000	86.77%	376,252	24,089	1 3/5
25,000	89.88%	389,752	13,501	2
30,000	**92.31%**	**400,280**	**10,527**	**2 3/8**
35,000	94.01%	407,628	7,348	2 7/9
40,000	95.28%	413,164	5,536	3 1/6
45,000	96.18%	417,045	3,882	3 4/7
50,000	96.58%	418,808	1,763	4
55,000	96.97%	420,475	1,667	4 1/3
60,000	97.35%	422,142	1,667	4 3/4
65,000	97.74%	423,808	1,667	5 1/6
70,000	98.12%	425,475	1,667	5 5/9
75,000	98.51%	427,142	1,667	6
80,000	98.89%	428,808	1,667	6 1/3

Table - 1

Storage Costs $1.50-3.50 Per Gallon Installed!

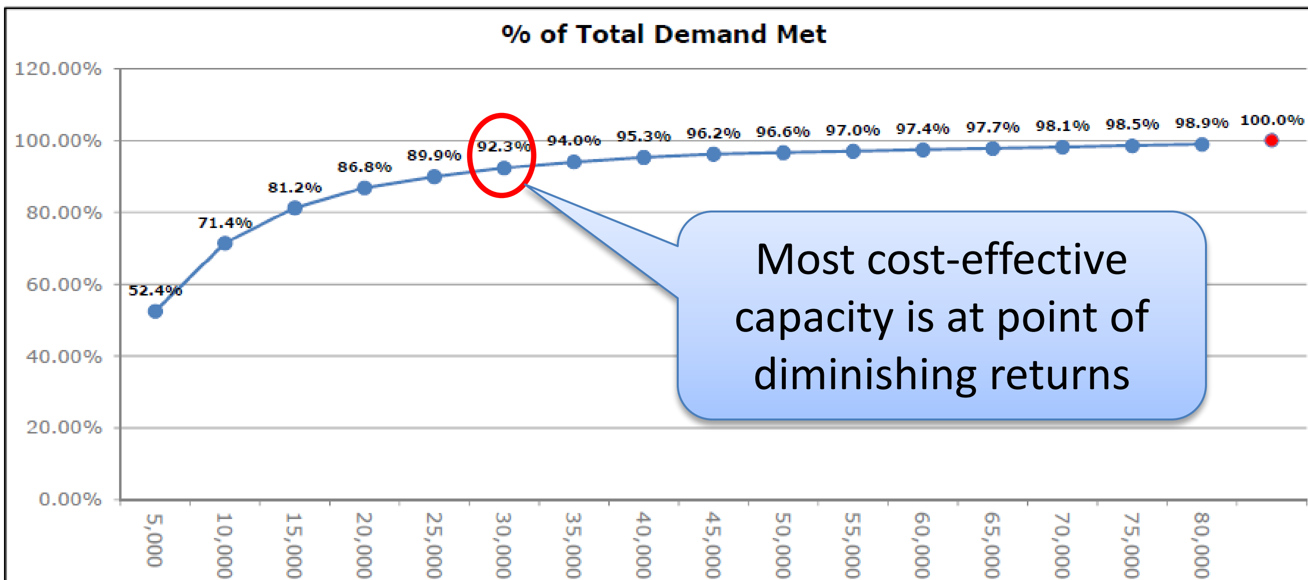
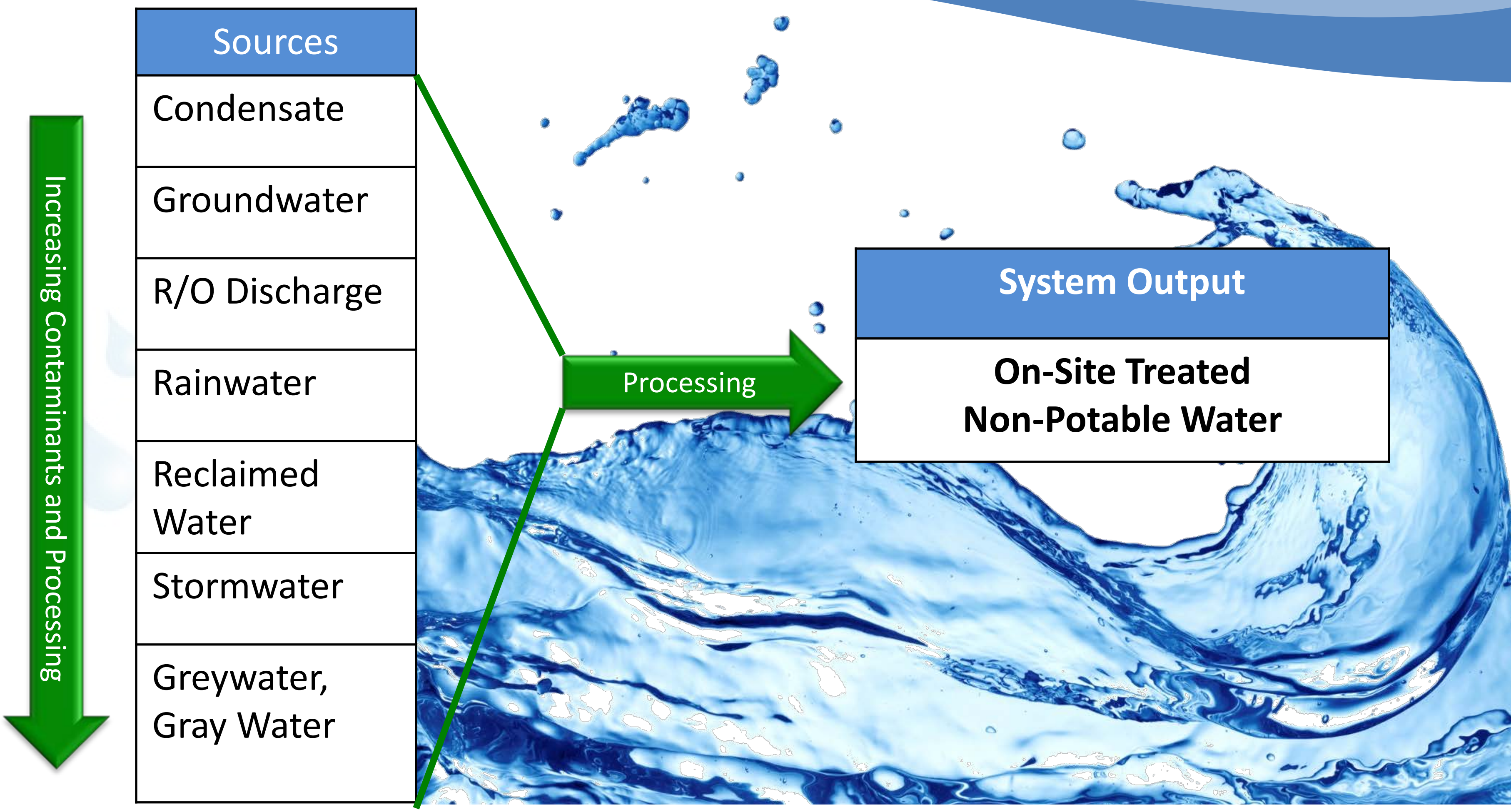
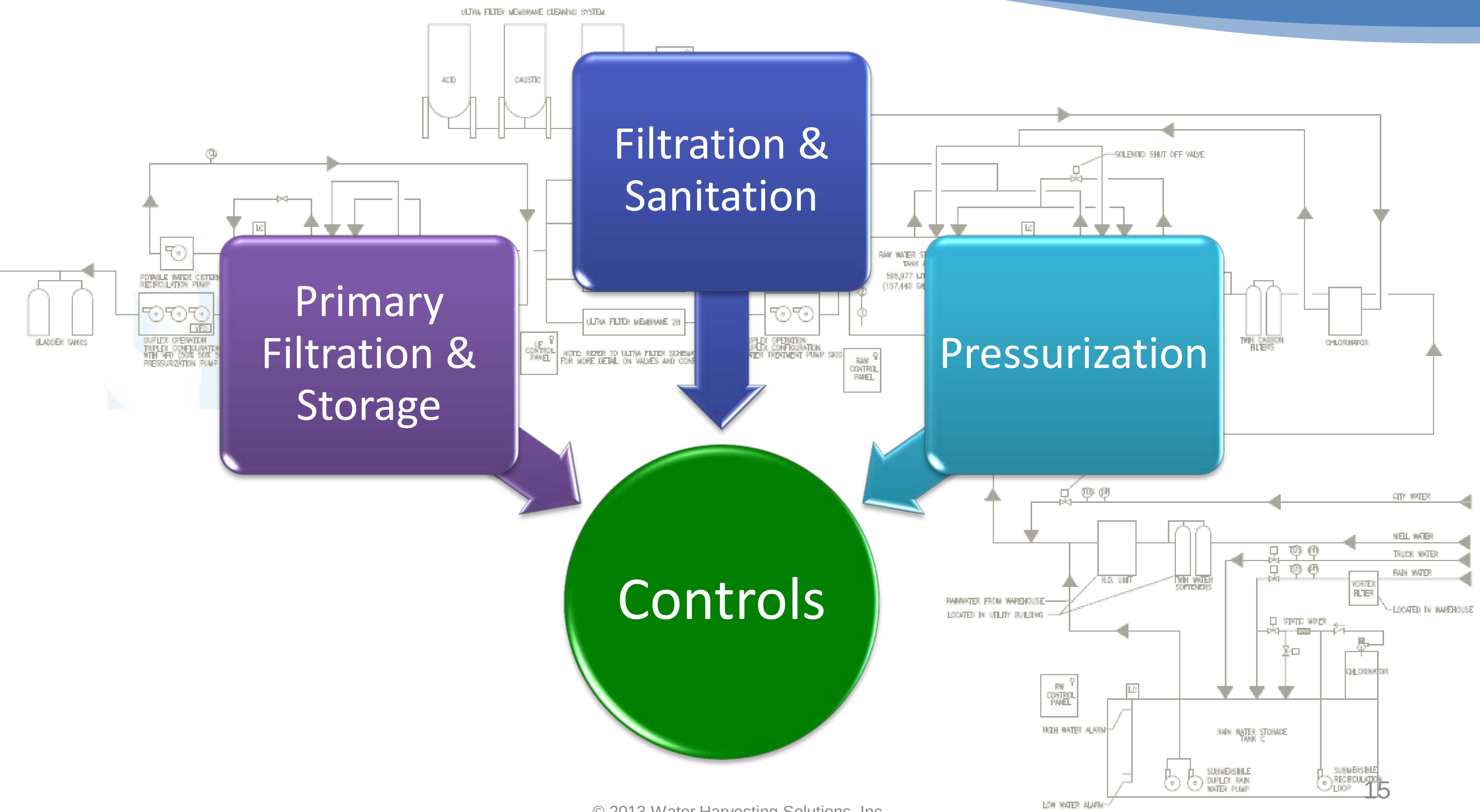


Table - 2

Regardless of the Source, We Want to Achieve One Standard Output



Basic Components of Every System

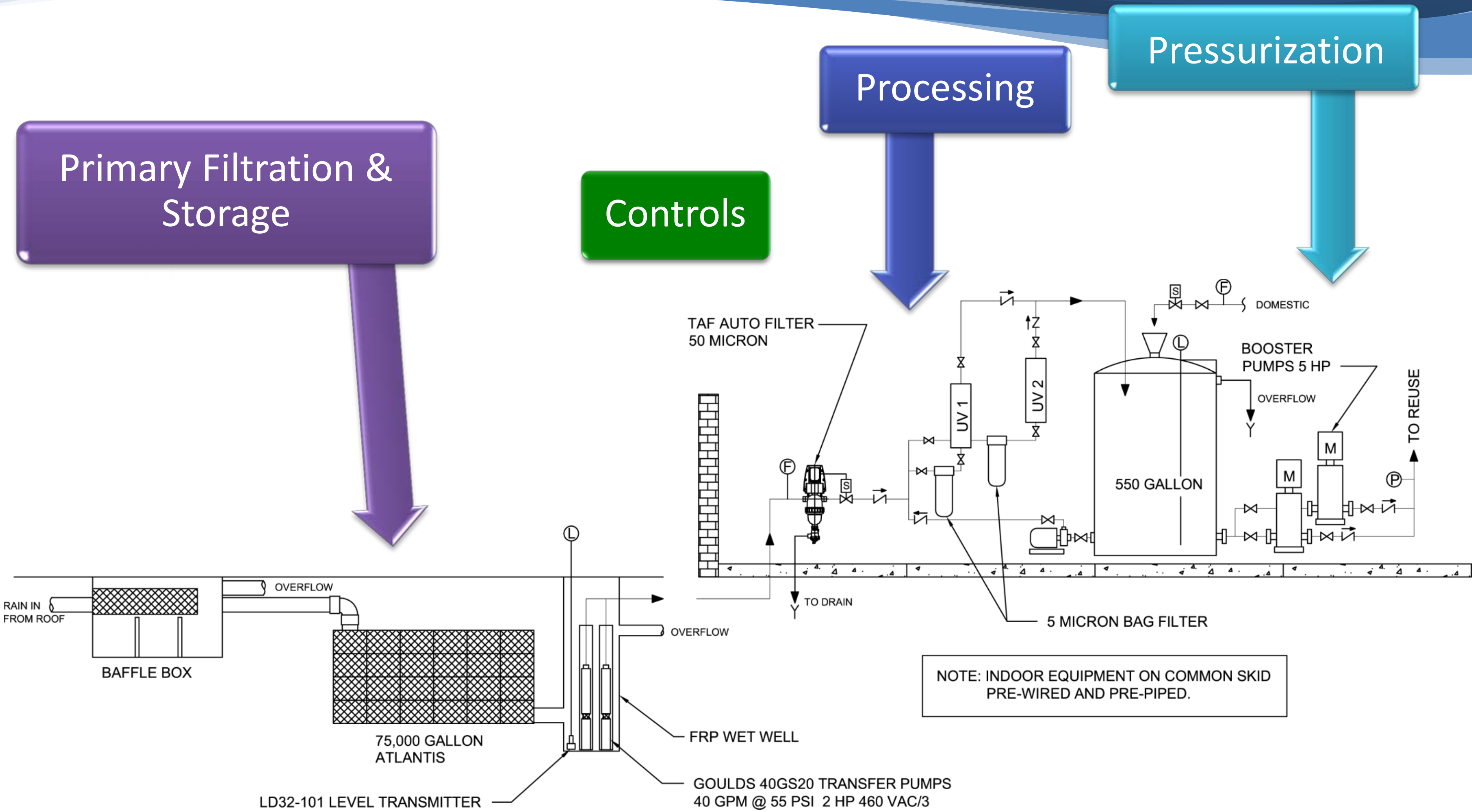


Processing Steps Added as Contaminants Increase

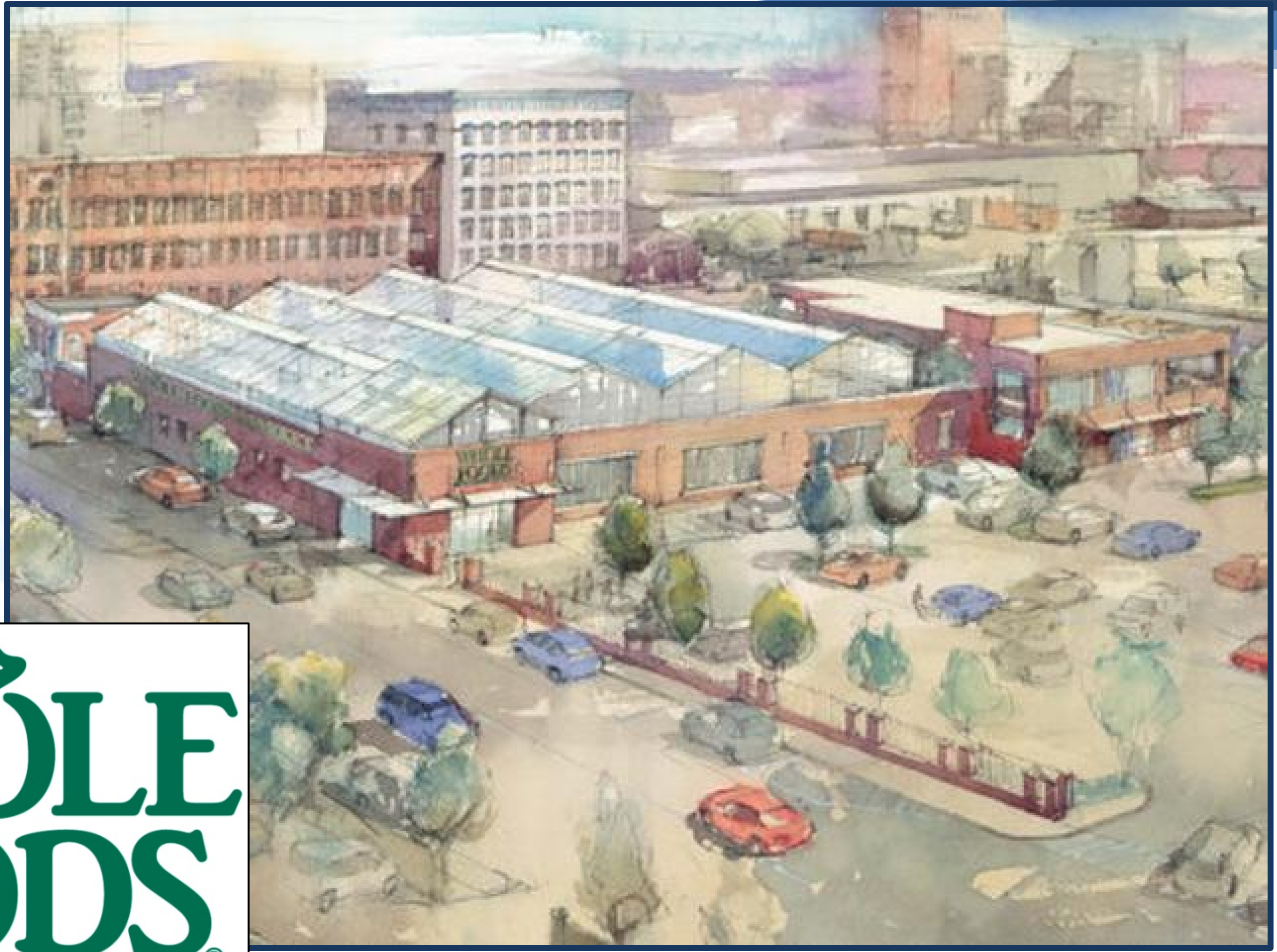
Increasing Contaminants and Processing

Sources	Processing Approach
Condensate	10u filter, U.V.
Groundwater	10u filter, U.V.
R/O Discharge	10u filter, U.V.
Rainwater	Pre-filter (150u), Primary Filter (50u), Final filter (5 u), U.V. or Chlorine
Reclaimed Water	Pre-filter (150u), Primary Filter (50u), Final filter (5 u), U.V. or Chlorine, Carbon Filter (odor/color)
Stormwater	Pre-filter (150u), Oil Separator/Absorption, Primary Filter (50u), Final filter (5 u), U.V. or Chlorine
Greywater, Gray Water	Settling Tank, Chlorine, Floating Filter (250 u) Primary Filter (70u), Final filter (10 u), U.V.

Typical System Design



Case Study:
Gowanus Whole Foods, Brooklyn, NY



WHOLE FOODS MARKET

Gowanus Whole Foods, Brooklyn

Project:	Gowanus Whole Foods
Location:	Third Ave. & Third Street, Brooklyn, NY
Customer:	Whole Foods, NY
Engineers:	BL Companies
System Type:	Multi-Source, Multi-Use
Considerations:	Maximize Water Savings, Contaminated Soil
Storage:	30,000 Gallons Steel Wrapped PVC
Sanitation:	Chlorine (Calcium Hypochlorite) & U.V.
Projected Annual Water Savings:	1,617,00 gallons (72% of Demand)
Commissioning Date:	Q1 2014

Toilet Use & Greywater Calculations

Greywater Supply/Toilet Flushing Demand Analysis - Whole Foods Brooklyn

	Toilet Flushing Demand Assumptions		
	Total	Head Count	Flushes/ Day
Employees (FTE) [1]		286	3
Customers		9,285	0.5
Total Flushes Per Day	5,501		
Percentage Female	50%		2750.25
Percentage Male	50%		2750.25
Male Urinal Use	75%		
Male Urinal Flushes	2,063		
Male Water Closet Flushes	688		

	Female Water Closets	Male Water Closets [3]	Urinals	**Total**
Uses Per Day By Fixture	2,750	688	2,063	5,501
GPF	1.15 (Avg Based on Dual Flush 1.6/1.0)	1.6	0.0	
Total Gallons Demand For Flushing Per Day of Use	3,162.8	1,100.1	-	**4,263**

Greywater Supply - Lavatory Use Assumptions

Lavatory Sink Uses (Washroom Post Toilet)	5,501
Employee Compliance Hand Washings [4]	514.8
Sink Flow Rate (GPM)	2.5
Sink Use Duration for Washrooms (min)	0.12
Employee Sink Duration for Compliance (min)	0.17
Total Greywater Supply Per Day of Use	**1,865**

Building Assumptions

[1] Based on 400 Employees. (400 Employees x 40 Hours) / 8 Hour FTE Shifts = 2,000. 2000/ 7 Days = 286 FTE Per Day

[2] It Is Assumed That The Dual Flush Toilets Are 1.6/1.0, and that the 1.0 Flush Is Used 75% Of The Time.

[3] It Is Assumed that Males Will Use The 1.6 GPF Of The Dual Flush Toilets When Not Using the Urinal (25% of The Time)

[4] 60% of Employees Will Wash Their Hands 3X Per Day Above and Beyond Toilet Uses at 10 Seconds Per Washing.

Toilet Flushing Demand

Total Daily Employees + Guests

X Flushes per person

X Gallons Per Flush

Greywater Supply

Total Daily Employees + Guests

X Lav uses per person

X Gallons per use

Irrigation Demand Based on Estimated E.T. Requirements Net of Rainfall

If we have estimated landscape irrigation requirements for you, then we have used an "ET" model that estimates the water required by plants based on their "evapo-transpiration" which takes into account the type of plant and the weather conditions. Ours is a rough estimate that gives us a daily water requirement by zone type. Then our model subtracts the average rainfall for your area to estimate the amount of irrigation the system will need to provide.

	Percentage	Square Footage
A. Trees, Groundcover	20%	7,010
B. Shrubs, Perennials	80%	28,040
C. Cool Season Turfgrass, Annuals	0%	-
D. Warm Season Turfgrass	0%	-
Total Irrigated Square Footage	100%	35,050

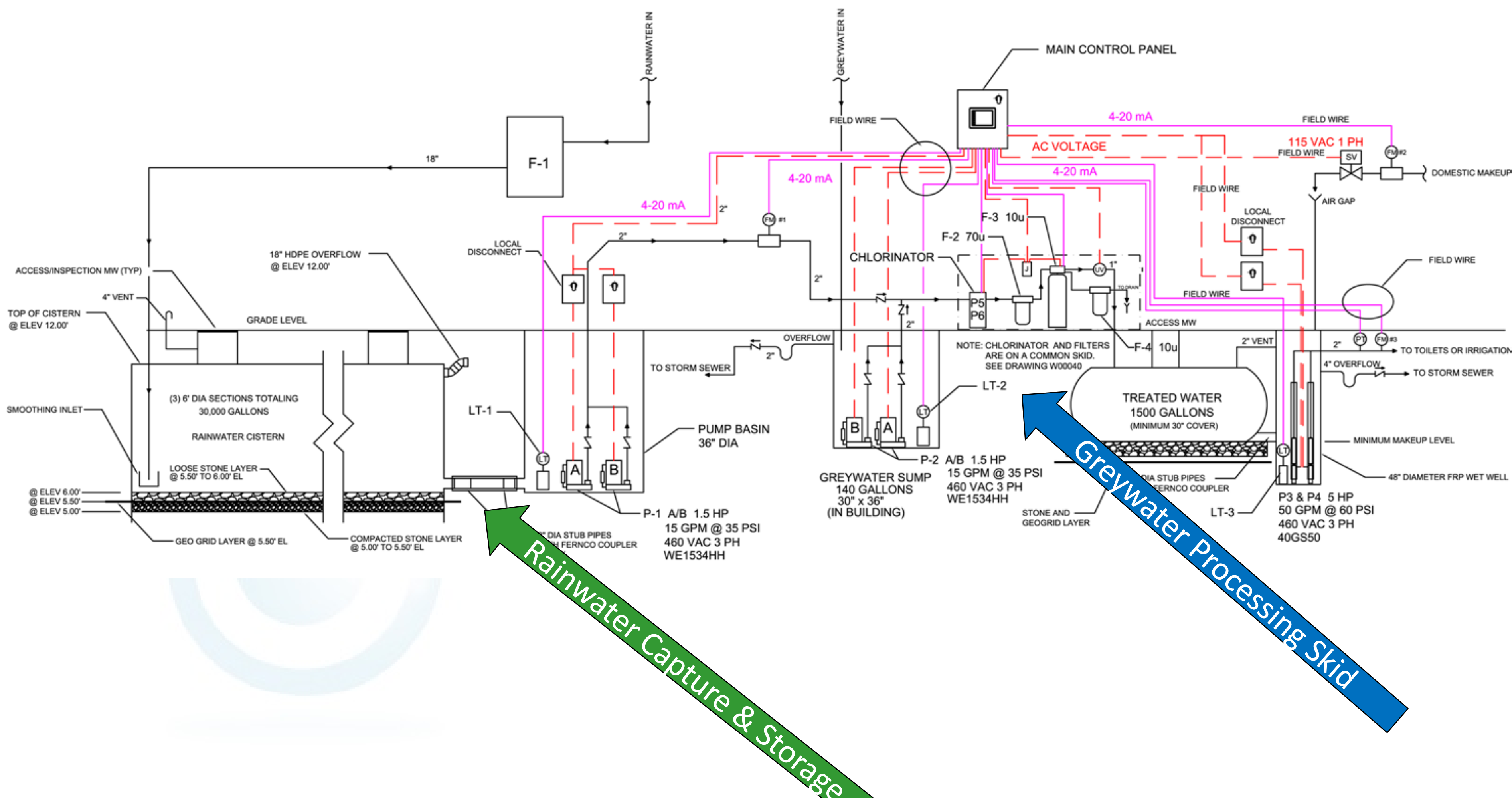
Percentage of rainfall reaching plants after evaporation	75%
Reference Evapo-transpiration in inches per month - based on cool-searopn grasses in this area:	8.00
Irrigation System Efficiency (% of water reaching plants)	Input by Zone

	Monthly Gross Water Requirement (Inches)	Gross Monthly Water Requirement (Gallons)	Average Daily Requirement Before Rainfall (Gallons)
A. Trees, Groundcover	5.20	22,721.4	1,419.0
B. Shrubs, Perennials	5.20	90,885.7	5,675.9
C. Cool Season Turfgrass, Annuals	5.20	-	-
D. Warm Season Turfgrass	4.80	-	-
TOTALS		113,607	7,095
ANNUAL DEMAND (Gallons)			697,839

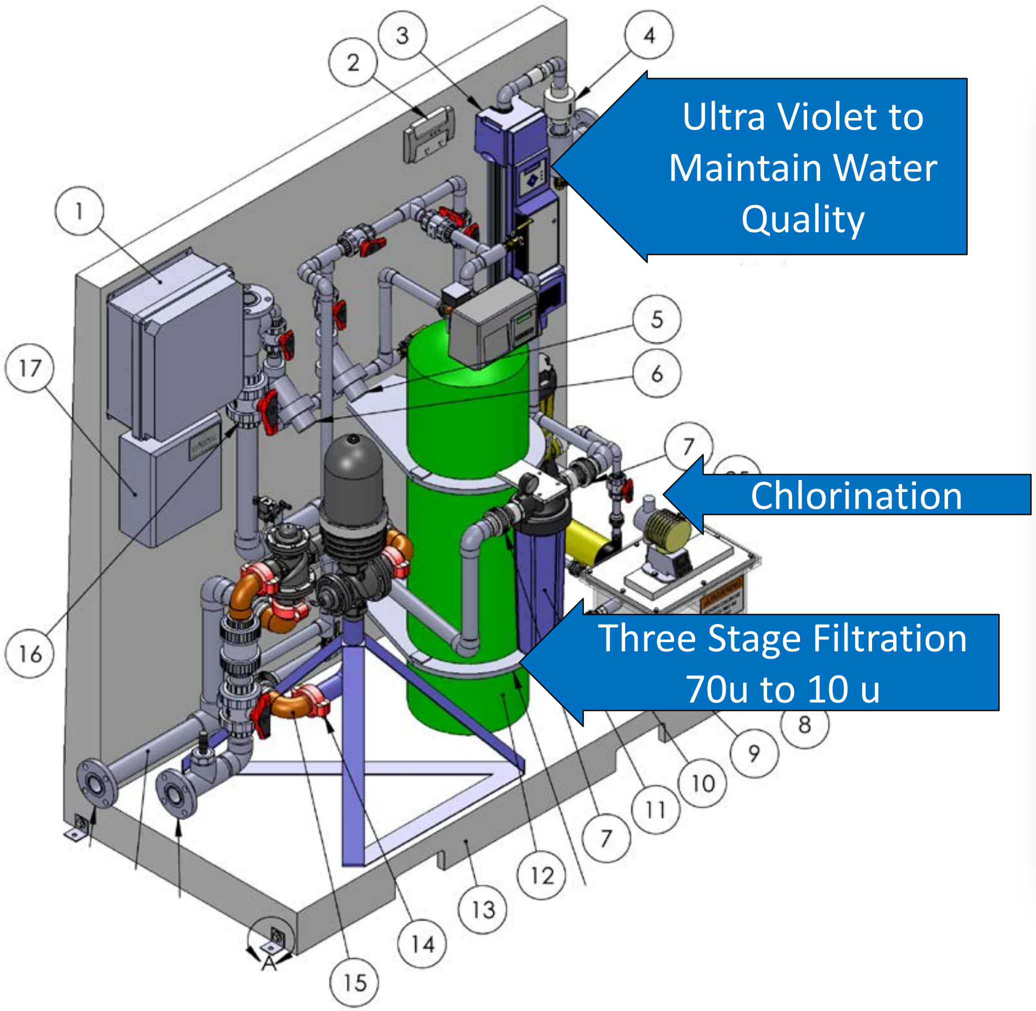
System Approach

- Capture filtered rainwater into 30,000 gallon below-grade cistern in parking area
- Capture raw greywater into ejector pit
- Process greywater as collected through multi-stage filter; chlorinate
- Process rainwater through same system
- Hold common processed water in 1,500 gallon tank
- For toilets and irrigation:
  1. Processed greywater
  2. Processed rainwater
  3. Municipal make-up

Whole Foods System Design



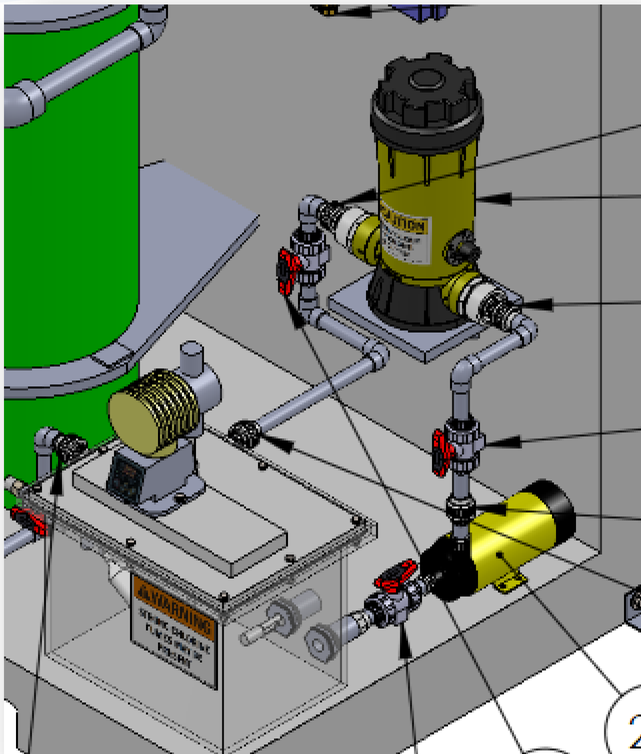
System Effectively Treats Greywater For Reuse

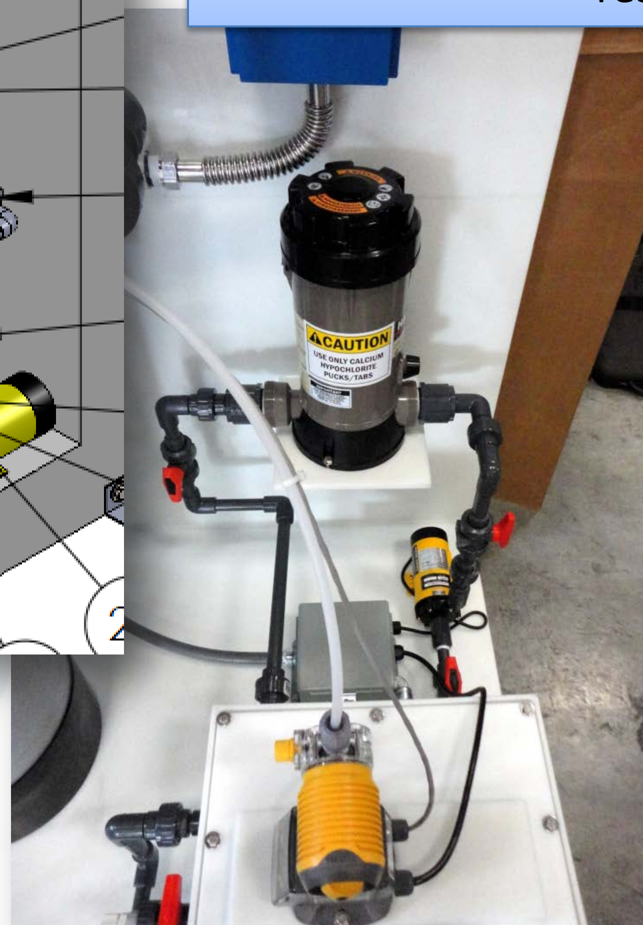


Fabricated skid at production facility

Custom Chlorination System

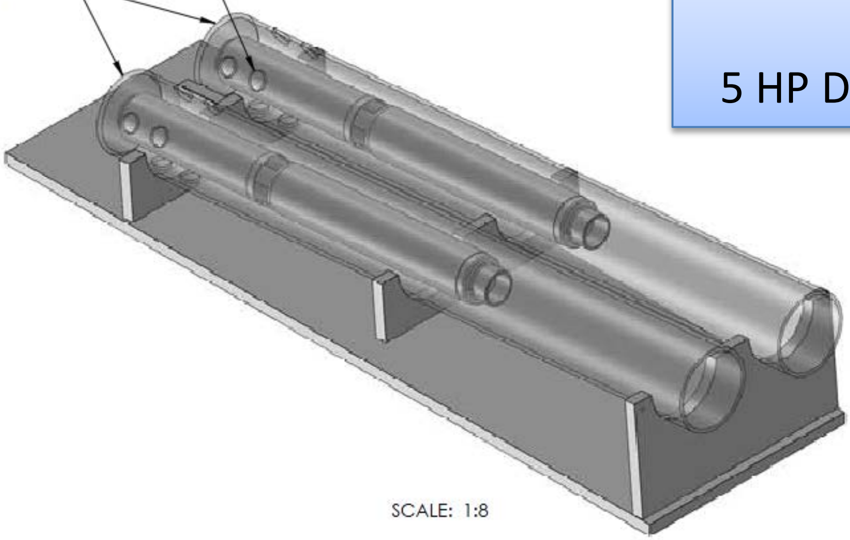
Liquid chlorine is produced from tablets and system automatically injects chlorine to achieve a target residual level

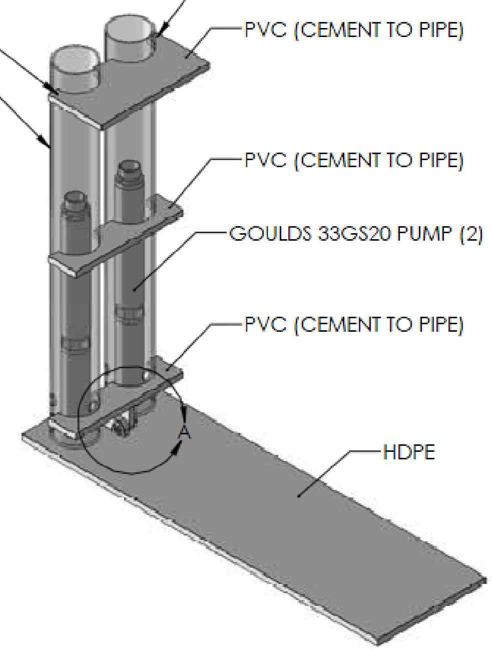


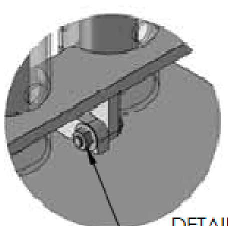


Innovative Pump Assembly Inside Cistern

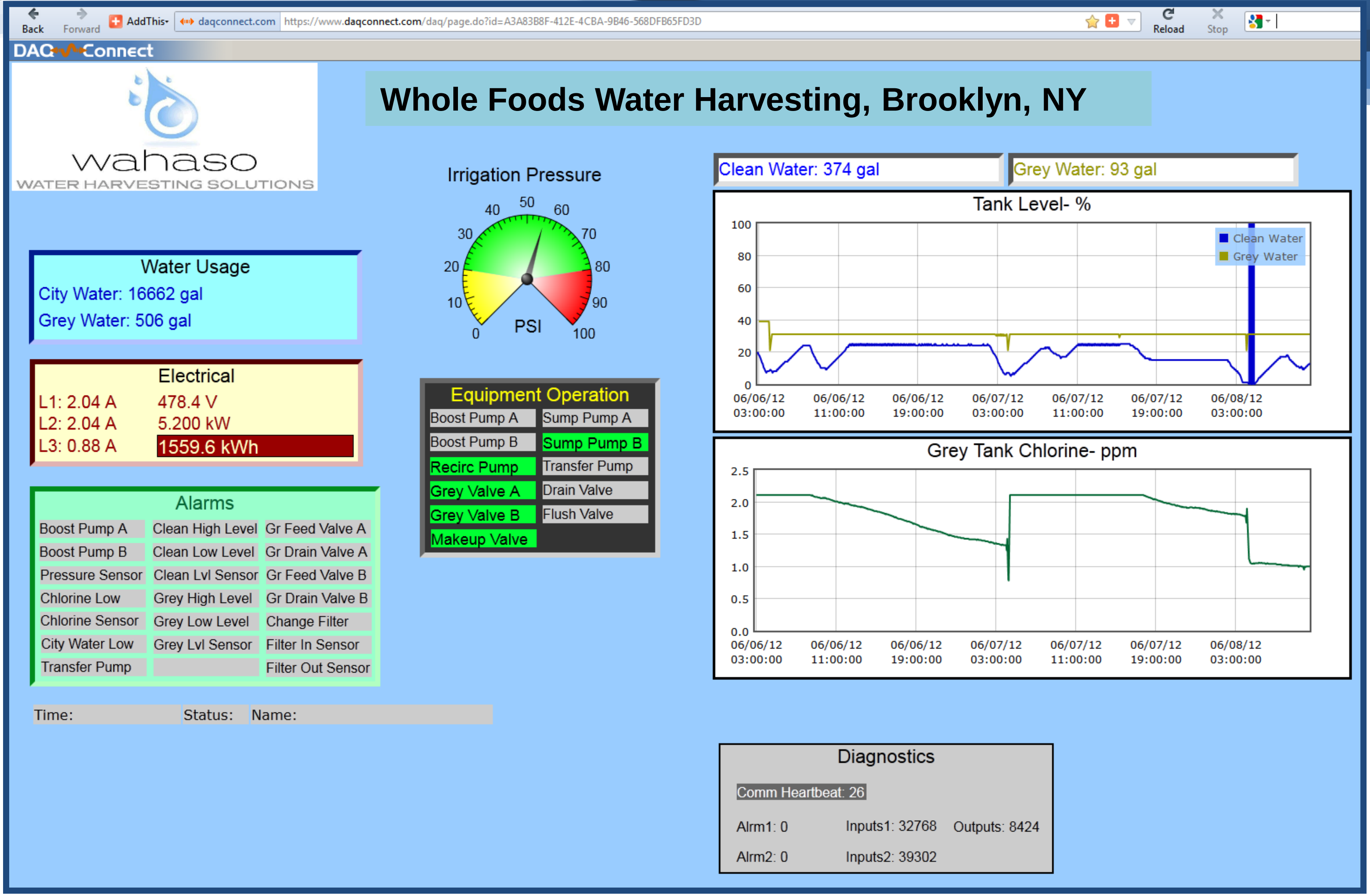
Efficient high-capacity well pumps will provide pressurized water from cistern.
5 HP Duplex Pumps Deliver 50 GPM at 50 PSI.







System Will Tie to BAS & Be Monitored Via Web Interface



System is Projected to Save Over 70% of Water Needed for Toilets & Irrigation

System Effectiveness Based on Recommended 30K Gallon Cistern

Projected Annual Averages Based On Past Six Years of Actual Daily Rainfall

Total Supply	Total Demand	Harvested Gallons Used	Municipal Gallons Used	Total Days Requiring Municipal Make-Up
3,031,617	2,258,827	1,616,861	641,966	112

Theoretical % of Total Demand Met		
Based on These Past Years		6 Year Average
2007	72.8%	71.7 %
2008	71.6%	
2009	75.2%	
2010	62.9%	
2011	78.5%	
2012	69.4%	

Projected Monthly Supply & Demand

Based on Historical 6-Year Daily Rainfall Amounts

Estimated Average Demand	132,150	119,361	132,150	149,584	180,327	248,679	282,591	267,996	257,911	228,045	127,887	132,150
Estimated Municipal Make-up Required	4,171	11,498	10,233	22,311	32,114	94,664	128,200	106,746	139,139	84,772	7,050	1,069
Estimated Average Supply	198,976	189,501	268,718	295,152	225,337	261,334	248,964	379,049	253,394	266,878	157,585	286,727

Review: Strategies for an Efficient System

- *Identify* and *quantify* all potential sources and uses of on-site water for reuse.
- Look at total supply and demand – but also their seasonality to balance the two.
- Design a system for the most-contaminated water source
- Optimize the cistern size
- Identify options and their relative cost & benefit
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