


Water Reuse and Mixology within the Biopharmaceutical Industry: A Case Study

New Jersey Water Environment Association
Annual Conference

May 11, 2015

MedImmune

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Presentation Agenda

- Project Objective
- Data Collection
- Facility Overview
- Site Water Balance Review
- Cooling Tower Modeling Results
- Water Conservation Plan
- Global Water Tool Results
- Summary and Recommendations
- System Design and Cost

Project Objectives

- AstraZeneca's 10-year safety, health and environment (SHE) and sustainability strategy – goal is to reduce water use by 25% by 2015.
- Complete a water use assessment:
  - Delineation of water use across the site and development of a facility water balance from available information
  - Identification of methods and/or tools to collect water usage information/data
- Prepare a Water Conservation Plan (WCP) including:
  - Options to reduce water consumption
  - Technical and economic evaluations of water conservation alternatives to serve as a basis for decision making
- Complete a cooling tower modeling evaluation for the utilization of reclaimed makeup
  - Use WaterCycle® Software to model current and prospective operations using reclaimed makeup and assess risks due to scaling, corrosion, and fouling
  - Provide recommendations and water reuse options for towers
- Implement the recommendations

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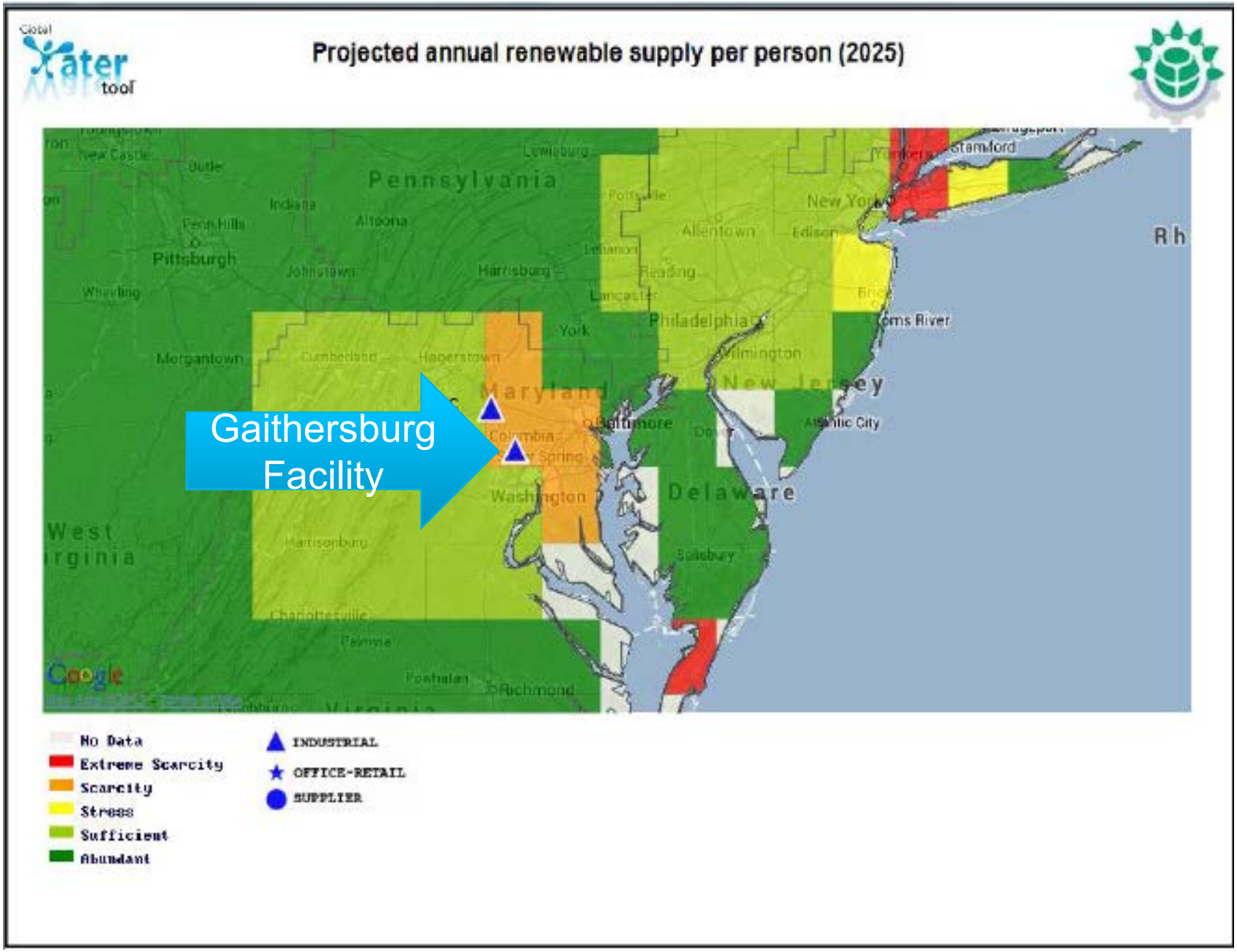
Global Water Tool



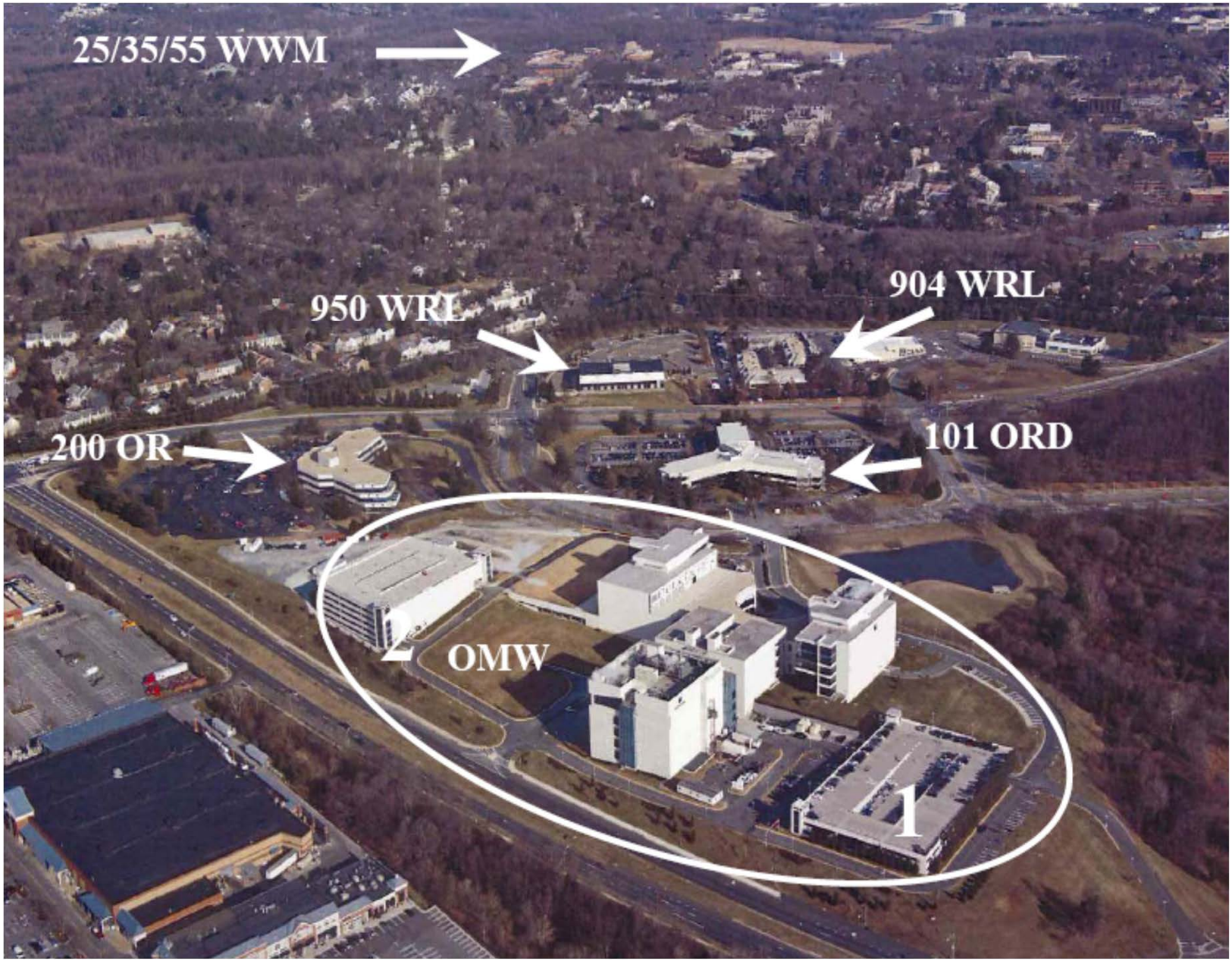
Data Collection

- Site visits
- Site walks of water use systems including cooling towers, USP/WFI treatment, and process biowaste treatment systems
- Water and sewer invoices from the Washington Suburban Sanitary Commission (WSSC)
- Process Control System (PCS) and Building Management System (BMS) data

Water use area discussions

- SHE Water Reduction strategy
- WSSC billing
- Cooling towers and utilities
- USP Treatment Systems
- Irrigation
- Flowmeters, piping configuration, and BMS data
- Lab glassware cleaning
- CIP and Manufacturing Process Optimization
- Domestic water use

Site Layout



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Facility Overview

- 2012 water use = 81 million gallons
- The Facility accounts for 8.4% of AZ's total water use
- Campus consists of 9 buildings
-

Building	Building Area (ft^2)	Employee Population
OMW	816,975	1,206
35 WWM	51,522	21
200 ORD	108,000	356
101 ORD	102,975	245
950 WRL	49,980	144
WWM 25	31,181	162
WWM 55	41,508	134
902 WRL	12,500	29
904 WRL	23,185	40
Total	**1,237,826**	**2,337**

** Table reflects 2012 employee headcount*

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Building Water Use

OMW

- 3 lab/pilot production facilities
- 3 cooling tower systems
- 3 Soft water systems (boilers and steam generation)
- 3 USP/WFI treatment systems
- 2 Process and Biowaste treatment systems
- Sanitary/domestic water use
- Irrigation

35 WWM

- USP (RODI) Treatment System
- Soft Water System (boilers and steam generation)
- Process and Biowaste Treatment
- Sanitary/domestic water use

Cooling towers and irrigation systems

- Irrigation
  - 101 ORD
  - 950 WRL
- Cooling Towers
  - 101 ORD
  - 200 ORD
  - 950 WRL

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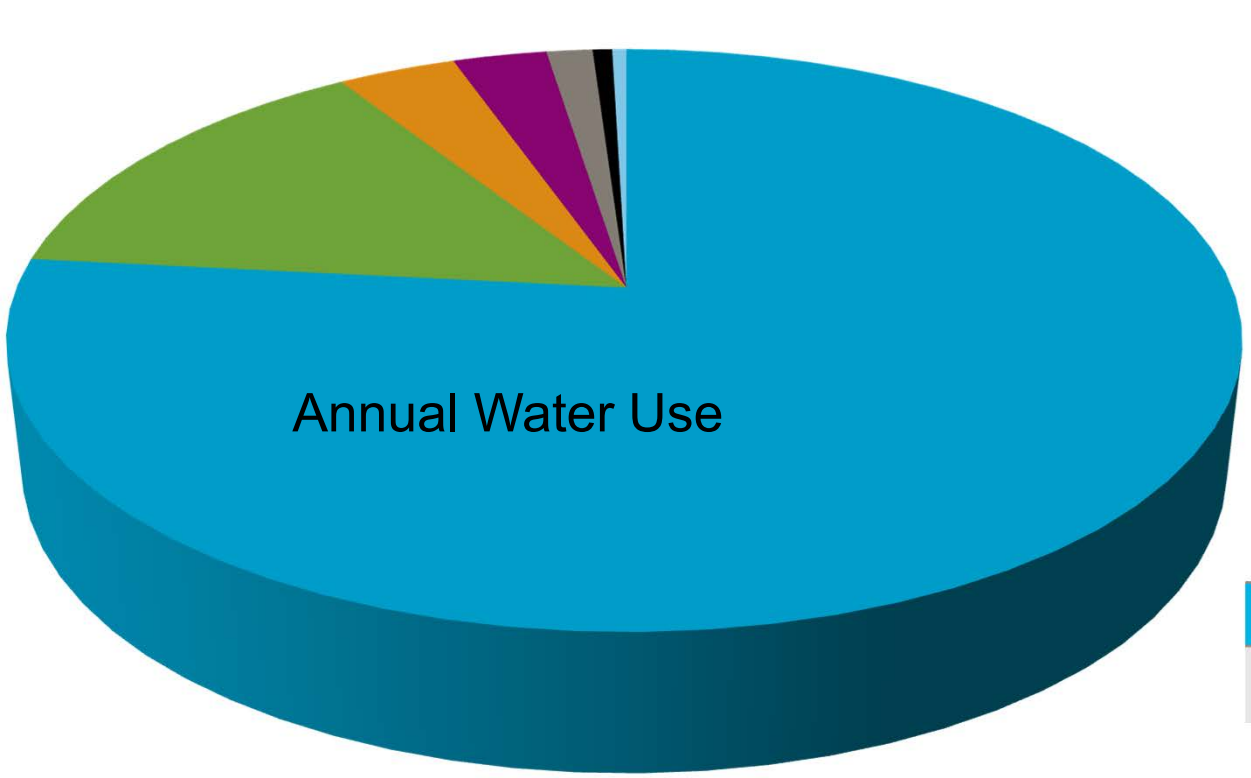
Facility Water Use



Annual Water Use (gal.)		
OMW	61,954,218	76.6%
35 WWM	11,535,825	14.3%
200 ORD	2,974,446	3.7%
101 ORD	2,363,679	2.9%
950 WRL	1,158,601	1.4%
55 WWM	490,013	0.6%
25 WWM	355,328	0.4%
Total	**80,832,200**	

1 year's worth of WSSC water and sewer bills (July 2012-July 2013).

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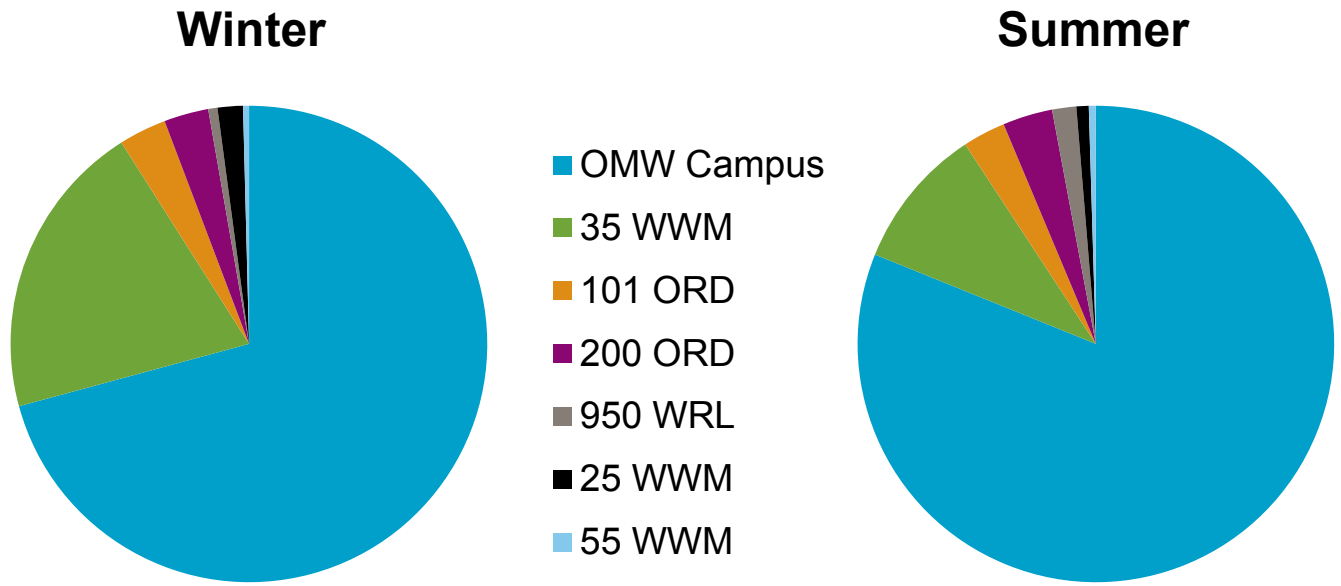
Facility Water Use

- Seasonal Water Use Breakdown (WSSC Data)
  - Summer: April 2012-September 2012
  - Winter: October 2012 - March 2013

Building	Summer (gal/ month)	% of Total	Winter (gal/ month)	% of Total
OMW	8.4M	81%	3.5M	71%
35 WWM	1.0M	10%	1.0M	20%
101 ORD	0.3M	3%	0.16M	3%
200 ORD	0.35M	3%	0.15M	3%
950 WRL	0.17M	2%	0.03M	1%
25 WWM	0.085M	1%	0.085M	2%
55 WWM	0.05M	< 1%	0.02M	< 1%
Total	**10.4M**		**4.9M**	



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Water and Sewer Costs

Building	Consumption Rate (1K gal)	Disposal Rate (1K gal)
OMW **35 WWM** **101 ORD**	$6.76	$10.29
200 ORD	$6.64	$10.03
950 WRL **25 WWM**	$6.31	$8.68
55 WWM	$6.19	$8.32
Cost	$500,000/yr	$400,000/yr

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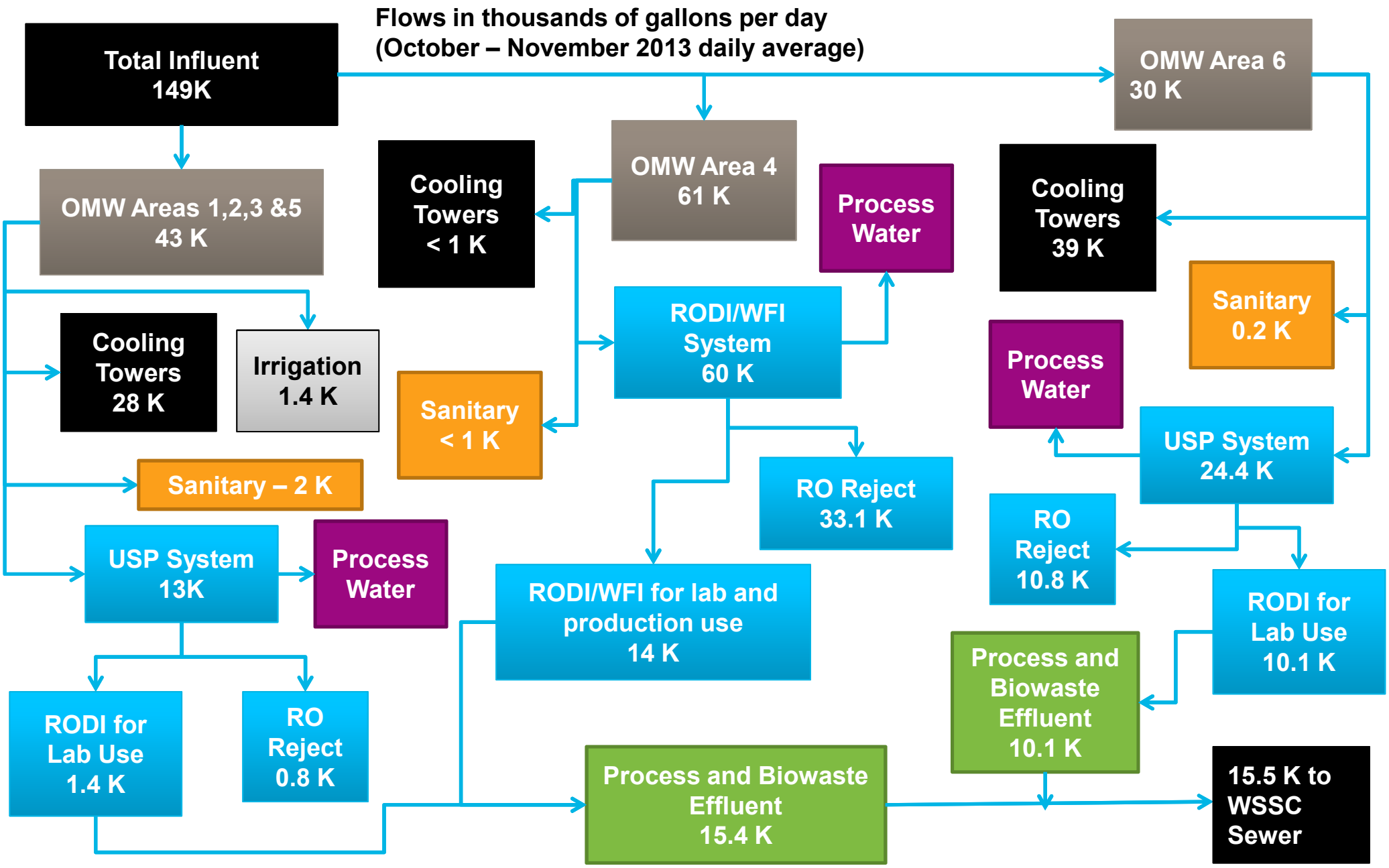
OMW Building Layout

Simplified Site Water Balance (OMW)

*Flow color coding on next slide



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Selection Criteria

- Expected capital expenditure
- Expected water savings
- Shut down time required
- Changes to a validated system
- MedImmune's input and preferences

Water Reduction Focus Areas – OMW Utilities

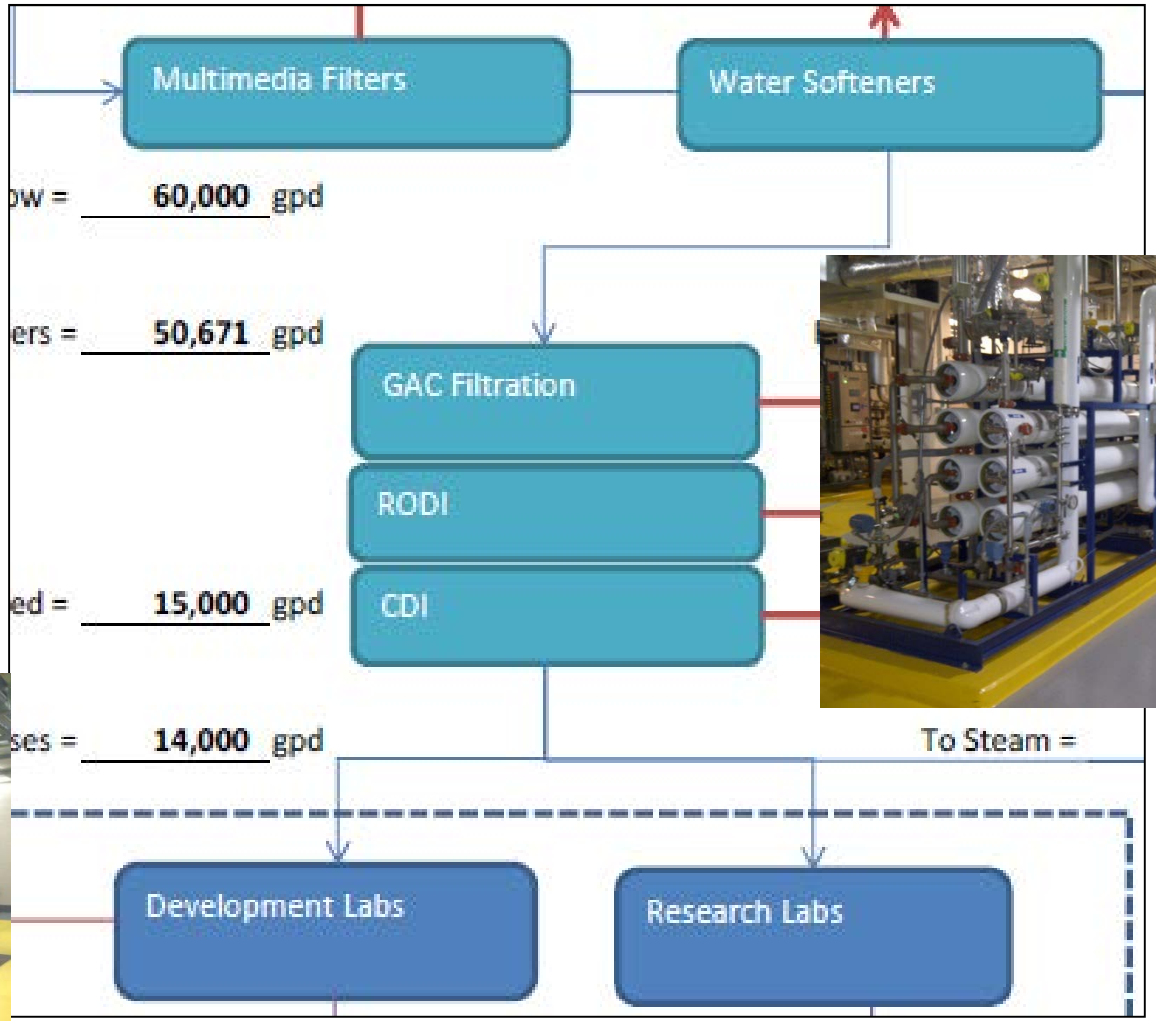
- Majority of Water Use Occurs in OMW - 76%
- 97% of OMW water use occurs in Utilities and USP systems.
- Of this quantity, 32% is used in cooling (i.e. includes Cooling Towers), and 65% in USP and process water treatment
  - Several flows are available for reuse as cooling tower makeup
    - RO reject from Area 3, Area 4, and Area 6 USP treatment systems
    - Groundwater
    - AHU condensate
  - The Production Processes and CIP continued to be focus based on discussions with Facility
    - Reduction in USP water use
  - Opportunity to replace outdated and inefficient plumbing fixtures
  - Additional opportunities include WSSC meter installation for cooling tower and irrigation credits and rainwater harvesting

USP/WFI Treatment Systems

Total USP system influent:
- Area 3 System: 5 MG/yr
- Area 4 System: 22 MG/yr
- Area 6 System: 8 MG/yr
- Total: 35 MG/yr

Total USP system Ro Reject:
- Area 3 RO Reject: 0.3 MG/yr
- Area 4 RO Reject: 12 MG/yr
- Area 6 RO Reject: 4 MG/yr
- Total: 16.3 MG/yr

Area 4 USP/WFI Treatment System



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Non-priority Options

System Modification	Contributing Criteria
Large-scale gray water system implementation (e.g. utilize gray water for cooling tower makeup, toilet flushing, and/or irrigation)	- Extensive building modification - High capital expenditure and shut down time required
Vacuum pump and chiller operations	Equipment is cooled on a closed-loop glycol system. Water use is minimal
Replace trap primers with trap sealers, replace failed steam traps, repair pipe and faucet leaks	Repairs and/or replacements not recommended as systems are well-maintained and in good condition
Water use reduction for CIP, process area cleaning, production processes, and safety equipment testing	- Safety and quality standards - Validated changes - Generally not recommended
Irrigation duration and volume	- Irrigation volume is small in comparison to other water use systems such as cooling towers and USP treatment

Focus Area: Cooling Towers

Cooling Tower Demand

Area 2 Towers

- 4 BAC towers serve Areas 1,2,3 & 5
- ΔT = 24ºF
- Recirculation Rate = 1350 - 2700 gpm
- 4 Cycles of Concentration
- 2013 Water Use = **10.4 MG**

Area 4 Towers

- 4 Marley towers serve Area 4 and GPF
- ΔT = 22ºF
- Recirculation Rate = 150 - 400 gpm
- 4 Cycles of Concentration
- June 2012- June 2013 Water use = **9.74 MG**

Area 6 Towers

- 3 Marley towers serve Area 6
- ΔT = 24ºF
- Recirculation Rate = 1000 -6000 gpm
- 4 Cycles of Concentration
- 2013 Water Use = **14.3 MG**

Sources of Cooling Tower Water

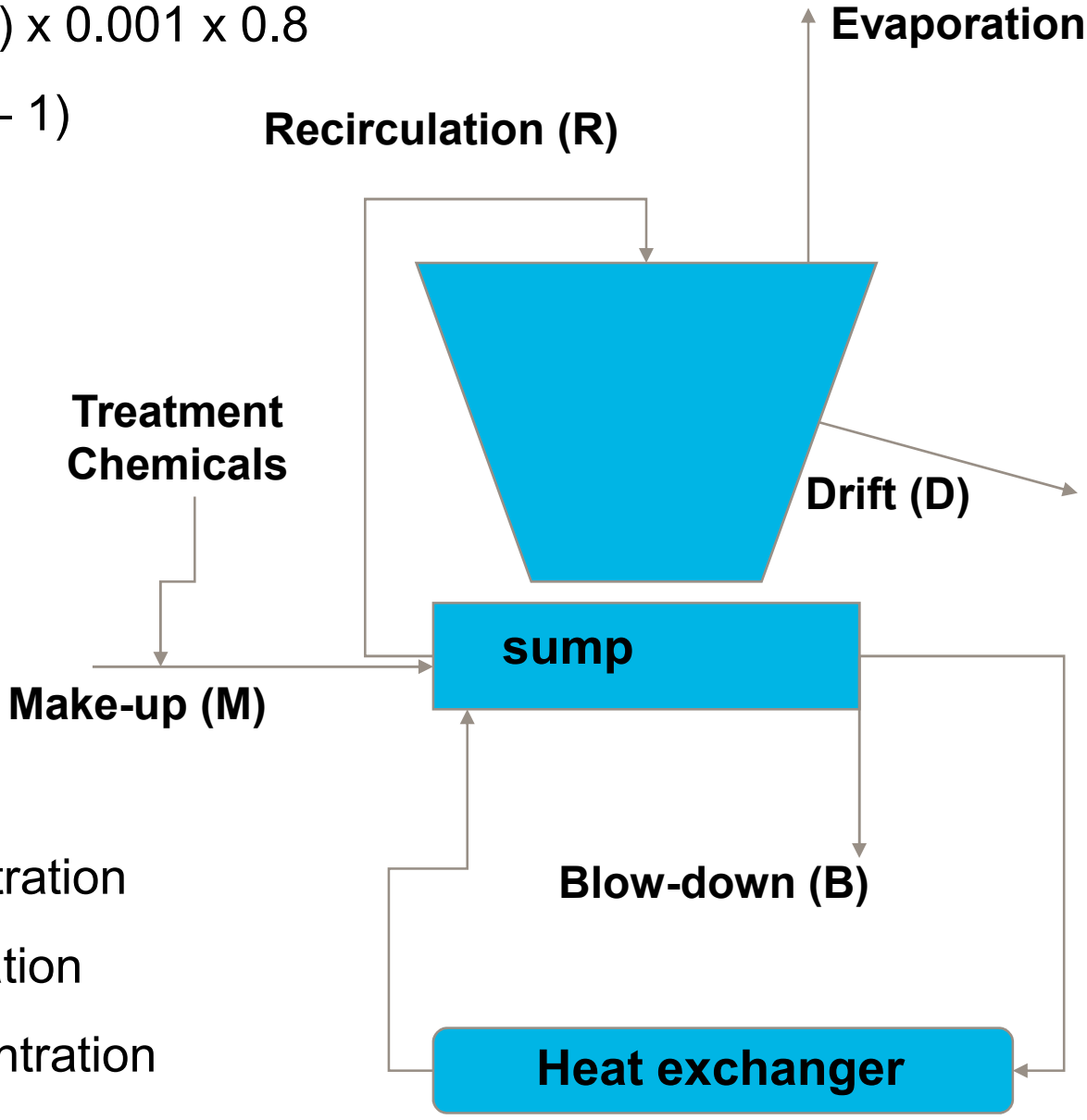
- Collection of reclaimed flows in the Area 6 groundwater sump for Area 6 cooling tower makeup:
- Area 4 RO Reject
- Reuse Area 6 AHU condensate for Area 6 cooling tower makeup
- Rainwater harvesting from Area 6 rooftop for Area 6 cooling tower makeup

Cooling Towers

(1) E (gpm) = R x ΔT (ºF) x 0.001 x 0.8

(2) B (gpm) = E / (COC – 1)

(3) M (gpm) = E+ B



$COC = C_B / C_M$

C_B = Blowdown Concentration

C_M = Makeup Concentration

COC = Cycles of Concentration

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WaterCycle Modeling Evaluation

- Cooling Tower Modeling Inputs
  - Water quality parameters – sampling results for all sources
  - Blended makeup using mass balance
  - Operational parameters and seasonal variation (summer vs. winter operations)
    - Basin volume, Recirculation rate, temperature differential, cycles of concentration
- Model Output and Analysis
  - 12 scenarios evaluated for Area 6 towers
  - 4 scenarios evaluated for Area 2 towers
  - Program output allows for comparison of parameters of concern and simple indices
  - COCs were varied from 1-7

Modeling Scenarios: Area 6 Towers, Summer Operations

Scenario #	Demand (gpd)	% GW	% A6 RO	% A4 RO	% AHU	% City
Area 6 Towers – Summer (August 2012 water use)						
1	78,803	-	-	-	-	100%
2	78,803	41%	11%	32%	13%	3%
3	78,803	41%	11%	-	-	48%
4	78,803	41%	-	32%	-	27%
5	78,803	-	-	-	13%	87%
6	78,803	41%	-	-	-	59%
7	78,803	41%	11%	32%	-	16%

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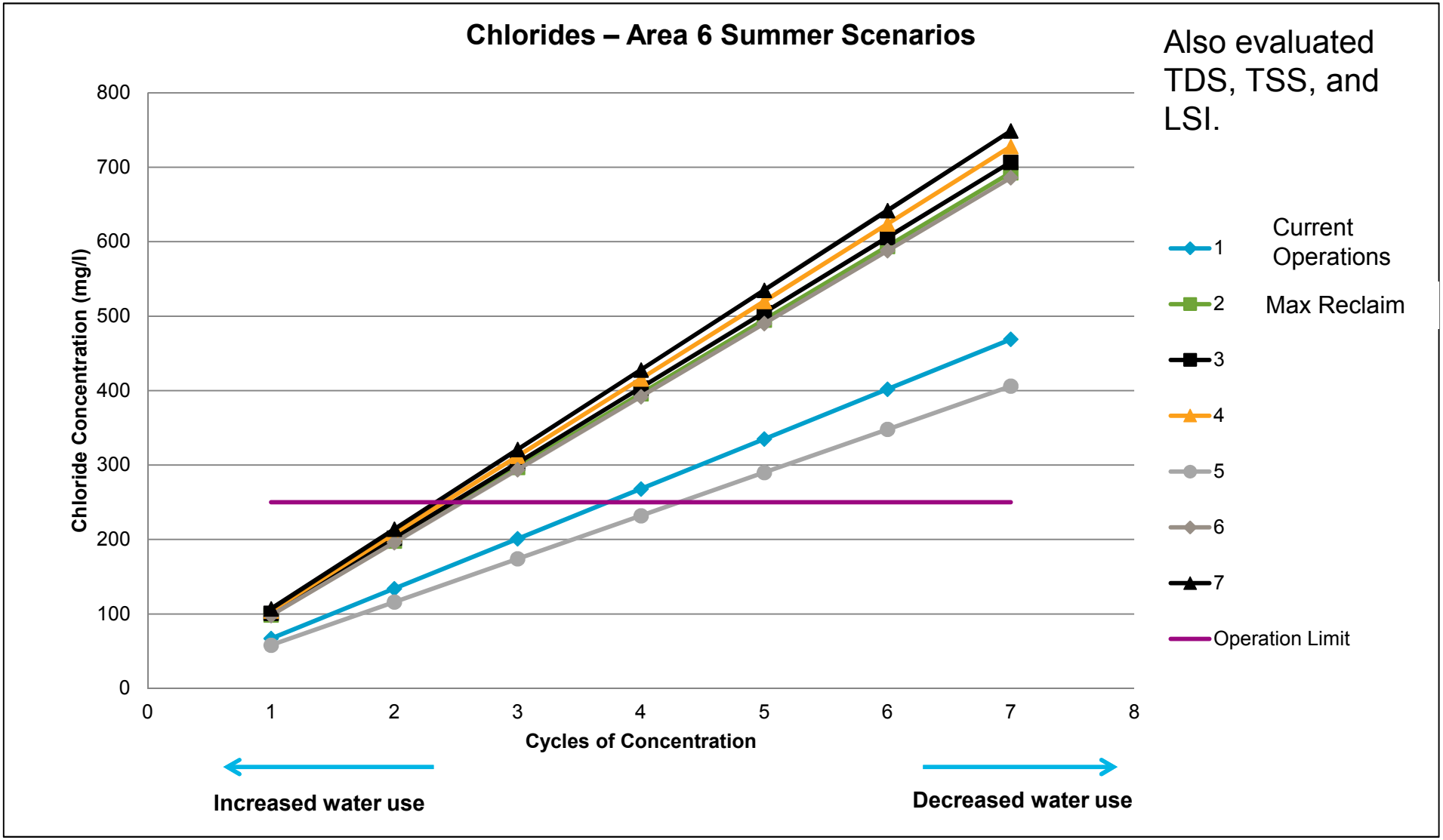
Chlorides – limiting parameter



Chlorides were determined to be the limiting parameter in all cases evaluated besides AHU condensate use.

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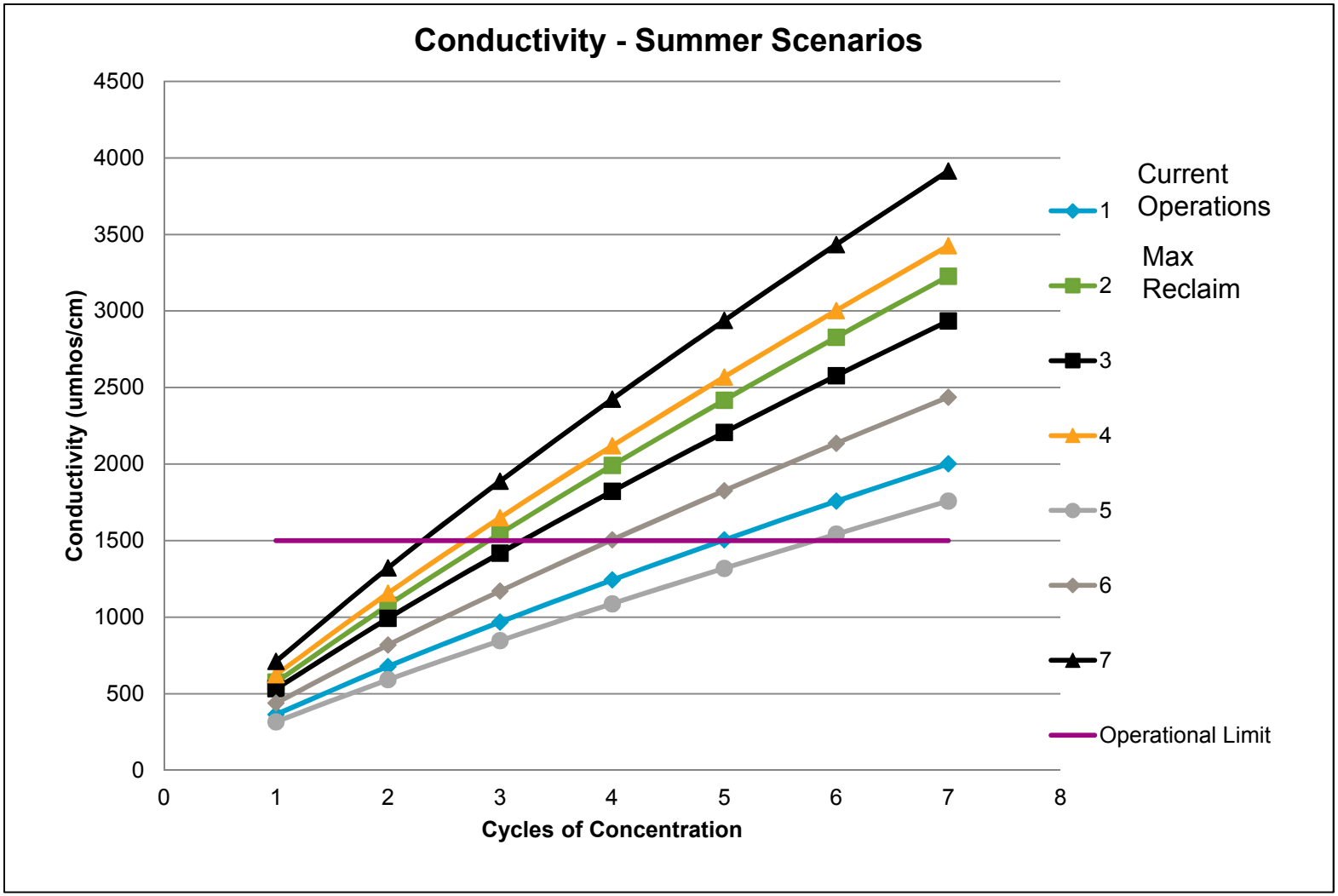
Conductivity



Cooling Tower Modeling Results

- Area 2 and 6 towers – water reuse a challenge due to the small amount of RO reject (Area 3 labs) available and the reject quality
- Groundwater and Area 4 RO reject are the preferred sources for reuse due to lower conductivity, chloride concentration, and TDS concentration
- Sampling data is limited for the AHU condensate, but pH is expected to be < 5.0 with no alkalinity – condensate will contribute to corrosive conditions in blended makeup water
- Reuse of groundwater and Area 4 RO reject will require reducing cycles of concentration to 2.5 in the Area 6 towers

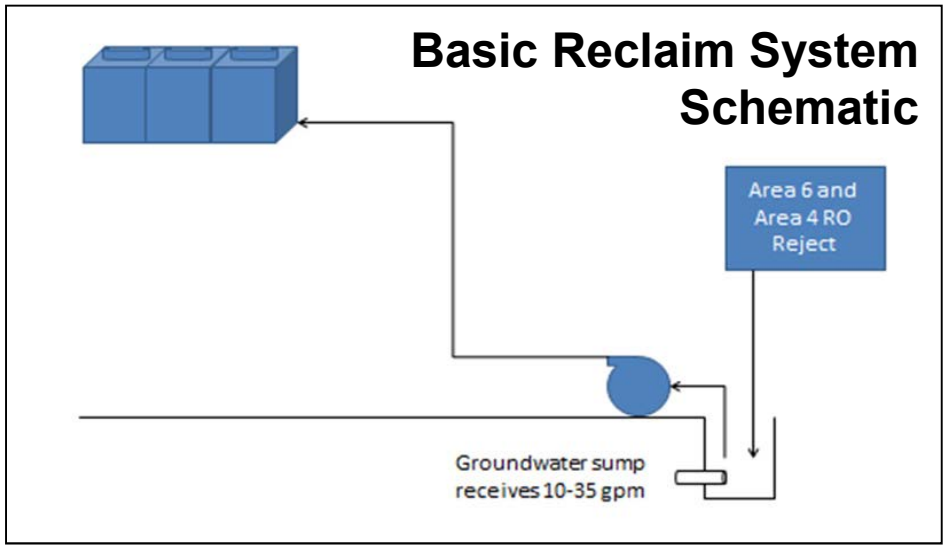
Cooling Tower Recommendations

- A potable water use reduction of 5.1 million gallons per year is possible. The listed percentages of reclaimed water, including groundwater, and excluding potable water should not be exceeded in order to maintain water quality:
  - 20% of demand by Area 4 Reverse Osmosis (RO) Reject
  - 40% of demand by groundwater
  - 35% of demand by potable water
  - 5% of annual demand can be met by AHU condensate on average as limited by expected condensate production. This proportion could be as high as 10% during summer operations when the most AHU condensate is produced.
- 65% of annual cooling tower demand can be met through reclaimed sources if Cycles of Concentration are decreased to 2.5 without significant changes in chemical treatment.

Option 1a. Gray Water Makeup System for Area 6 Cooling Towers

- Groundwater can supply up to 40% of total demand
- Area 4 RO Reject can supply up to 20% of demand
- Cooling Tower makeup demand
  - 78,800 gpd (summer)
  - 3,200 gpd (winter)
- Operational change:
  - COCs decrease to 2.5 with reclaimed makeup use
  - This increases overall water use, but decreases potable water use
  - Changes to corrosion inhibitor dosing are expected

Cost and Water Savings	
Water Savings	4.65 MG/yr
Cost Savings	$44,344
Capital	$101,156
Payback Period	2.3 years
% Reduction	5.7



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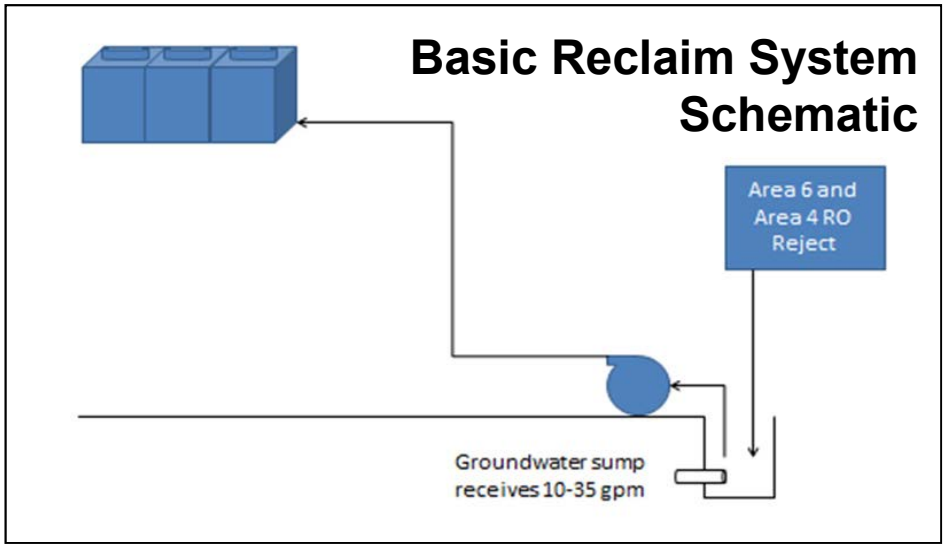
Option 1b. Gray Water Makeup System for Area 6 Cooling Towers

- Groundwater can supply up to 40% of total demand
- Cooling Tower makeup demand
  - 78,800 gpd (summer)
  - 3,200 gpd (winter)
- Operational change:
  - COCs decrease to 2.5 with reclaimed makeup use
  - This increases overall water use, but decreases potable water use
  - Changes to corrosion inhibitor dosing are expected

Cost and Water Savings	
Water Savings	2.15 MG/yr
Cost Savings	$20,466
Capital	$45,065
Payback Period	2.2 years
% Reduction	2.7



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Gray Water Makeup System for Area 6 Cooling Towers

Option	Description	Water Use Reduction (Gal.)	Savings	Capital	Payback Period (yr.)
A	GW & A4 RO Reject	4,649,041	$ 44,344	$ 101,156	2.3
B	GW only	2,145,711	$ 20,466	$ 45,065	2.2

- Option A, in which groundwater and Area 4 RO reject are reclaimed for cooling tower makeup to the Area 6 towers will result in the greatest water savings with short payback period.

Option 2. AHU Condensate Makeup to Area 6 Cooling Towers

- Average summer condensate production = 22 gpm
- Simple conveyance system installation – close proximity to Area 6 towers
- Condensate estimated to makeup 5% of annual tower demand (up to 10% in summer)
- Condensate to offset evaporation during peak tower operation

Cost and Water Savings	
Water Savings	0.48 MG/yr
Cost Savings	$4,605
Capital	$17,560
Payback Period	3.8
% Reduction	0.6

Option 3. Rainwater Harvesting for Area 6 Cooling Tower Makeup

- Maryland receives an average of 40 in. of rainfall per year.
- Collection area provided by the Area 6 rooftop is 4,590 ft.2
- Assume a capture efficiency of 0.46 gallons/ft.2/in.
- Re-route roof drain stormwater piping to ground-level collection tank from where it can be pumped to the Area 6 cooling towers

Cost and Water Savings (glassware washers)	
Water Savings	0.08 MG/yr
Cost Savings	$806
Capital	$109,410
Payback Period	136
% Reduction	0.1

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Focus Area: Production, Plumbing, and Metering

Option 4. Laboratory Washing Procedures Optimization

- MedImmune has successfully validated the following cleaning process modifications:
  - Reduction in glassware washer cleaning cycles from 6 cycles to 3 cycles
  - Elimination of cooling water use for autoclave operations
  - Reuse of final cycle cleaning water for initial cleaning cycle of the next run in Vivarium cage washers

Cost and Water Savings (glassware washers)	
Water Savings	0.38 MG/yr
Cost Savings	$6,534
Capital	0
Payback Period	0
% Reduction	0.5

Cleaning cycles per run were decreased by 50% from 6 to 3 cycles in July 2013 (35 gallons cycles)

Savings = 35 gal./cycle x 3 cycles/run x 10 runs/day = 1050 gpd (383,250 gallons per year)

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Option 5. CIP and Production Process Optimization

- MedImmune has successfully validated the following procedures:
  - 1) WFI rinse in place of a full CIP cycle for buffer prep tanks
  - 2) Hydroxide top offs of buffer tanks
  - 3) Point of use cooling for WFI

- The following initiatives are either in process or under consideration:
  - 1) Reduce or eliminate 2 minute weekly WFI drop and startup flushes
  - 2) Implement WFI rinses in place of full CIPs in areas beyond buffer prep
  - 3) Improve recording of past work to reduce waste and provide guidance for appropriate volumes for buffer prep operations.

Option 6. Plumbing Fixture Efficiency Upgrade

- Identify and replace OMW fixtures with more water efficient models
- Match OMW Area 6 modifications
  - Waterless urinals
  - Low-flow automatic sinks
- Water savings are based on building occupancy and EPA WaterSense plumbing fixture efficiency standards

Cost and Water Savings (1c.)	
Water Savings	2.74 MG/yr
Cost Savings	$46,727
Capital	TBD
Payback Period	TBD
% Reduction	3.36

Proposed Changes:

Toilets: 3.5 gpf → 1.6 gpf
Urinals: 2 gpf → 0 gpf
Sinks: 1.5 → 0.5 gpm

gpf = gallons per flush
gpm = gallons per minute

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Option 7. WSSC Submeter Installation

- Maximize receipt of 73% credit for irrigation and cooling water use offered by WSSC.
- Install WSSC cooling tower submeters in the following locations:
  - OMW Area 6 cooling towers
  - OMW Area 2 cooling towers
  - 200 ORD cooling towers
- Repair existing WSSC submeter:
  - 950 WRL

Cost and Water Savings	
Water Savings	0
Cost Savings	$129,030 per year
Capital	$31,000
Payback Period	3 months
% Reduction	0

Cost and Water Savings Summary

Option	Description	Water Use Reduction (Gal.)	Savings	Capital	Payback Period (yr.)	% of 2012 Campus Total
1	Area 6 Cooling Tower Reclaimed makeup	---	---	---	---	---
1a	GW & A4 RO Reject	4,694,041	$ 44,344	$ 101,156	2.3	5.7
1b	GW only	2,145,711	$ 20,466	$ 45,065	2.2	2.7
2	Plumbing Fixtures	2,740,608	$ 46,727	TBD	TBD	3.4
3	AHU Condensate (Area 6 Cooling Towers)	482,785	$ 4,605	$ 17,560	3.8	0.6
4	Lab Washing Process	383,250	$ 6,534	$ 0	0	0.5
5	A6 Rainwater Harvesting (Area 6 Cooling Towers)	84,456	$ 806	$ 109,410	136	0.1
6	CIP/Production Process	NA	NA	NA	NA	NA
7	WSSC Flowmeters	0	$ 129,030	$ 31,000	0.24	0
	Total	**8,385,140**	**$ 232,046**	**$ 259,126**	**1.1**	**10.4%**

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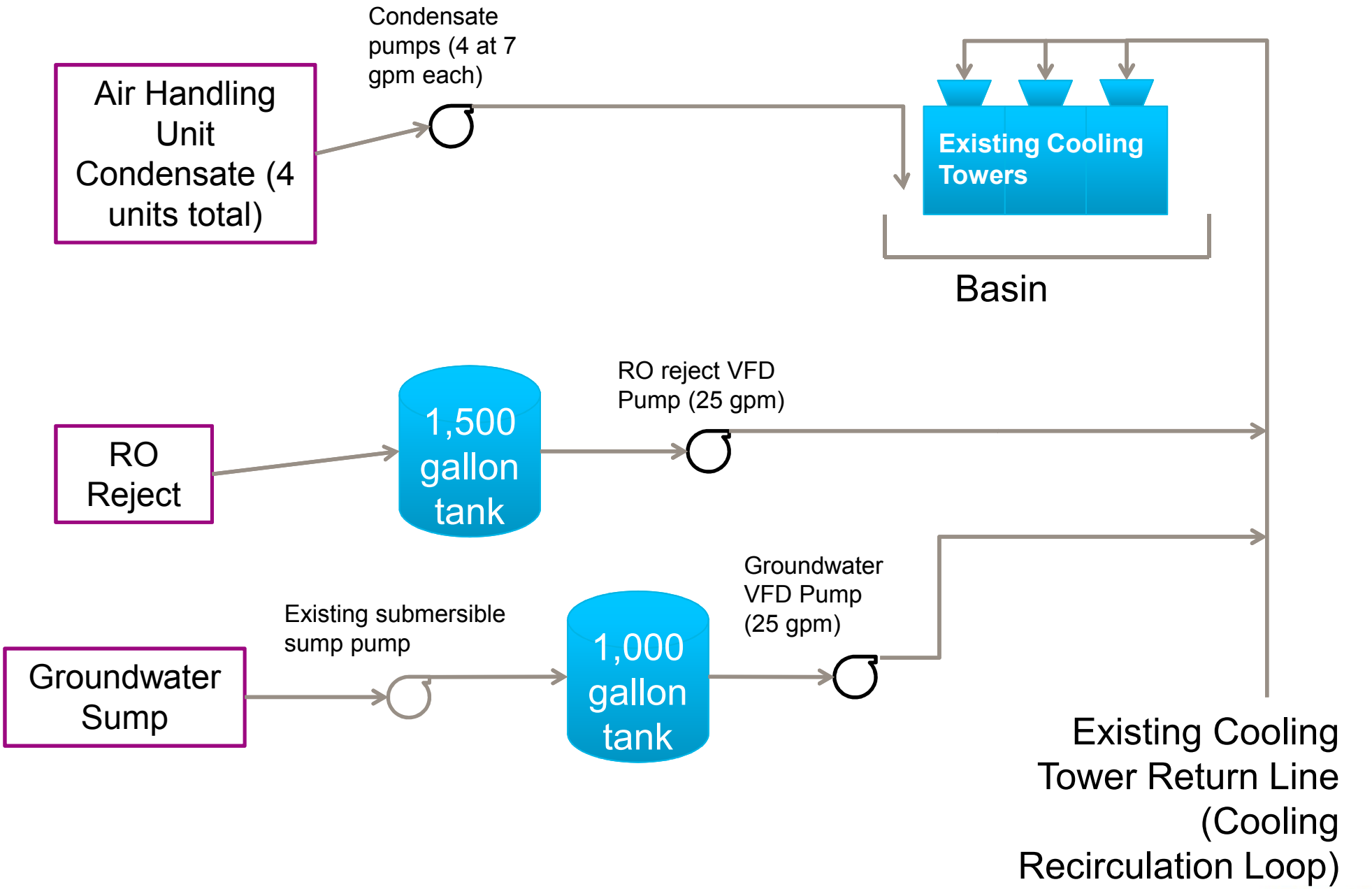
Recommendations

- If recommended options were implemented MedImmune could reduce current water use by at least 10.4% (8.39 million gallons annually) and save nearly $232,000 per year.
  - Recommendations:
    - Reclaim Area 4 RO Reject, groundwater, and AHU condensate for Area 6 cooling towers
    - Optimization efforts for CIP, production process, and other WFI/RODI use applications
      - Reduction in cycles for lab glass washers is a great example of success in this area
    - Installation of WSSC flowmeters on irrigation and cooling tower systems

Cooling Tower Water Reuse System Design

- MedImmune chose to proceed with the design of a water reuse system for cooling tower makeup based on the results of the water reuse evaluation
  - Collection of reclaimed flows in the Area 6 groundwater sump for Area 6 cooling tower makeup:
    - Groundwater and Area 4 RO reject
    - Groundwater only
  - Reuse Area 6 AHU condensate for Area 6 cooling tower makeup
- Minor changes in cost, water savings, and available reclaim water based on new data
  - Maryland Dept. of Environment groundwater withdrawal permit was required to utilize groundwater and withdrawal quantity was capped at 9,900 gallons per day

System Process Flow Diagram with Design Flows



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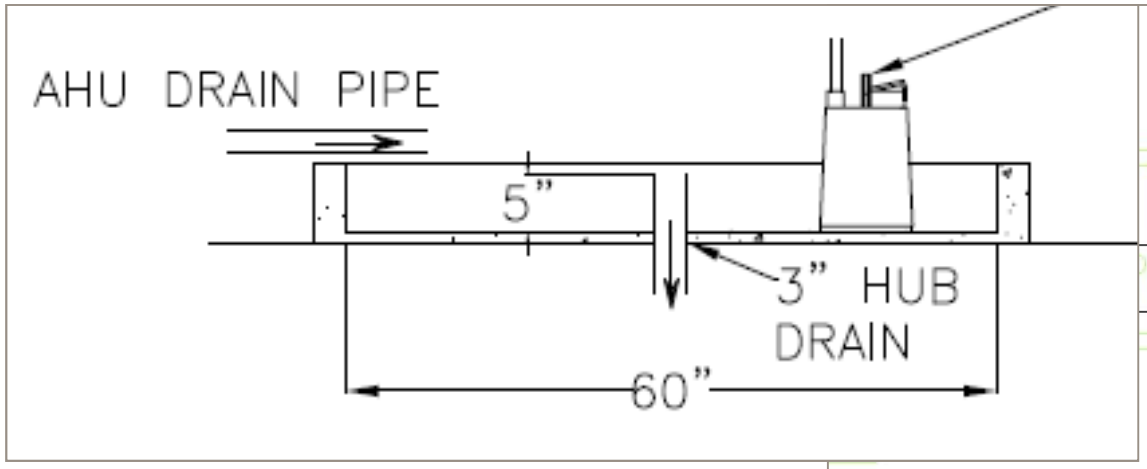
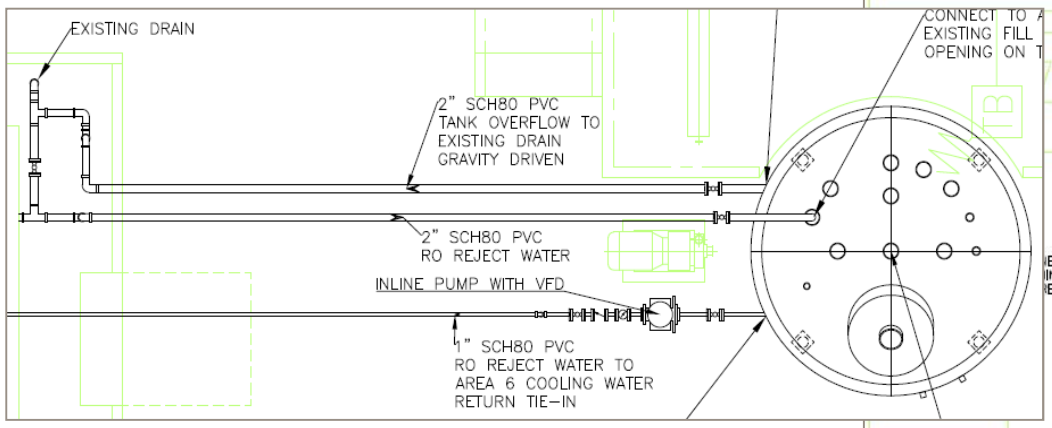
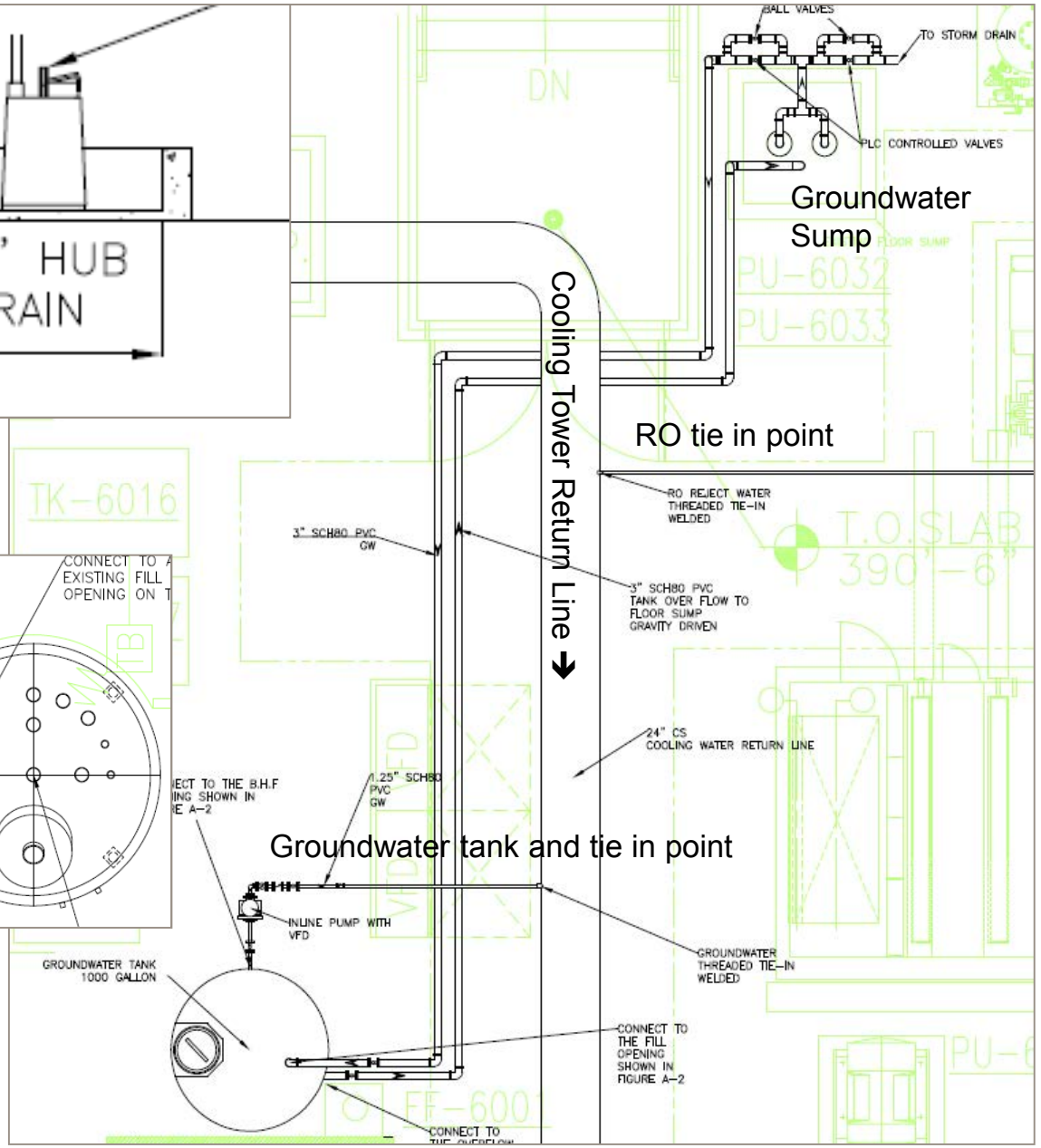
Site Layout Design Details



Condensate Collection Basin Detail



RO Collection Detail



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Total project Costs

- Total estimated cost of $258,000 for design and construction
- Total estimated cost savings of $102,637
- Simple payback period calculated to be 2.5 years

Source	Quantity Used in CT		Water Consumption Annual Savings	Sewer Discharge Annual Savings
	Gal./day	Gal./Year		
Groundwater	9,700	3,540,500	$25,810	-
RO Reject	9,700	3,540,500	$25,810	$37,883
AHU Condensate	2,000	730,000	$5,322	$7,811
		Subtotal =	$56,942	$45,694
		Total Annual Savings =		$102,637

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Thank You

Patrick Cyr, PE, BCEE

Patrick.cyr@aecom.com

215-514-5956

References

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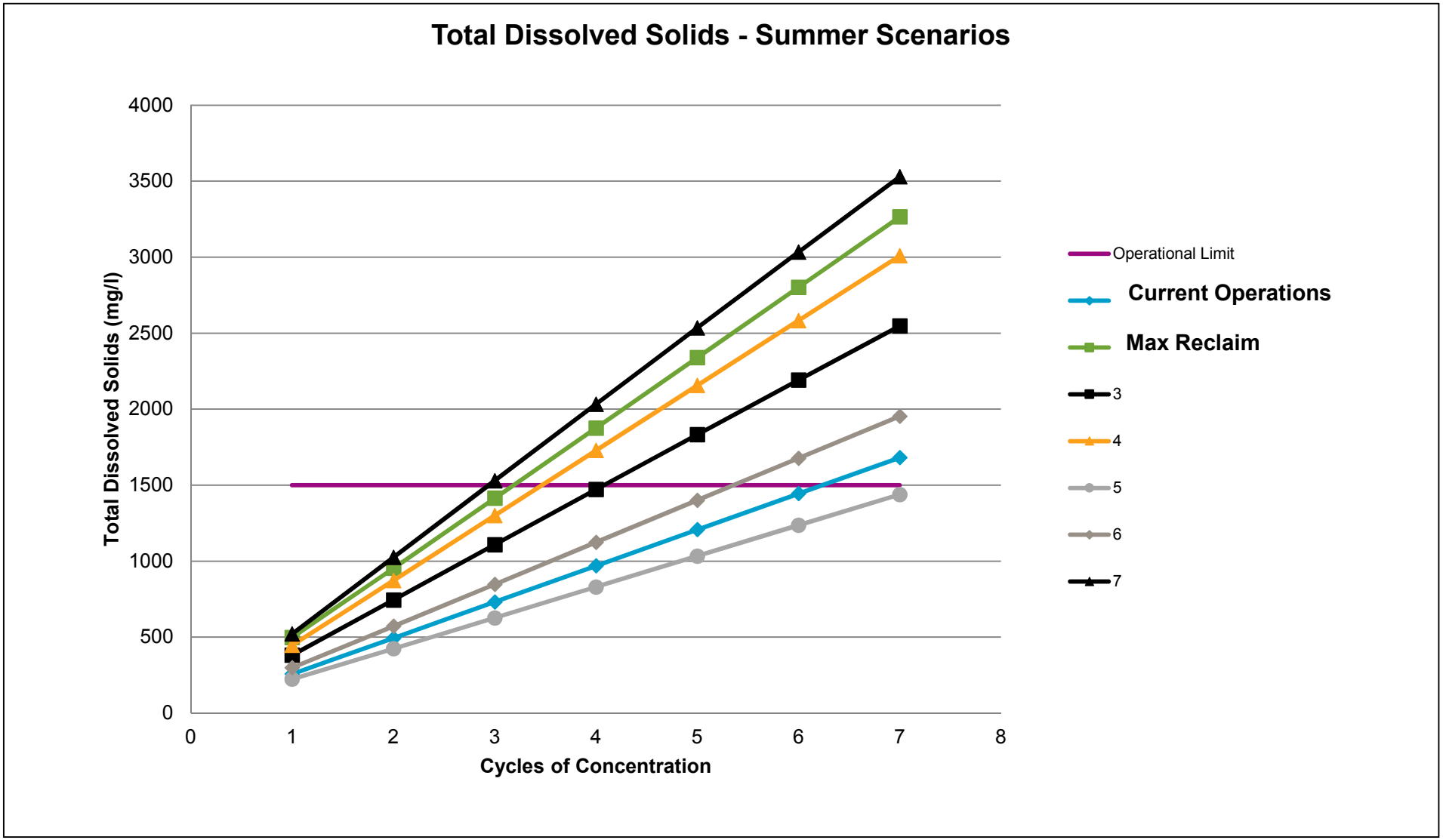
Total Dissolved Solids



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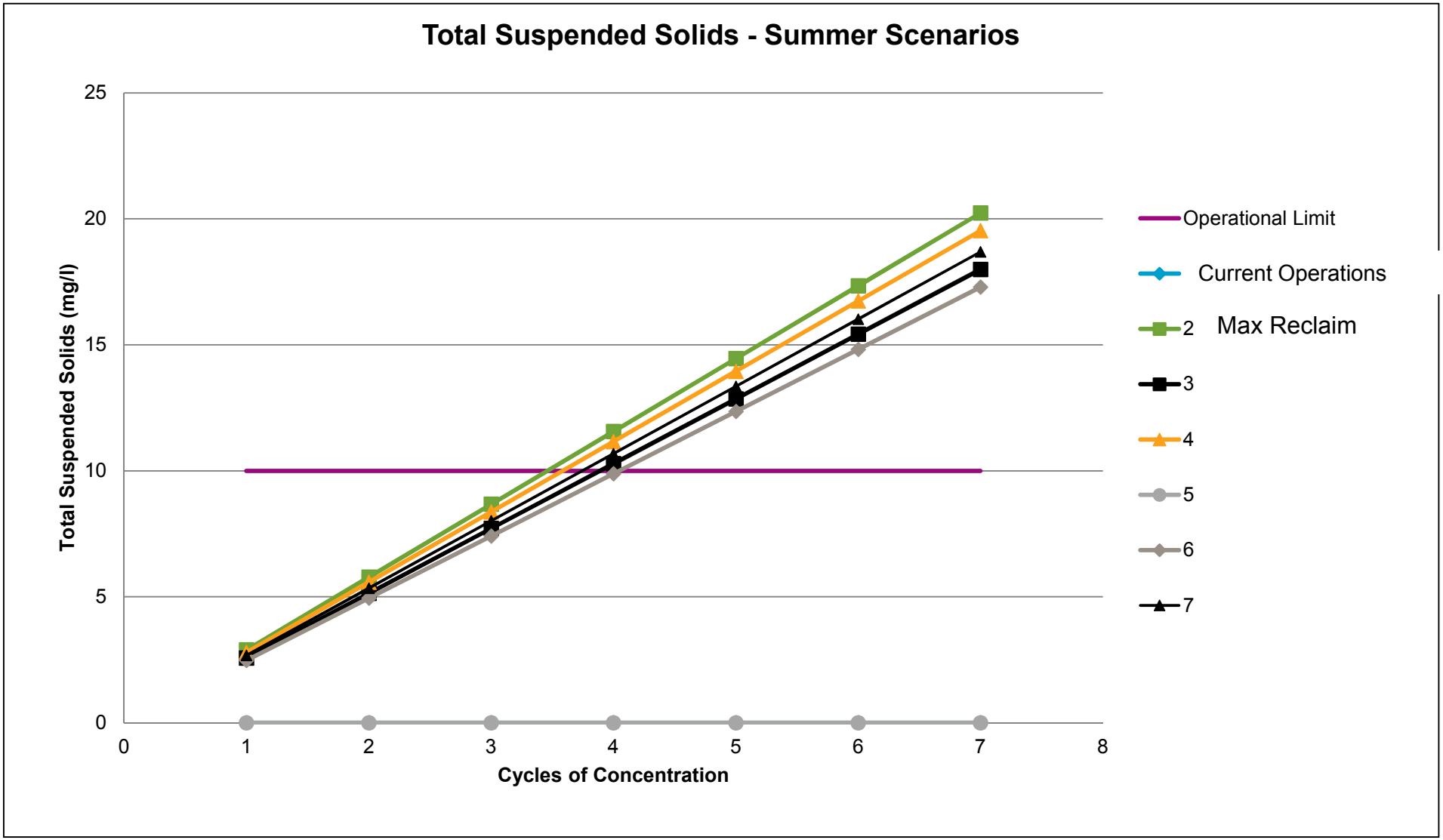
Total Suspended Solids



TSS concentrations in groundwater and RO reject are higher than WSSC supply, but should be adequately addressed by 0.5-micron sidestream filters

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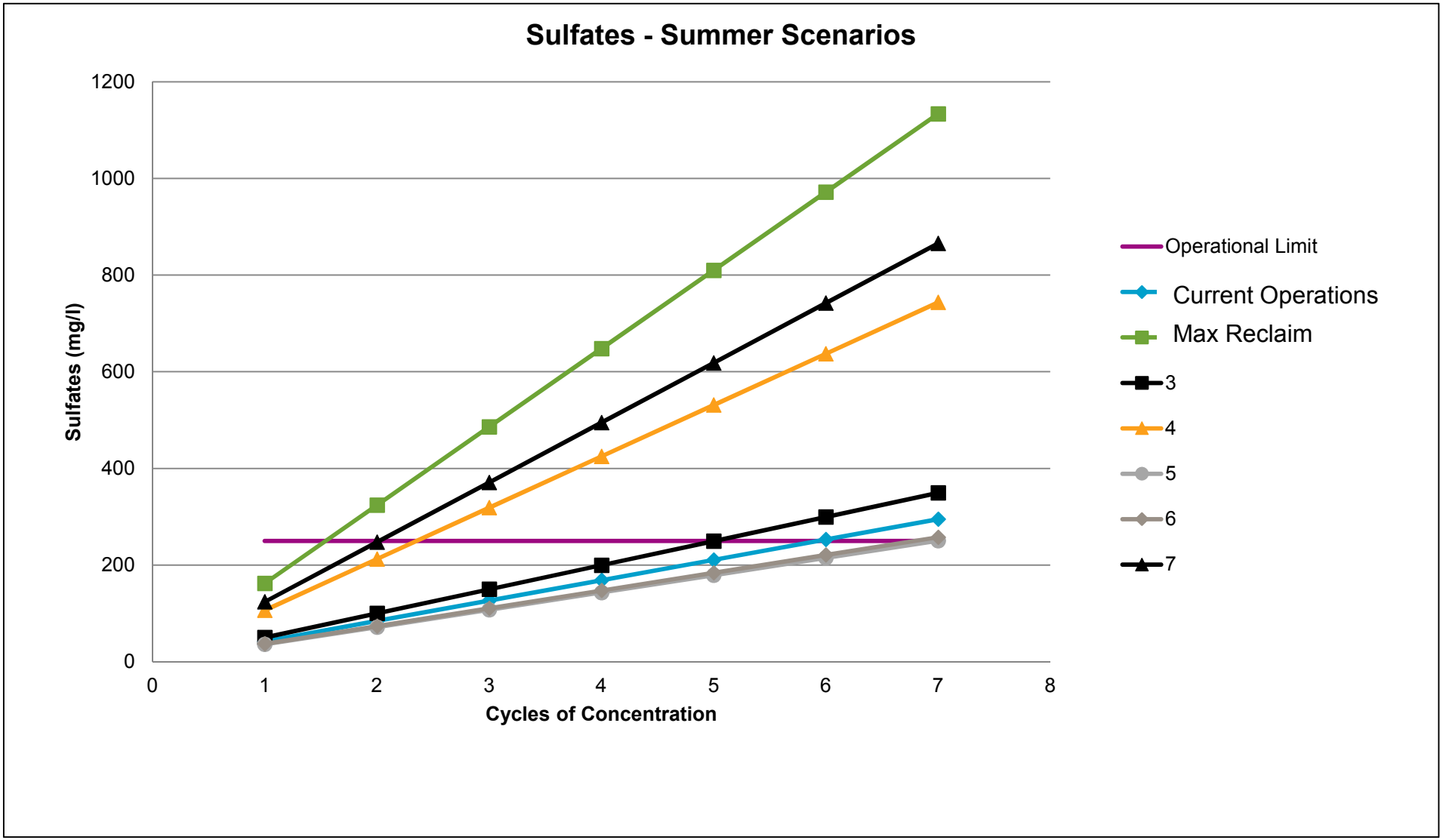
Sulfates



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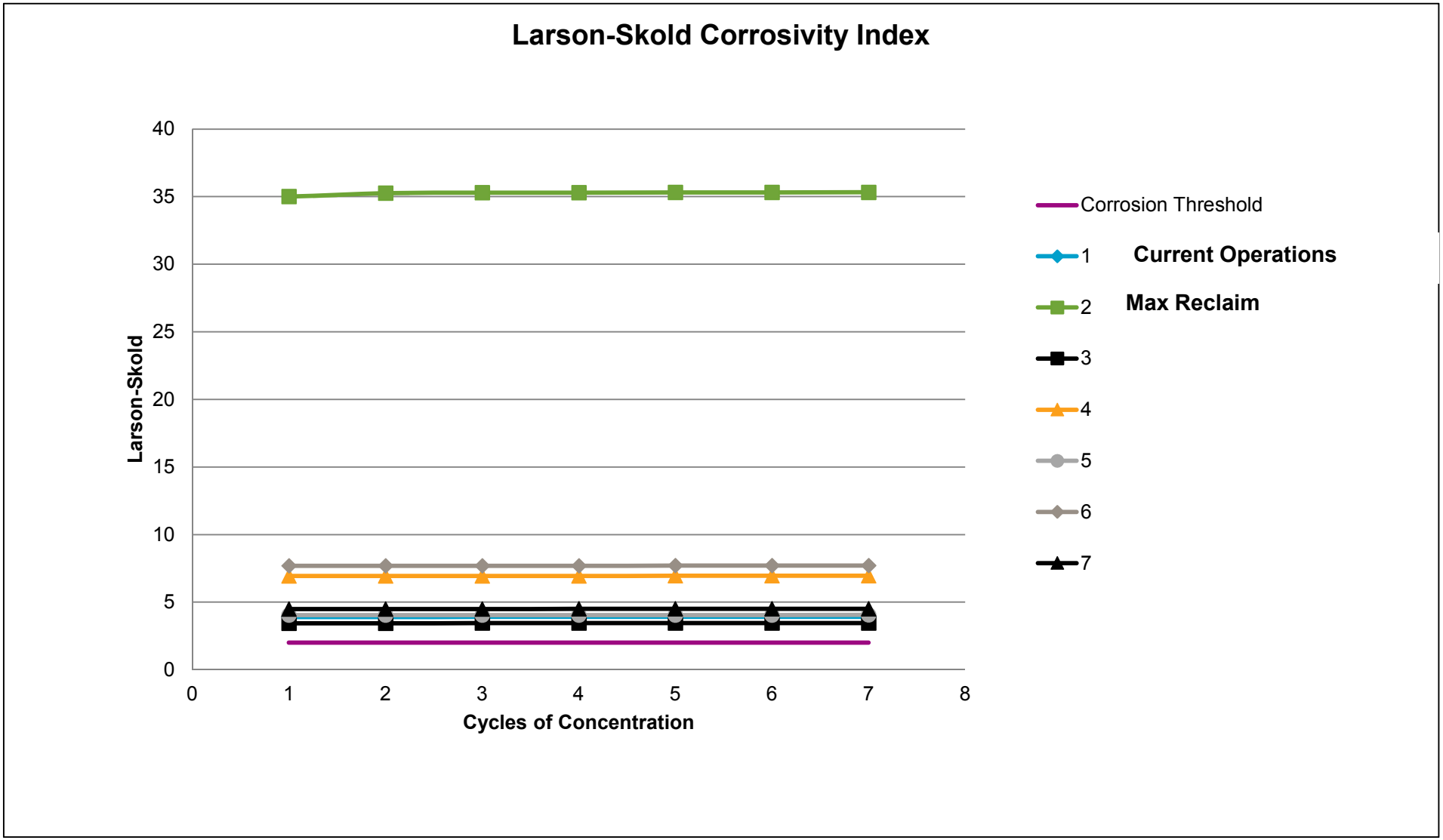
Reclaimed makeup and corrosive conditions



Reclaimed makeup (particularly RO reject) will contribute to corrosive conditions in cooling towers.

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Global Water Tool

- Excel spreadsheet program developed by the World Business Council for Sustainable Development (WBCSD)
  - Allows companies and organizations to assess and communicate their water use and risks relative to water availability in their global operations and supply chains.
- Parts of Maryland often experience moderate to severe drought conditions during the summer months.
  - Regional climate change predictions indicate climate conditions are likely to become more variable indicating that the incidence of drought conditions may become more common and/or severe.
- The GWT output classifies Gaithersburg as “water scarce”
  - 1995 Annual projected renewable water supply per person of 500-1000 m3/person/year
  - 2025 Annual projected renewable water supply per person of 500-1000 m3/person/year

Reuse and Reduction Summary

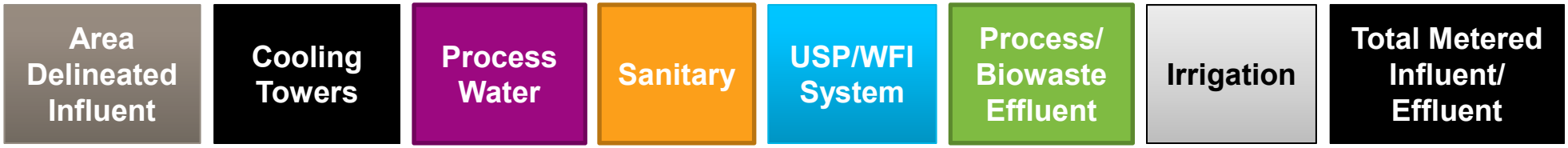
System	USP/WFI Systems	Cooling Towers
Reduction Options	- Production and CIP Process optimizations	- Optimize operations (increase cycles of concentration)
Reuse Options	- Reclaim GW for cooling tower makeup - Reclaim RO reject flows for cooling tower makeup - Reclaim AHU condensate for cooling tower makeup - Harvest rainwater for cooling tower makeup	- Reclaim GW for cooling tower makeup - Reclaim RO reject flows for cooling tower makeup - Reclaim AHU condensate for cooling tower makeup

Additional Comments

- Several operations at the facility are water-use efficient
  - Closed-loop glycol cooling for vacuum pumps and chillers
  - WFI and RODI use (CIP, buffer prep, media prep, and laboratory cleaning process) optimization initiatives
  - MedImmune utilizes waterless urinals and low-flow motion activated faucets in the lavatories located in 101 ORD and OMW Area 6
  - Increase COCs from 4 to 4.5
- MedImmune stands to benefit from improved monitoring and understanding of current water use
  - Flowmeter installation and monitoring program recommended for high water use systems in order to evaluate future and current water use reduction initiatives
    - Temporary meters may be used
    - Area 6 BMS system – repairs to existing influent meter
  - Tracking water use impact of CIP, buffer and media prep, and lab cleaning optimizations is recommended
  - Exchange knowledge with other AZ/MedImmune facilities pursuing water reduction initiatives

Water Balance Considerations

Flow Color Coding



- Challenges with Flow Balancing:
  - Data originates from a combination of sources captured during different time periods
  - Temporary flow meter study to delineate flow to separate areas of OMW occurred late September through late December.
    - Cooling tower water use was lower than average
    - GPF shutdown

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Recommended Opportunities

- The top (7) feasible water conservation opportunities identified include:
  - Collection of reclaimed flows in the Area 6 groundwater sump for Area 6 cooling tower makeup:
    - a. Groundwater and Area 4 RO reject
    - b. Groundwater only
  - Reuse Area 6 AHU condensate for Area 6 cooling tower makeup
  - Combine Options 1a and 2
  - Rainwater harvesting from Area 6 rooftop for Area 6 cooling tower makeup
  - Laboratory cleaning procedure water reduction initiatives
  - CIP and Production process optimization
  - Plumbing fixture efficiency upgrades
  - WSSC flowmeter installation on all cooling towers and irrigation systems

Design Hydraulic Loading Information

Tower System	Demand	Groundwater	A4 RO Reject	AHU Condensate	City Water
Maximum Flow Conditions (July)	82,000 gpd	25% 20,500 gpd	25% 20,500 gpd	10% 8,200 gpd	40% 32,800 gpd
Design Flow (gpm)	57	25	25	28**	N/A*

*The WRS relies on the existing makeup water conveyance system for potable water.

**Sump pumps were selected to deliver 7 gpm per AHU (28 gpm total) to the cooling towers, as determined for a design day with 80°F with 80% humidity.