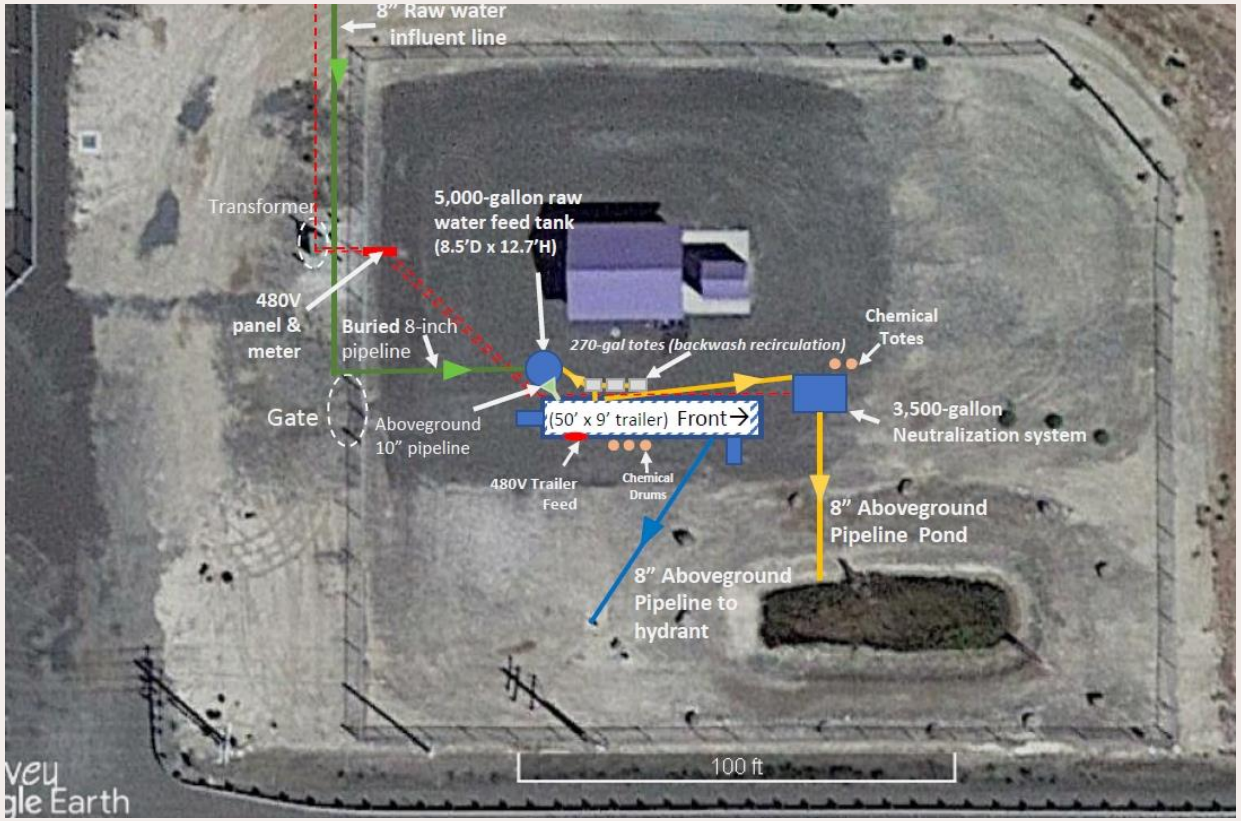
Pilot Testing Supports ASR Decision Making



Lee Odell, PE

Water Treatment Technology Lead

Consor Engineers

American Water Works Association
Pacific Northwest Section

Agenda

Introduction

ASR Water Quality Issues

ASR Regulatory Framework

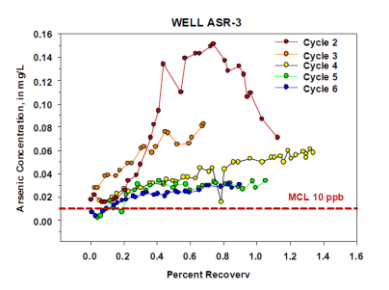
Case Studies

Questions

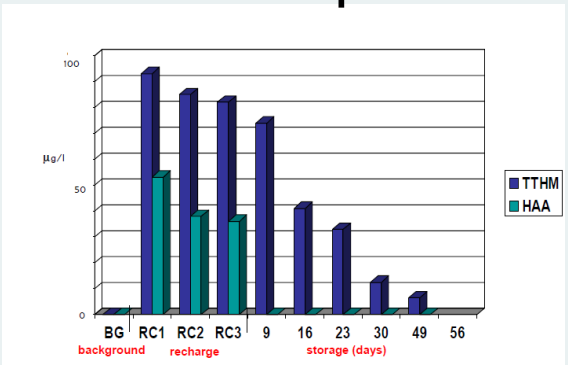
ASR Water Quality Issues

Aquifer Storage and Recovery (ASR) WQ Issues

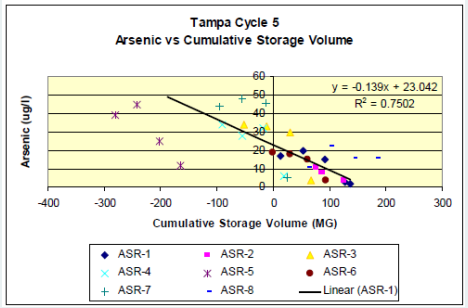
Arsenic Release



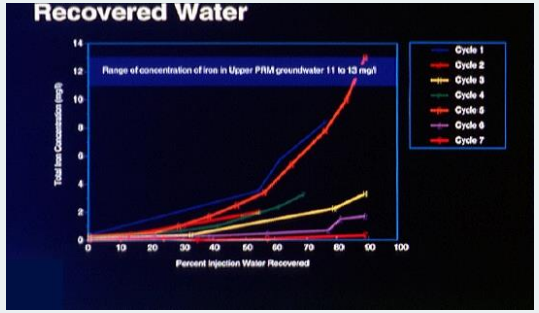
Microbial Fate and Transport



Disinfection By Products



Mixing Zones Issues



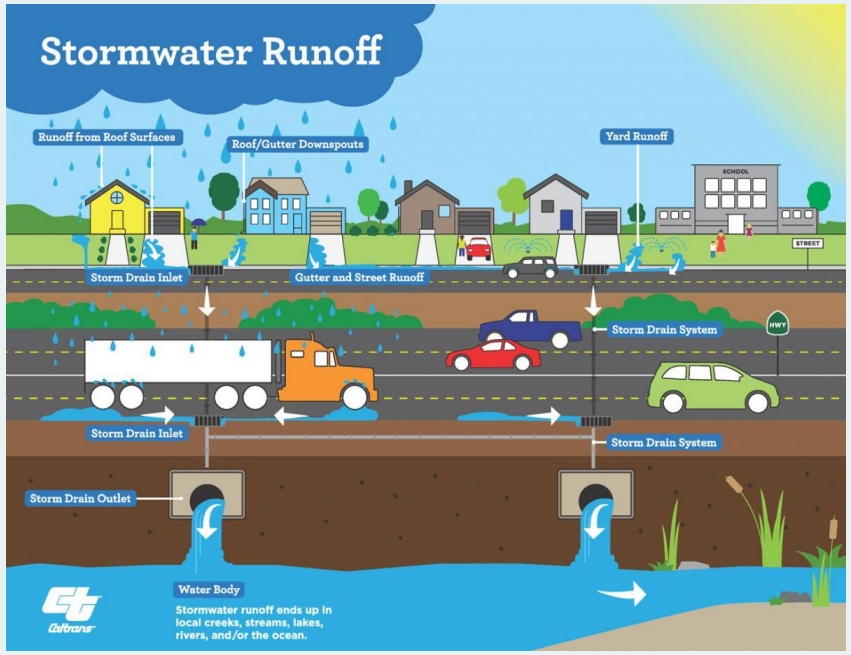
Regulatory Framework

Comparison

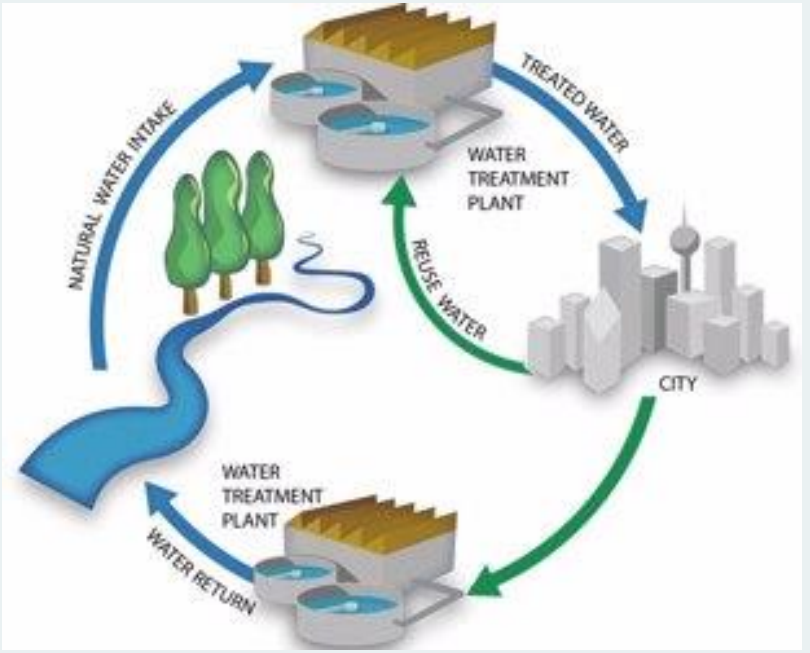
State	Washington	Oregon
GW Quality Protection	Ecology WAC 173-200 Antidegradation, Criteria	Water Resource Dept, OAR 690-350, Standards, Treatment Requirements
Drinking Water Treatment	DOH Office of DW Regs	OHA Drinking Water Services Regs
ASR Permitting	Underground Artificial Storage and Recovery Reservoir Permit, DOH Treatment Approval	Limited License for ASR Testing, Water Right, ASR permit

New Water Supplies Being Used for ASR

Stormwater



Industrial and Municipal Reuse



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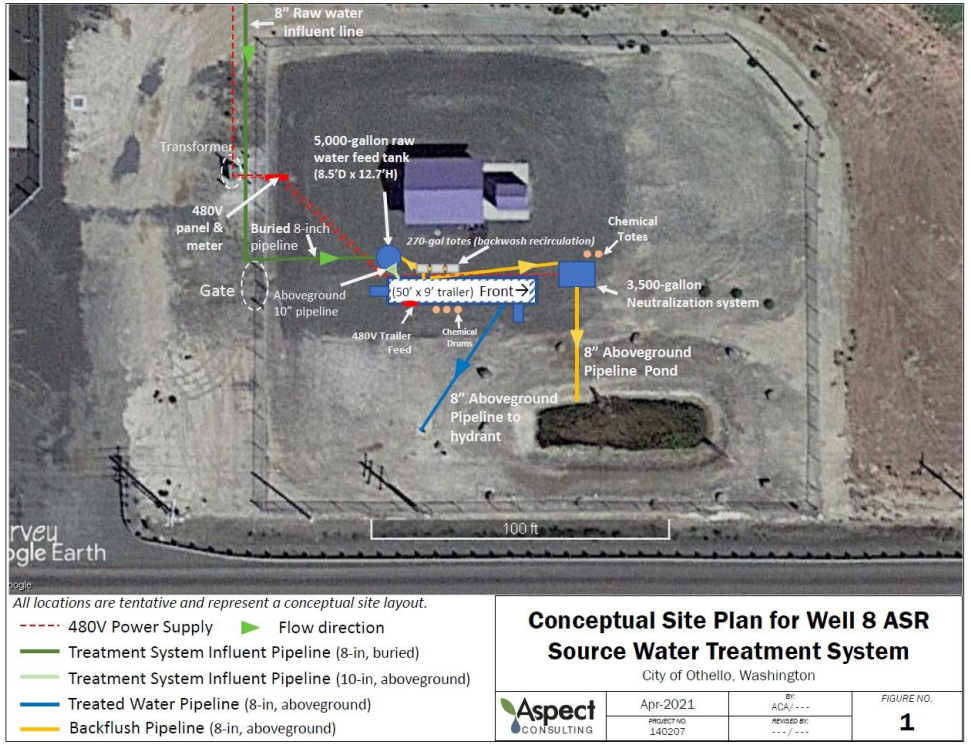
Pilot Testing Case Studies

Beaverton ASR Pilot Testing

BEAVERTON PURPLE PIPE

Connecting the right water with the right uses.

Othello ASR Demonstration Project



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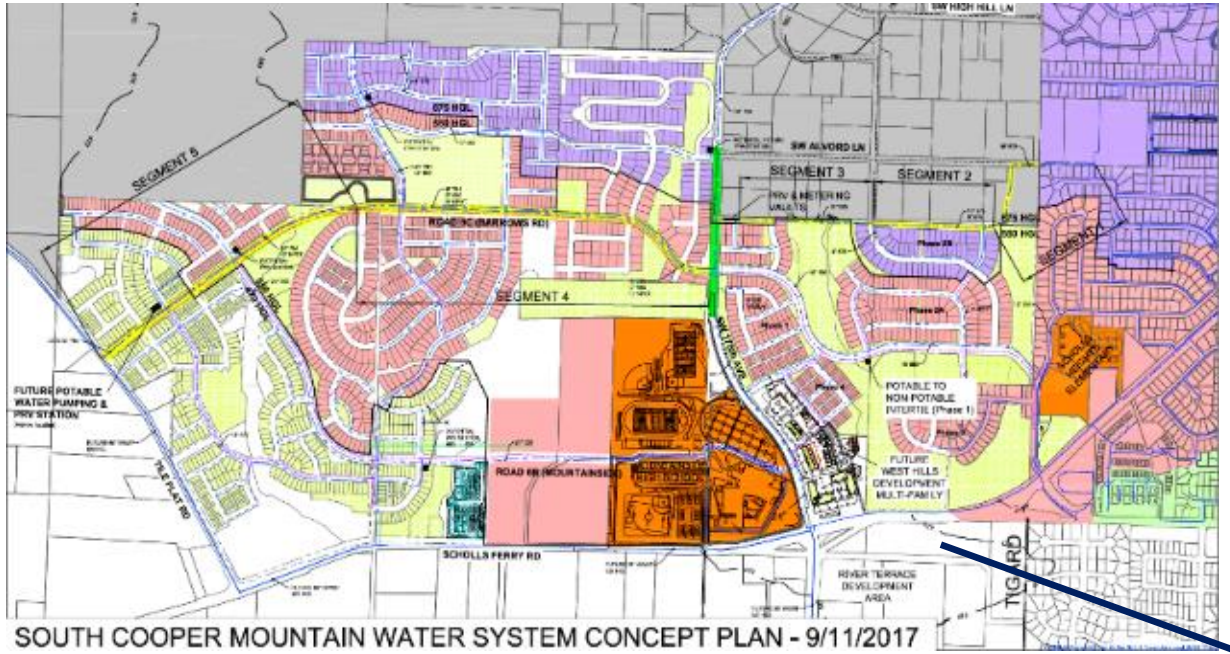
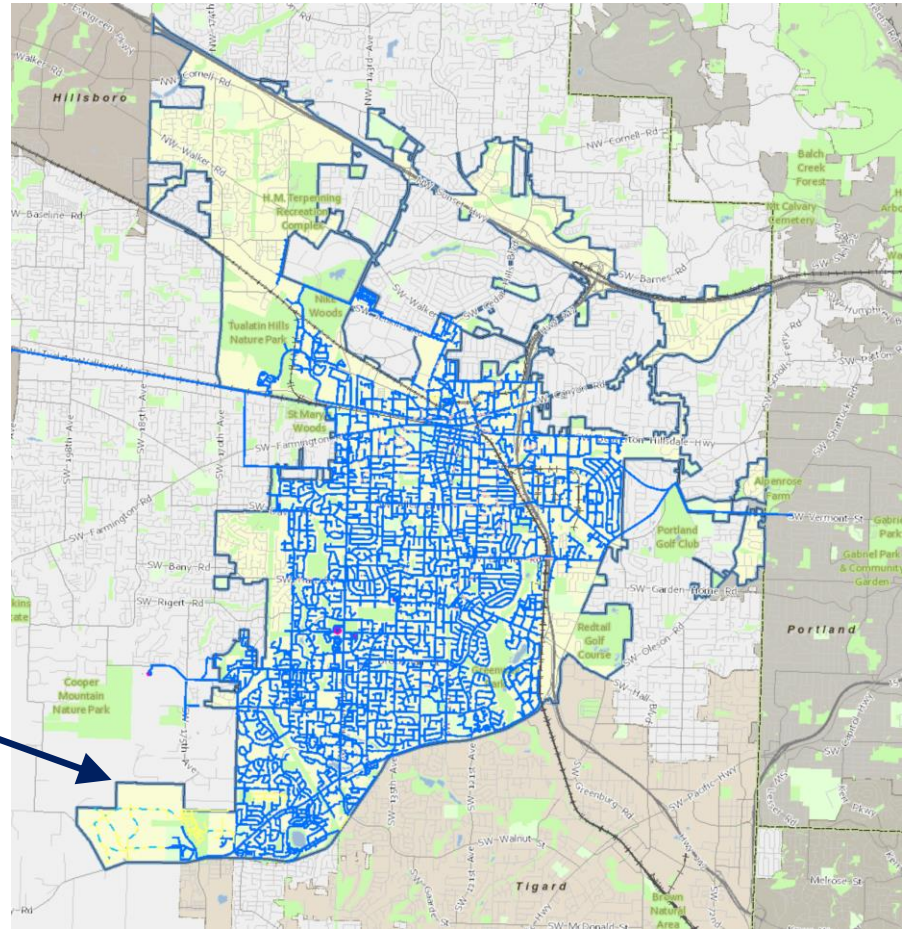
South Cooper Mountain

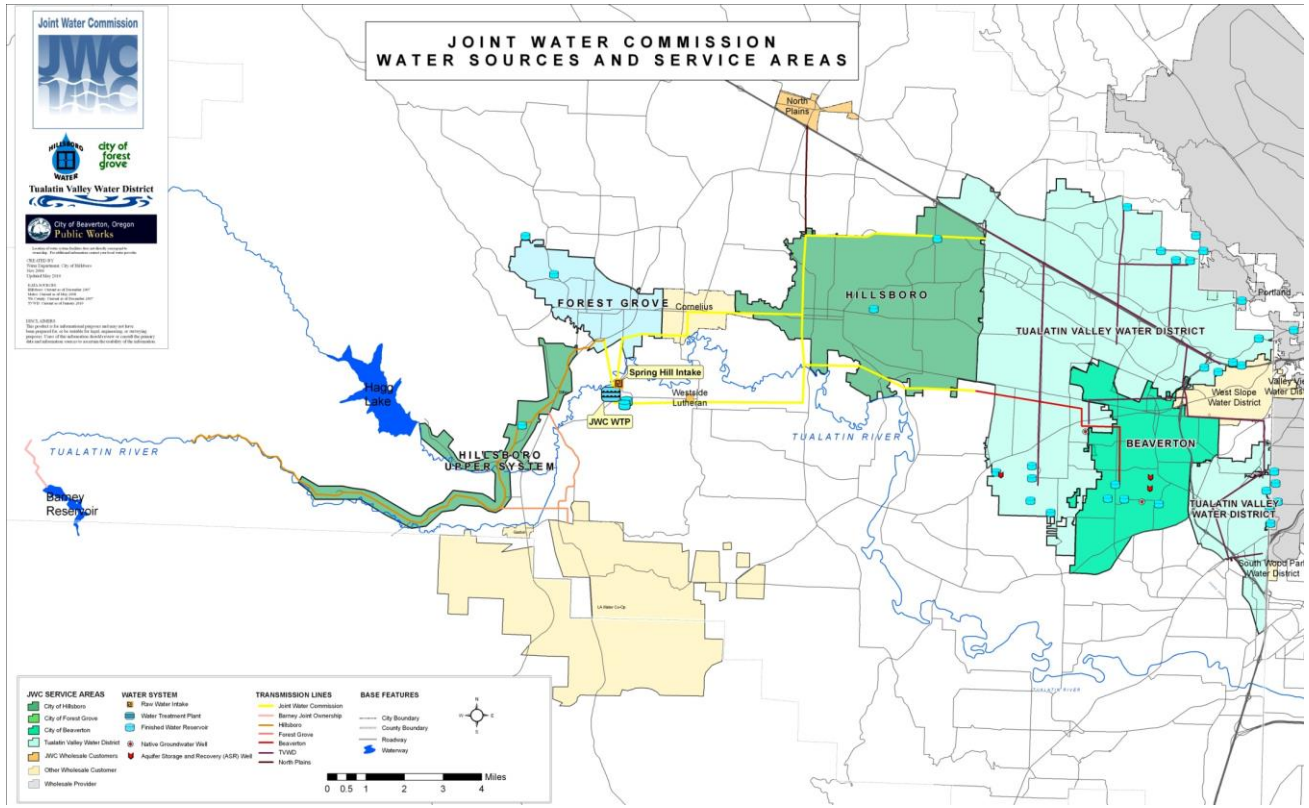
Annexed in 2013: 544 acres, 3,500 new homes, 2,200-student high school and future elementary school; approximately 9,000 population

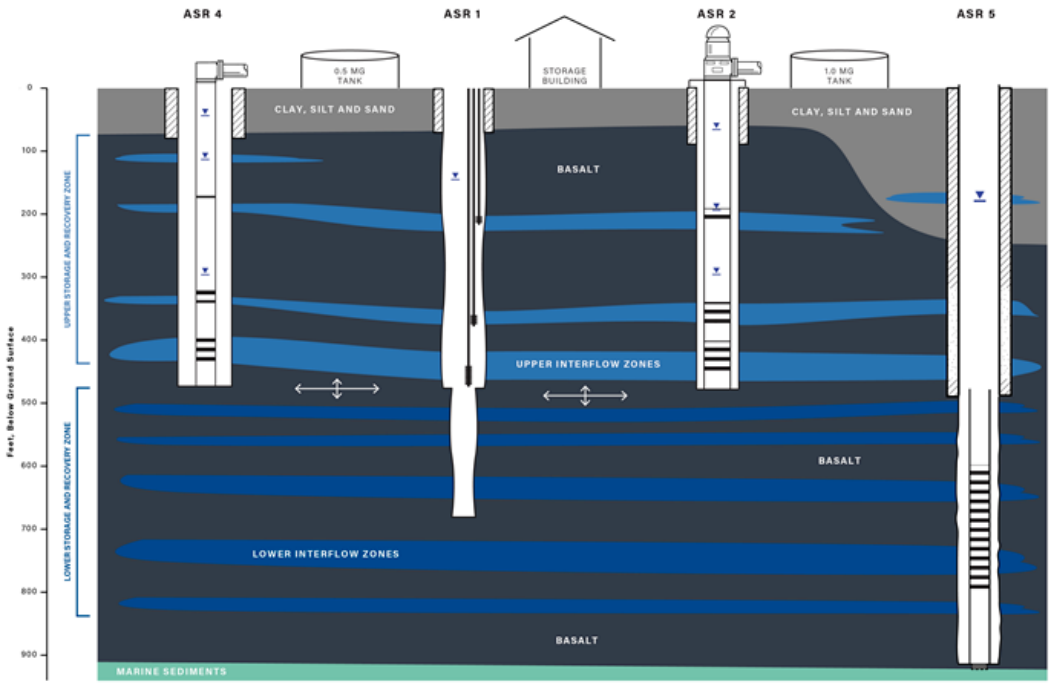


SOUTH COOPER MOUNTAIN WATER SYSTEM CONCEPT PLAN - 9/11/2017



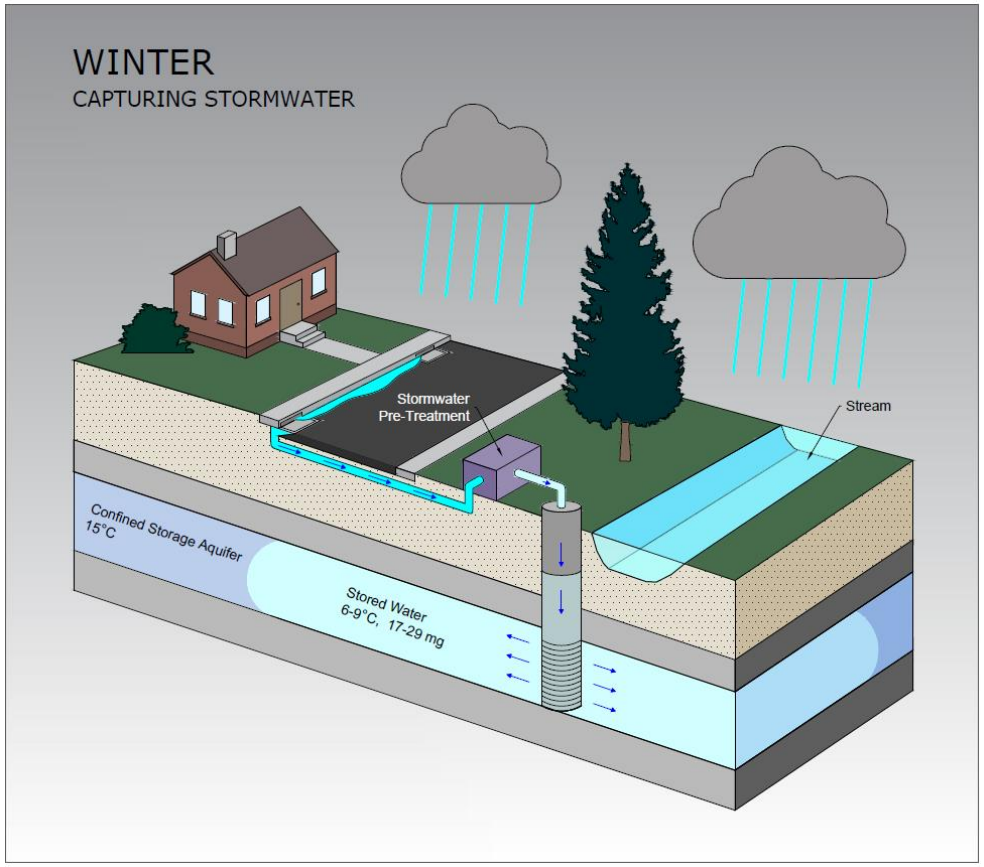
JWC Water Supply System: 75% of summer water
Aquifer Storage and Recovery (ASR): 25% summer water

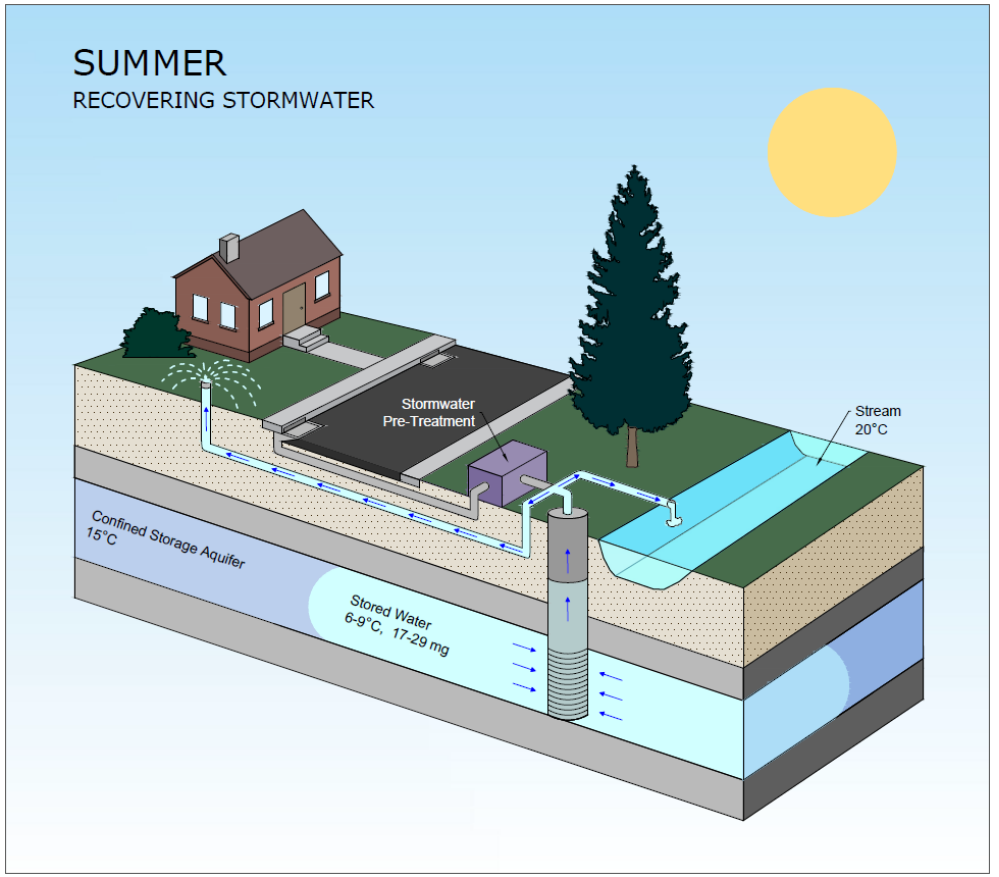




Stormwater to Augment Non-potable Supply

- City partnered with Clean Water Services to conduct a feasibility study with OWRD grant in 2016-2017
- Benefits of the concept:
  - Enhanced groundwater supply
  - Reduced stormwater runoff
  - Increase capacity to stormwater infrastructure
  - -- Mitigate flow and temperature issues to local streams
  - -- Reduce surface water demand





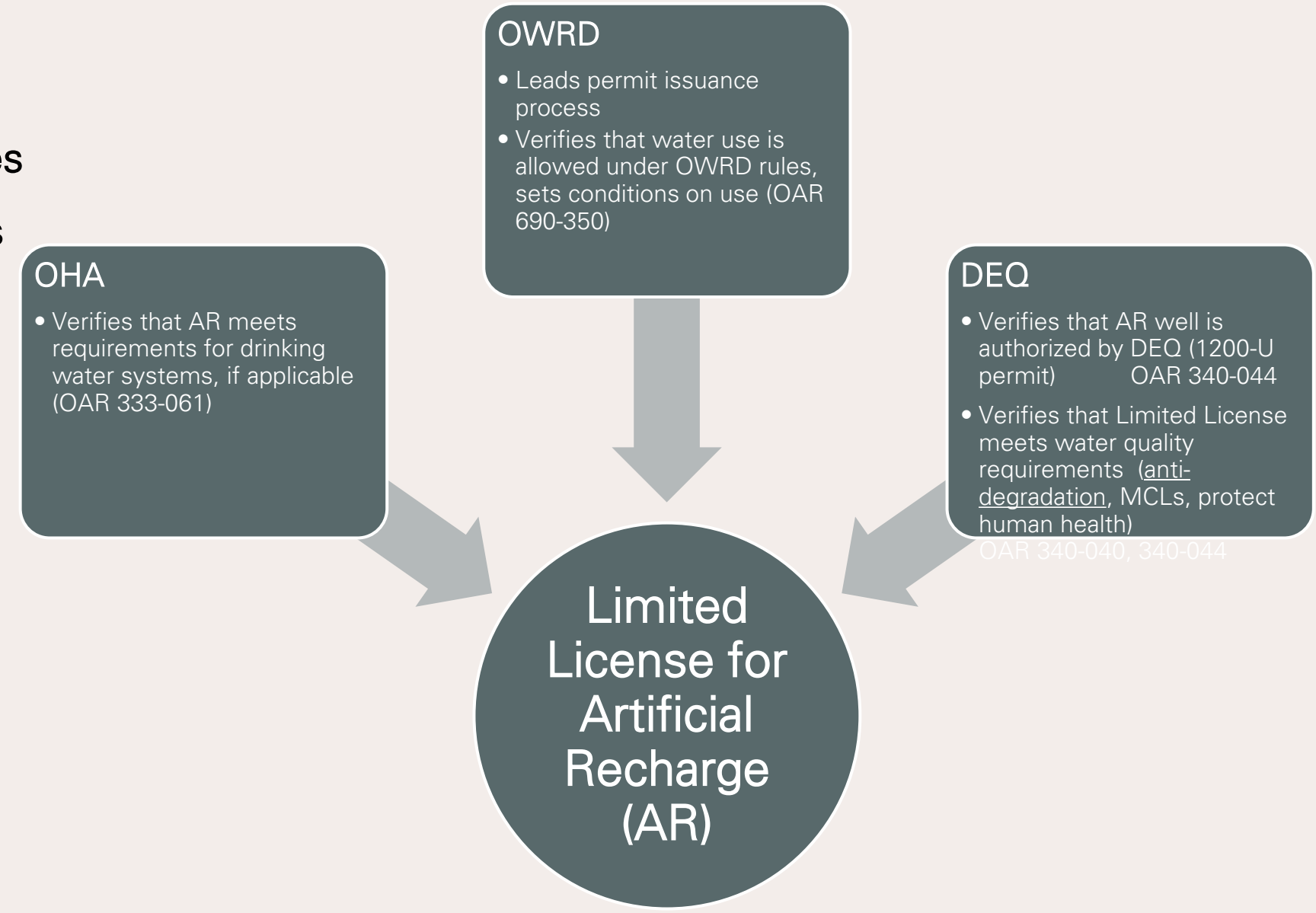
Project Permitting, Stormwater Quality & Quantity

State Regulatory Agencies

Oregon Water Resources Department (OWRD)

Oregon Health Authority (OHA)

Oregon Department of Environmental Quality (DEQ)



Stormwater Quality – Bacteriological, General Chemistry, and Metals COI's

Analyte Class	Analyte	Units	Concentrations		
			n-=	Sterling Park Stormwater Average Concentration	Background Groundwater
Bacteriological	Total Coliform	MPN/100 mL	25	>2420	< 1
Gen. Chem.	Turbidity	NTU	25	9.6	ND
	Nitrate + Nitrite	mg/L	20	0.27	ND
	Sulfate	mg/L	7	2.99	1.6
Metals	Manganese	ug/L	8	126	48
	Iron	ug/L	11	810	110
	Aluminum	ug/L	12	215	ND
	Zinc	ug/L	28	322	22

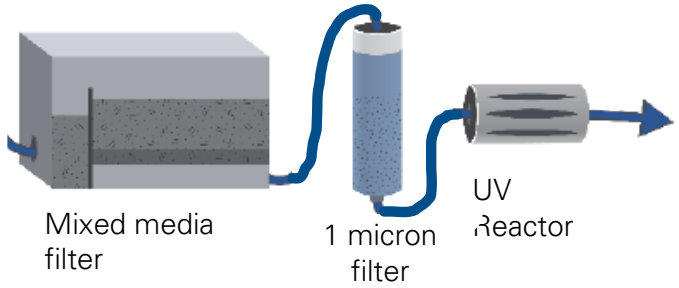
Stormwater Quality – Anthropogenic Compound COI's

Analyte Class	Analyte	Units	Concentrations		
			n=	Sterling Park Stormwater Average Concentration	Background Groundwater
PAHs	Di-n-octylphthalate	ug/L	20	0.85	ND
Pesticides	2,4-D	ug/L	9	1.32	ND
	Paraquat	ug/L	7	2.6	ND
	MCPP-p	ug/L	2	0.26	ND
	Diuron	ug/L	7	0.08	ND
	Triclopyr	ug/L	7	0.11	ND
PFAS/PFOA	PFHxA	ug/L	2	0.0035	ND
	PFOA	ug/L	2	0.0048	ND
	Perfluorononanoic acid	ug/L	2	0.0010	ND
	Perfluorodecanoic acid	ug/L	2	0.0012	ND
	PFOS	ug/L	2	0.0064	ND
Petroleum Hydro	Toluene	ug/L	23	0.88	ND

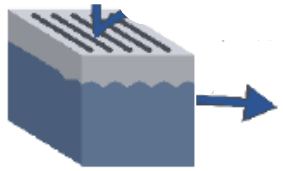
Stormwater Treatment Pilot/Bench Testing

Raw Stormwater
- Turbidity/TSS
- Microbiological
- Metals
- Synthetic Pesticides
- PAH's
- Petroleum Hydrocarbons
- PFAS/PFOA

A



Treated Effluent
- Turbidity/TSS
- Synthetic Pesticides
- PFAS/PFOA

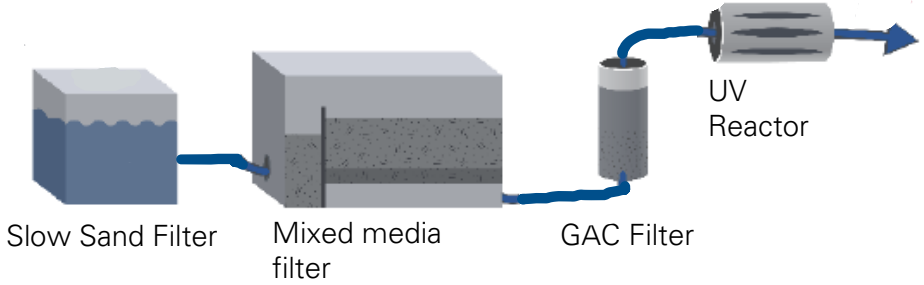


Treated Effluent
- PAH's
- Pesticides
- PFAS
- Metals

B

Treated Effluent
- PFAS/PFOA

C



Treated Effluent
- Below background

Water Quality – Bacteriological, General Chemistry, and Metals

NOTE: Table only shows analytes with concentrations in raw stormwater above background in native basalt groundwater

Analyte Class	Analyte	Units	Concentrations				
			Raw Stormwater Pilot Testing	Treated Stormwater Package System A	Treated Stormwater Coagulant/Pressure Filter/GAC B	Treated Stormwater SS/Package/GAC C	Background Groundwater
Bacteriological	Fecal Coliform	MPN/100 mL	> 2,420	< 1	< 1	< 1	< 1
Gen. Chem.	Nitrate + Nitrite	mg/L	0.26-0.46	0.32	0.21	0.28	ND
	Sulfate	mg/L	2.3-3.9	48	19	59	1.6
Metals	Manganese	ug/L	29-170	130	41	15	48
	Iron	ug/L	460-530	250	180	120	110
	Aluminum	ug/L	140-430	110	1100	330	ND
	Zinc	ug/L	130-690	29	130	ND	22

BLUE = Treatment reduces analyte concentration to below background
ORANGE = Treatment reduces analyte concentration, but not to below background
BLACK = Treatment raises analyte concentration, or analyte not significantly affected by treatment

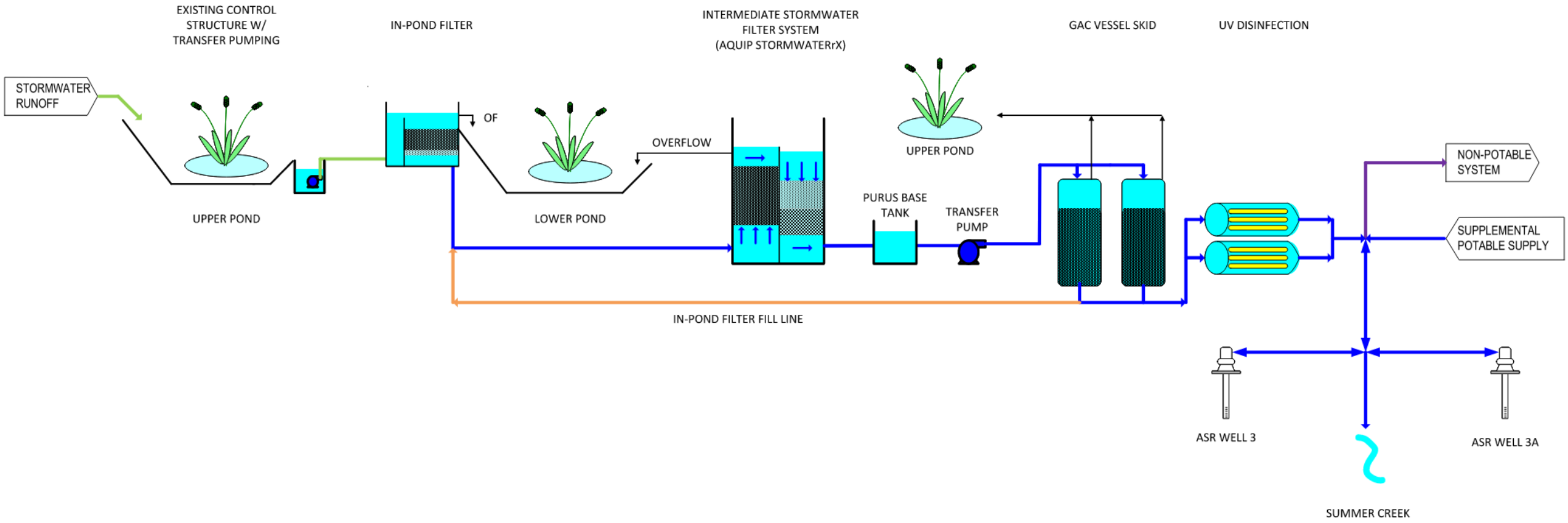
Water Quality – Anthropogenic Compounds

NOTE: Table only shows anthropogenic compounds that were detected in stormwater

Analyte Class	Analyte	Units	Concentrations				
			Raw Stormwater Pilot Testing	Treated Stormwater Package System A	Treated Stormwater Coagulant/Pressure Filter/GAC B	Treated Stormwater SS/Package/GAC C	Background Groundwater
PAHs	Di-n-octylphthalate	ug/L	ND-0.85	0.14	ND	ND	ND
Pesticides	2,4-D	ug/L	1.7-2	0.63	0.14	ND	ND
	Paraquat	ug/L	ND-2.6	ND	ND	ND	ND
	MCPP-p	ug/L	0.11-0.6	ND	ND	ND	ND
	Diuron	ug/L	ND-0.08	ND	ND	ND	ND
	Triclopyr	ug/L	0.094-0.13	0.087	ND	ND	ND
PFAS/PFOA	PFHxA	ug/L	0.0027-0.0046	0.0021	0.00355	ND	ND
	PFOA	ug/L	0.0045-0.0051	0.0031	0.0038	ND	ND
	Perfluorononanoic acid	ug/L	ND-0.002	ND	ND	ND	ND
	Perfluorodecanoic acid	ug/L	ND-0.0024	ND	ND	ND	ND
	PFOS	ug/L	0.0044-0.0093	0.0044	0.0044	ND	ND
Petroleum Hydro	Toluene	ug/L	ND-0.88	ND	ND	ND	ND

BLUE = Treatment reduces analyte concentration to below background
ORANGE = Treatment reduces analyte concentration, but not to below background
BLACK = Treatment raises analyte concentration, or analyte not significantly affected by treatment

Sterling Park
Stormwater Treatment
Process Flow



consor

Rendering of Sterling Park ASR 3 Pump Station and Stormwater Treatment Facility

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O&M - Sterling Park ASR 3 Pump Station and Stormwater Treatment Facility

Slow Sand Filter
- Seasonal Schmutzdecke removal
- 10 Years – Replace Media

AQUIP Filter
- Seasonal Media Removal
- 3-6 Years – Replace Media

GAC
- Backwash
- Annual Media Replacement

UV
- Monitor Performance
- Bulb Replacement

Chlorination System
- Brine Tank Filling
- Monitor Performance

Water Quality & Instruments
- Monitor Performance
- Periodic Grab Samples

Wells & ASR Valves
- Monitor Performance

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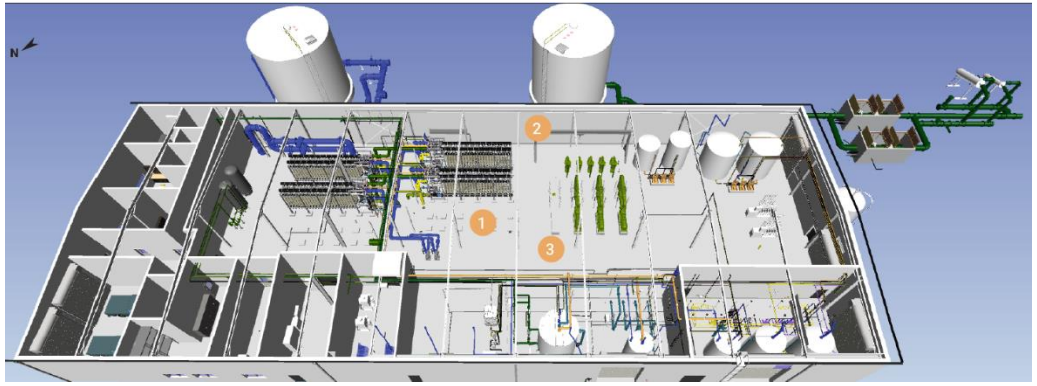
City of Othello Regional Water Supply:

Source Development & ASR

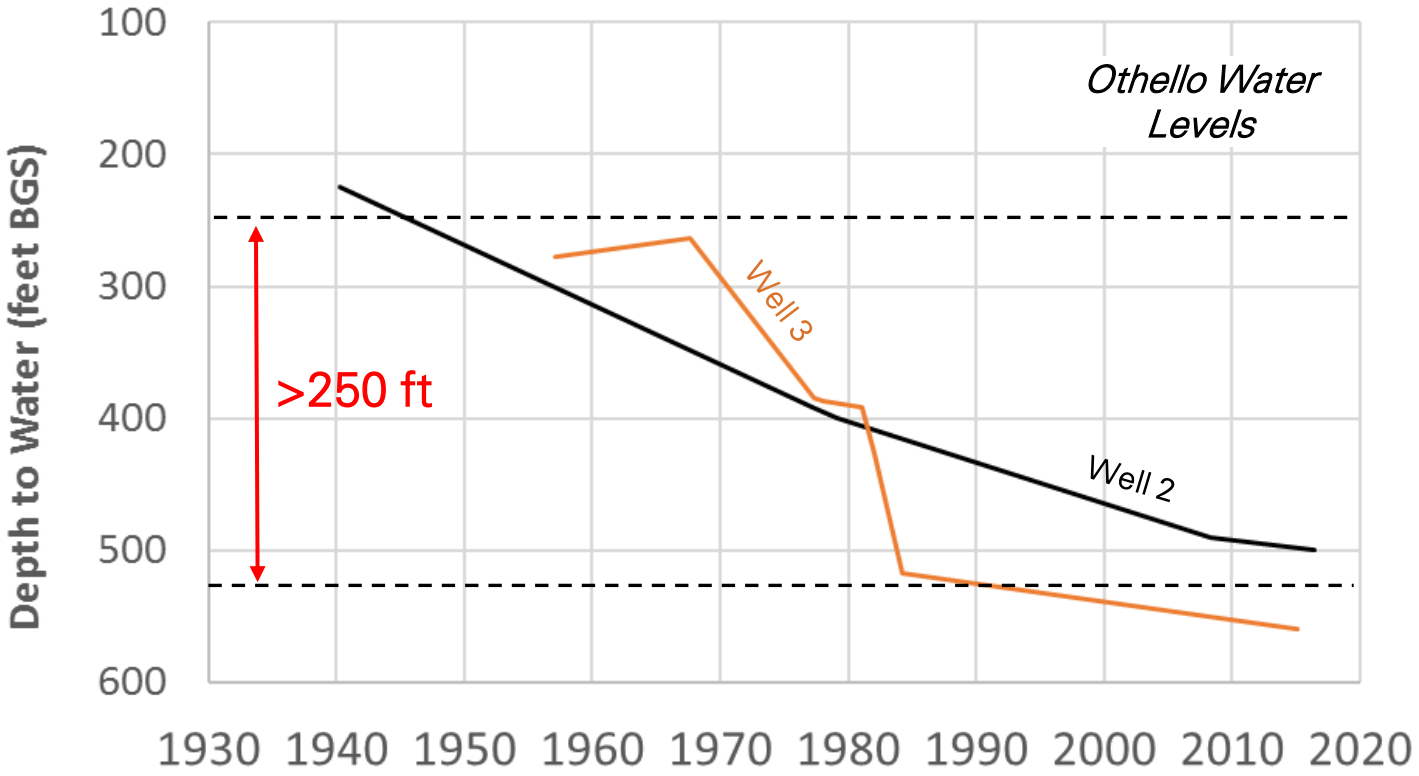


CITY OF OTHELLO ESTABLISHED 1910

Aspect CONSULTING

Regional Water Supply Needs

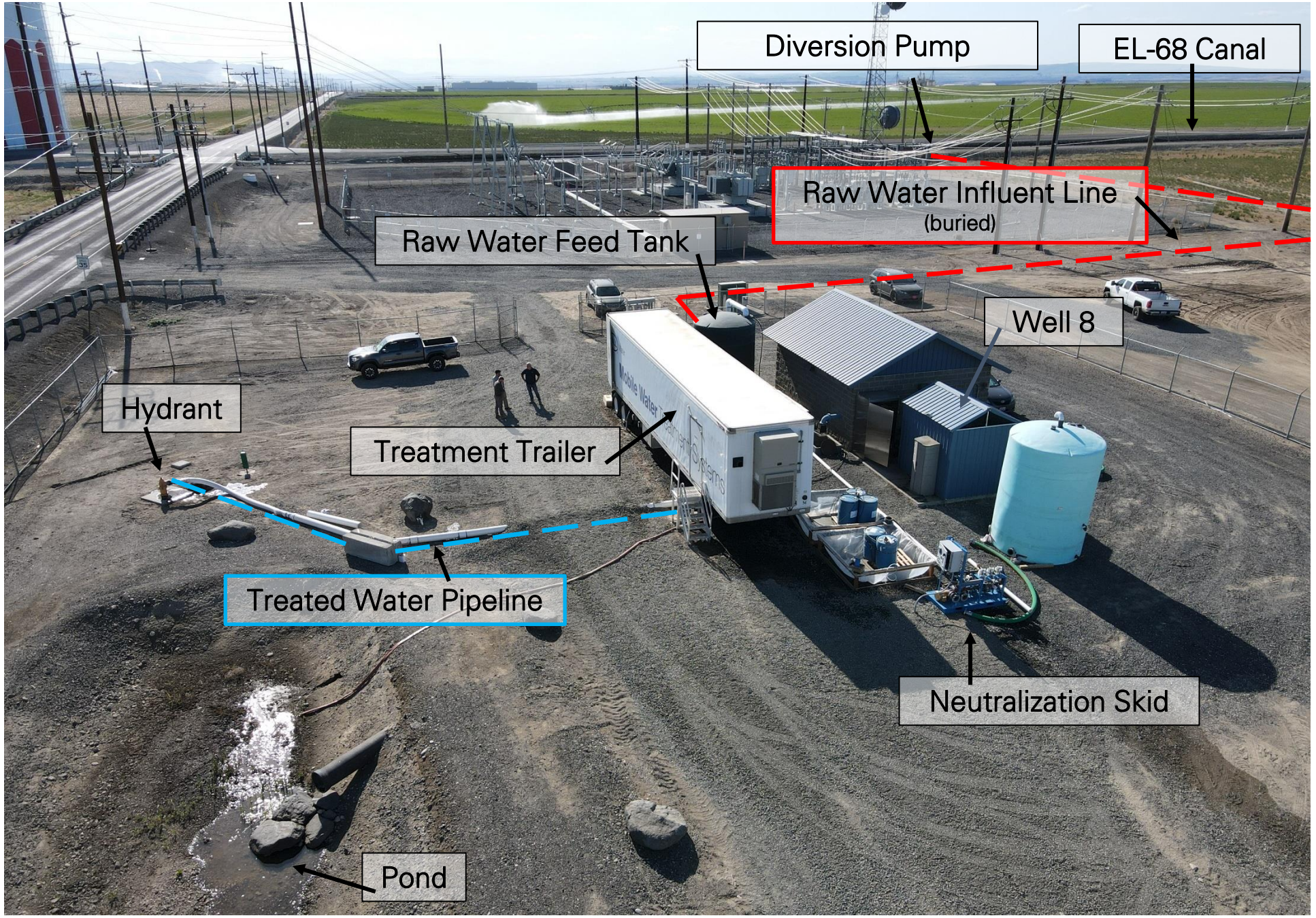
- Groundwater Declining throughout the Columbia Basin
- Ag and Other Users Need Surface Water for Sustainability
- OCR Implementing Source Exchange *(Odessa GW Replacement)*
- Municipalities Also Impacted by GW Depletion



New Source to Augment Groundwater

Irrigation Canals Have Seasonal Capacity

- 8,500 afy of M&I water available
- Either canal could supply up to 12 MGD (May – Oct)
- Water is High Quality
- ASR Extends Benefits to Year-round


Diversion Pump
EL-68 Canal
Raw Water Influent Line
(buried)
Raw Water Feed Tank
Well 8
Hydrant
Treatment Trailer
Treated Water Pipeline
Neutralization Skid
Pond

Pilot Testing Results

Table 1. Calculation Variables (P_{test})

Item	Description	Unit	Value
P_{test}	Test pressure for required resolution	psi	17.47
k	Shape correction factor	dimensionless	1
σ	Surface tension of water @ 5 °C	dynes/cm	74.97
θ	Water contact angle of membrane medium	degree	0.00
BP_{max}	Sum of backpressure and static head	psid	3.00

Since the testing pressure to be used is 25 psi or above and the pressure decay is anticipated lower than 1 psi during the duration of the test for Pall MF system, the resolution criterion is satisfied.

Membrane Removal LRV >4 for 3- micron and Larger in Daily Calculations

Direct Integrity Test – All Passed

Summary Water Quality Sampling

Table 1 - Water Quality Results for Groundwater, Treated Recharge, and Storage

Project #140207 - City of Othello ASR Phase 2 Pilot Testing

Analyte Group	Parameter (unit)	Ambient Well 8 5/10/2021	Treated Recharge 10/19/2021	Storage 4/5/2022	MCL / SMCL	Groundwater Standard (WAC 173-200)
Total Metals	Aluminum (ug/L)	4.5	4.2	7.6	200	--
	Antimony (ug/L)	<0.050	0.118	0.066	6	--
	Arsenic (ug/L)	*0.61*	*0.74*	<0.50	10	0.05
	Barium (ug/L)	21.5	32.8	27.1	2000	1000
	Beryllium (ug/L)	<0.020	<0.020	<0.020	4	--
	Cadmium (ug/L)	<0.020	<0.020	<0.020	5	10
	Calcium (mg/l)	2.49	20.0	7.7	--	--
	Chromium (ug/L)	<0.20	<0.20	0.2	100	50
	Copper (ug/L)	51.50	3.01	1.20	1300	1000
	Iron (ug/L)	57	3.5	30.4	300	300
	Lead (ug/L)	1.970	0.167	0.793	15	50
	Magnesium (mg/l)	0.86	4.66	2.31	--	--
	Manganese (ug/L)	10.6	0.78	7.37	50	50
	Mercury (ug/L)	<0.20	<0.20	<0.20	2	2
	Nickel (ug/L)	<0.20	<0.20	<0.20	--	--
	Potassium (mg/l)	13.1	0.83	10.50	--	--
	Selenium (ug/L)	<1.0	<1.0	<1.0	50	10
	Silica (mg/l as SiO2)	61.1	4.6	41.6	--	--
	Silver (ug/L)	<0.020	<0.020	<0.020	100	50
	Sodium (mg/l)	75.5	2.19	54.10	--	--
	Thallium (ug/L)	<0.020	<0.020	<0.020	2	--

Summary of Water Quality

Table 1 - Water Quality Results for Groundwater, Treated Recharge, and Storage

Project #140207 - City of Othello ASR Phase 2 Pilot Testing

Analyte Group	Parameter (unit)	Ambient Well 8 5/10/2021	Treated Recharge 10/19/2021	Storage 4/5/2022	MCL / SMCL	Groundwater Standard (WAC 173-200)
Conventionals	Alkalinity (mg/l CaCO3)	138	64.2	116[1]	--	--
	Bicarbonate (mg/l)	132	64	113[1]	--	--
	Bromide (mg/L)	0.15	<0.10	<0.10[1]	--	--
	Chloride (mg/l)	12.300	1.00	9.83[1]	250	250
	Fluoride (mg/l)	2.54	<0.20	1.3[1]	4	4
	Nitrate/Nitrite (mg/l as N)	<0.050	<0.050	<0.050[1]	10	10
	Phosphorus (mg/l as P)	0.047	<0.020	0.027[1]	--	--
	Sulfate (mg/l)	29.00	9.79	24.1[1]	250	250
	Total Organic Carbon (mg/L)	0.60	1.30	0.6[1]	--	--
	Total Suspended Solids (mg/L)	36	<5.0	7.5[1]	--	--
	Total dissolved solids (mg/l)	271	77.3	209[1]	500	--
Field Parameters	Dissolved Oxygen	6.49	10.74	2.41	--	--
	pH (std units)	8.09	7.45	8.32	--	--
	Specific conductance (uS/cm @25C)	556	243.1	160	700	--
	Temperature, water (deg C)	24.4	11.7	20.7	--	--
	Turbidity (NTU)	3.73	1.03	--		
Bacteria	E. Coli	ABSENT	ABSENT	ABSENT[2]	1	--
	Total Coliform	ABSENT	ABSENT	PRESENT[2]	--	1

Notes:
mg/l = milligrams per liter
ug/L = micrograms per liter
MCL = maximum contaminant level
SMCL = secondary maximum contaminant level
Results reported to Reporting Detection Limit (RDL)
Bold font indicates results exceeding MCL/SMCL
Italic font indicates results exceeding WAC 273-200 Groundwater Standard
1 Results from most recent sample not yet available. Those shown are from 3/8/2022
[2] Bacteria not reanalyzed since 11/17 at beginning of storage. City will resample for coliforms before well startup

Sampling Results

VOC Analyte List

No SVOCs,VOCs, Herbicides, or Pesticides Detected During Pilot Test

Table 2. Summary of Bacteria Monitoring Results DRAFT

Project #140207 - City of Othello Phase 2 Pilot Testing

City of Othello ASR Demonstration-Scale Test: Summary of Bacteria Monitoring

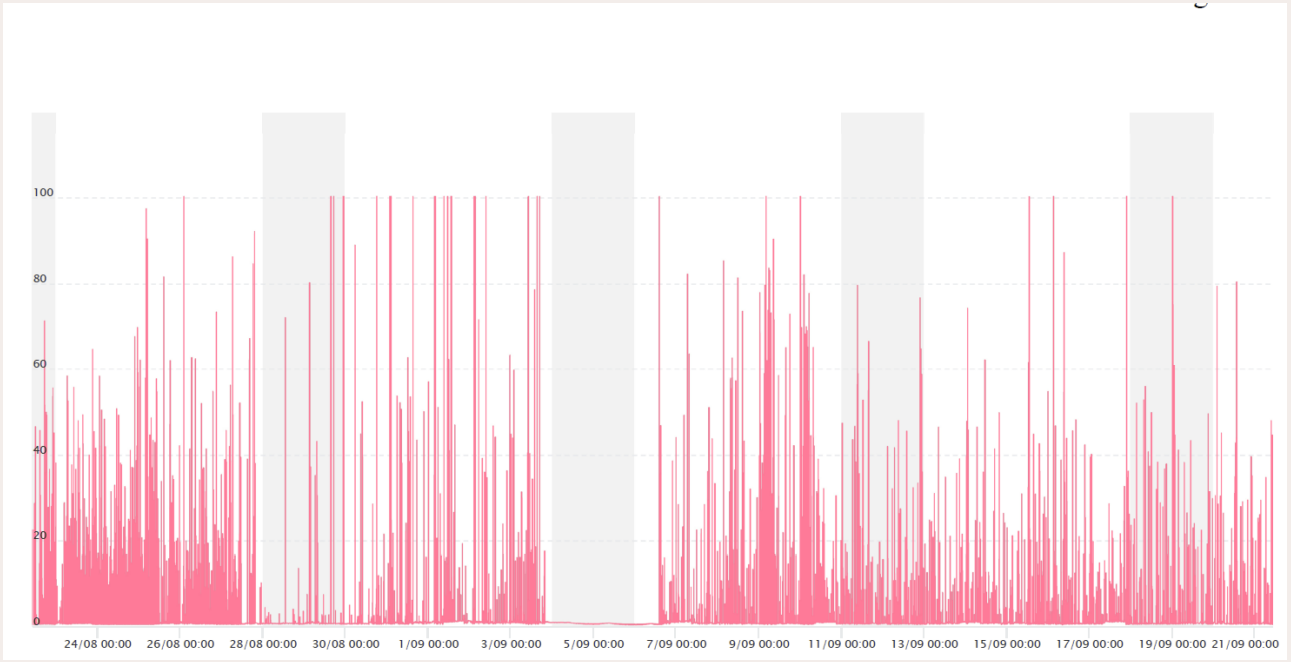
	Raw Water		*Treated Water*		*Well 8*	
Sample Date	Total Coliform	E. Coli	Total Coliform	E. Coli	Total Coliform	E. Coli
Pre-Recharge (background)						
5/10/2021	--	--	--	--	Present	Absent
Recharge						
5/12/2021[1]	Present	Present	Absent	Absent	--	--
5/17/2021			<1 MPN/100mL	<1 MPN/100mL		
5/25/2021	--	--	Absent	Absent	--	--
6/10/2021	Present	Present	Absent	Absent	--	--
7/6/2021	--	--	Absent	Absent	--	--
8/10/2021	488 MPN/100 mL[2]	8.5 MPN/100 mL	--	--	--	--
8/19/2021	Present	Present	Absent	Absent	--	--
10/19/2021	Present	Present	Absent	Absent	--	--
Storage Phase						
11/16/2021	--	--	--	--	Present	Absent
11/29/2021	--	--	--	--	Absent	Absent
2/8/2022	--	--	--	--	Absent	Absent
5/3/2022	--	--	--	--	<1 MPN/100mL	<1 MPN/100mL
7/20/2022					<1 MPN/100mL	<1 MPN/100mL
Recovery Phase						
7/13/2023					Absent	Absent
7/13/2023					Absent	Absent
7/13/2023					<5 MPN/100mL	<5 MPN/100mL

1. Samples collected in advance of initiating full-scale recharge. Treated sample collected on 5/13/21
2. Count is for Fecal Coliform

Othello Water Quality Challenges

OTHELLO RAW WATER TURBIDITY, NTU

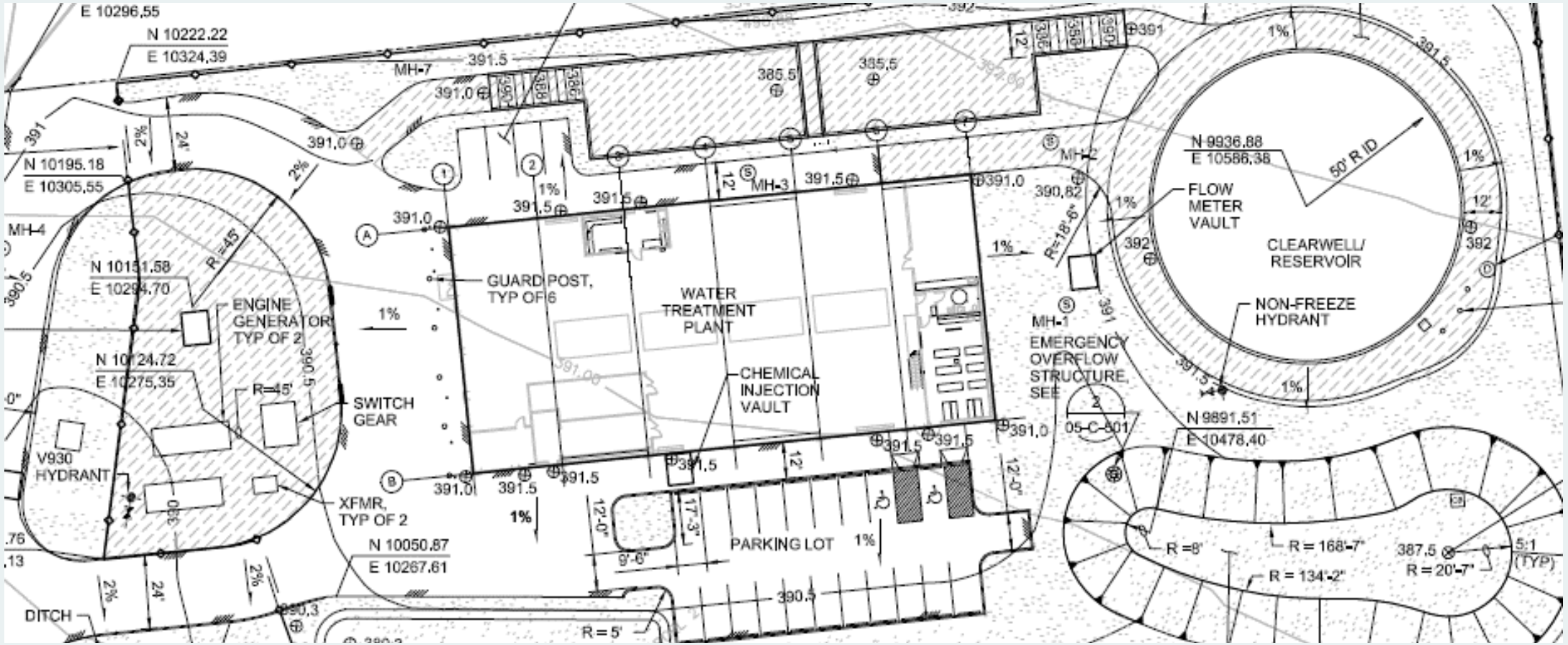
100 NTU



DATE AND TIME

- Wind Causes Large Turbidity Spikes
- Potential Algae in Canals
- Potential for Spills

Predesign - 2024

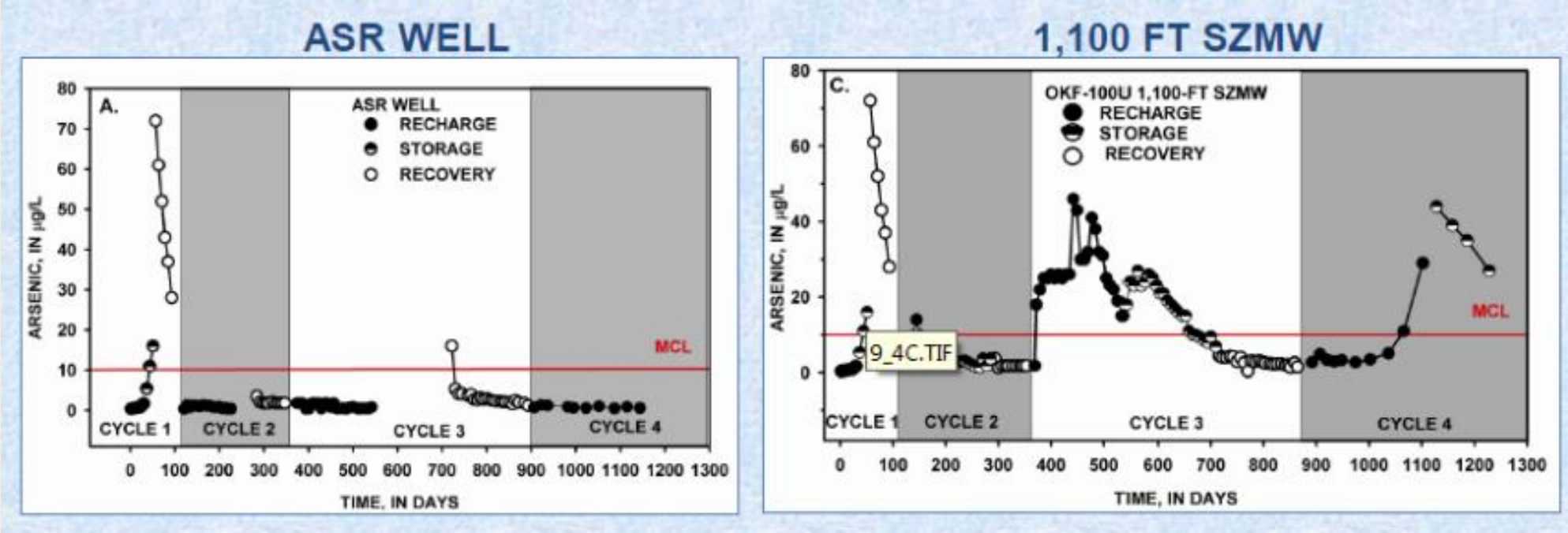


Thank you

Lee Odell, PE

Lee.odell@consoreng.com

ASR Arsenic Release



Arsenic release occurred in Cycle 1 in ASR well, subsequent cycles did not show release.

Arsenic concentrations in 1,100’ monitoring well showed attenuation during storage period

Attenuation trends occurred in Cycles 3 and 4

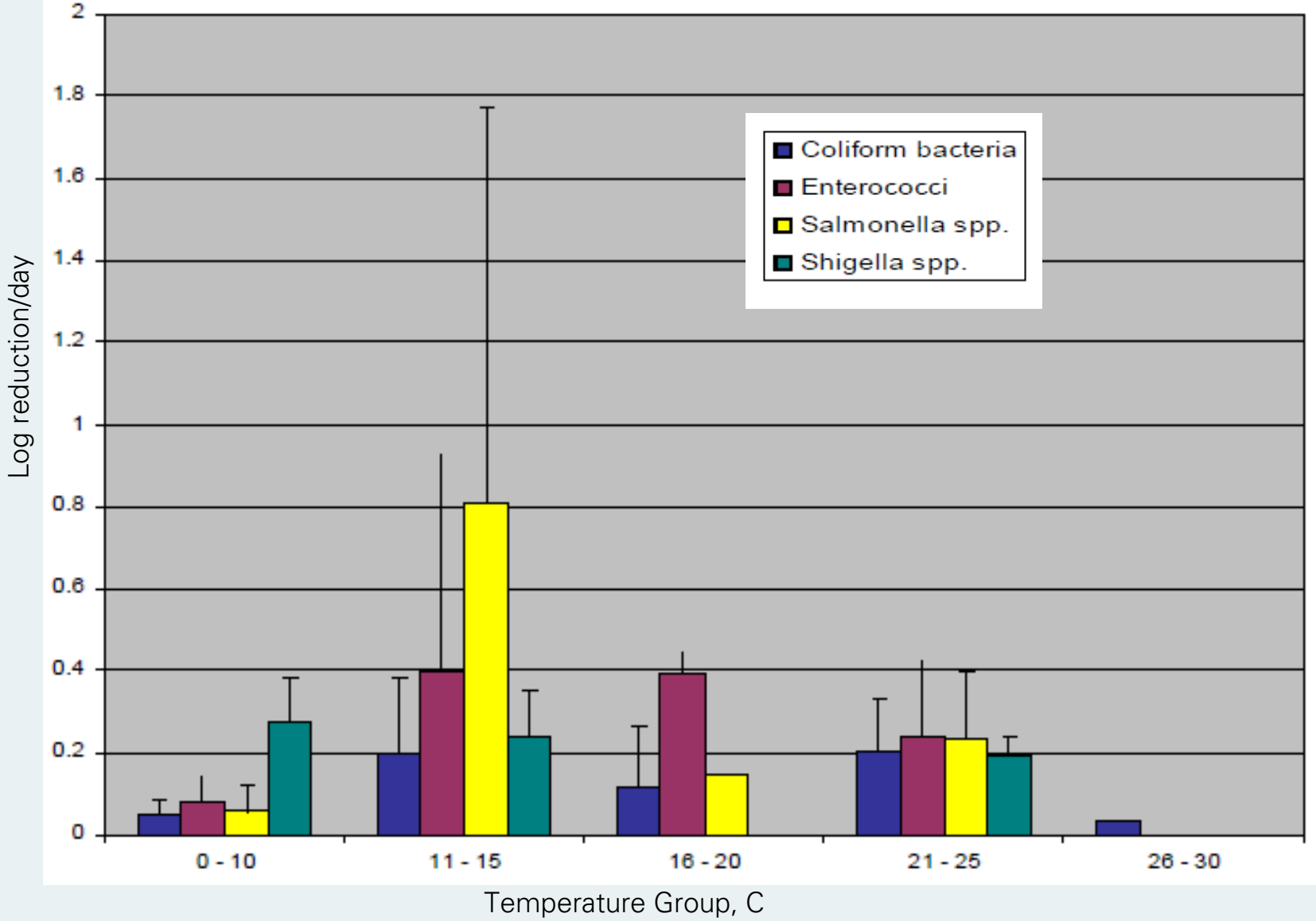
Kissimmee River ASR Cycle Testing, US COE, 2009 – 2013

June Mirecki, PhD, Jacksonville District

ASR Microbial Fate and Transport
(Joan B. Rose and David E. Johns, University of South Florida, 2002)

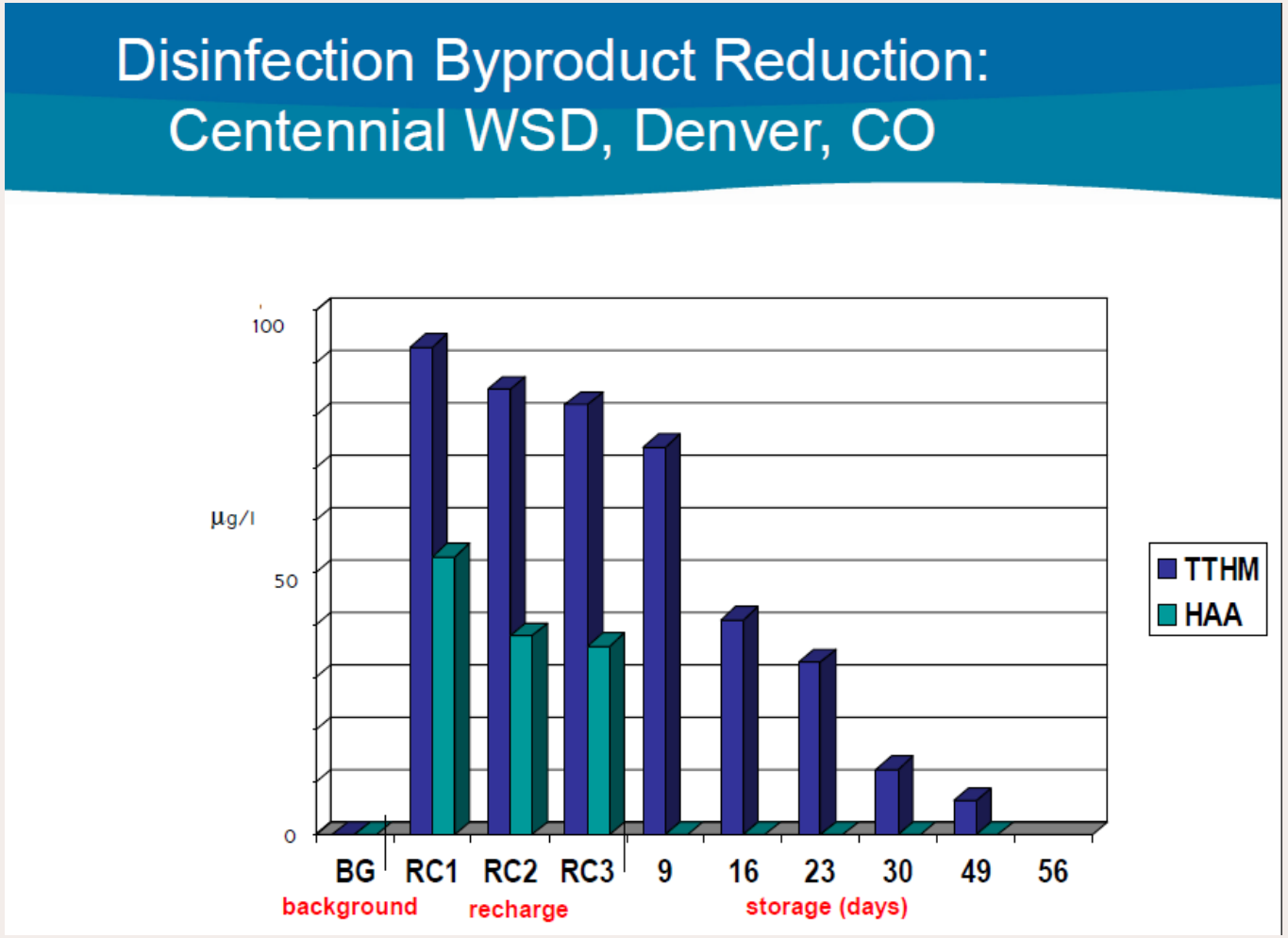
Bacterial Log Reductions in Recovered Groundwater,

(Per day by Temperature Group)



ASR Disinfection By-Products

Water Research Foundation, Aquifer Storage and Recovery of Treated Drinking Water, 1996 Results shown for Centennial Water and Sewer District, CO



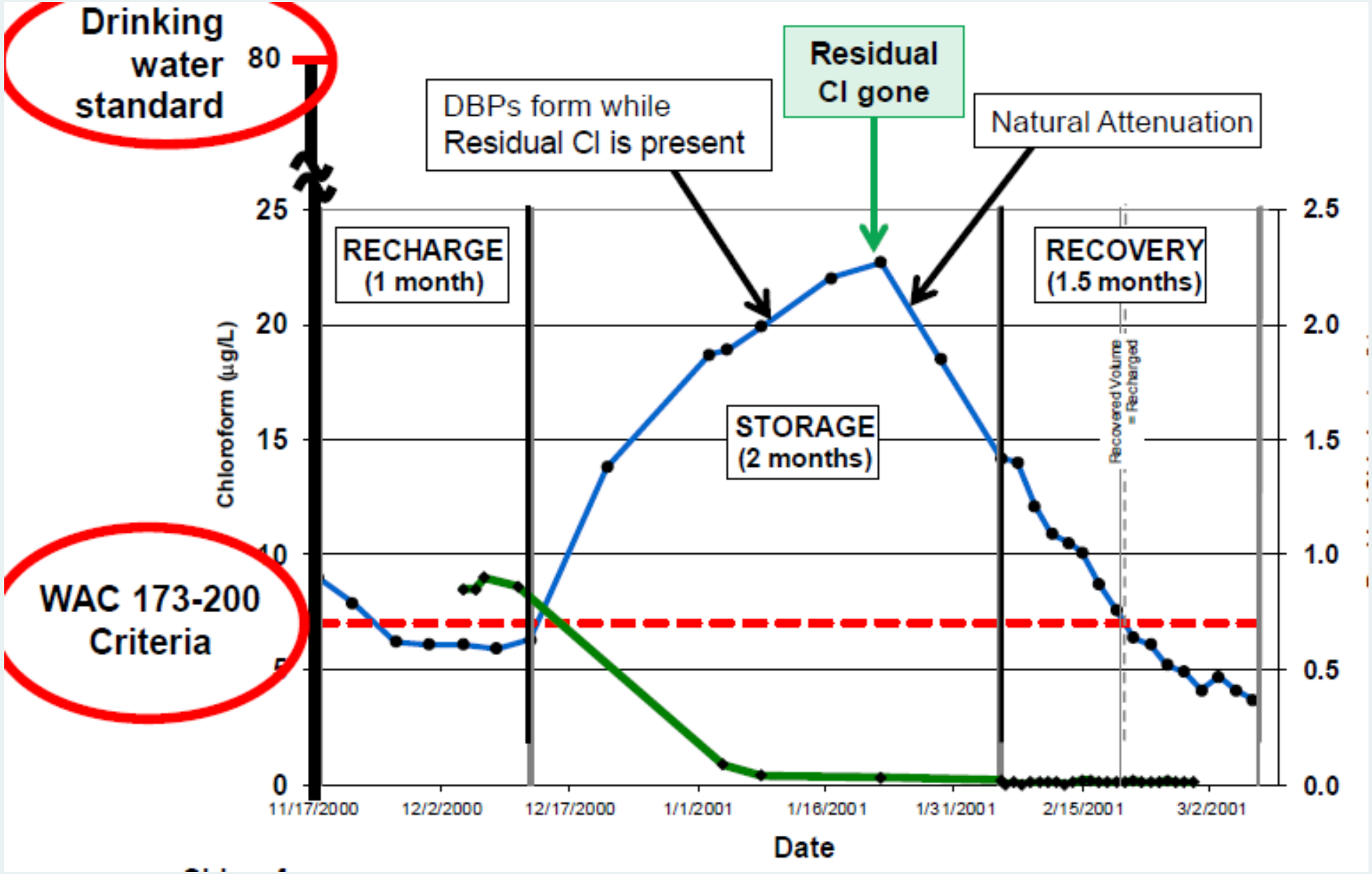
Early studies showed attenuation of DBPs

Reduction of THMs may take significant amounts of time and certainly varies from place to place

More of a concern for single injection/recovery systems with Short Storage periods

ASR Disinfection By Products -
Jason Pulley, City of Salem, THM Concentrations and Cumulative Storage Volume

ASR – Disinfection By Products
City of Yakima ASR Project – Chris Pitrie,, 2013 PNWS AWWA Conference



ASR Mixing Zone Requirements
Larry Eaton & Jason Melady,, City of Cornelius ASR Project, 2015