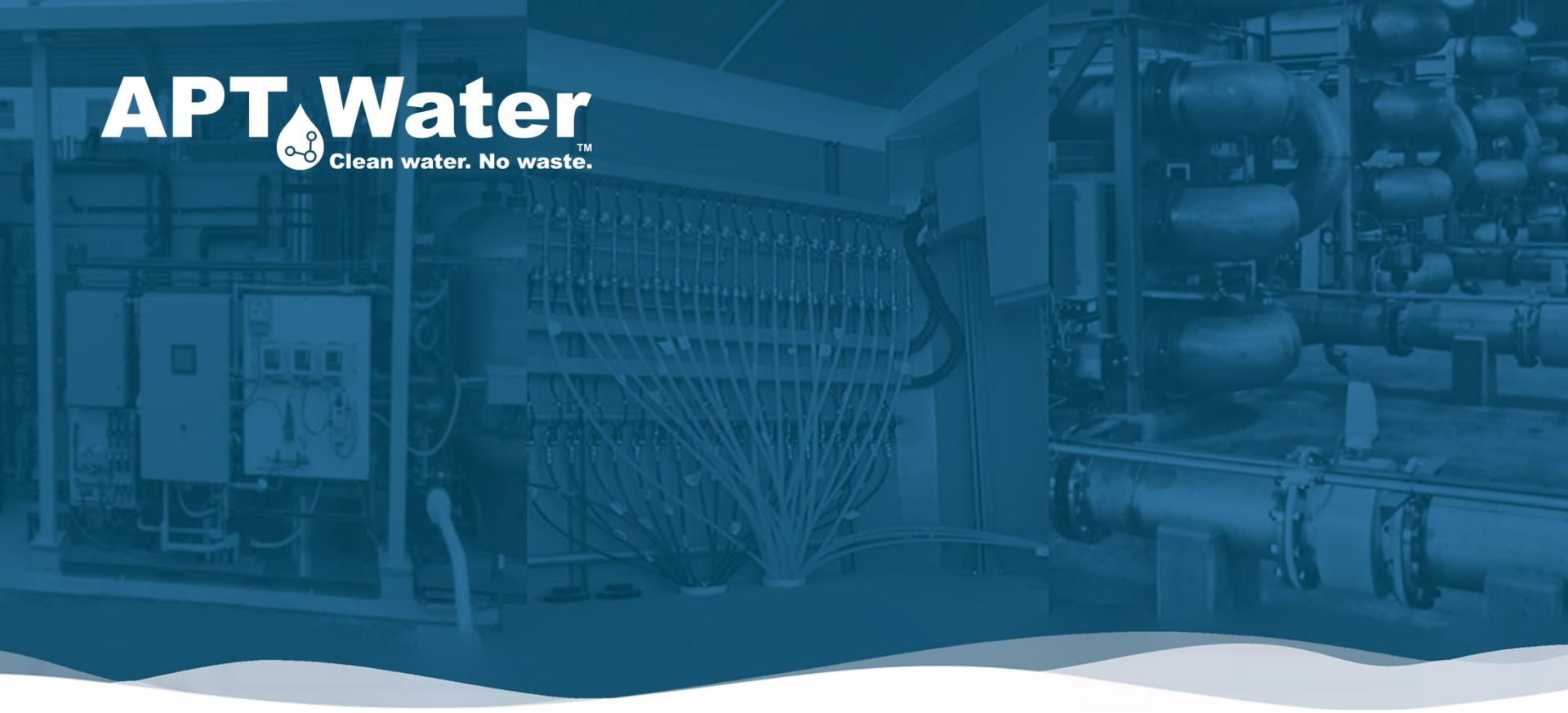


WATER REUSE – HIPOX ADVANCED OXIDATION PROCESS

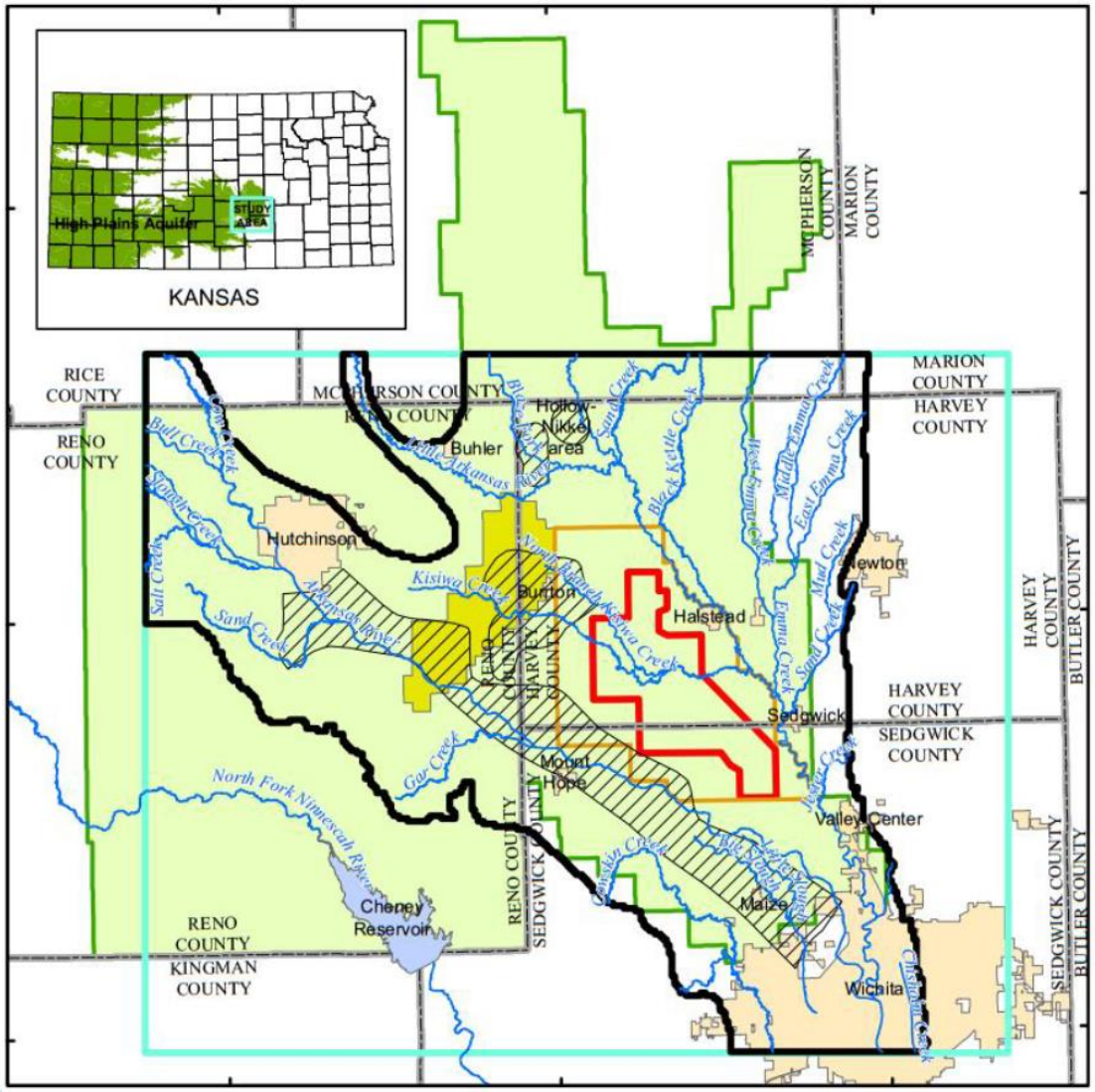
HOW THE CITY OF WICHITA CONQUERED ELEVATED ATRAZINE, VIRUSES, TOC & TURBIDITY WITH CONTROLLED BROMATE FORMATION TO SUCCESSFULLY RECHARGE GROUNDWATER

Scott A. Miller, P.E., Chief Executive Officer

Wichita ASR and Location

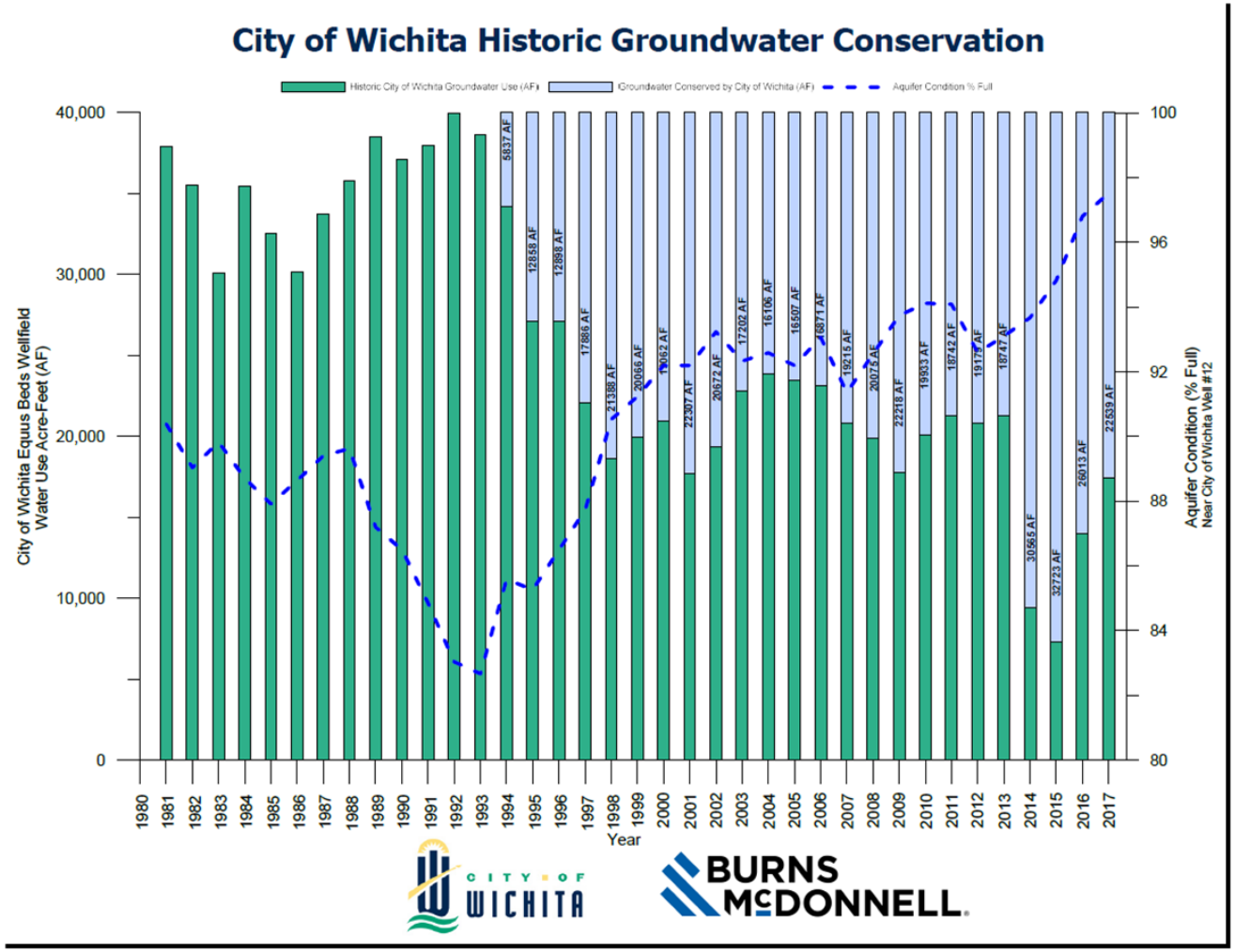
Integrated Local Water Supply (ILWS) Plan for City of Wichita

- Aquifer Storage Recovery (ASR) Program
- Use surplus flows from the Little Arkansas River (LAR)
- Prevent chloride brine infiltration
- Recharge the 125 square mile Equus Beds Aquifer
- Divert and recharge 100 million gallons per day (mgd)



Why Wichita Water ASR?

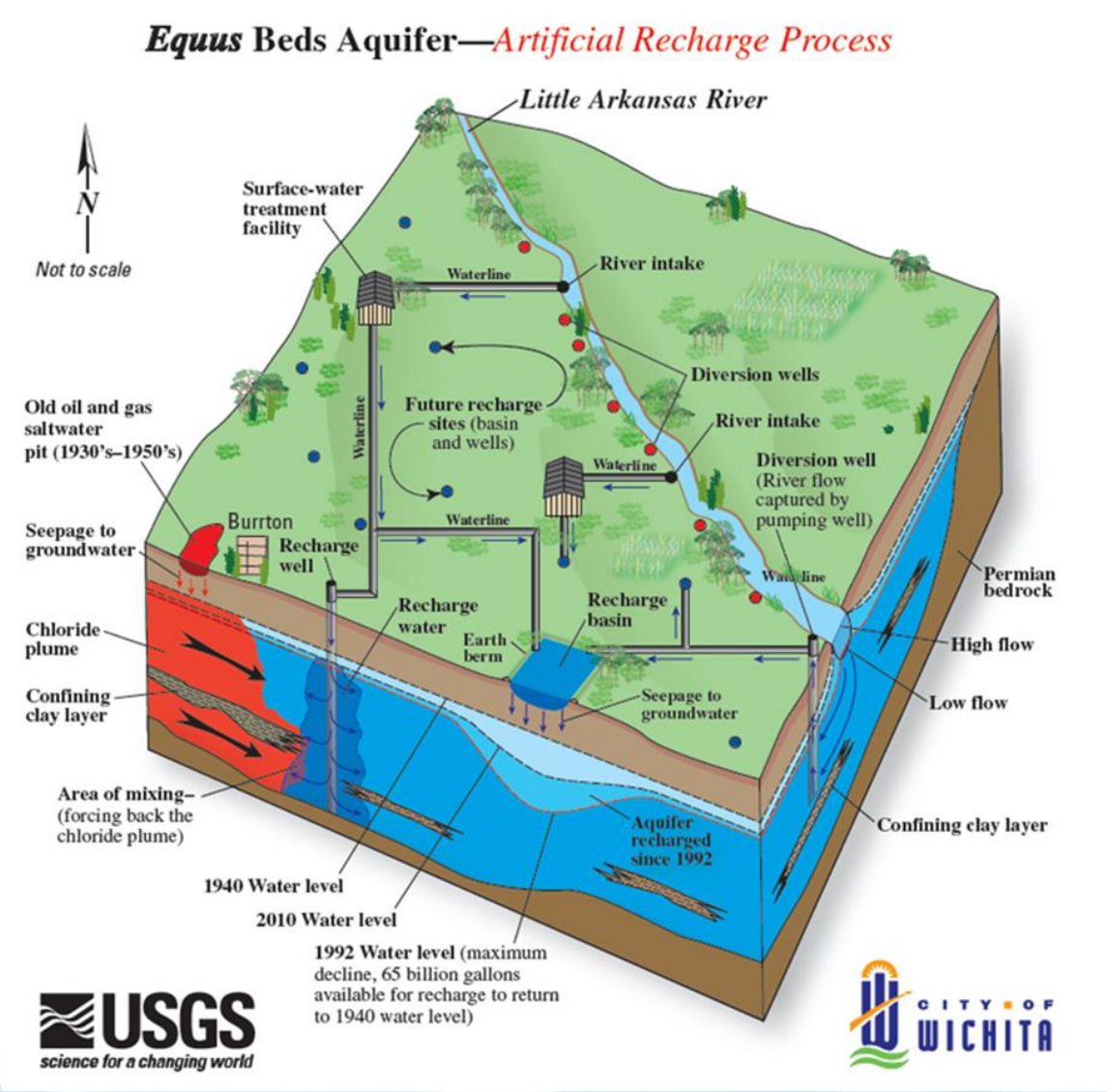
- Water levels in EB Aquifer dropped 40 feet to historic lows in 1993
- Pumping rates continued to exceed recharge
- EB Aquifer had become vulnerable to saltwater intrusion



Why Wichita Water ASR?

Phase I facilities constructed to divert and recharge up to 10 mgd of surface water from the Little Arkansas River to create a hydraulic barrier to prevent migration of a brine plume into the northwestern region of the Equus Beds Aquifer.

The **Phase II Program** and facility was to build an additional 30 mgd of surface water diversion and recharge capacity into the Equus Beds Aquifer during rain events.



ASR Phase II SWTF Treatment Targets

The Little Arkansas River water has highly variable water quality characteristics. The Phase II Surface Water Treatment facility (SWTF) would be designed to;

- remove suspended solids in water due to significant rain events,
- destroy atrazine, a chlorinated herbicide applied as preemergent control of weeds on corn fields, below the Primary Drinking Water Standard (PDWS) of 3 µg/L to a target value of 2 µg/L,
- limit bromate formation to less than the PDWS of 10 µg/L in the presence of raw water bromide concentrations up to 340 µg/L of bromide, and
- achieve a minimum 5.4-log inactivation of MS-2 microphage, which corresponds to 4-log polio-virus inactivation4-log virus inactivation.

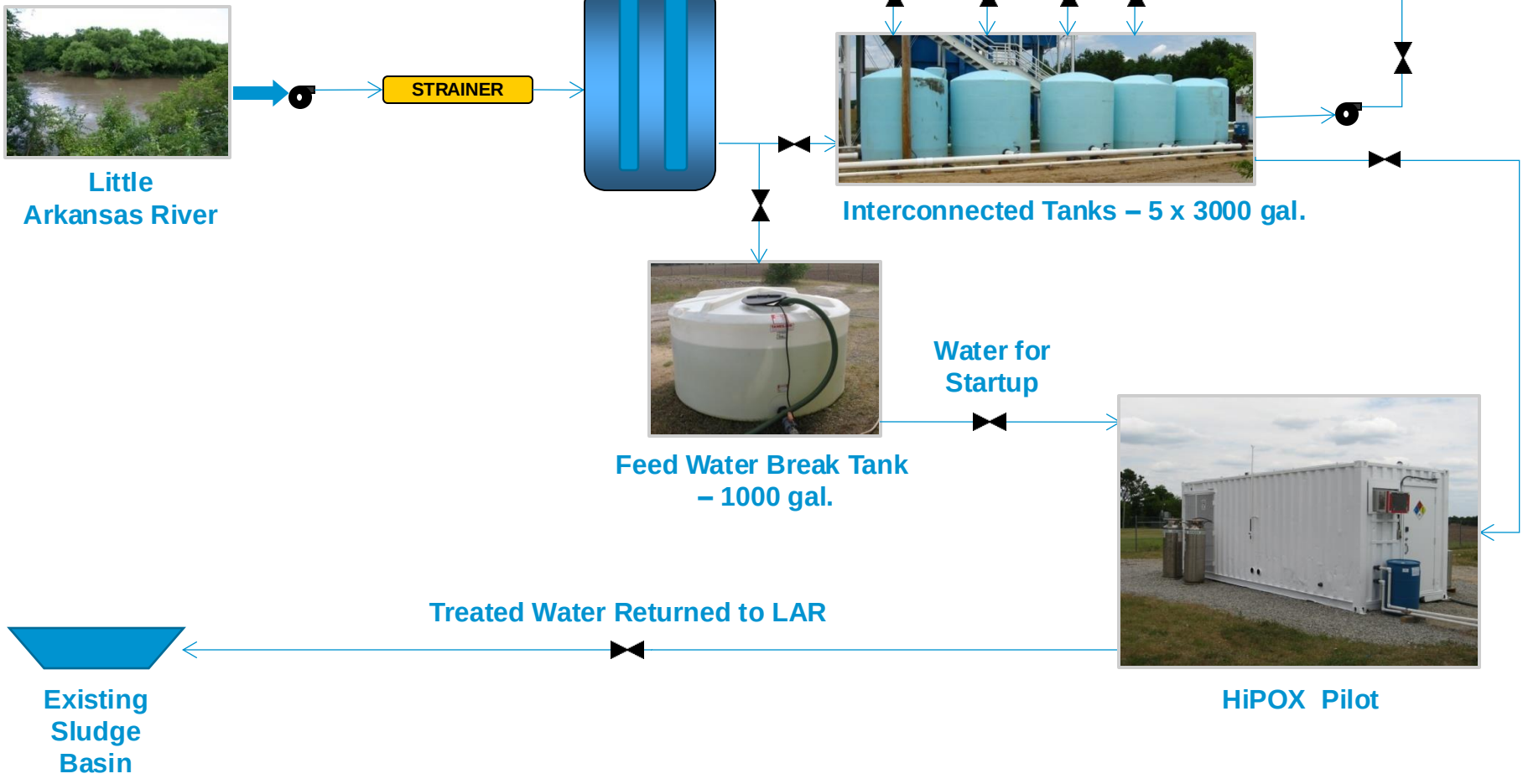
Phase II Treatment Options Evaluation

Option #1 - **Powder activated carbon (PAC) slurry injection** - Based on data collected, there wasn't convincing evidence that PAC would successfully reduce atrazine to the MCL value of 3 ug/L.

Option #2 – **Ozone/peroxide AOP** – proven technology to achieve the twin goals of atrazine reduction and bromate formation control in AOP mode. Virus inactivation using hydroxyl radical formation in the HiPOx® proprietary AOP system was a secondary beneficial outcome.

(The HiPOx® system had previously been proven to achieve California Title 22 reuse certification.)

HiPOx Pilot Plant Setup

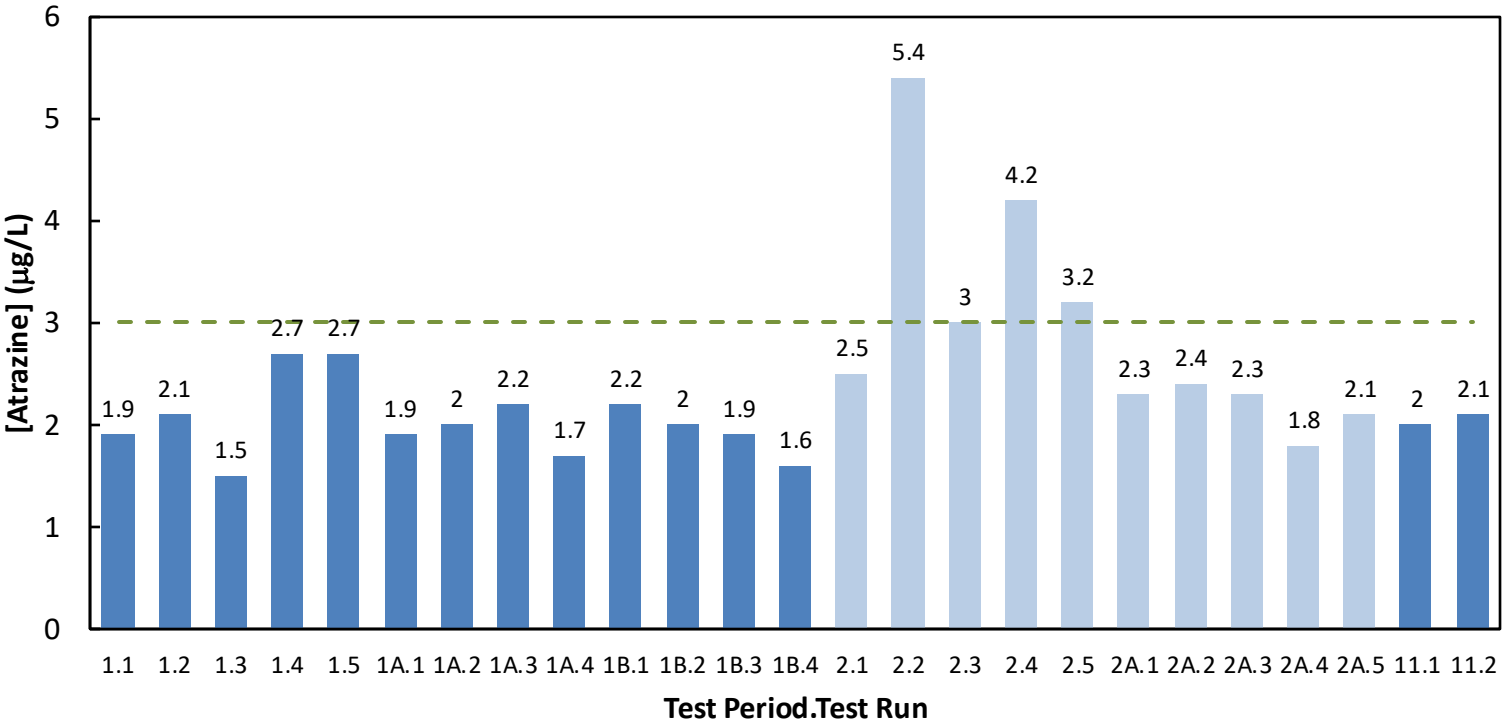


HiPOx Pilot Test Matrix

- 79 test runs
- Over 500 analyses
- Critical test runs performed in triplicate
- Specific analyses performed in duplicate with others in triplicate
- Reactor conditions tested with ozone dose set at 15 mg/L
  - Various H2O2:O3 mole ratios tested
  - Various number of O3 injectors tested

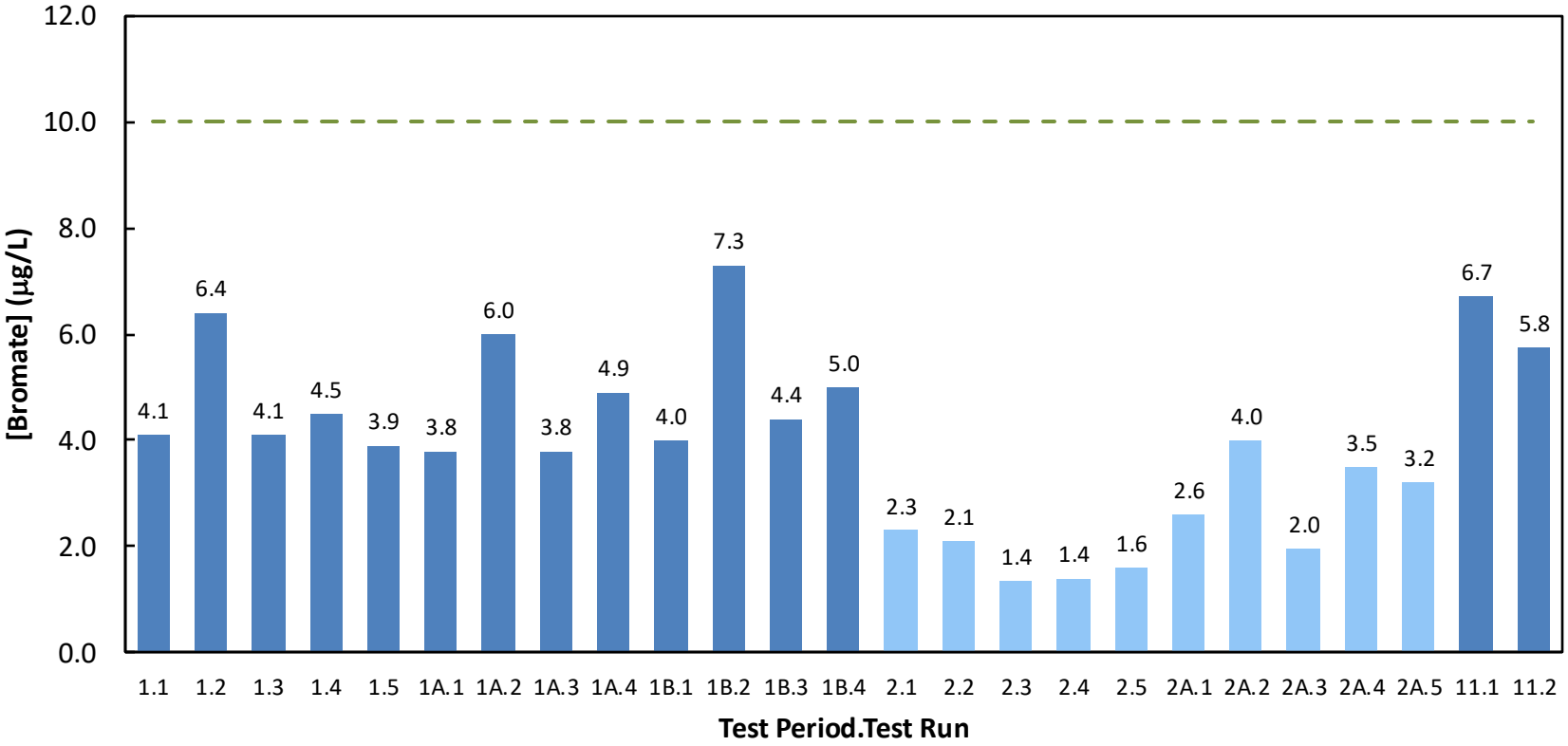
HiPOx Pilot Test Results

Atrazine in effluent almost always below MCL for ozone dose of 15 mg/L



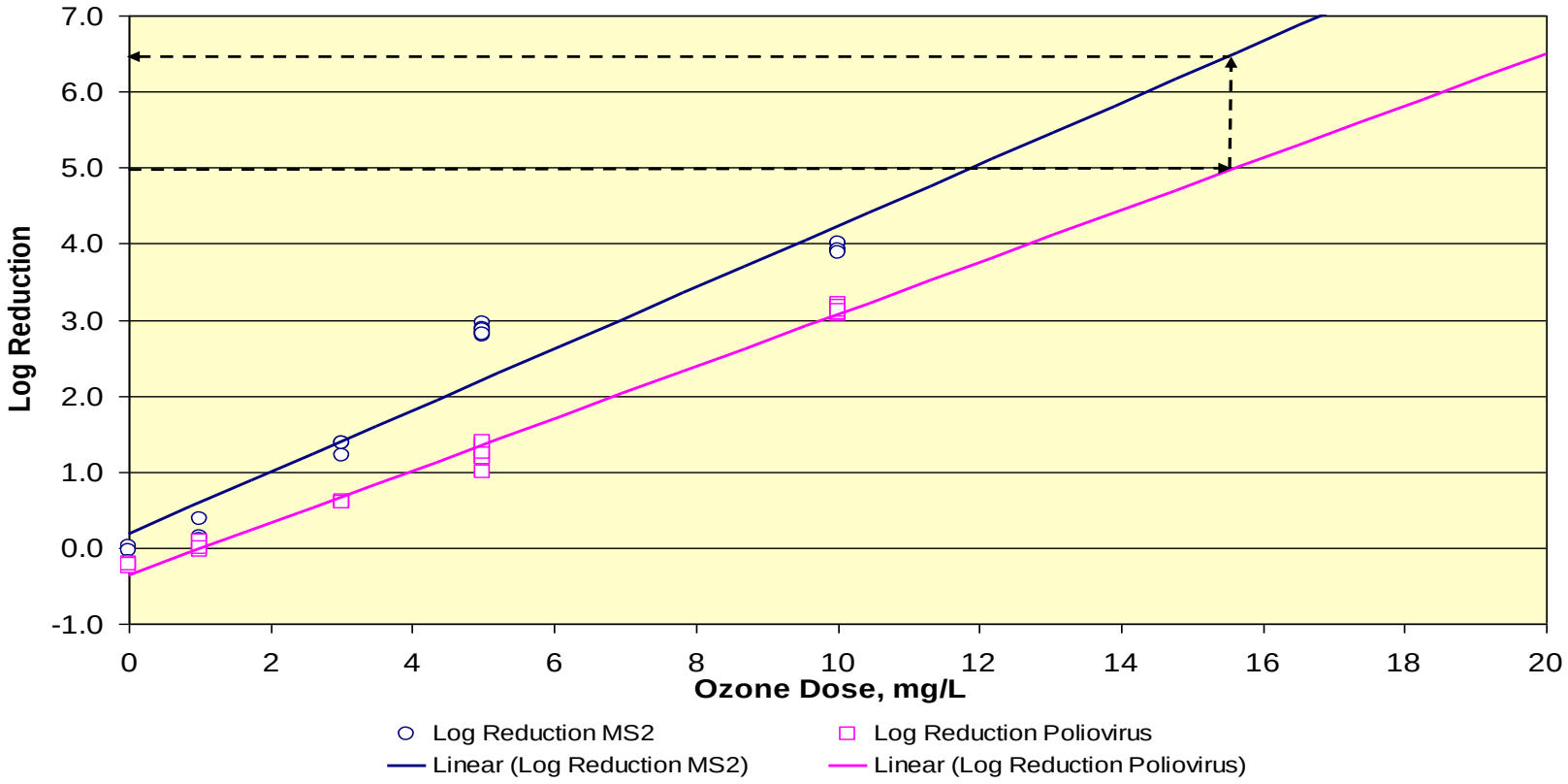
Pilot Test Results Cont'd

Effluent bromate was always below MCL for high oxidant demand water

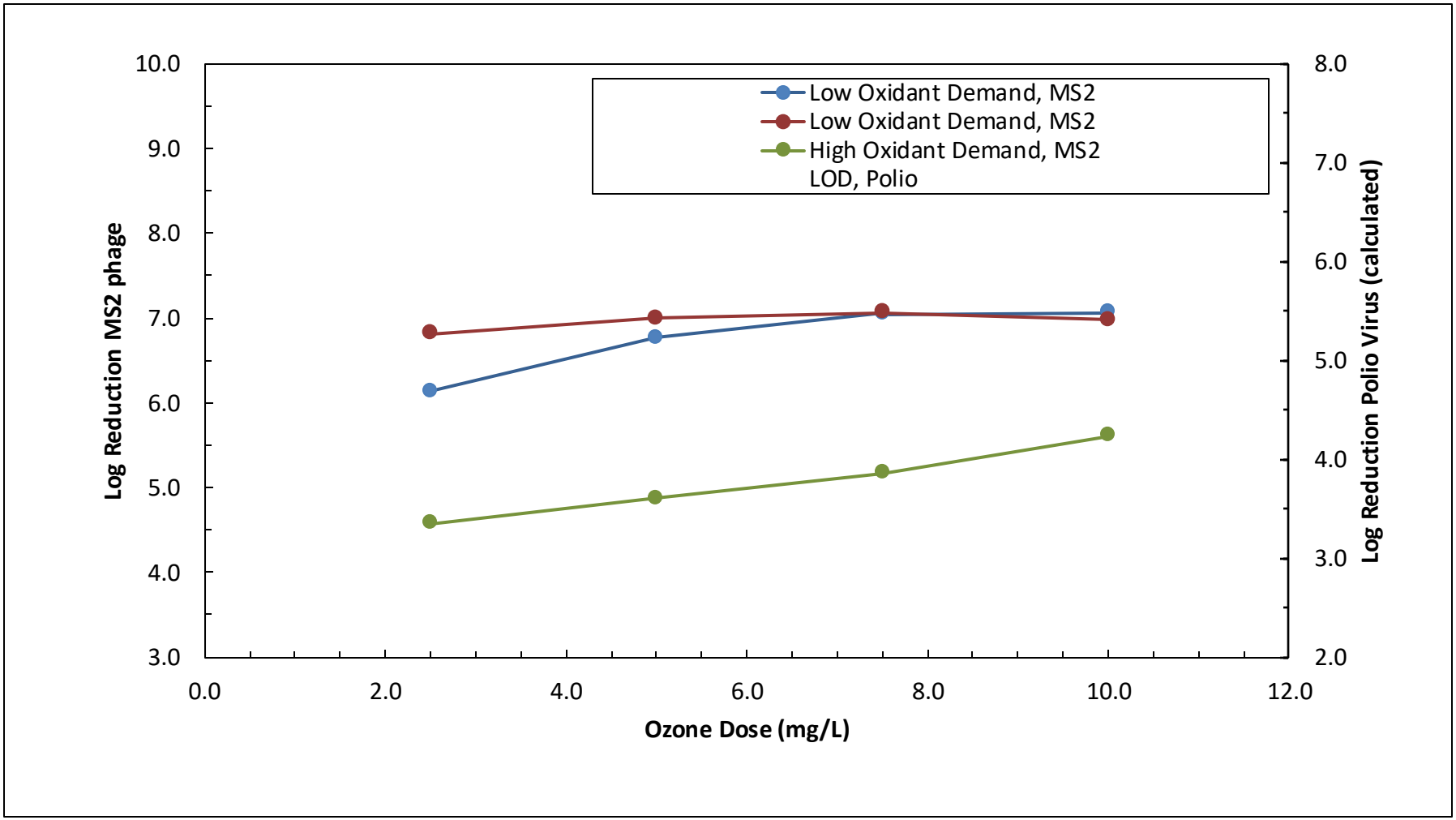


Pilot Test Results Cont'd

MS2 Virus Correlation – California Title 22 virus correlation tests showed that 6.5-Log reduction of MS2 is equivalent to 5-Log reduction of Poliovirus



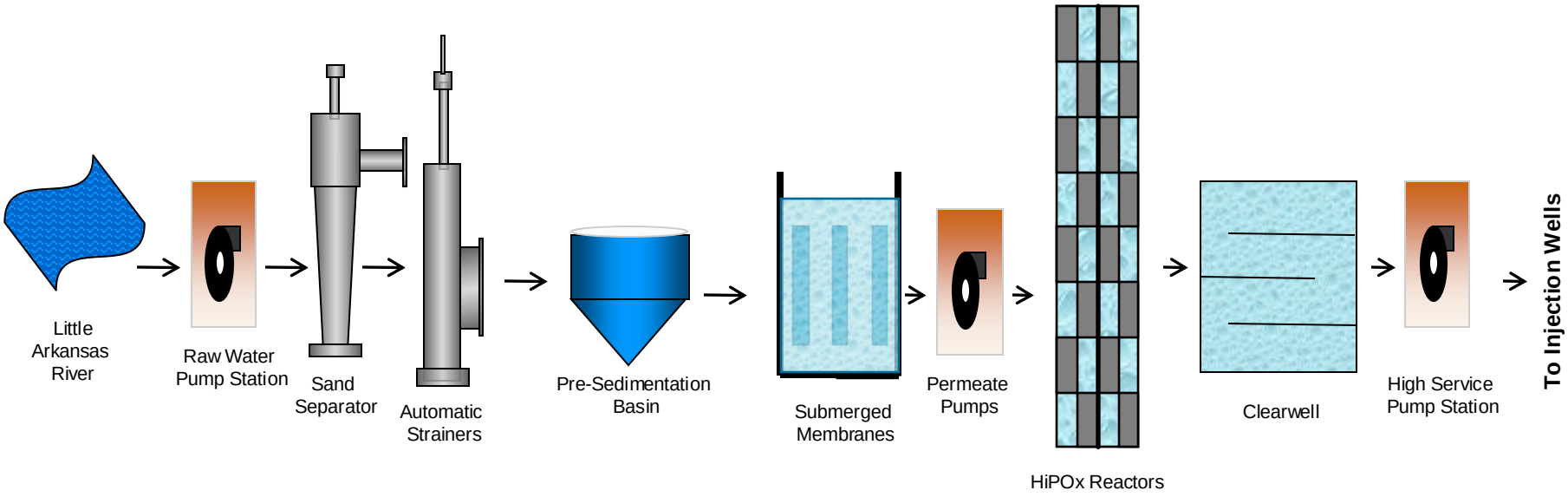
MS2 Inactivation



HiPOx Testing Summary

- An ozone dose of 15 mg/L and 2.1:1 H_2O_2:O_3 mole ratio reduced atrazine below the MCL in all high oxidant demand tests without MS2 addition
- Bromate formation control was demonstrated in all tests = representative of the proposed full-scale operating conditions
- Ozone dose may be reduced for low oxidant demand conditions and still reduce atrazine to below the MCL
- Calculated poliovirus reduction ranged between 3.8-log and 5.5-log in all tests = representative of the proposed full-scale operating conditions

Phase II Process Flow Diagram

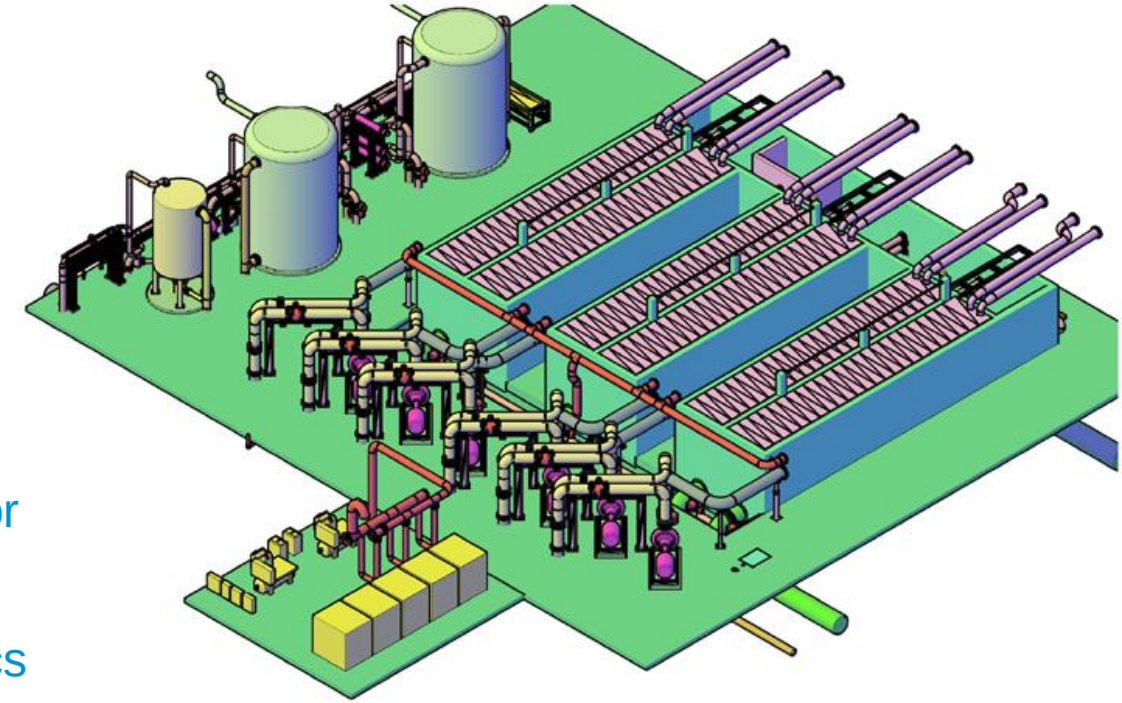


1. Cyclone Sand Separation
2. Pre-Sedimentation
3. ZeeWeed Submerged UF Membrane Filtration
4. HiPOx AOP
5. Clearwell Storage
6. High Service Pump Station
7. Unique combined Production/Recharge Injection wells with 4” downtubes

GE ZeeWeed Submerged Membranes

Ultrafiltration, GE Zenon Zee-Weed 500d, 0.04 micron

- Membranes are under suction
- 6 Trains, 7 Cassettes/Train
- 36 Modules/Cassette
- = ~2 million total fibers
- 1,140,480 ft2 total surface area
- Sodium hypochlorite cleaning for organics
- Citric acid cleaning for inorganics
- Air scour
- Backpulsing

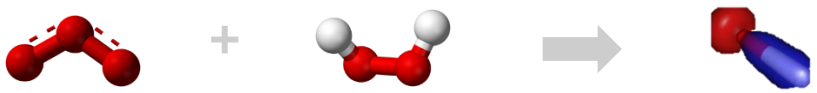


GE ZeeWeed Submerged Membranes

Pictures of a membrane module and water pre & post filtration

HiPOx® AOP Chemistry

Ozone + Hydrogen Peroxide → Hydroxyl Radical

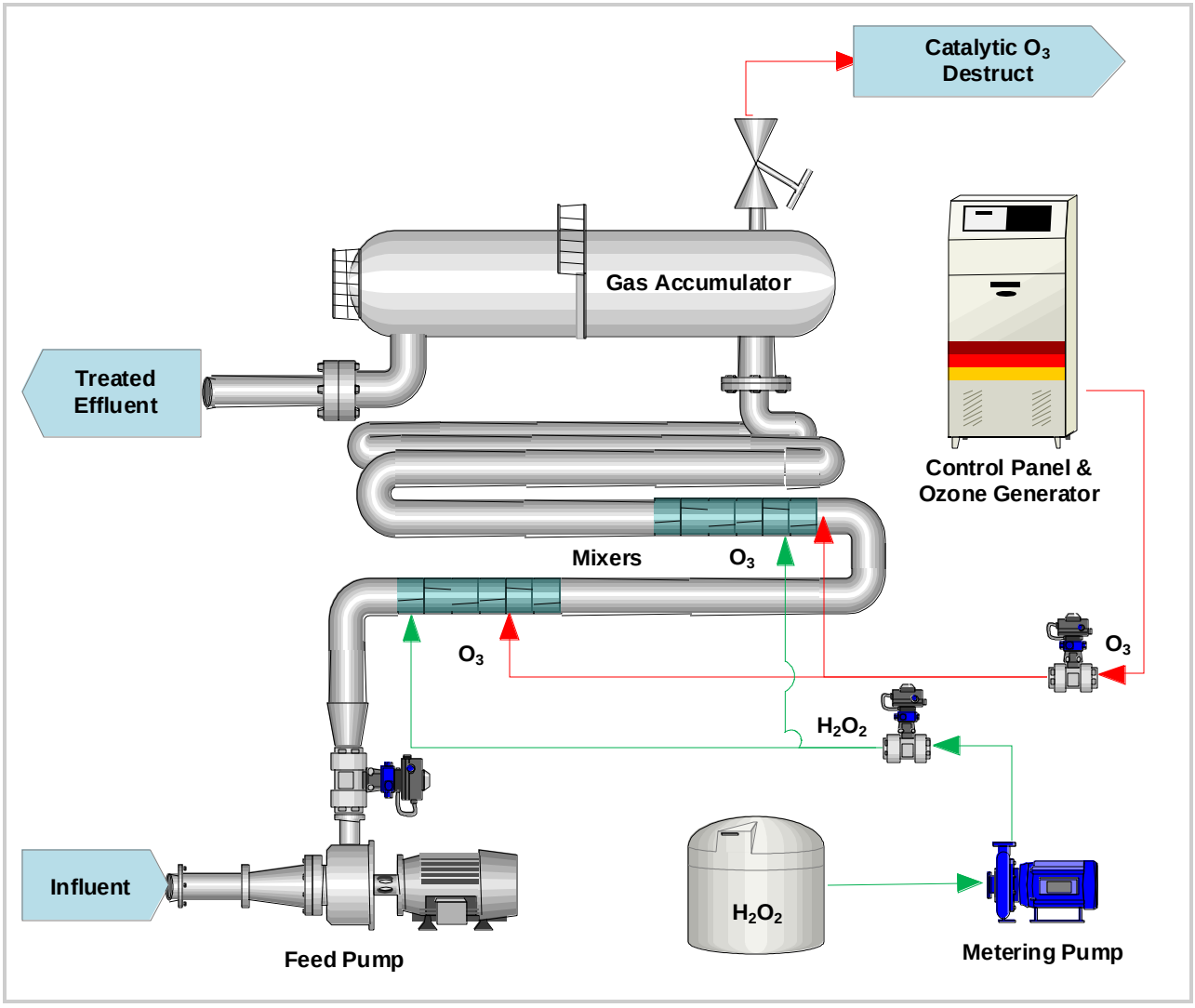


- Ozone-based advanced oxidation technology utilizing either ozone alone or ozone with hydrogen peroxide to provide disinfection and oxidation
- Ozone alone provides disinfection
- Ozone with peroxide accelerates the production of hydroxyl radicals resulting in faster reactions and does not impact virus disinfection while eliminating need for significant contact time
- **The chemistry will always work** if hydrogen peroxide and ozone are injected and mixed properly at the right concentrations

COMPLETE DESTRUCTION & MINERALIZATION OF MANY CONTAMINANTS INCLUDING:

- **Chlorinated Solvents:** 1,4-Dioxane, PCE, TCE, VC, DCE
- **Fuels**: BTEX, TPHg, TPHd
- **Oxygenates**: MTBE, TBA, Benzene, TAME
- **Aromatics**: PAHs, Phenols, Chlorobenzenes, Creosols
- **Pesticides & Herbicides:** Atrazine, Dioxins, Lindane
- **Taste, Odor, Color Compounds:** MIB, Geosmin, Sulfides

HiPOx® AOP System Highlights



PROCESS FEATURES:

- **Plug flow reactor technology**
- Mass optimized oxidant dosing
- Multiple O_3/H_2O_2 injection points
- High mixing efficiency >98%
- Patented bromate control
- Application specific reaction times

SAFETY FEATURES:

- Catalytic ozone destruct
- **Ozone sensors/alarms**
- Automatic alarms

OPERATION FEATURES:

- Fully automated, remote operation
- **5 positive auto-shutdown modes**
- Touchscreen PLC
- Fully enclosed control panel

HiPOx Reactors Installed

New Phase II ASR Facility

The City completed the construction phase of the ASR Phase II SWTP in September 2011.

Operating Parameters

- The minimum LAR flow rate to operate is 100 cfs (or approximately 64.6 mgd).
- Continuously monitor for atrazine and bromide in LAR
- Will not operate when atrazine is above 30 ug/l or bromide is above 430 ug/l
- Low bromide at high river flow, conversely high bromide at lower river flow

Phase II System Operating Results

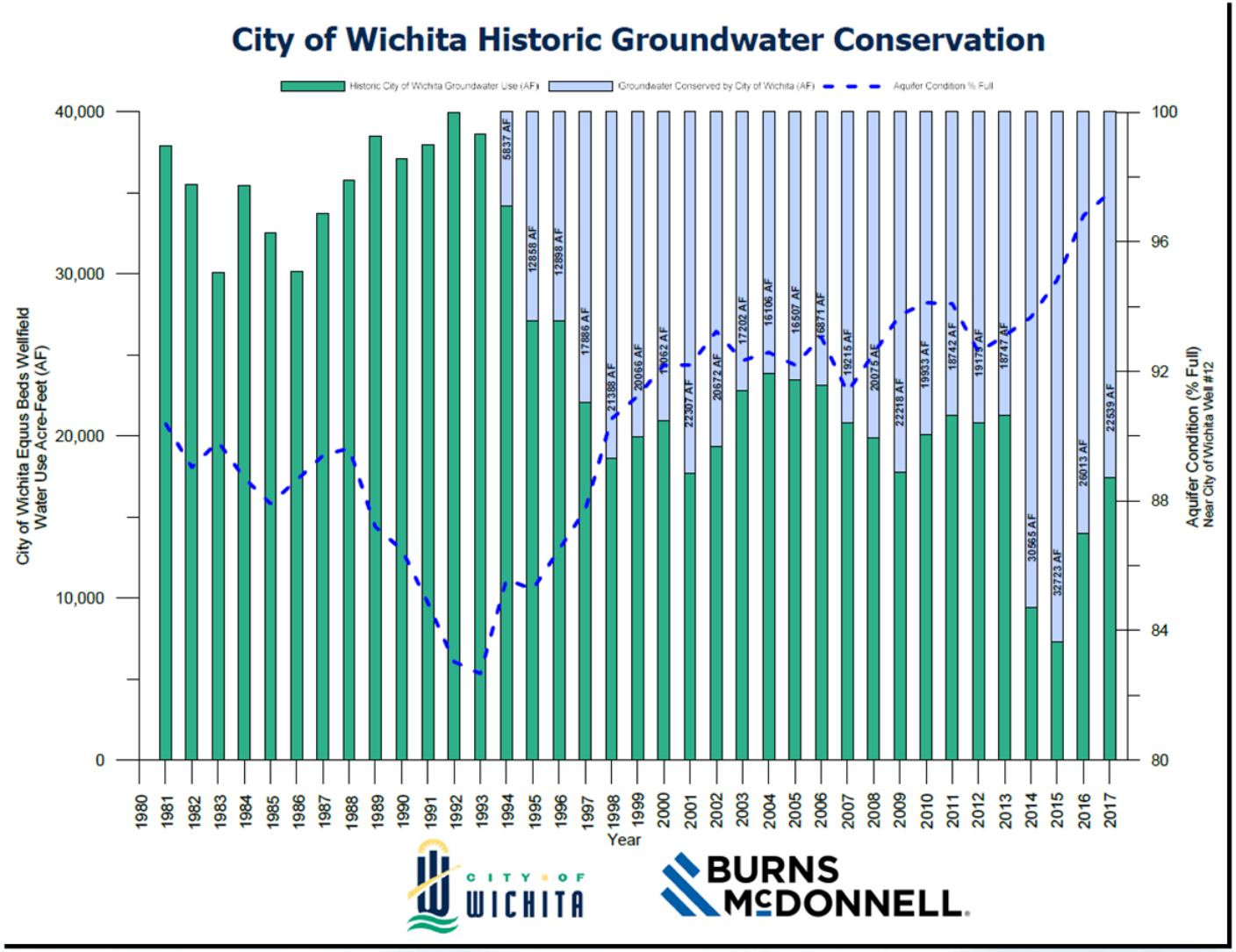
Gallons of Water Recharged Through Recharge Basins and Wells during phase 1 and phase 2

	January	February	March	April	May	June	July	August	September	October	November	December	Sum
2006	--	--	--	--	--	--	--	--	0	0	0	0	0 MG
2007	0	0	36,670,000	34,700,000	69,010,000	64,386,000	82,828,300	36,488,600	7,838,100	18,587,500	0	18,265,700	369 MG
2008	23,359,000	27,007,300	51,928,000	58,824,500	48,955,400	39,416,600	11,567,800	0	20,992,000	36,516,200	23,400	331,900	319 MG
2009	0	0	13,260,000	58,939,000	40,924,768	20,697,584	17,524,712	0	10,908,752	0	7,779,880	0	170 MG
2010	16,313,272	18,463,752	23,344,784	0	0	15,759,624	15,500,928	6,974,656	0	0	6,616,144	0	103 MG
2011	0	0	0	0	0	0	0	0	0	0	0	0	0 MG
2012	0	8,065,325	21,995,272	2,115,756	0	5,189,744	0	0	0	0	0	0	37 MG
2013	0	0	0	1,862,500	31,018,000	62,115,550	28,759,244	192,089,255	49,327,000	0	329,225	0	366 MG
2014	0	0	0	470,425	39,982,175	119,807,854	62,375,891	0	51,978,655	13,566,932	6,587,365	15,311,590	310 MG
2015	0	0	0	16,261,596	113,762,679	204,547,762	63,616,900	158,353,508	0	0	389,312	19,138,651	576 MG
2016	0	0	0	22,226,150	177,922,475	194,182,850	158,770,175	175,378,430	214,620,313	43,230,046	0	0	986 MG
2017	0	0	17,832,099	73,378,094	0	0	1,707,899	0	0	0	0	0	93 MG
2018	0	11,462	7,975,432	0	0	17,492,111	65,118,912	124,156,483	94,027,615	322,197,453	39,655,625	43,553,929	714 MG
2019	19,319,845	37,468,284	156,887,407	83,884,874	145,437,146	0	12,909,505	72,084,715	0	0	113,158	0	528 MG
2020	18,064,459	46,052,933	24,225,172	0	32,519,061	7,968,081	17,349,588	0	0	0	0	0	146 MG
2021	3,862,186	13,392,718	43,633,649	5,447,046	79,348,105	50,086,074	23,392,459	33,438,926	25,186,208	86,811,018	4,648,868	3,649,072	373 MG
2022	13,312	0	16,533,696	0	11,207,754	144,102,956	6,594,700	0	0	0	0	0	178 MG
2023	0	0	0	0	0	13,980,721	0	3,141,001	0	0	0	4,306,048	21 MG
2024	4,102,016	24,506,958	9,427,388	0	0	109,675,687	60,130,045	1,212,544	0	0	176,885,247	0	386 MG
												Cumulative Total	5676 MG
Monthly Sums	85 MG	175 MG	424 MG	358 MG	790 MG	1069 MG	628 MG	803 MG	475 MG	521 MG	243 MG	105 MG	

5.7 billion gallons or 17,433 acre-feet recharged through 2024

Phase II System Operating Results

- In 2021, the Equus Beds Aquifer had recharged to 98%
- In the past 3 years of drought conditions, the aquifer remained at 92%



Acknowledgements

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- Shawn Maloney, Wichita ASR/Wellfield Program Manager

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THANK YOU!

ANY QUESTIONS?

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