Standards

Texas Produced Water Consortium

Tuesday, Sep 10, 2024

Summary of Standards & Guidelines Reviewed

Standards

- Clean Water Act
- TX RRC Pilot Study Framework
- TCEQ TPDES
- TCEQ TLAP
- Other states: NM, OK, MT, PA, WY

Overview

Great opportunities for **beneficial use** of **treated produced water in:**

- Industry
- Land application / agricultural irrigation
- Discharge to surface water

TPW applications *may be subject to* ***standards*** *and/or* ***guidelines to protect humans*** *and the* ***environment***[1].

[1] Amy Hardberger. (2024) The Challenges and Opportunities of Beneficially Reusing Produced Water, *Duke Environmental Law & Policy Forum,* https://scholarship.law.duke.edu/delpf/vol34/iss1/1

Clean Water Act

Federal Water Pollution Control Act (FWPCA)

1948

Enacted

1972

Expanded

Clean Water Act (CWA)

applies to navigable

"waters of the United States"

Codified in

Code of Federal Regulations (CFR)

Title 33 U.S. Code § 1251 et seq[1] regulations

Title 40 CFR addresses Protection of the Environment

Chapter I[2] Subchapters **A – U**, Parts **1 – 1099**

Outlines **Environmental Protection Agency (EPA)**

[1] https://www.govinfo.gov/link/uscode/33/1251

[2] https://www.ecfr.gov/current/title-40/chapter-I

Clean Water Act

Water Programs[1]

40 CFR Chapter **I**, Subchapter **D** (Parts **100-149**)

Parts **122 - 125** *outline*

NPDES National Pollutant Discharge Elimination System

§**122.2 Definitions** (discharge, pollutant, hazardous substances, etc.)

Part **123**	State program requirements
Part **130**	Water quality planning and management
Part **131**	Water quality standards (WQS)
Part **144-147**	Underground injection control
Part **148**	Hazardous waste injection restrictions

[1] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D

Clean Water Act

40 CFR Chapter **I**, Subchapter **N** (Parts **400-471**)

Effluent Guidelines and Standards[1]

Part **401** General provisions

§401.1511 Toxic pollutants

benzene, ethylbenzene, naphthalene, and toluene

Part **419** Petroleum refining

Part **435** Oil and gas extraction

Part **437** Centralized waste treatment category

[1] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-N

EPA Oil and Gas Extraction Effluent Guidelines

Agricultural and **Wildlife Water Use** Subcategory

40 CFR 435 Subpart **E** *promulgated* 1979

Allows for discharge of produced water from onshore facilities into navigable waters west of the 98th meridian if the produced water has a use in agriculture or wildlife propagation.

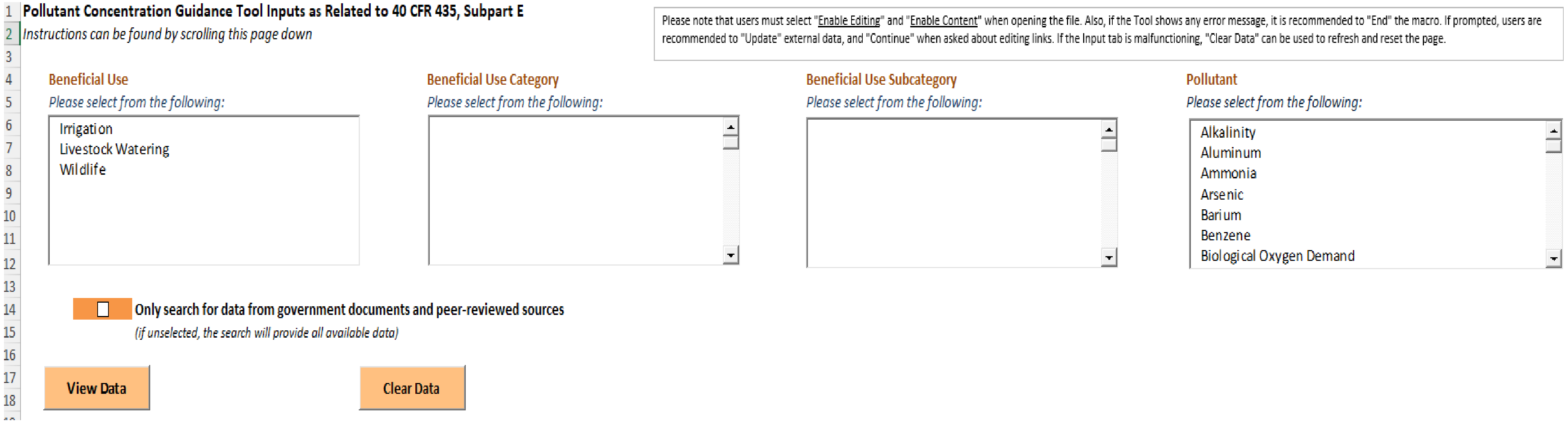
EPA *currently evaluating* whether affordable and available treatment technologies can reduce discharge of pollutants.

For additional information on the study please contact:
Jesse Pritts pritts.jesse@epa.gov 202-566-1038

[1] https://www.epa.gov/eg/oil-and-gas-extraction-effluent-guidelines

EPA Oil and Gas Extraction Effluent Guidelines

EPA Pollutant Concentration Tool for **Agricultural** and **Wildlife Water Use**



Tool provides pollutant concentration data reflecting various uses from the scientific literature.

Tool can be used by NPDES permitting authorities and others to inform what levels of pollutants contained in produced water may be protective of various beneficial uses.

[1] https://www.epa.gov/eg/oil-and-gas-extraction-effluent-guidelines

Texas Railroad Commission (RRC)

Tx HB 3516 (87th Leg, 2021) *encouraged* recycling[1]

RRC *recycling authority* from **Natural Resources Code §122**

RRC *promulgated rules* in **16 TAC §3.8 (d) (7) (A), (B),** and **(C) Recycling of produced water**

RRC released the Produced Water Beneficial Reuse Framework for Pilot Study Authorization ("Pilot Study Framework") for land application

- Requires monitoring of hundreds of WQ constituents, effluent limits on 38 parameters
- No ponding, no runoff

[1] https://www.rrc.texas.gov/oil-and-gas/applications-and-permits/environmental-permit-types/pilot-projects/

TCEQ TPDES

1998 EPA *authorized* **TCEQ** *to manage* **NPDES** program for Texas (named **TPDES)**

TCEQ Form 10055 Industrial Wastewater Permit Application required for a **TPDES** *or* **TLAP permit**

2019 Texas HB 2771 *directed* **TCEQ** *to seek primacy from* **EPA** for discharges of treated produced water into "water in the State"

2021 (Jan 15) **EPA** *approved, and upon delegation, the* **State** *program transferred from* **RRC to TCEQ TPDES**

TCEQ Form 20893 Industrial Wastewater Application Checklist for Oil and Gas *is required*

TCEQ TLAP

TLAPs *authorize* disposal of treated domestic and non-oil-and-gas wastewater at a property, not discharge into water in the State.

Types of TLAPs: **evaporation** (30 TAC 309), **surface irrigation** (30 TAC 309), **subsurface irrigation** (30 TAC 309), and **subsurface area drip dispersal system** (SADDS, 30 TAC 222).

TCEQ Form 10054 *is required*.

Application process involves review of site aspects including:
Geologic- surface water, groundwater, wells, topography, etc.) and
Agronomic- water application rate, average rainfall, evapo-
transpiration, nutrient application rate, cropping plan, dry matter production, etc.)

Per 30 TAC 222 and 309 All SADDS and subsurface drip systems have a max application rate of 0.1 gal/ft^2/day (4.88 acre-feet/acre per year)

Comments on RRC PSF WQ Criteria

Lowest Value	Next Group	Highest Group

Constituent	CAS	Units	TX RRC	Corn	Sorghum	Cotton	Wheat	Std Fig 3	NMAC	GWPC LT	GWPC ST	NMAC2	MDEQ	MDEQ RRV	MDEQ Crit	Cattle	Livestock	GWPC LS
Alkalinity, tot	-	mg/L as CaCO3	100															
Boron	7440-42-8	mg/L	0.75	2	3	3	3		0.75	0.75	2		5			5	5	5
Chloride	16887-00-6	mg/L	100	533	710	710												
Chlorine	7782-50-5	mg/L										0.011						
Electrical Conductivity	-	µS/cm	1500	1100	1700	5100	4000											
Fluoride	16984-48-8	mg/L	1					1		1	15		3	0.2	2	2		2
Hardness, tot	-	mg/L	150															
pH	-		6.5-8.4										6.0-9.0					
Phosphorus	7723-14-0	mg/L	5															
Sodium	7440-23-5	mg/L	100	533	710	710												
Sodium Absorption Ratio	-	mg/L	4	10	10	10	13											
Sulfate	14808-79-8	mg/L												100				
Total Dissolved Solids	-	mg/L	1000	704	1088	3264	2200											
Turbidity	-	NTU	30															

Lowest Value	Next Group	Highest Group

Constituent	CAS	Units	TX RRC	Corn	Sorghum	Cotton	Wheat	Std Fig 3	NMAC	GWPC LT	GWPC ST	NMAC2	MDEQ	MDEQ RRV	MDEQ Crit	Cattle	Livestock	GWPC LS
Aluminum	7429-90-5	mg/L	5					5	5	5	20					0.5		5
Arsenic	7440-38-2	mg/L	0.1					0.1	0.1	0.1	2		0.5	0.001	0.5	0.05	0.2	0.2
Beryllium	7440-41-7	mg/L	0.1					0.1		0.1	0.5							
Cadmium	7440-43-9	mg/L	0.01					0.01	0.01	0.01	0.05			0.00003	0.08	0.005	0.05	0.05
Chromium	7440-47-3	mg/L	0.1					0.1	0.1	0.1	1			0.01	1		1	1
Cobalt	7440-48-4	mg/L	0.05					0.05	0.05	0.05	5			0.05	1	1	1	1
Copper	7440-50-8	mg/L	0.2					0.2	0.2	0.2	5		0.5	0.002	0.5	1	0.5	10.5
Iron	7439-89-6	mg/L	5					5		5	20							
Lead	7439-92-1	mg/L	5					5	5	5	10		0.1	0.0003	0.1	0.015	0.1	0.1
Lithium	7439-93-2	mg/L	2.5					2.5		2.5	2.5							
Manganese	7439-96-5	mg/L	0.2					0.2		0.2	10					0.05		
Mercury	7439-97-6	mg/L										0.00077				0.01	0.01	0.01
Molybdenum	7439-98-7	mg/L	0.01					0.01	1	0.01	0.05							
Nickel	7440-02-0	mg/L	0.2					0.2		0.2	2					0.25		
Selenium	7782-49-2	mg/L	0.02					0.02		0.02	0.02		0.05	0.001	0.05	0.05	0.05	0.05
Strontium (pCi/L)	7440-24-6	mg/L							8									
Total Metals		mg/L	10															
Vanadium	7440-62-2	mg/L	0.1					0.1		0.1	1					0.1		0.1

Comments on RRC PSF WQ Criteria

Lowest Value	Next Group	Highest Group

Constituent	CAS	Units	TX RRC	Corn	Sorghum	Cotton	Wheat	Std Fig 3	NMAC	GWPC LT	GWPC ST	NMAC2	MDEQ	MDEQ RRV	MDEQ Crit	Cattle	Livestock	GWPC LS
Zinc	7440-66-6	mg/L	2					2		2	10		25	0.008	25	5		24
Cyanide, tot	57-12-5	mg/L										0.0052						
Nitrite+Nitrate	14797-65-0 14797-55-8	mg/L as N															132	100
Nitrogen, ammonia	7664-41-7	mg/L as N	30															
Nitrogen, nitrate	14797-55-8	mg/L as N	45										100	0.02	100			
Nitrogen, nitrite	14797-65-0	mg/L as N	10										10	0.01	10			10
4-4'-DDT and derivatives	50-29-3	mg/L										0.000001						
Polychlorinated Biphenyls	1336-36-3	mg/L										0.000014						
Total Oil and Grease	-	mg/L	35										10					
Total Organic Carbon	-	mg/L	10															
Total Petroleum Hydrocarbons	-	mg/L	10															
Gross Alpha/Beta	-	pCi/L	15															
Radium 226	13982-63-3	pCi/L	30															

Comments on RRC PSF WQ Criteria

RRC Salinity limits

TDS Total Dissolved Solids — 1000 mg/L

EC Electrical conductivity — 1500 μS/cm = 1.5 dS/m

suitable for most crops and soils

Ammonia

RRC Limit as Nitrogen

N Nitrogen — 30 mg/L as nitrogen

Irrigating 48 inch/yr = 4 acre feet/yr
= 326 pounds ammonia-nitrogen per acre

Some soil-crop combinations able to assimilate this mass loading, while others would not

Comments on RRC PSF WQ Criteria

Sodium Adsorption Ratio (SAR)

Assuming max RRC limits for

Sodium	100 mg/L	=	4.35 meq/L
Hardness	150 mg/L as $CaCO_3$	=	3.0 meq/L
SAR		=	3.55 $meq/L^{0.5}$

Assuming max RRC limit of

Sodium	100 mg/L	=	4.35 meq/L
Hardness ***at least***	119 mg/L as $CaCO_3$	=	2.38 meq/L
SAR		<	4.0 $meq/L^{0.5}$

Comments on RRC PSF WQ Criteria

Radionuclides

Considering

Ra 226 half-life 1600 yr decay emission mainly alpha particles with RRC Gross Alpha/Beta limit of **15 pCi/L**

RRC limit of 30 pCi/L for Ra 226 appears high

Ra 228 half-life 5.75 yr decay emission mainly alpha particles with RRC Gross Alpha/Beta limit of **15 pCi/L**

RRC limit of 30 pCi/L for Ra 228 appears high

USBR Report 157 (2011) p.60 **"[Radium] (226+228)** *is regulated at a maximum concentration of* **5 pCi/L in drinking water sources**; *therefore, most sources require treatment to lower levels in produced water to meet this standard"*

Comments on RRC PSF WQ Criteria

- Hazardous substances and toxic pollutants

Substance	Volatility	CAS	Hazardous Substance[1] (40 CFR §116.4)	Toxic Pollutants[2] (40 CFR §401.15)
Benzene	VOC	71432	✓	✓
Toluene	VOC	108883	✓	✓
Ethylbenzene	VOC	100414	✓	✓
Xylene (mixed)	VOC	1330207	✓	
Naphthalene	S/VOC	91203	✓	✓
Phenol	SVOC	108952	✓	✓

[1] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D/part-116/section-116.4
[2] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-N/part-401/section-401.15

Toxicity Tests

Whole Effluent Toxicity (WET) Tests[1]

- Acute vs chronic
- Aquatic
  - EPA 1001.0 Fathead minnow, *Pimephales promelas*, larval survival and teratogenicity
  - EPA 1002.0 Daphnia, *Ceriodaphnia dubia*, survival and reproduction
  - EPA 1003.0 Green alga, *Selenastrum capricornutum*, growth (species is now known as *Raphidocelis subcapitata*)
- Terrestrial
  - earthworm (*Eisenia fetida*)
- Phytotoxicity
  - alfalfa (*medicago sativa*)
  - Northern wheatgrass (*Elymus lanceolatus*)
- Methods for sub-lethal endpoints
  - Zebrafish embryo toxicity (ZFET)

[1] https://www.epa.gov/cwa-methods/whole-effluent-toxicity-methods

The four R's of water treatment

Reliability is built on redundancy, robustness, and resilience

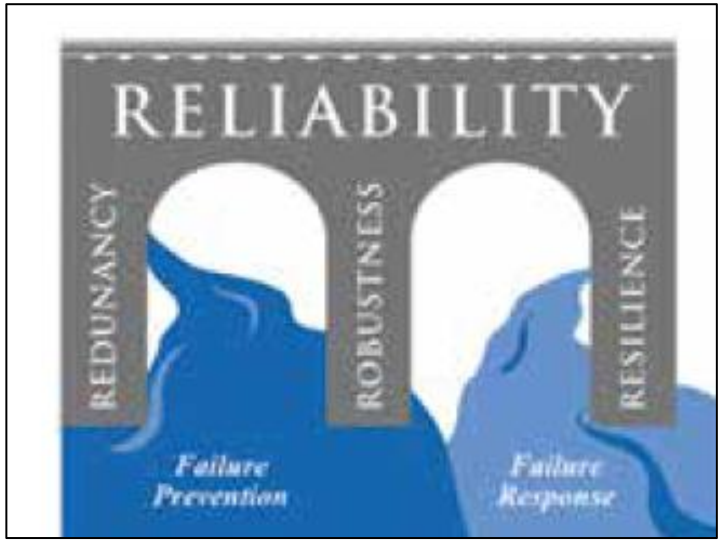
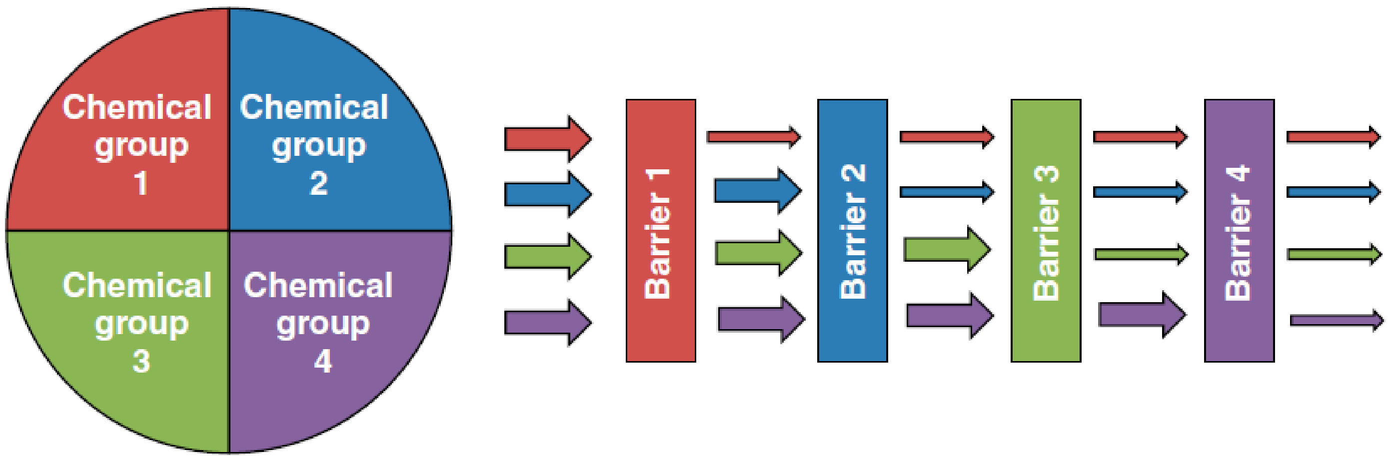


FIGURE 4 Robustness and the use of diverse barriers to protect against diverse contaminants

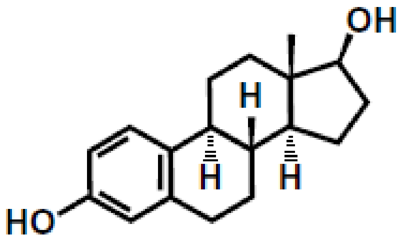
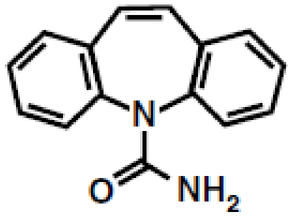
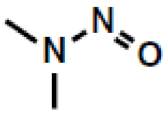
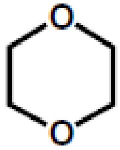


[1] Pecson et al. (2015) Achieving Reliability in Potable Reuse: The Four Rs, *J. American Water Works Association*, http://dx.doi.org/10.5942/jawwa.2015.107.0047

The four R’s of water treatment

FIGURE 5 (A) Four diverse chemical contaminants and (B) the effectiveness of treatment processes in removing chemical and microbial contaminants

A

	17β-estradiol	Carbamazepine	NDMA	1,4-dioxane
Description	Synthetic sex hormone for birth control	Anticonvulsant/ mood stabilizer	Disinfection by-product	Stabilizer
Structure				
Characteristics	Large MW Uncharged Biodegradable Low photolysis Sensitive to $OH^{\cdot}$	Large MW Uncharged Low biodegradation Low photolysis Sensitive to $OH^{\cdot}$	Small MW Uncharged Low biodegradation High photolysis Low reaction to $OH^{\cdot}$	Small MW Uncharged Low biodegradation Low photolysis Sensitive to $OH^{\cdot}$

[1] Pecson et al. (2015) Achieving Reliability in Potable Reuse: The Four Rs, *J. American Water Works Association*, http://dx.doi.org/10.5942/jawwa.2015.107.0047

The four R's of water treatment

B

Compound	Cl_2	Biological	MF	GAC	O_3	UV/AOP	UV	RO
Chemical contaminants								
17β-estradiol	Excellent	Excellent	Poor	Excellent	Excellent	Excellent	Poor	Excellent
Carbamazepine	Poor	Poor	Poor	Good	Excellent	Excellent	Poor	Excellent
NDMA	Poor	Fair	Poor	Poor	Poor	Poor	Good	Fair
1,4-dioxane	Poor	Poor	Poor	Poor	Fair	Good	Poor	Fair
Microbial contaminants								
Giardia	Fair	Unknown	Excellent	Poor	Good	Unknown	Excellent	Excellent
Cryptosporidium	Poor	Unknown	Excellent	Poor	Fair	Unknown	Excellent	Excellent
Virus	Excellent	Unknown	Poor	Poor	Good	Unknown	Good	Excellent
Bacteria	Good	Unknown	Good	Poor	Good	Unknown	Excellent	Excellent

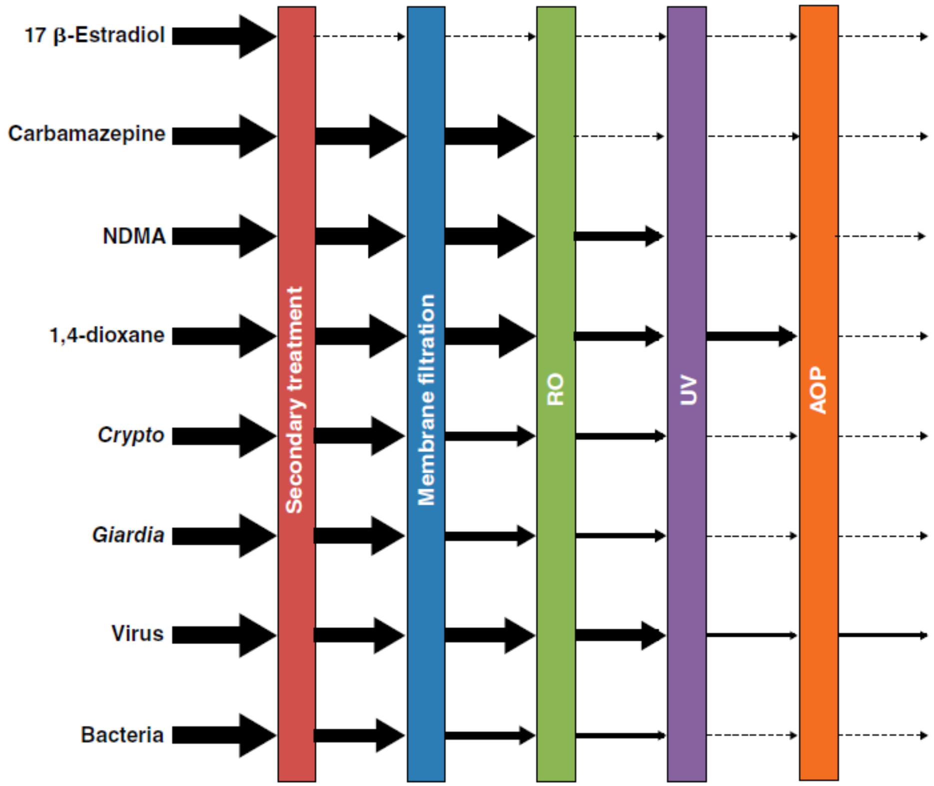
AOP—advanced oxidation process, Cl_2—chlorine, GAC—granular activated carbon, MF—microfiltration, MW—molecular weight, NDMA—*N*-nitrosodimethylamine, O_3—ozone, $OH^{\cdot}$—hydroxide, RO—reverse osmosis, UV—ultraviolet irradiation

*UV doses applied in AOP settings (typically 500–1,000 mJ/cm^2), which often are in great excess of the doses needed for pathogen inactivation (50–100 mJ/cm^2).

[1] Pecson et al. (2015) Achieving Reliability in Potable Reuse: The Four Rs, *J. American Water Works Association,* http://dx.doi.org/10.5942/jawwa.2015.107.0047

The four R's of water treatment

FIGURE 6 Effectiveness of a robust advanced treatment train (MF/RO/UV/AOP) in the control of chemical contaminants and pathogens*



AOP—advanced oxidation process, *Crypto*—*Cryptosporidium*, NDMA—*N*-nitrosodimethylamine, RO—reverse osmosis, UV—ultraviolet irradiation

*Dotted lines show concentrations below public health thresholds.

[1] Pecson et al. (2015) Achieving Reliability in Potable Reuse: The Four Rs, *J. American Water Works Association*, http://dx.doi.org/10.5942/jawwa.2015.107.0047

Stream discharge

Salinity ?

What is the basis for a minimum salinity for streamflow discharge (e.g., Red Bluff Reservoir or Pecos River)?

Why would there be any restriction of water that is of the same quality as rainwater to be a concern about entering any hydrologic system if mimicking rate and pace of historic patterns?