

Water Resources Consulting: Case Studies and Career Paths

GRAD592 Lecture
Colorado State University

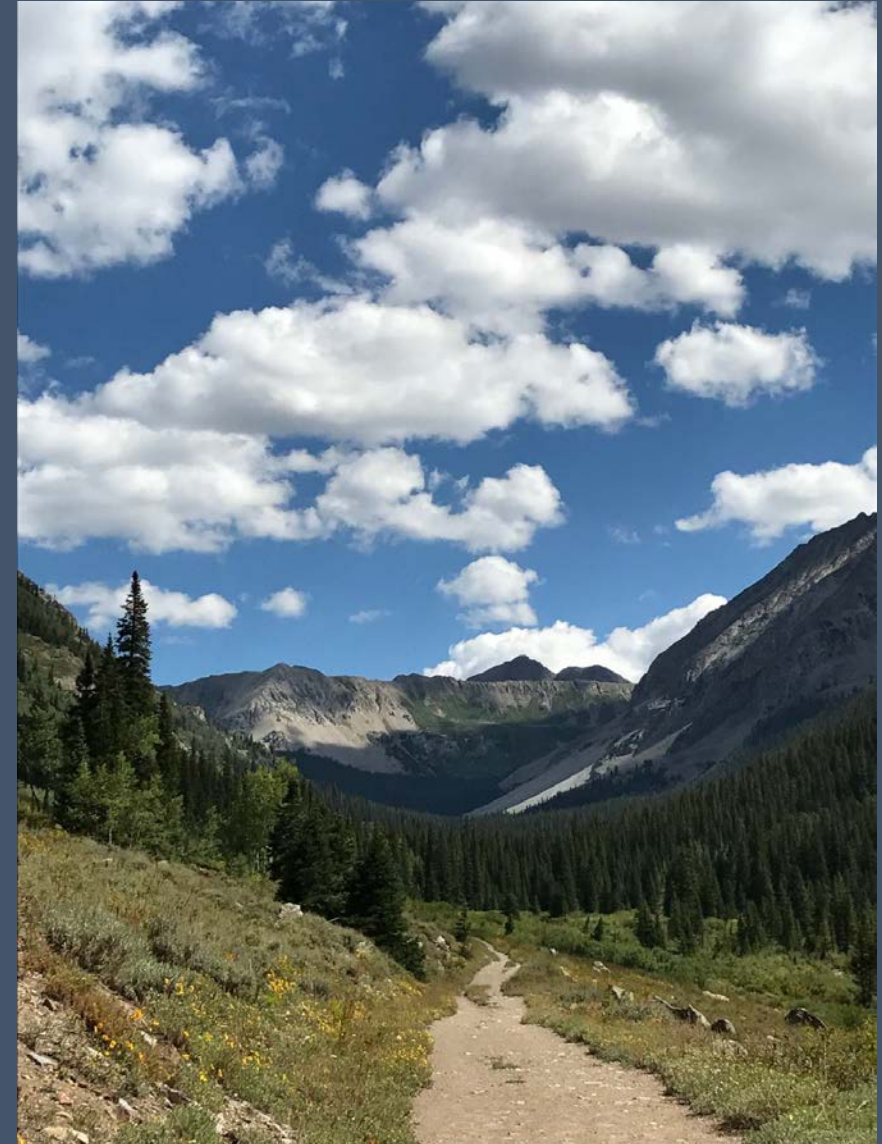


Jane Clary, Vice President
Wright Water Engineers
October 7, 2024



Career Path

- Public high school, Brookhaven, MS--1985
- Vanderbilt University, B.S. Economics--1989
- Whitewater raft guide/waitress
- U. Colorado, M.S. Environmental Science—1992
- Wright Water Engineers, Inc. Denver—1993+
 - Regulatory Specialist
 - Project Manager
 - Vice President of Water Quality and Regulatory Practice
 - Board of Directors



Wright Water Engineers

- Founded in 1961 by Ken Wright
 - Employee-owned with offices in Denver, Glenwood Springs, Durango
 - ~50 employees—civil engineers, biologists, environments scientists, geologists
 - Mostly in-person, but have a few remote staff
 - Clients: Municipal, private, state, federal, non-profit, research
- Representative Practice Areas
 - Stormwater Quality
 - Water Quality
 - Watershed Management
 - Stream Restoration
 - Storm Drainage/Flood Control
 - Municipal Water Supply/Wastewater
 - Water Conservation
 - Water Rights
 - Wetlands
 - Groundwater/Hydrogeology
 - Expert Testimony

Career/Professional Highlights

1. Urban Water Resources Research Council, Environmental and Water Resources Institute of ASCE (Past Chair)
2. Colorado Water Quality Control Commission (2017-2020)
3. Water Research Foundation (WRF/WERF) Projects
4. Cherry Creek Basin Water Quality Authority, Technical Manager
5. Mile High Flood District Regional Storm Drainage Criteria



Project Case Studies

1. International Stormwater BMP Database
2. Cherry Creek Basin Water Quality Authority
3. Big Dry Creek Watershed Association



International Stormwater BMP Database: Past, Present, Future

www.bmpdatabase.org





And many others!



[Urban Stormwater BMP Database](#)[DOT Portal to BMP Database](#)[Urban BMP Cost Database](#)[National Stormwater Quality Database](#)[Agricultural BMP Database](#)[Stream Restoration Database](#)

International Stormwater BMP Database

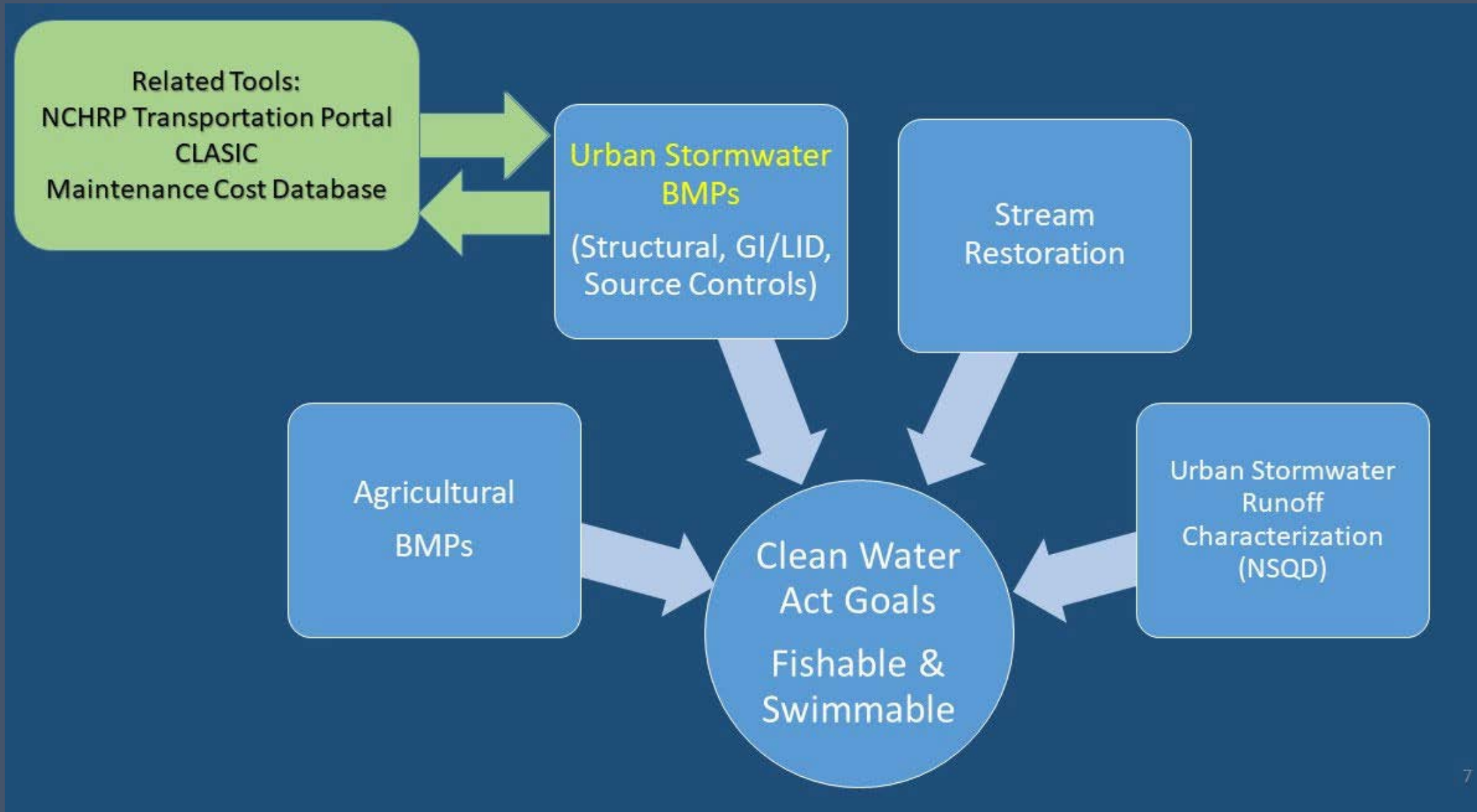
The International Stormwater Best Management Practices Database (BMPDB) is a repository of BMP field studies and related web tools, performance summaries, and monitoring guidance. Initiated over 25 years ago, the original focus was urban stormwater BMPs (stormwater control measures). Through the support of long-term partners, the project has expanded to develop additional resources related to both urban and agricultural runoff, treatment and management. Separate databases are accessible on this site for urban stormwater BMP performance, agricultural BMPs, stream restoration BMPs, and urban runoff quality characterization (National Stormwater Quality Runoff Database). Special resources have also been developed for Department of Transportation users through the DOT Portal. All of these resources can be accessed through this website, with the most developed tools available for urban stormwater BMPs.

What's New

[2020 Urban BMP Database Performance Summary](#)[2020 Agricultural BMP Database Summary](#)

Update to Stream Restoration Crediting Guidance 2021, (in progress)

BMP Database Project Modules as of 2024



BMP/SCM Stormwater Control Measure Examples



International Stormwater BMP Database

www.bmpdatabase.org

- Most recent published update: 2020
- Hundreds of Green Infrastructure practices
- Over 120 manufactured devices
- 2023 update complete and includes new MHFD data

BMP Types in 2020 Release	Total
Bioretention	84
Grass Strip	55
Grass Swale	57
Detention Basin	54
Media Filter	52
Retention Pond	87
Wetland Basin	44
Wetland Channel	23
Infiltration Basin	4
Percolation Trench/Well	12
Manufactured Treatment Device (see subtypes below)	123
Permeable Pavement	54
Permeable Friction Course	7
Green Roof	18
Rainwater Harvesting	3
Low Impact Development	10
Composite (Treatment Train)	33
Maintenance Practice	29
Other	9
Control Sites	36
Total	794

Manufactured Device Sub-type	Total
Hydrodynamic Separation Devices	31
High Rate Media Filtration	27
High Rate Biofiltration	6
Catch Basin Insert	20
Oil/Grit Separators and Baffle Boxes	19
Manufactured Volume Control/Attenuation	6
Multi-chambered Treatment Train	4
Disinfection System	2
Other Types	8
Total	123



How well do various BMP work?

Example Summary Statistics for TP (mg/L)

- How many sites?
- How many EMCs?
- How variable is the data?
- What is the effluent concentration?
- Is there a statistically significant difference between inflow and outflow?

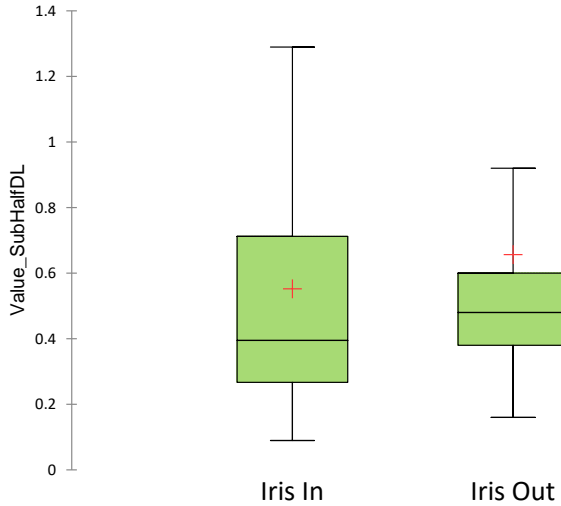
Table 4-3. Influent/Effluent Summary Statistics for Total Phosphorus as P (mg/L).

BMP Category	Study & Sample Count (% ND)		Interquartile Range (25 th – 75 th %tiles)		Median (95% Conf. Interval)*		In vs Out**
	In	Out	In	Out	In	Out	
Detention Basin	43; 542 (1.5%)	44; 577 (1.7%)	0.138 - 0.428	0.107 - 0.320	0.250 (0.216; 0.262)	0.186 (0.170; 0.200)	▼▼▼
Retention Pond	71; 1161 (0.9%)	75; 1138 (2.0%)	0.0996 - 0.542	0.0500 - 0.263	0.246 (0.220; 0.268)	0.120 (0.104; 0.129)	▼▼▼
Wetland Basin	27; 690 (0.3%)	27; 647 (1.4%)	0.106 - 0.319	0.0660 - 0.222	0.170 (0.151; 0.177)	0.122 (0.108; 0.133)	▼▼▼
Wetland Channel	15; 256 (0.4%)	13; 214 (0.0%)	0.129 - 0.372	0.120 - 0.338	0.201 (0.179; 0.230)	0.184 (0.160; 0.207)	◇◇▼
Grass Swale	34; 574 (0.3%)	39; 671 (0.3%)	0.0700 - 0.270	0.104 - 0.300	0.129 (0.118; 0.140)	0.180 (0.165; 0.190)	△△△
Grass Strip	50; 893 (8.2%)	50; 666 (3.2%)	0.0800 - 0.300	0.120 - 0.460	0.185 (0.160; 0.190)	0.230 (0.206; 0.240)	△△△
Bioretention	47; 850 (4.8%)	44; 667 (3.1%)	0.0800 - 0.460	0.0900 - 0.553	0.190 (0.170; 0.210)	0.240 (0.190; 0.270)	◇△△
Media Filter	32; 494 (1.4%)	35; 525 (5.1%)	0.0900 - 0.285	0.0490 - 0.147	0.165 (0.150; 0.180)	0.0900 (0.0800; 0.0973)	▼▼▼
HRBF	6; 100 (0.0%)	6; 100 (8.0%)	0.0640 - 0.157	0.0377 - 0.0848	0.0990 (0.0854; 0.112)	0.0500 (0.0409; 0.0600)	▼▼▼
HRMF	19; 349 (1.7%)	19; 351 (3.1%)	0.0680 - 0.500	0.0496 - 0.277	0.120 (0.100; 0.130)	0.0800 (0.0703; 0.0900)	▼▼▼
HDS	23; 338 (0.3%)	23; 303 (1.7%)	0.117 - 0.474	0.102 - 0.370	0.230 (0.198; 0.268)	0.176 (0.150; 0.197)	◇▼▼
OGS	10; 170 (4.7%)	10; 138 (10.9%)	0.0815 - 0.691	0.0367 - 0.530	0.316 (0.206; 0.428)	0.115 (0.0700; 0.213)	◇▼▼
PFC	NA	6; 124 (0.0%)	NA	0.0380 - 0.100	NA	0.0625 (0.0500; 0.0745)	NA
Porous Pavement	13; 447 (0.9%)	21; 365 (1.4%)	0.110 - 0.360	0.0700 - 0.194	0.170 (0.150; 0.180)	0.100 (0.0980; 0.112)	▼▼▼

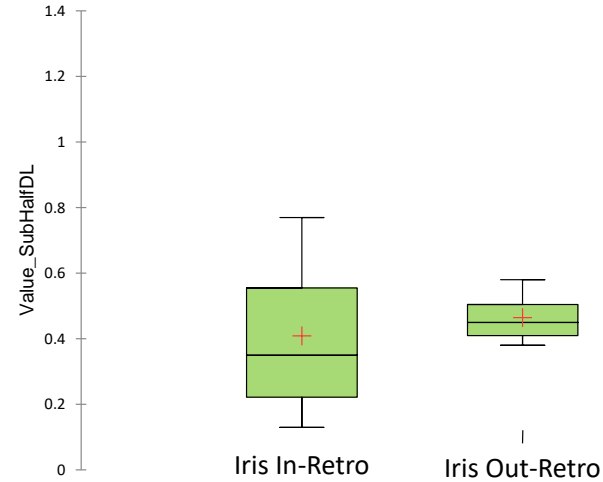
Example: CO Bioretention Monitoring for TP (mg/L) in BMP Database

What factors are leading to better performance? Why?

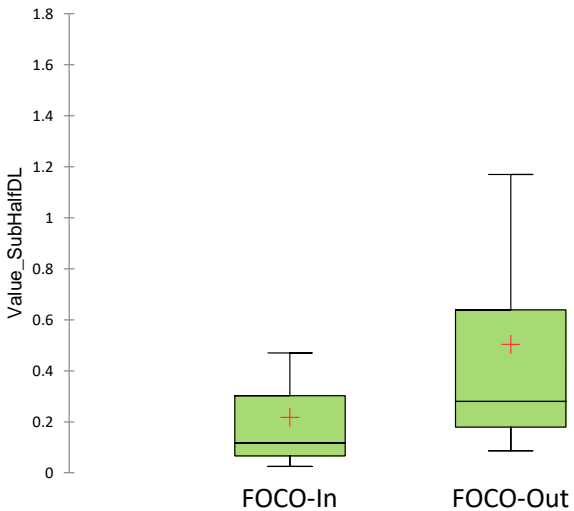
MHFD 21st & Iris



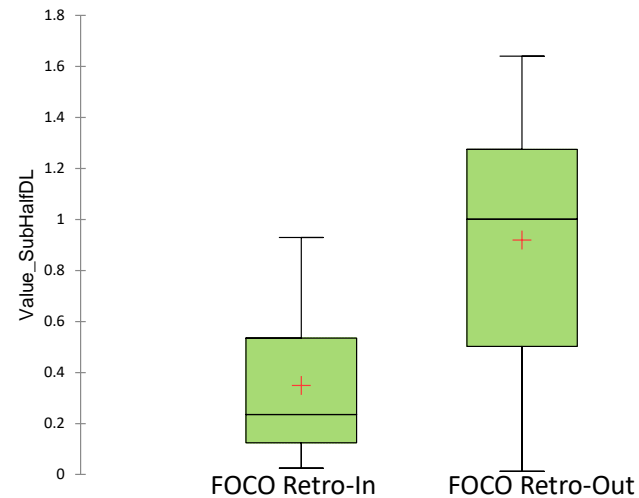
MHFD 21st & Iris (Retrofit-Upturned Elbow)



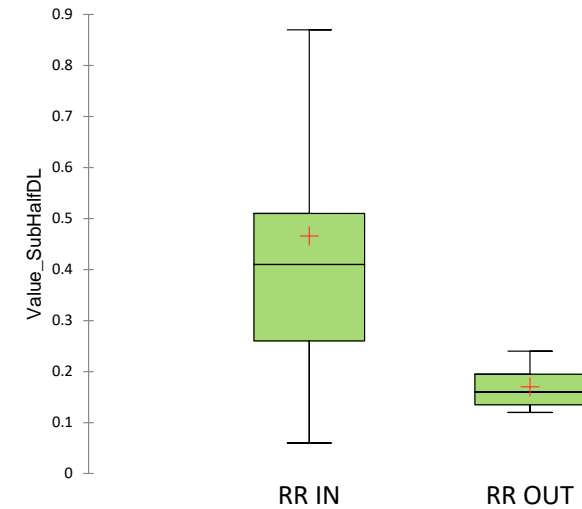
Fort Collins Utilities Parking Lot



Fort Collins Utilities Parking Lot Retrofit



MHFD River Run



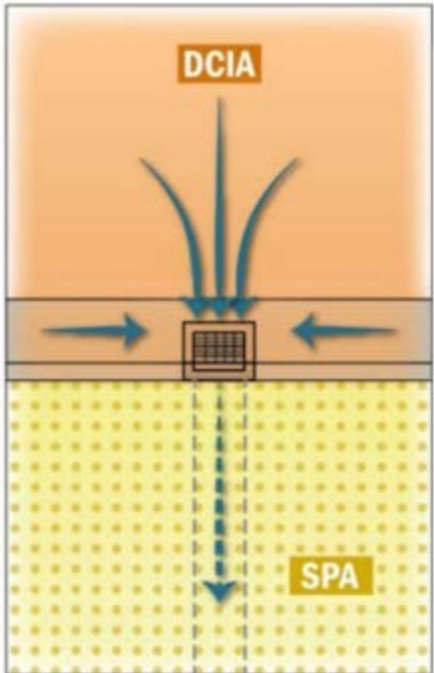
n = 37

n = 4

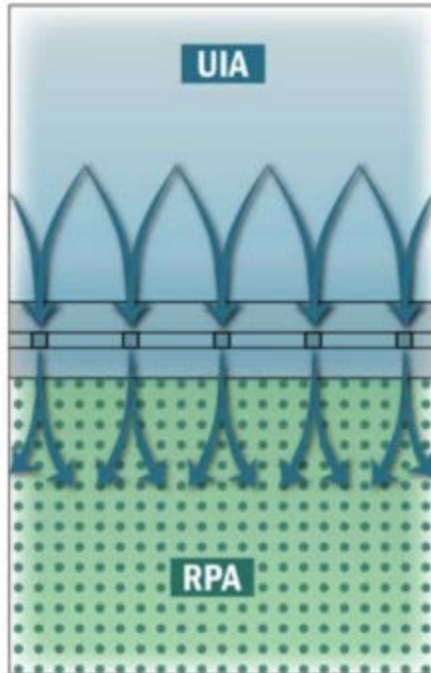
Encouraging Runoff Reduction

- Recognizes pollutant load reduction through volume reduction
- Reduces impacts to streams (e.g., erosion/sediment)

Conventional
Curb and Gutter w/ Inlet

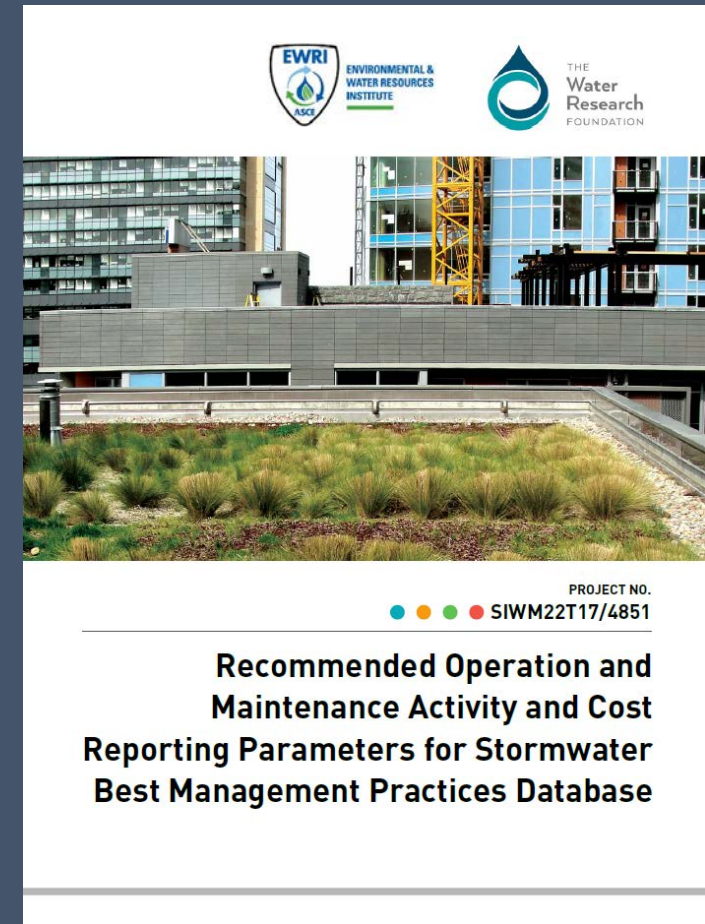
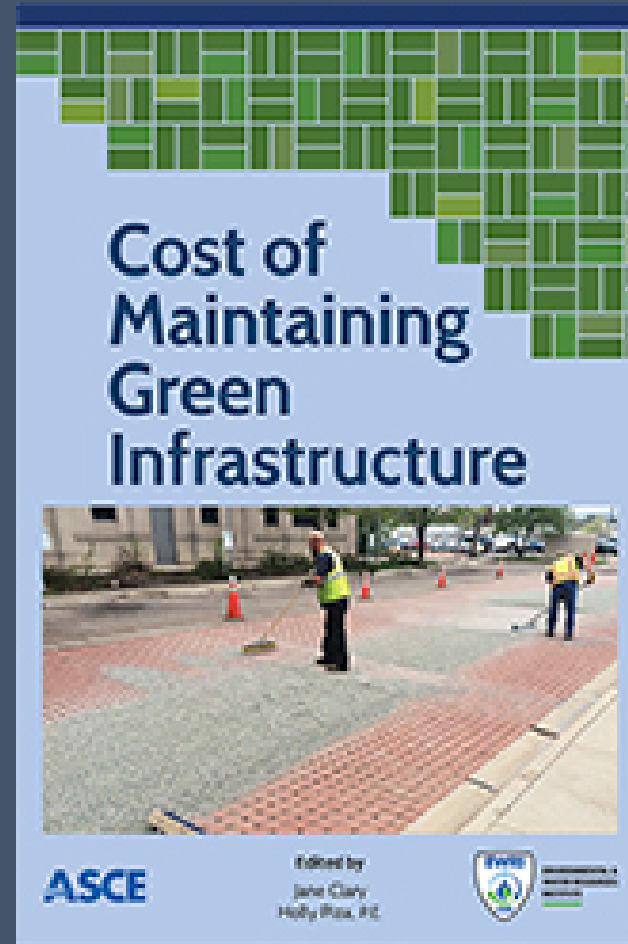


Runoff Reduction
Slotted Curb



BMP Cost Database: Can you maintain your BMP/SCM? Who is paying for it? Does it work for the long-term?

- O&M activities and costs to track
- Excel tool to use in tracking
- Goals
 - Improve tracking/cost data
 - Compile data to support better maintenance planning
- EWRI supported update of cost database (2022)
<https://bmpdatabase.org/urban-bmp-cost>

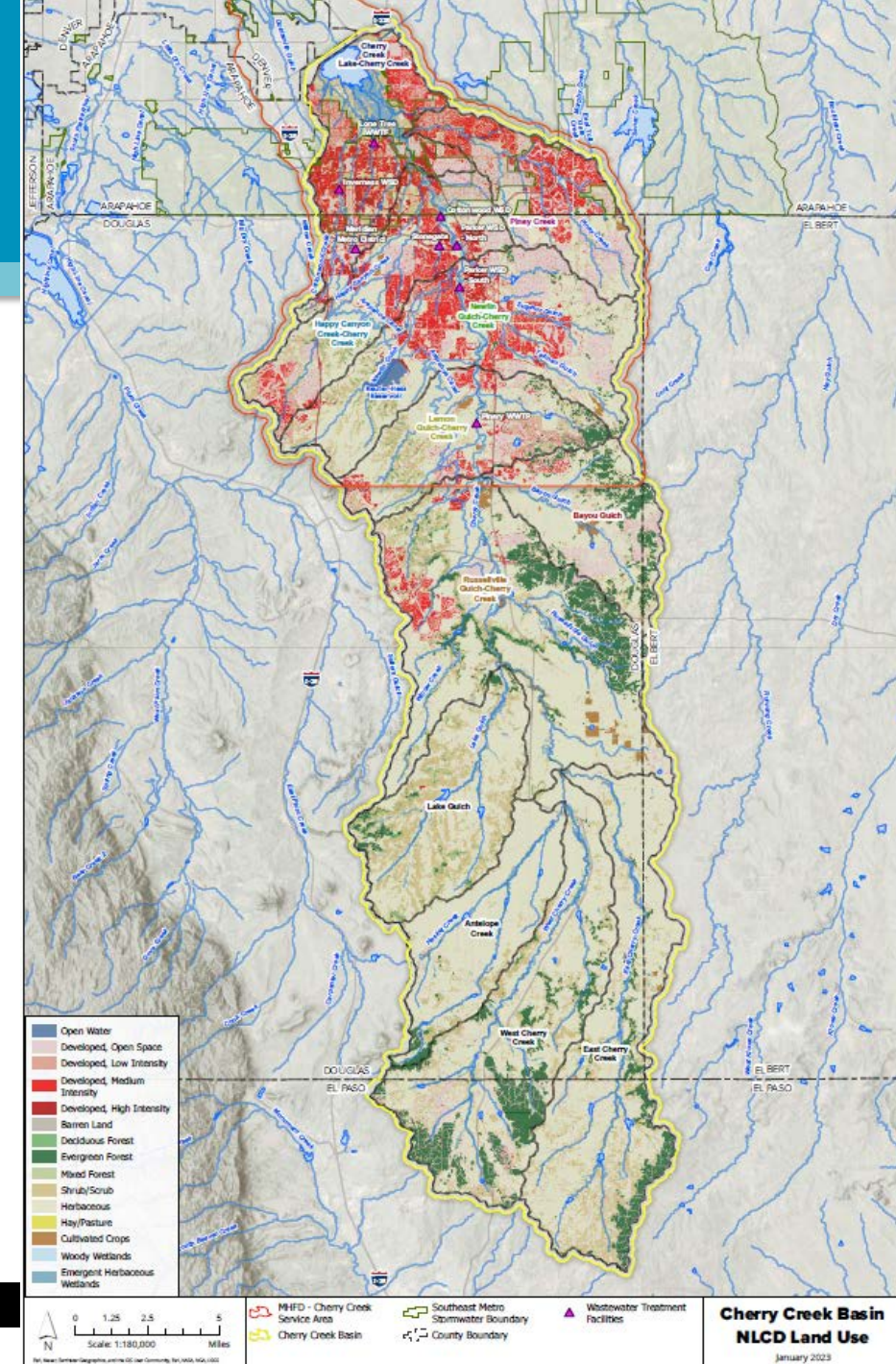


Cherry Creek Basin Water Quality Authority



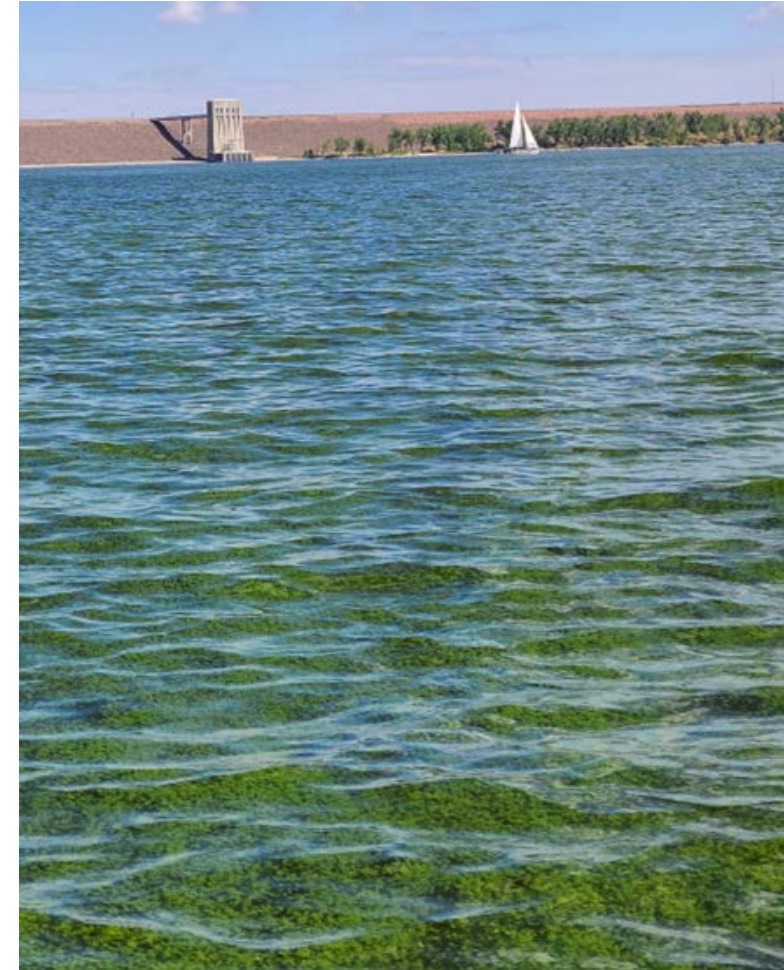
Cherry Creek Reservoir Basics

- Reservoir constructed for flood control by U.S. Army Corps of Engineers (1950)
- Cherry Creek State Park created (1959)—now ~1.5 million visitors per year
- Clean Lakes Study showed eutrophication (1984)
- CCBWQA (Authority) created by the Colorado Legislature in 1988, primarily funded by property tax
- Regulation 72 Control Regulation
- Watershed Size: ~386 square miles
- Reservoir Size: 850 acres with 13,000 AF of storage



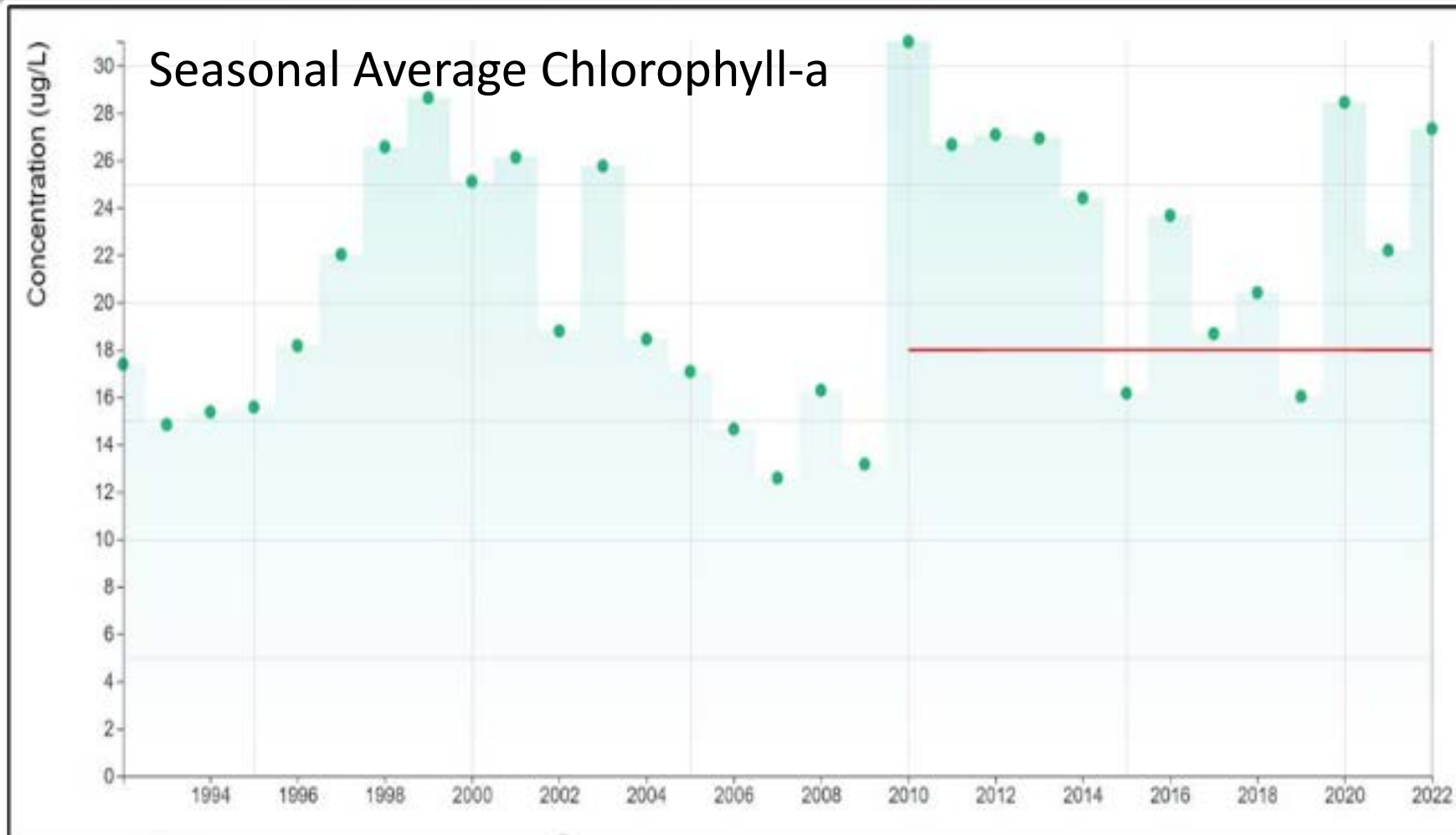
Established Vision & Mission

- **Vision:** Restore and maintain the chemical, physical, and biological integrity of the nation's waters and specifically those in the Cherry Creek Basin.
- **Mission:**
 - Improve, protect, and preserve water quality in Cherry Creek and Cherry Creek Reservoir for recreation, fisheries, water supplies, and other beneficial uses.
 - Provide for effective efforts by counties, municipalities, special districts, and landowners within the basin in the protection of water quality.
 - Promote public health, safety, and welfare.

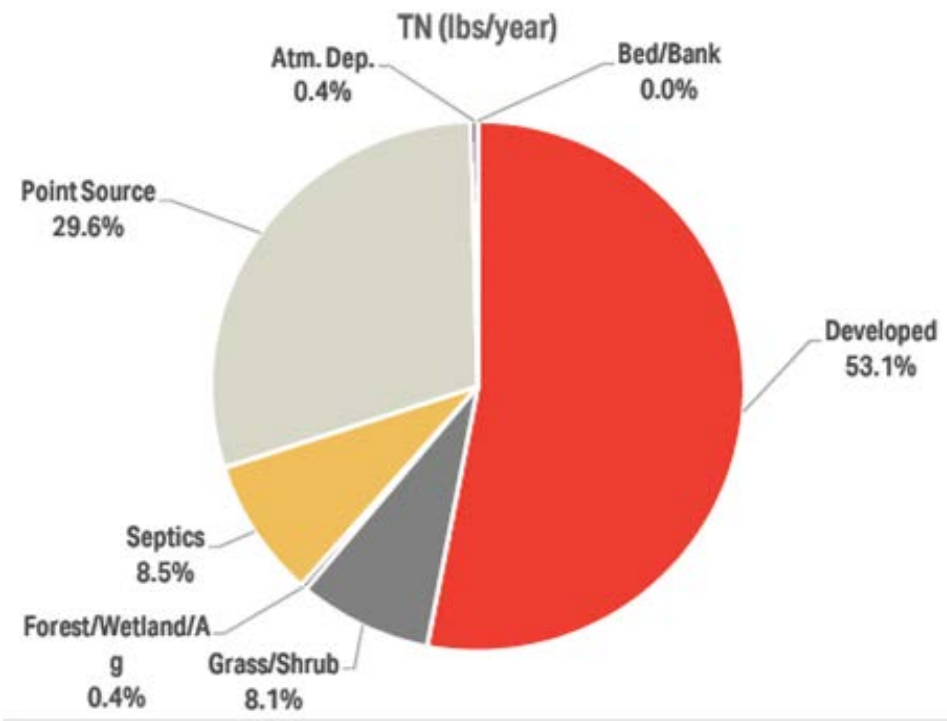
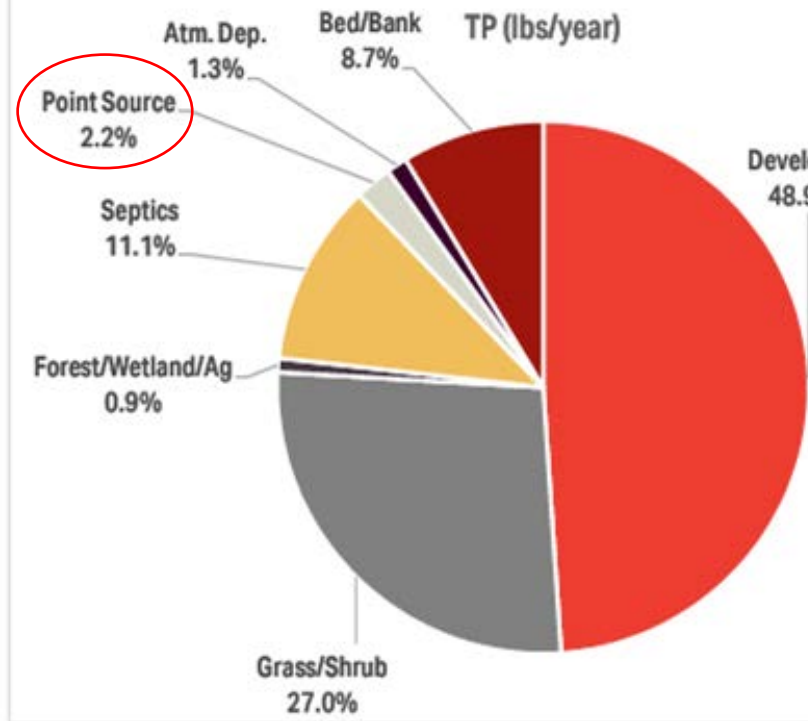
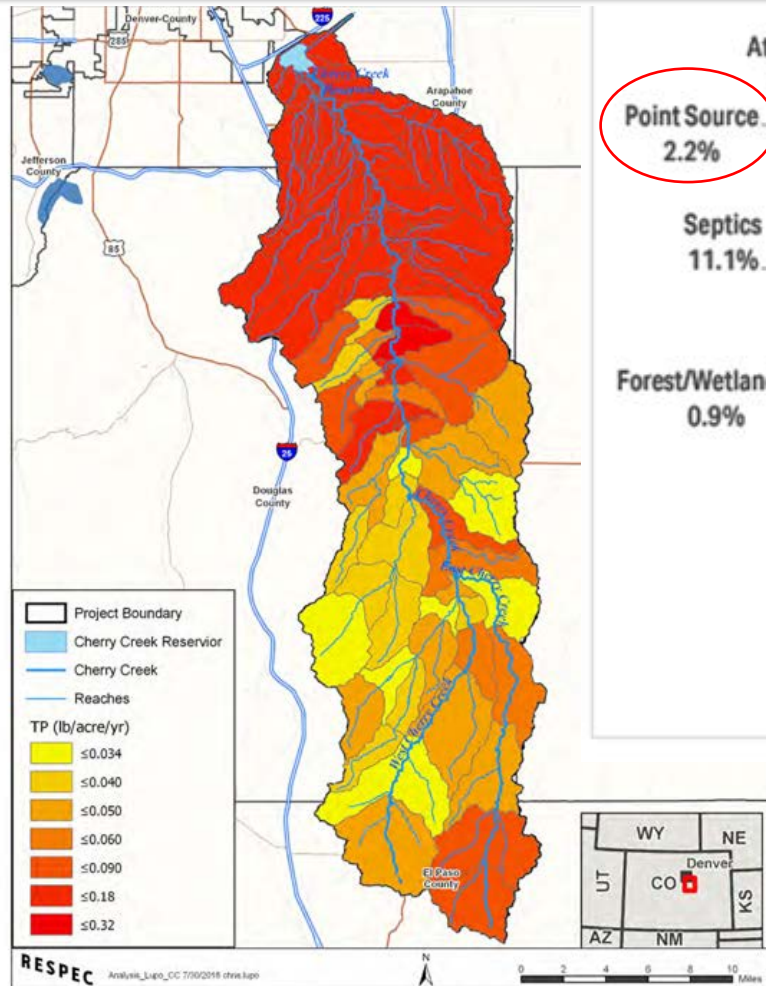


Status for 2023:

Status Quo Will Not Meet the Chlorophyll-a Standard



Understanding Relative Source Contributions



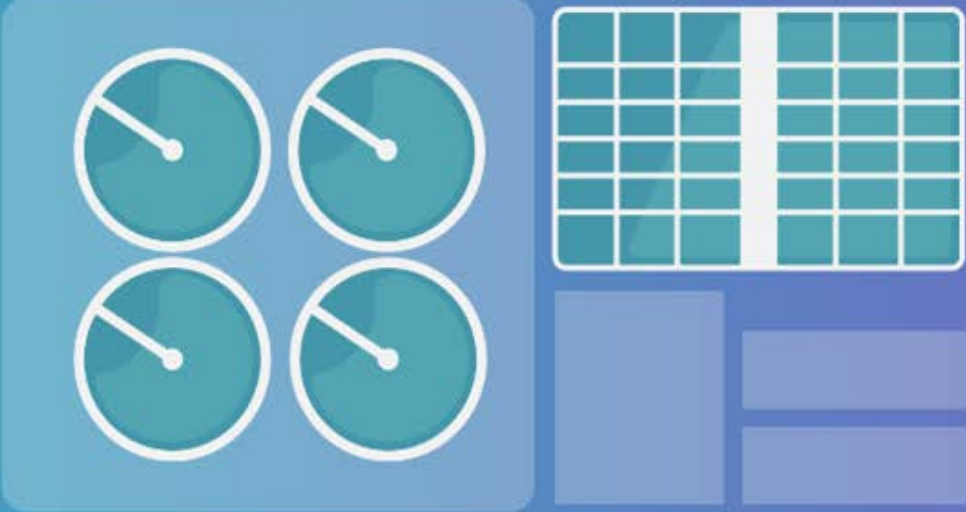
TP and TN Relative Source Contributions
RESPEC HSPF Watershed Model: Baseline Conditions

Simulated Total Phosphorus Loading Rates by Sub-watershed

Watershed Plan:

- Leverage Watershed Model results

WWTFs



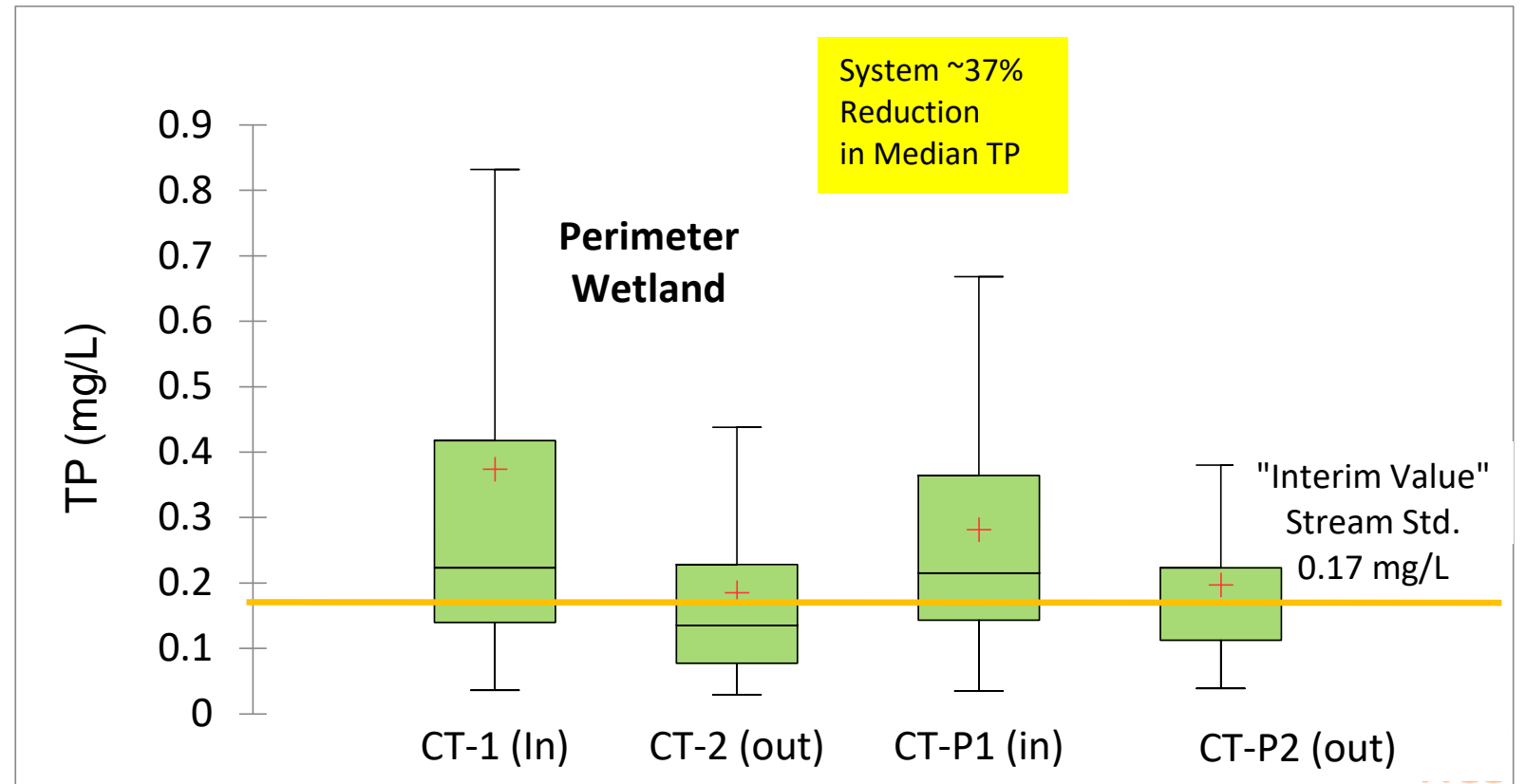
Wastewater treatment facilities in the basin provide TP removal through advanced wastewater treatment processes.



- Treat phosphorus to 0.05 mg/L
 - significantly lower than inflow concentrations to the reservoir or background (0.20 mg/L)
- Direct discharge or land application



Cottonwood Wetland System Performance



Reservoir Destratification System (RDS)

- Controlling internal P loading is part of the solution
- RDS limits stratification when temperatures are not extreme
- When dissolved oxygen is high at the bottom of the reservoir, internal loading is reduced
- Artificially mixes cyanobacteria
- Benefit to fishery
- But, it has design limitations





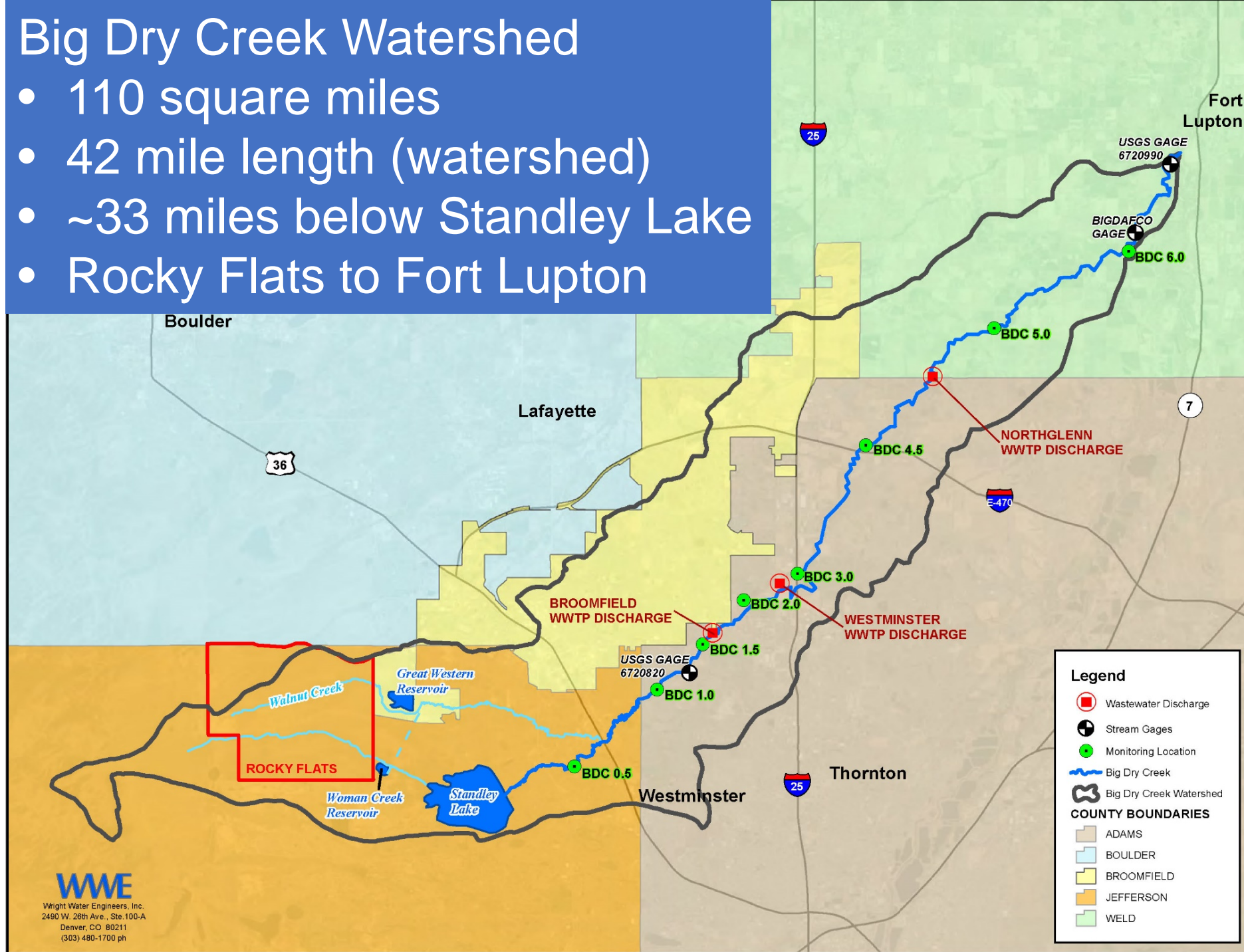
Big Dry Creek Watershed Association

- Formed 501(c)(3) in 2004; active since 1997
- Financially Contributing Members
 - Board of Directors
 - City and County of Broomfield
 - City of Westminster
 - City of Northglenn
 - City of Thornton (no WWTP discharge to BDC)
 - Adams County (no WWTP discharge to BDC)
 - Weld County (no WWTP discharge to BDC)
 - Woman Creek Reservoir Authority



Big Dry Creek Watershed

- 110 square miles
- 42 mile length (watershed)
- ~33 miles below Standley Lake
- Rocky Flats to Fort Lupton



Monitoring and Analysis: Science-based Decision Making

- Monitoring plan on website: www.bigdrycreek.org
- 8 locations monitored monthly for water quality and/or flow
- Nutrients, metals, *E. coli*, other
- Macroinvertebrate, fish and habitat assessment—now biennially at 6 sites
- USGS Gage at Westminster (funding)

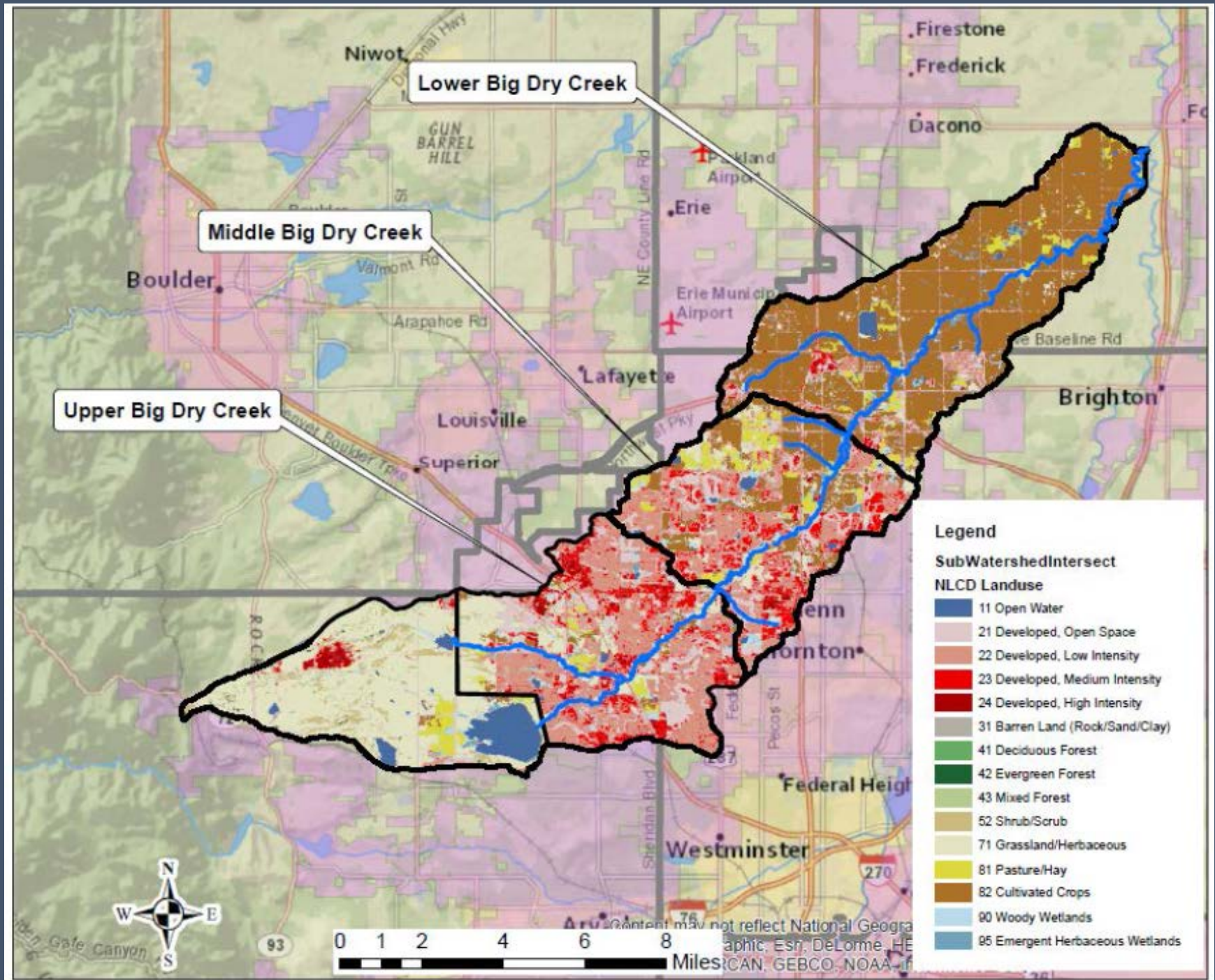


June 2020 Regulation 38 Standards

1. Mainstem of Big Dry Creek, including all tributaries and wetlands, from the outlet of Standley Lake to the confluence with the South Platte River. Walnut Creek, including tributaries and wetlands, from the outlet of Great Western Reservoir to the confluence with Big Dry Creek.							
COSPBD01	Classifications	Physical and Biological			Metals (ug/L)		
Designation	Agriculture		DM	MWAT		acute	chronic
UP	Aq Life Warm 1	Temperature °C	WS-I	WS-I	Arsenic	340	---
	Water Supply		acute	chronic	Arsenic(T)	---	0.02-10 ^A
	Recreation E	D.O. (mg/L)	---	5.0	Beryllium(T)	---	100
Qualifiers:		pH	6.5 - 9.0	---	Cadmium	TVS	TVS
Fish Ingestion Standards Do Not Apply		chlorophyll a (mg/m ²)	---	150*	Cadmium(T)	5.0	---
Other:		E. Coli (per 100 mL)	---	126	Chromium III	---	TVS
		Inorganic (mg/L)			Chromium III(T)	50	---
			acute	chronic	Chromium VI	TVS	TVS
		Ammonia	TVS	TVS	Copper	TVS	TVS
		Boron	---	0.75	Iron	---	WS
		Chloride	---	250	Iron(T)	---	1000
		Chlorine	0.019	0.011	Lead	TVS	TVS
		Cyanide	0.005	---	Lead(T)	50	---
		Nitrate	10	---	Manganese	TVS	TVS/WS
		Nitrite	---	4.5	Mercury(T)	---	0.01
		Phosphorus	---	0.17*	Molybdenum(T)	---	150
		Sulfate	---	WS	Nickel	TVS	TVS
		Sulfide	---	0.002	Nickel(T)	---	100
					Selenium	varies*	---
					Selenium	---	varies*
					Silver	TVS	TVS
					Uranium	varies*	varies*
					Zinc	TVS	TVS
	*chlorophyll a (mg/m ²)(chronic) = applies only above the facilities listed at 38.5(4).						
	*Phosphorus(chronic) = applies only above the facilities listed at 38.5(4).						
	*Selenium(acute) = 19.1 ug/L from 11/1 - 3/31 TVS from 4/1 - 10/31.						
	Refer to Section 38.6(4)(d).						
	*Selenium(chronic) = 15 ug/L from 11/1 - 3/31 7.4 ug/L from 4/1 - 10/31.						
	Refer to Section 38.6(4)(d).						
	*Uranium(acute) = See 38.5(3) for details.						
	*Uranium(chronic) = See 38.5(3) for details.						

E. coli TMDL 2016

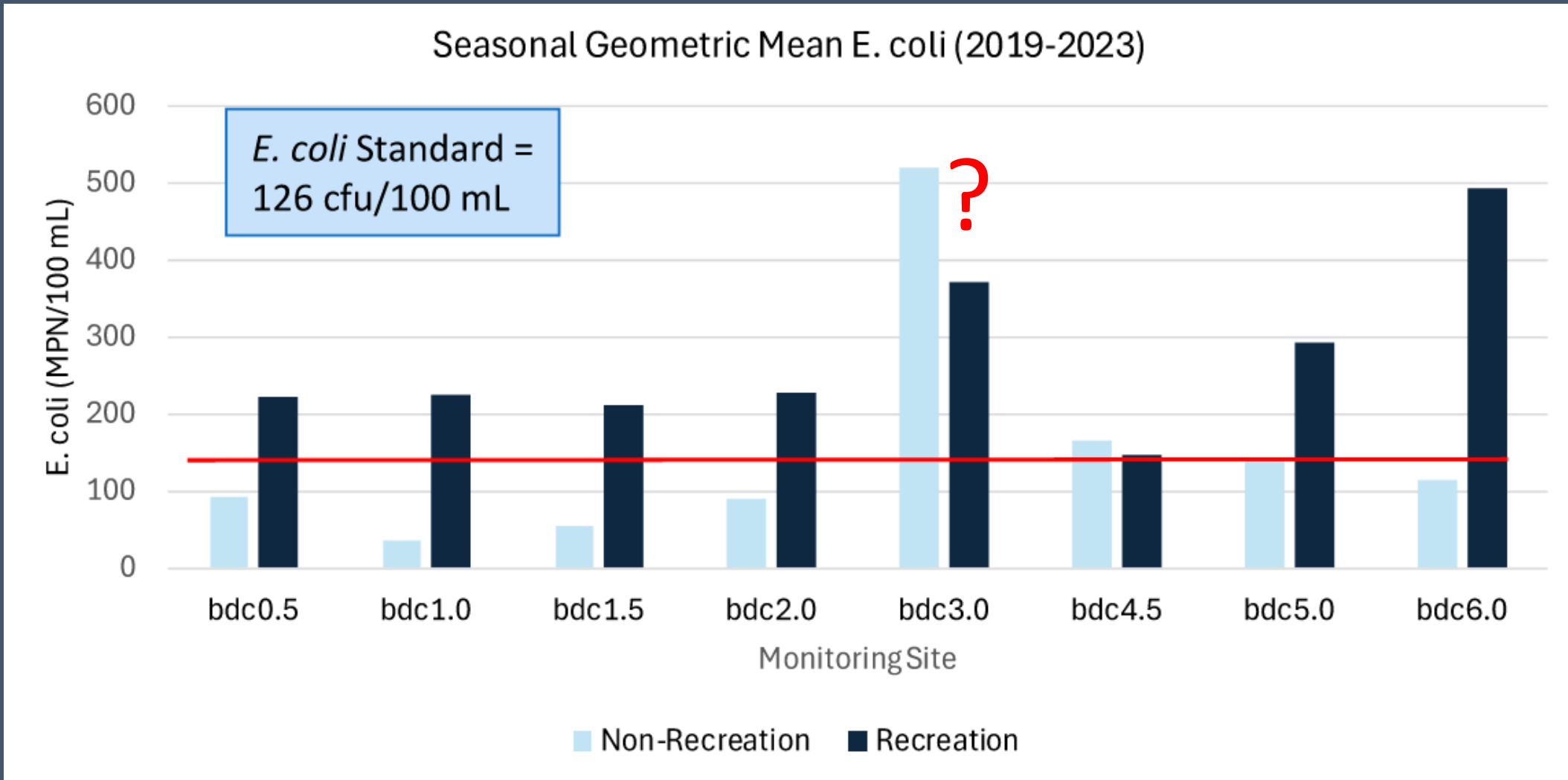
--completed for
205 MPN/100 mL
--new standard is
126 MPN/100 mL



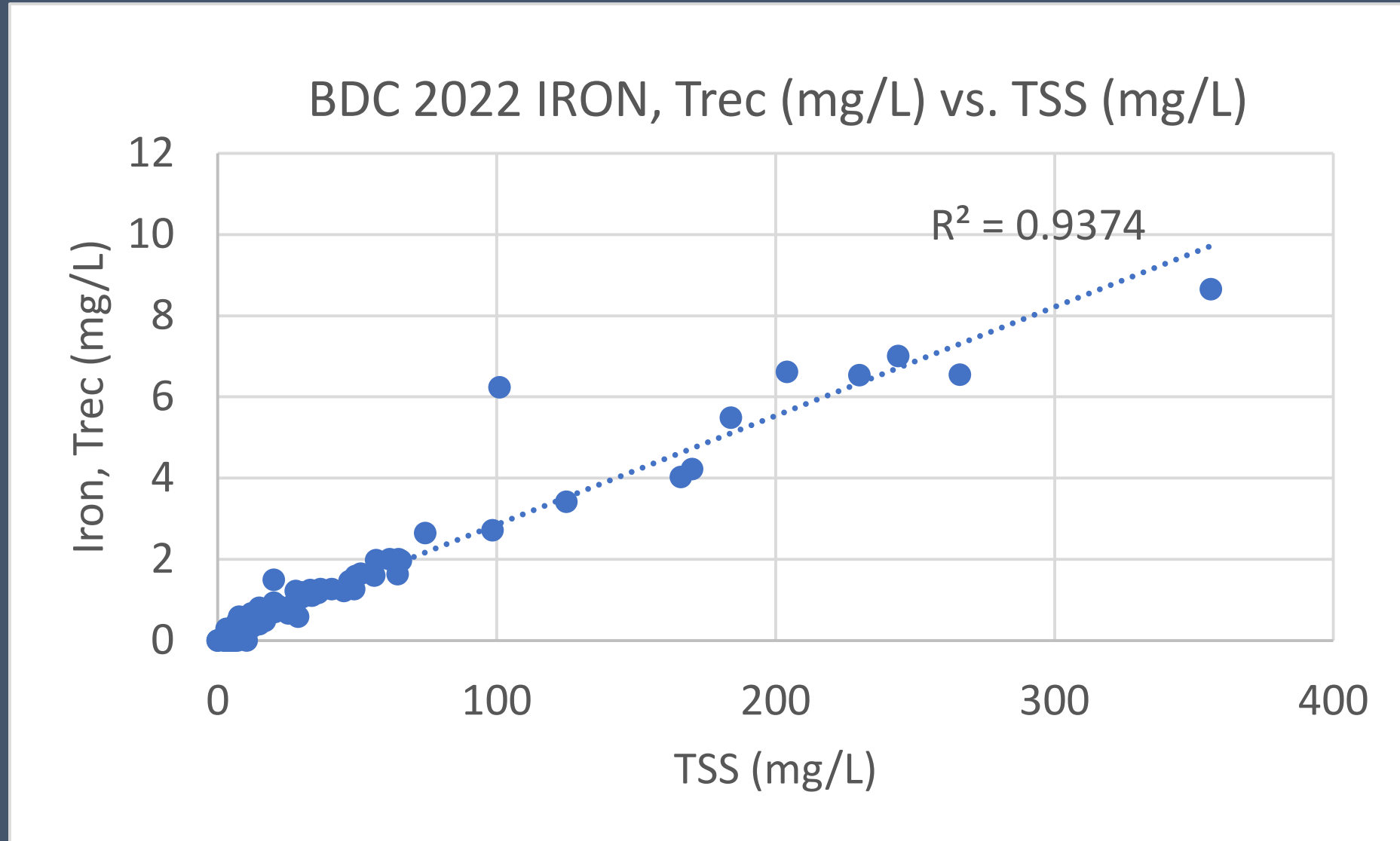
Fecal Indicator Bacteria Sources



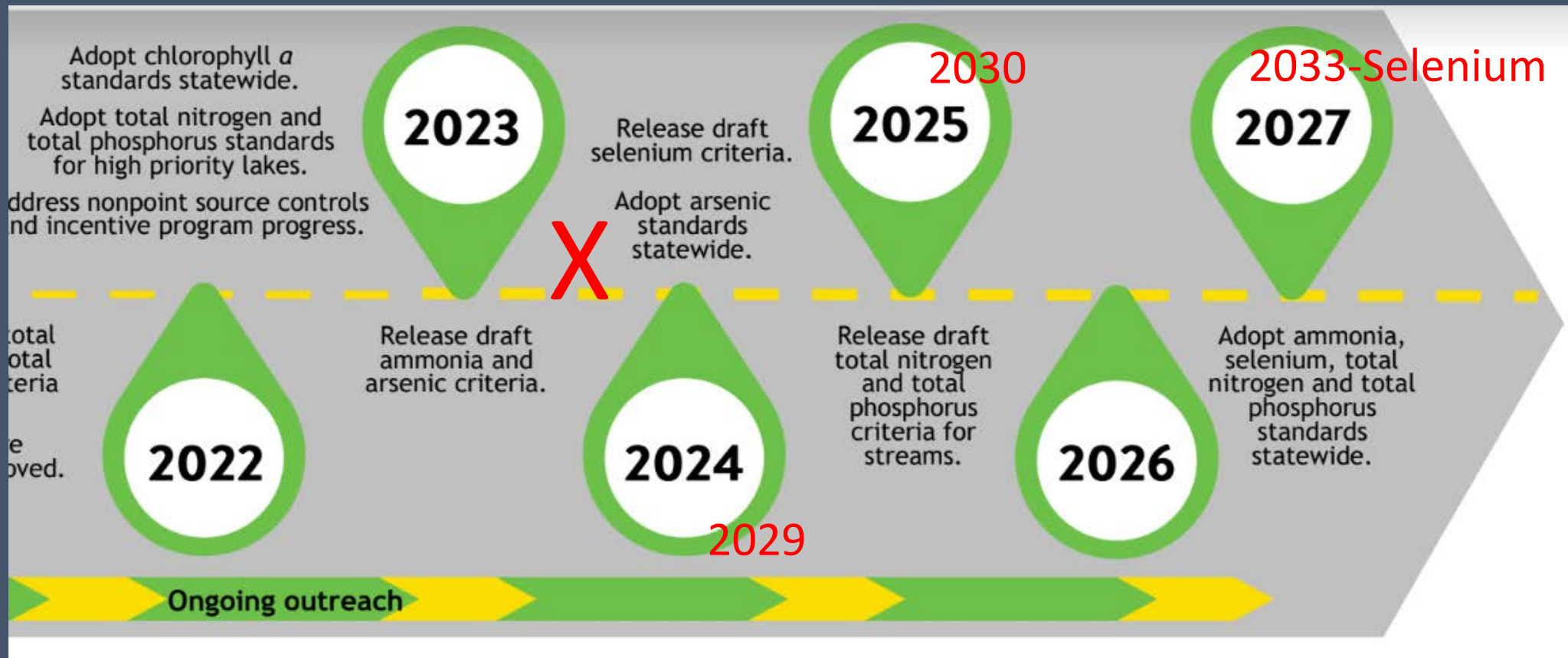
2019-2023 Seasonal Geometric Mean E. coli (MPN/100 mL)



2022 Instream Iron vs. TSS



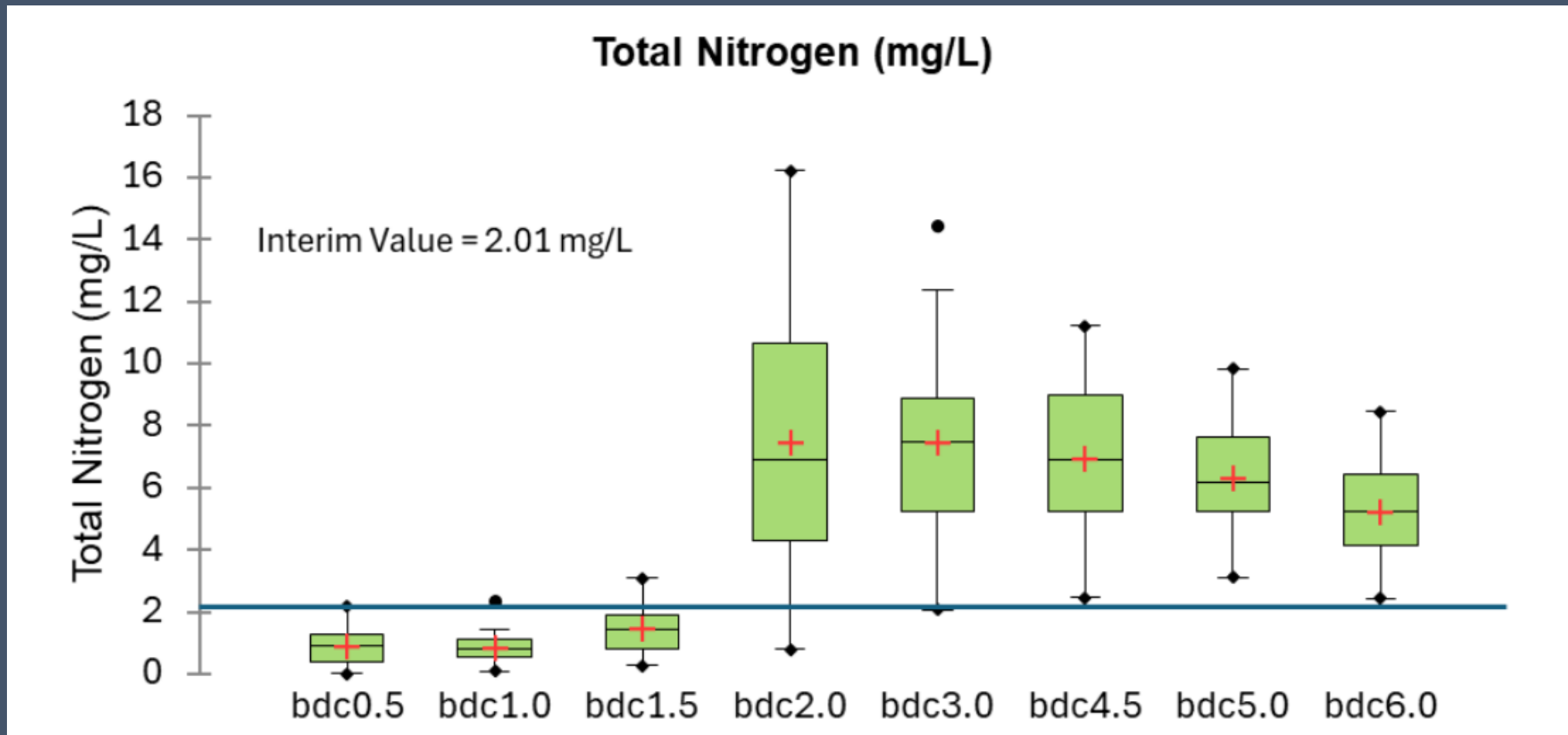
10-year Water Quality Roadmap is Evolving



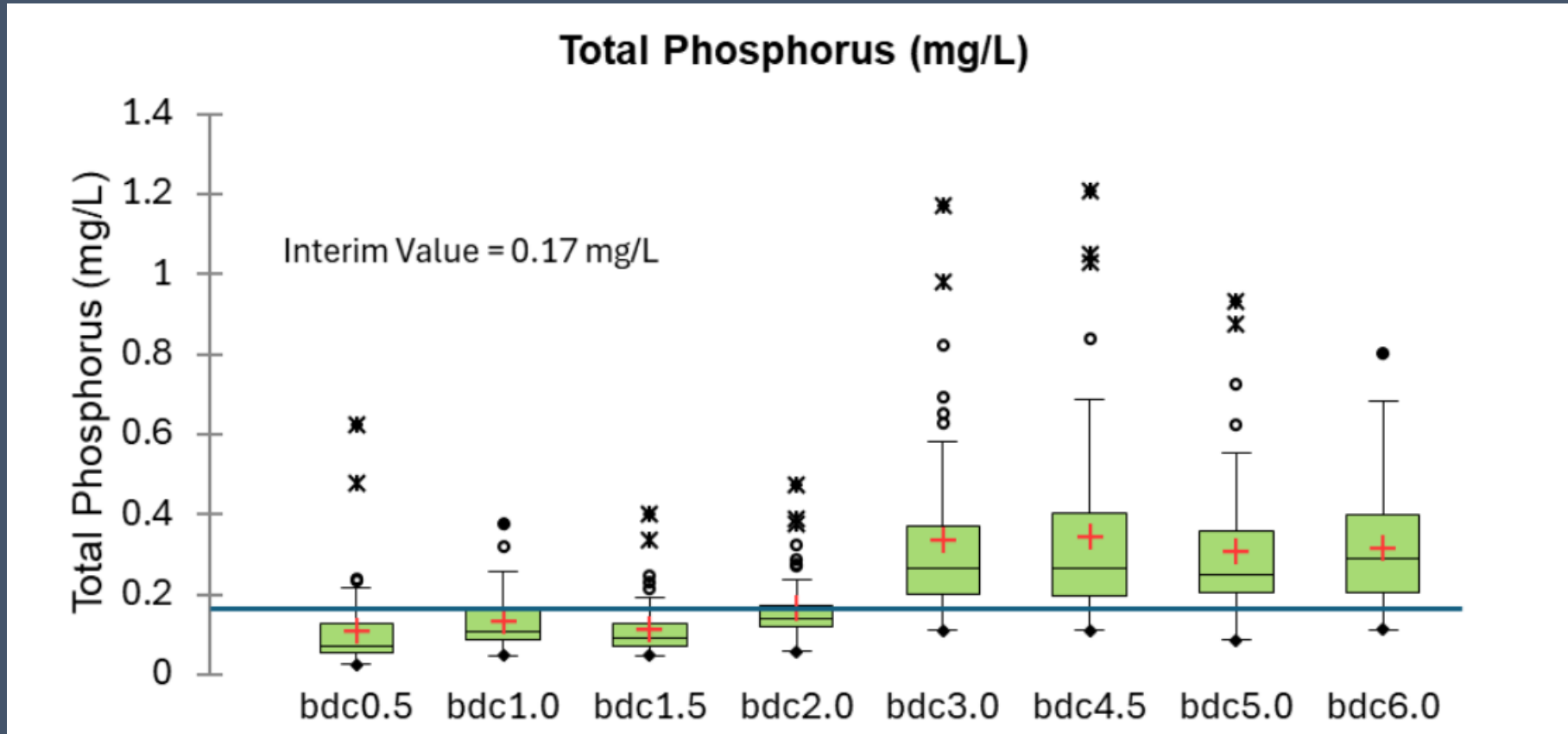
www.colorado.gov/cdphe/WQ-10-Year-Roadmap

Big Dry Creek Total Nitrogen (2023)

- Does not meet interim values below WWTPs to South Platte.
- 4/1/2025 compliance schedule for WWTPs: 15 mg/L annual running median and 20 mg/L 95th percentile.



Big Dry Creek Total Phosphorus (2023)



- Above WWTPs, stream can meet standard.
- Currently not meeting interim value below Westminster WWTP & agricultural area. (bdc2.0 attained 4 of last 5 yrs below Broomfield WWTP)

Decreases in TP @ Broomfield and Westminster WWTPs

- Biological nutrient removal at Broomfield and Westminster WWTPs.
- Compliance plans for new permits limits to reach 1 mg/L TP as annual median

Figure 24. Decreases in Total P Concentrations in Broomfield WWTP Discharge (2002-2023)

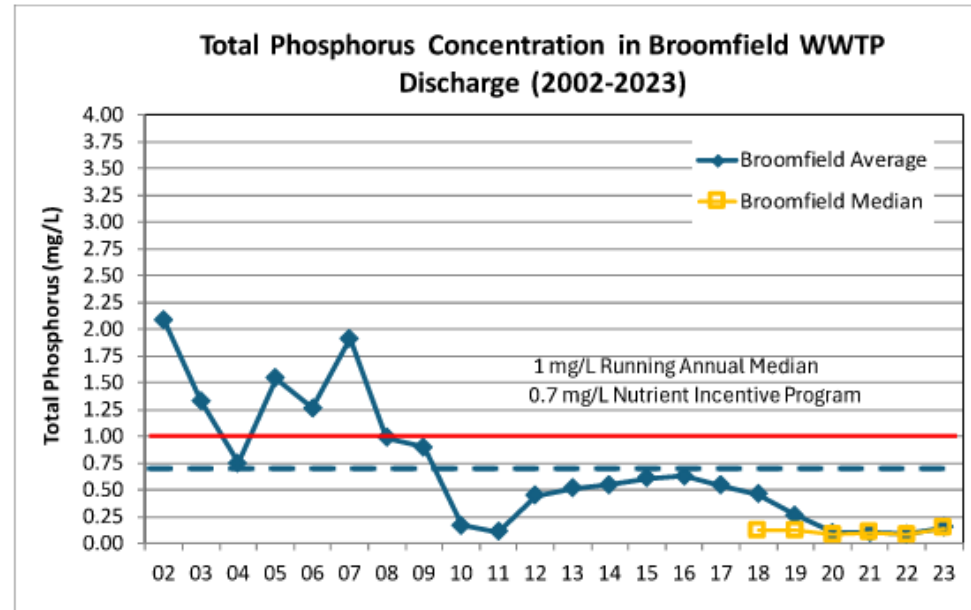
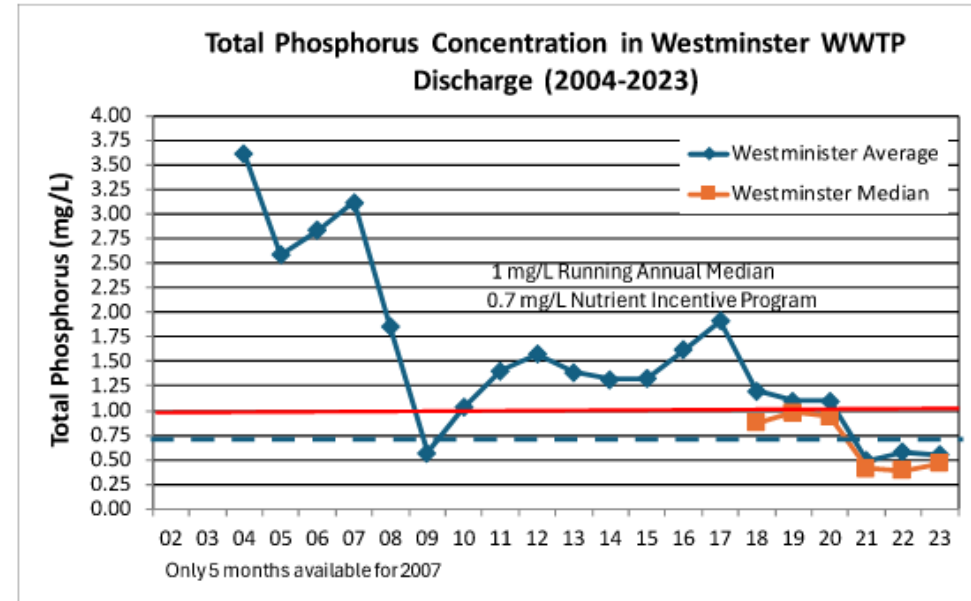
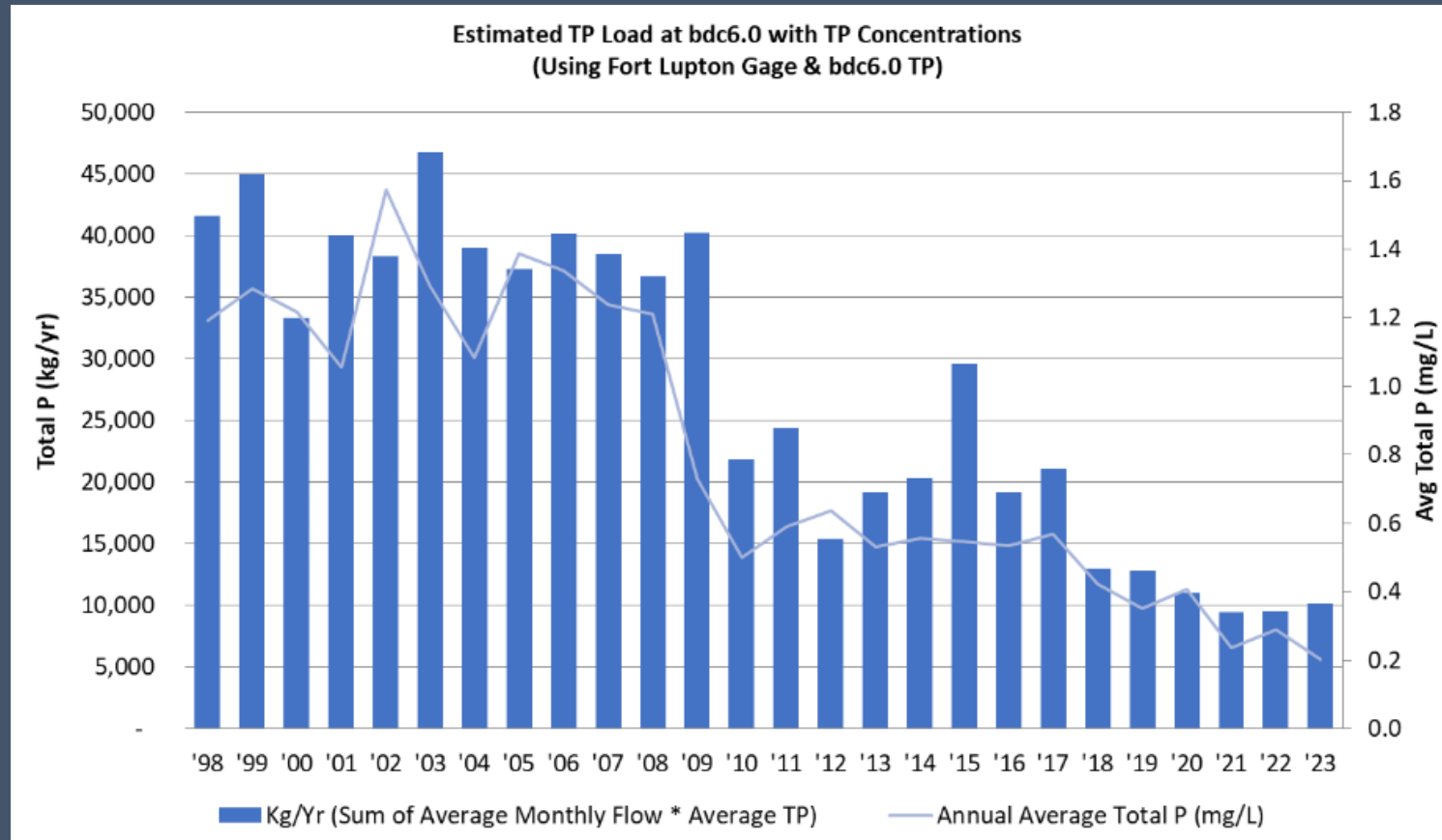


Figure 25. Decreases in Total P Concentrations in Westminster WWTP Discharge (2004-2023)

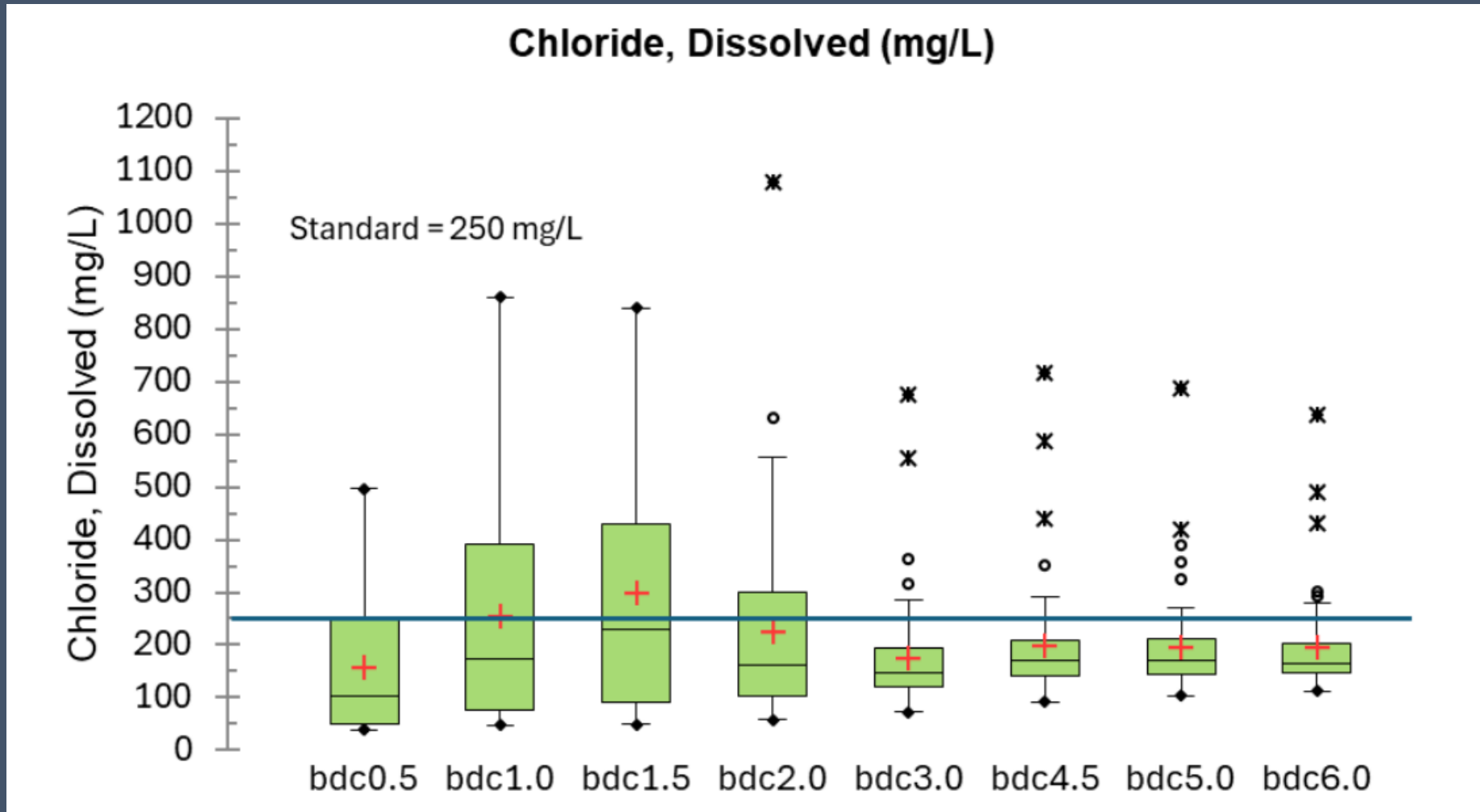


TP Load Reductions at bdc6.0

- BMW Target 20% load reduction relative to 2004.
- 2023 load is 68 and 74% lower than 2004 and 2003, respectively.
- Flow variations affect load.
- WWTP decreases affect TP load.



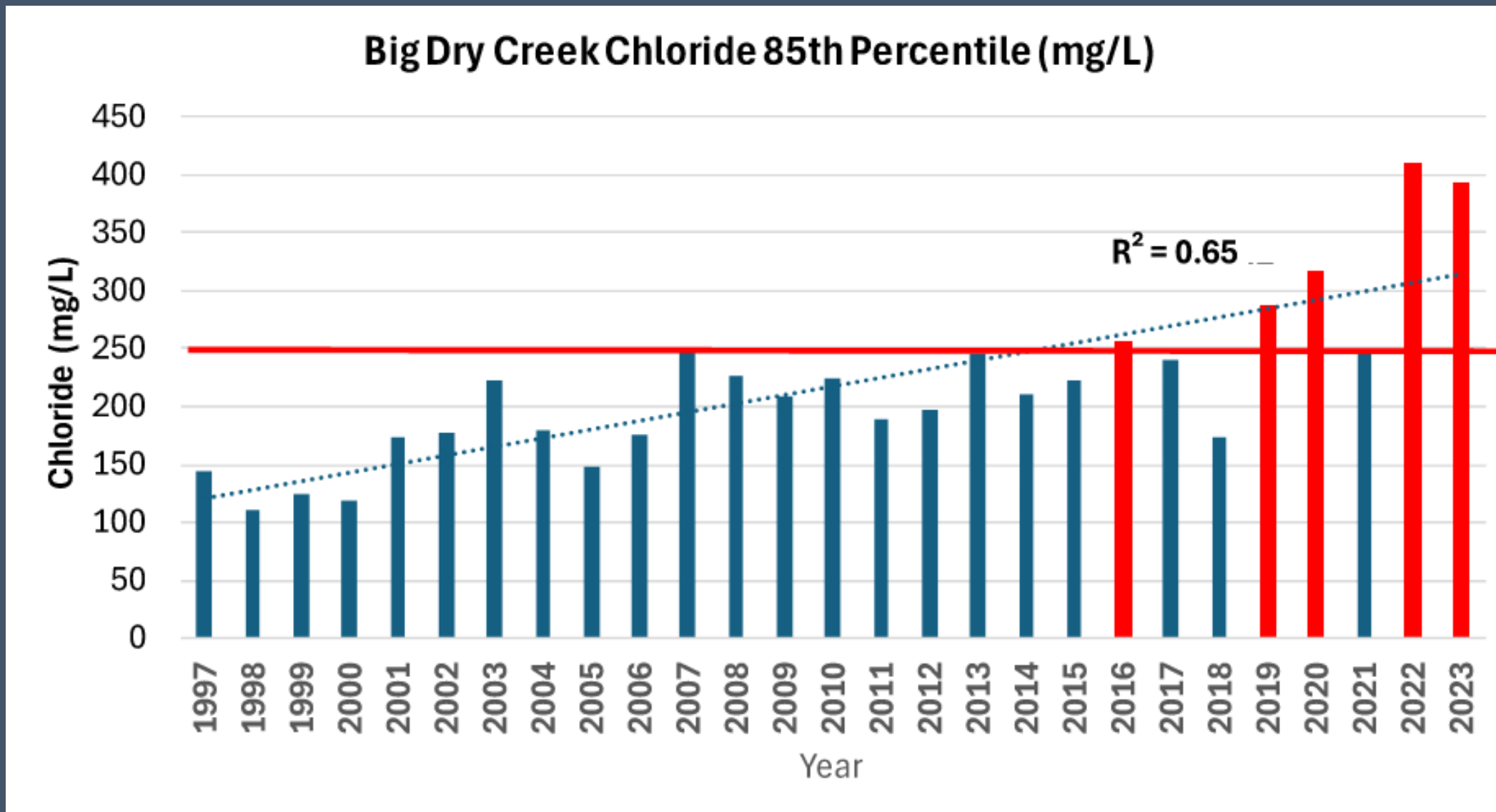
New Water Supply Standard: Chloride



2019-2023 Data Set: 85th Percentile = 330 mg/L.

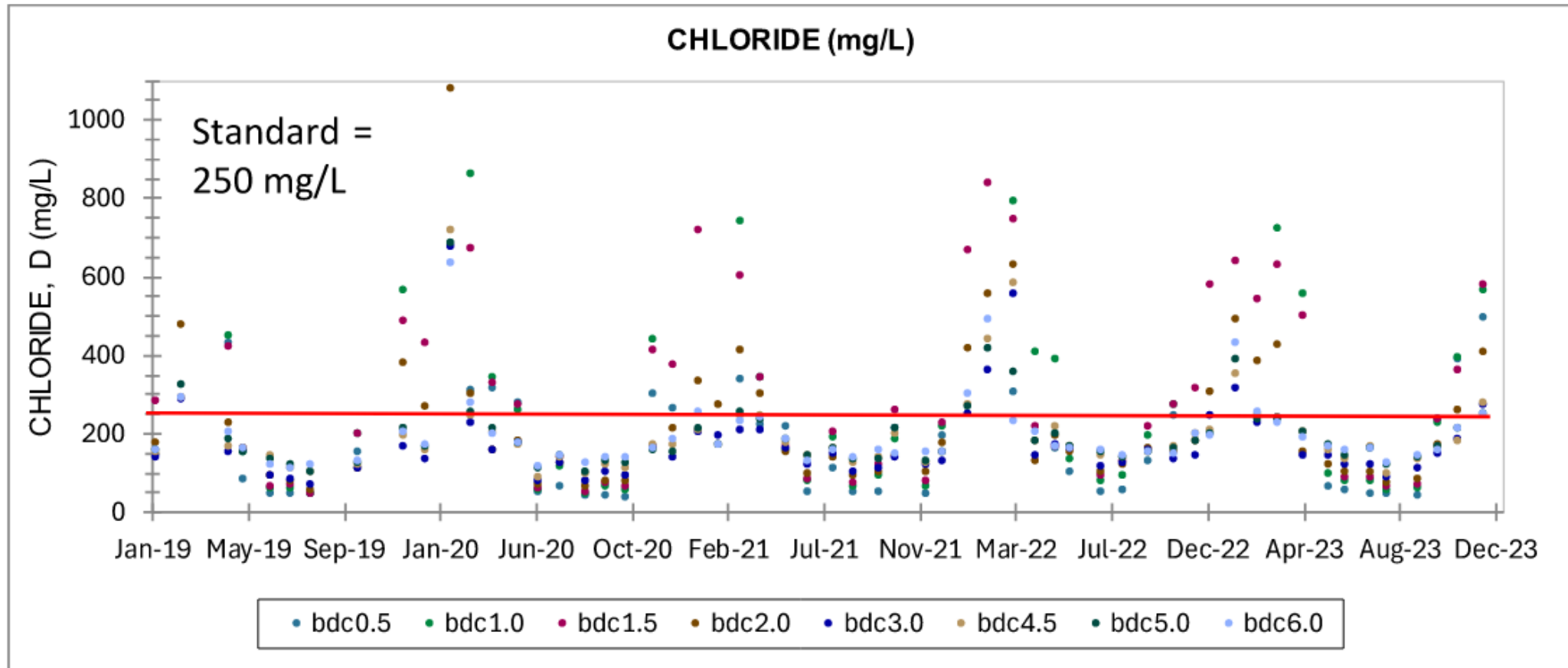
Note: bdc0.5, bdc1.0 & bdc1.5 are missing data for some frozen stream conditions in some winter months, also 2023 construction activities at bdc0.5.

Chloride Trends and Standards Exceedances



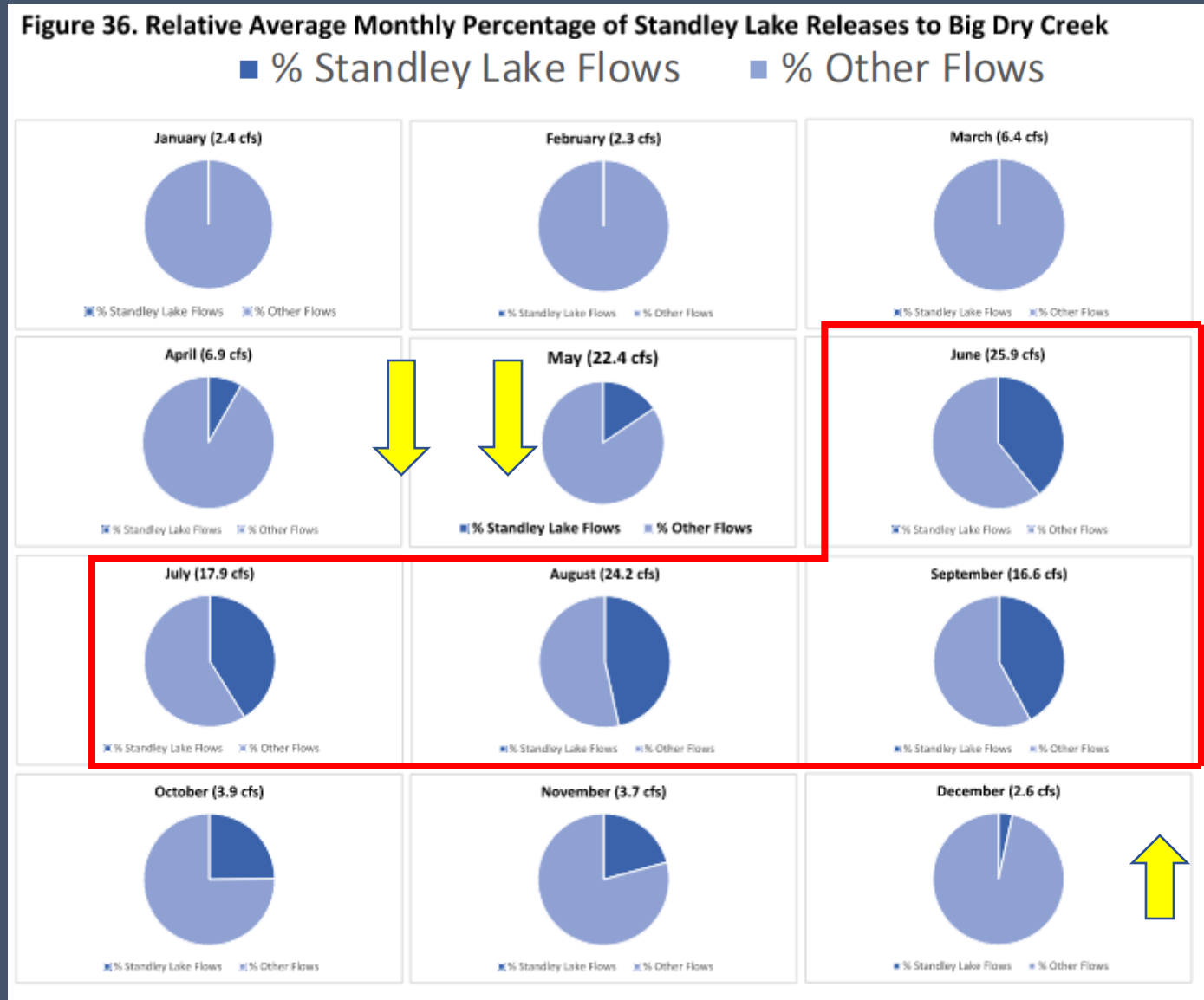
Chloride Seasonal-Spatial Analysis

Figure 17. Big Dry Creek Chloride Seasonal Trend (2019-2023)



Note: Note that bdc0.5 and bdc1.0 are missing multiple winter samples due to frozen samples or construction activities.

Role of Hydrology: Influence of Standley Lake Discharges Upper Watershed



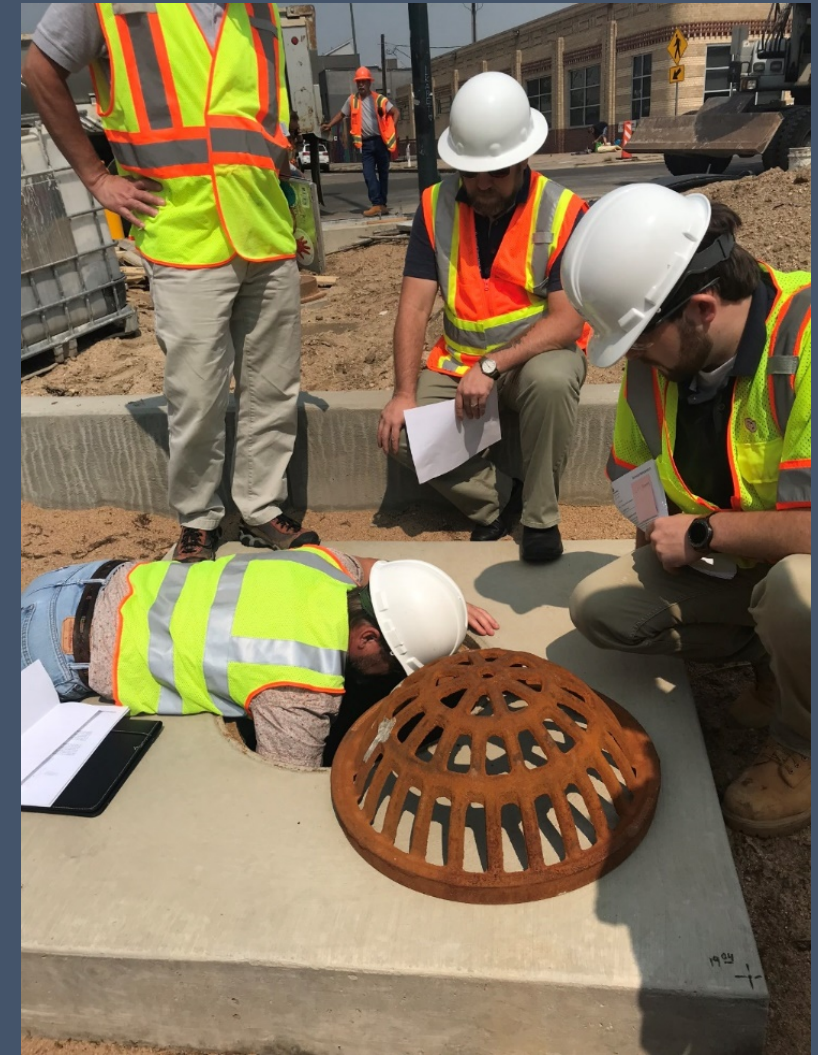
Three Issues/Concerns in Water Field

- Water Quality Regulations: Balance between protection and technical/economic/environmental feasibility
- Resilience to climate extremes and water shortages
- Identifying and making progress on controllable sources of pollution



Useful Skills in the Water Field

- Useful coursework for scientists
 - Statistics
 - Chemistry
 - Hydrology
 - Biology (aquatic, vegetation)
 - Applied Policy/Regulatory/Water Rights
 - GIS
- Communication—writing and speaking
- Work ethic—commitment to excellence
- Sense of responsibility— “own” your work
- Tenacity—no easy answers
- Entrepreneurship—build your own future





Questions?

Jane Clary,
Wright Water Engineers, Inc.
(clary@wrightwater.com)

