URS

Pushing the Limits: Challenges of Compliance with Ohio EPAs TDS Regulations

Robert T. Shoaf, P.E., BCEE

Columbus, OH

One Water

August 29, 2014

Presentation Summary

- Introduction
- Current Regulations in Ohio
  - Residue, Total Filterable (i.e. Total Dissolved Solids (TDS))
  - Acute Toxicity TU_a
  - Chronic Toxicity TU_c
- Other States
  - Ion Specific Limits
- Case Studies / Compliance Strategies

Ohio EPA Permit Limits (NPDES Permits)

- TDS limits are intended to keep the receiving stream TDS concentration less than 1,500 mg/l based on $7Q_{10}$ (seven day, ten year low flow)
- The larger the stream, the less stringent the concentration limit is:
  - For zero flow or intermittant streams (where $7Q_{10}$ is zero), then permit limit is 1,500 mg/l (based on chronic toxicity)
  - For very large streams / rivers, TDS impacts will be small and practically not limited

Recent Ohio EPA Permit Actions

- Some Recent WWTP NPDES permit renewals have been given new compliance and/or monitoring parameters:
  - Residue, Total Filterable (TDS)
  - Acute Toxicity
  - Chronic Toxicity
  - Stream Mussel Study Requirements

Example of New NPDES Permit

Effluent Characteristic	Discharge Limitations							Monitoring Requirements		
	Concentration Specified Units				Loading* kg/day					
Parameter	Maximum	Minimum	Weekly	Monthly	Daily	Weekly	Monthly	Measuring Frequency	Sampling Type	Monitoring Months
39100 - Bis(2-ethylhexyl) Phthalate - ug/l	1112	-	-	8.4	10.2	-	0.0764	1/Quarter	Composite	Quarterly
50050 - Flow Rate - MGD	-	-	-	-	-	-	-	1/Day	Continuous	All
50092 - Mercury, Total (Low Level) - ng/l	1700	-	-	5.4	0.0155	-	0.0000491	1/Month	Grab	All
61425 - Acute Toxicity, Ceriodaphnia dubia - TUa	1.0	-	-	-	-	-	-	1/Quarter	24hr Composite	Quarterly
61426 - Chronic Toxicity, Ceriodaphnia dubia - TUc	-	-	-	1.0	-	-	-	1/Quarter	24hr Composite	Quarterly
61427 - Acute Toxicity, Pimephales promelas - TUa	1.0	-	-	-	-	-	-	1/Quarter	24hr Composite	Quarterly
61428 - Chronic Toxicity, Pimephales promelas - TUc	-	-	-	1.0	-	-	-	1/Quarter	24hr Composite	Quarterly
61941 - pH, Maximum - S.U.	9.0	-	-	-	-	-	-	1/Day	Multiple Grab	All
61942 - pH, Minimum - S.U.	-	6.5	-	-	-	-	-	1/Day	Multiple Grab	All
70300 - Residue, Total Filterable - mg/l	-	-	-	1504	-	-	13700	1 / 2 Weeks	24hr Composite	All
80082 - CBOD 5 day - mg/l	-	-	15	10	-	137	90.9	3/Week	24hr Composite	Summer
80082 - CBOD 5 day - mg/l	-	-	40	25	-	364	228	3/Week	24hr Composite	Winter

This is clearly discharging into a small ditch/stream (1,504 mg/l TDS limit)

Typical Testing for TDS

- Acute / Chronic toxicity testing for TDS typically involves testing with:
  - *Ceriodaphnia dubia* (water flea)
  - *Pimephales promelas (*fathead minnows)

Ceriodaphnia dubia (C.dubia) "Water Flea"

- Acute Toxicity
  - Observations – mortality rates are recorded with % effluent concentrations.
  - Some Test Features:
    - Duration < 48 hours
    - Age: < 24 hours old
    - Minimum of 20 organisms per sample concentration in 4 replicates of 5 organisms per sample.

- Chronic Toxicity
  - Observations:
    - mortality rates are recorded with % effluent concentrations.
    - Reproduction are recorded.
  - Some Test Features:
    - Up to 7 days.
    - Age < 24 hours and all neonates must have been released within 8 hours of each other.
    - Three samples sets and solutions renewed using those every 24-hours.
    - Minimum of 10 organisms per sample concentration in 10 replicates with 1 organism per sample.

Source: http://mblaquaculture.com/content/organisms/daphnids.php

Pimephales promelas (P.promelas)"Fathead Minnow"

- Acute Toxicity
- Observations – mortality rates are recorded with % effluent concentrations.
- Some Test Features:
  - Duration 48 - 96 hours
  - Age: 1 – 14 days old (e.g. 8 days)
  - Minimum of 10 organisms per sample concentration in 2 replicates of 10 organisms per sample.

- Chronic Toxicity
- Observations:
  - mortality rates are recorded with % effluent concentrations.
  - Survival and weight to larvae also recorded.
- Some Test Features:
  - Up to 7 days.
  - Age 24 - 48 hours fish larvae.
  - Three samples sets and solutions renewed using those every 24-hours.
  - Minimum of 40 organisms per sample concentration in 4 replicates with 10 organism per sample.

Source:
http://mblaquaculture.com/content/organisms/pimephales_promelas.php

Acute Toxicity - Example

- TUa = 100 / LC50
- LC50 = Lethal Concentration to 50% of the population (50% dead).

Control 0% Eff.	Sample 6.25%	Sample 12.5%	Sample 25%	Sample 50%	Sample 100%
0% dead	0% dead	0% dead	10% dead	20% dead	50% dead

- Above, the LC50 = 100% effluent; TUa = 100/100 = 1.0

Acute Toxicity - Example

- TUa = 100 / LC50
- LC50 = Lethal Concentration to 50% of the population (50% dead).

Control 0% Eff.	Sample 6.25%	Sample 12.5%	Sample 25%	Sample 50%	Sample 100%
0% dead	0% dead	0% dead	40% dead	60% dead	75% dead

- If LC50 realized between test sample concentrations, then interpolation. Above, the LC50 ~ 37.5%, TUa = 100/37.5 = 2.67

- If LC50 not realized with 100% effluent, then reported as fractional value estimated. If 100% effluent = 30% dead, then TUa = 0.60.

Chronic Toxicity - Example

- TUc = 100 / IC25.
- TUc = 100/sqrt(NOEC *LOEC) for C.dubia (“water flea”).
- NOEC = No Observed Effect Concentration – highest concentration without observed effects.
- LOEC = Lowest Observed Effect Concentration – lowest concentration with observed effects.
- IC25 = Inhibition Concentration of 25% of reproduction or growth
- As in acute toxicity, the dilution series of 0% (control), 6.25%, 12.5%, 25%, 50%, and 100% effluent are also used for chronic toxicity. [Example: If IC25 = 85%, then TUc = 100/85 = 1.18]

OAC 3745-1-04: Criteria applicable to all waters

The following general water quality criteria shall apply to all surface waters of the state including mixing zones… shall be:

A. Free from suspended solids …. that will settle to form putrescent or otherwise objectionable sludge deposits, or that will adversely affect aquatic life;
B. Free from floating debris, oil, scum and other floating materials …. to be unsightly or cause degradation;
C. Free from materials entering the waters … producing color, odor or other conditions in such a degree as to create a nuisance;
D. Free from substances entering the waters … in concentrations that are toxic or harmful to human, animal or aquatic life and/or are rapidly lethal in the mixing zone;
E. Free from nutrients entering the waters … that create nuisance growths of aquatic weeds and algae…
F. Free from public health nuisances associated with raw or poorly treated sewage…

Federal Requirements (adopted by the state)

- 40 CFR Sections 124.8 and 124.56 Require a Fact Sheet be prepared for receiving stream with pertinent data
  - Fact Sheet must contain data used in determining permit limits (flows, toxicity test data, background concentrations, etc.)

Typical Creek – Background Data (from Fact Sheet)

Parameter	Units	Value
[redacted]		
Total Dissolved Solids	mg/L	430
Hardness	mg/L as $CaCO_3$	370
pH	SU	8.0
[redacted]		
Annual 7Q10	cfs	0.61
Summer 30Q10	cfs	0.71
Winter 30Q10	cfs	1.71

Background Levels of TDS

- Vary by location within the state – but tend to be higher in NW Ohio and Central Ohio

- Previous work has defined the Aquatic Life Water Quality Standard at 1,500 mg/l outside of the mixing zone

TDS Variations By Region

Map Data Source:
US EPA 5/1/2010

50th percentile reference site stream data for all size streams in Ohio			
Ecoregion	TDS (mg/l)	% of TDS that is:	
		Sulfate	Chloride
IP	306	12%	9%
WAP	344	27%	6%
EOLP	408	15%	12%
ECBP	439	15%	9%
HELP	478	17%	11%
All	**420**	**16%**	**9%**

Data Source: Ohio EPA, Miltner, 10/2011

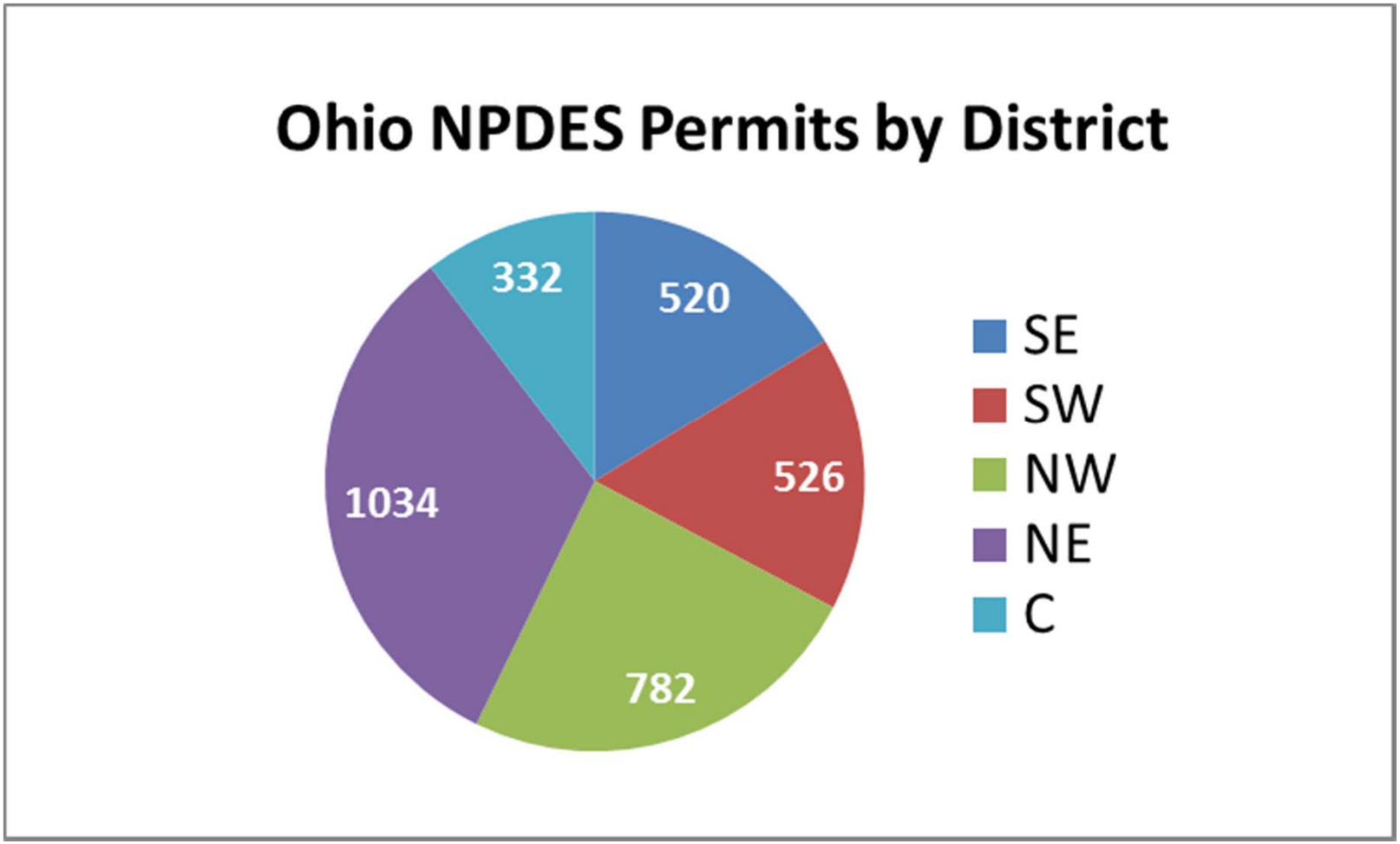
Ecoregions:
IP – Interior Plateau
WAP – Western Alleghany Plateau
EOLP – Erie/Ontario Lake Plain
ECBP – Eastern Corn Belt Plain
HELP – Huron/Erie Lake Plain

Toxicity Limitations by District

- List of Ohio NPDES Permits that have Chronic and/or Acute Monitoring OR Limits were obtained from Ohio EPA
- Total List of Direct Permits were estimated from Ohio EPA website.
- Approximately 20% of all NPDES permits now have TUa or TUc "action"

District	Total Permits	Acute Monitoring	Chronic Monitoring	Acute Limits	Chronic Limits	% with TU_a Or TU_c
SE	520	69	11	19	0	19.0%
SW	526	64	47	4	1	22.1%
NW	782	80	54	16	14	21.0%
NE	1034	85	71	22	18	19.0%
C	332	34	29	5	1	20.8%
Totals	3194	332	212	66	34	20.2%

NPDES Permits by District*



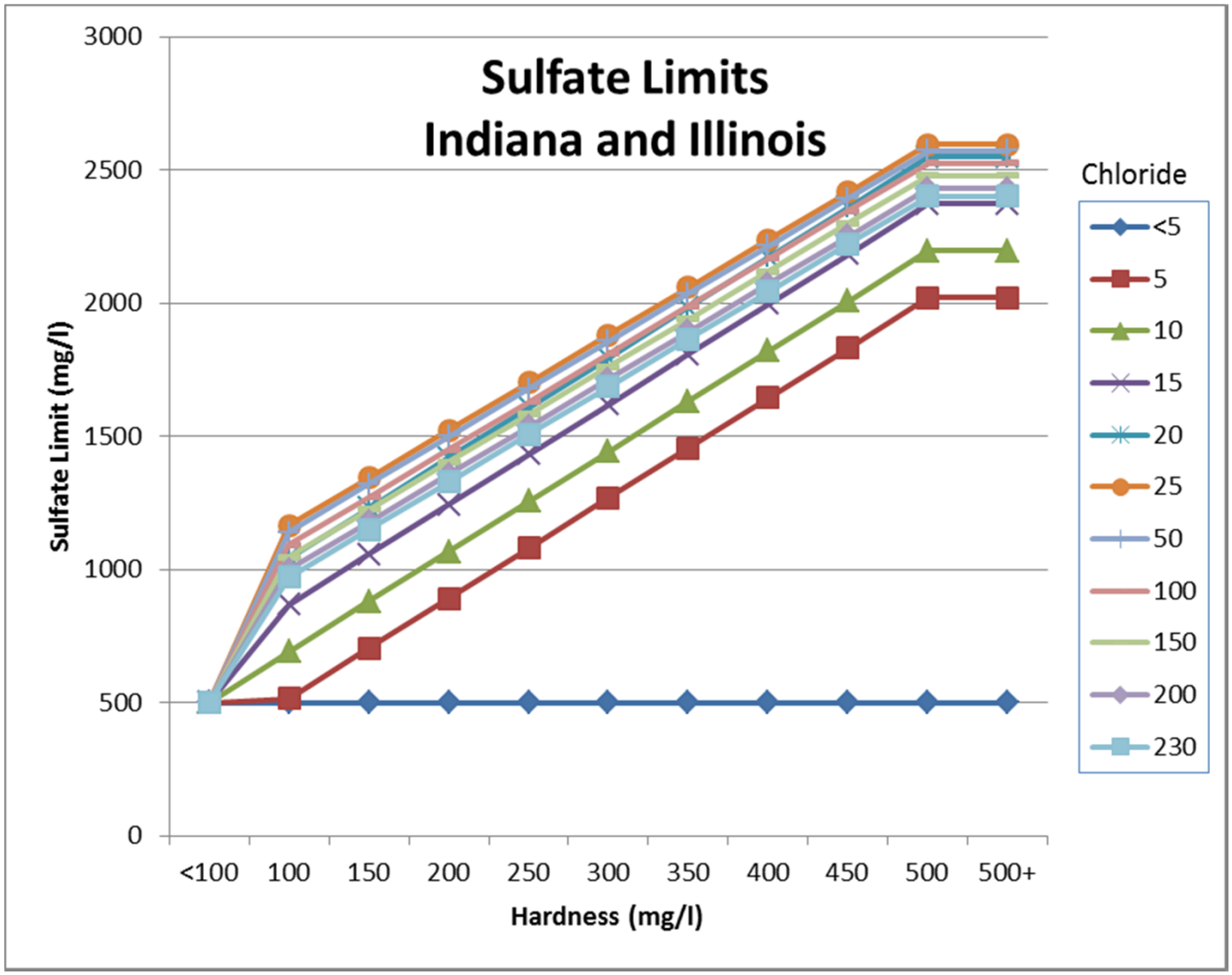
* Approximate

Ohio's Future TDS criteria

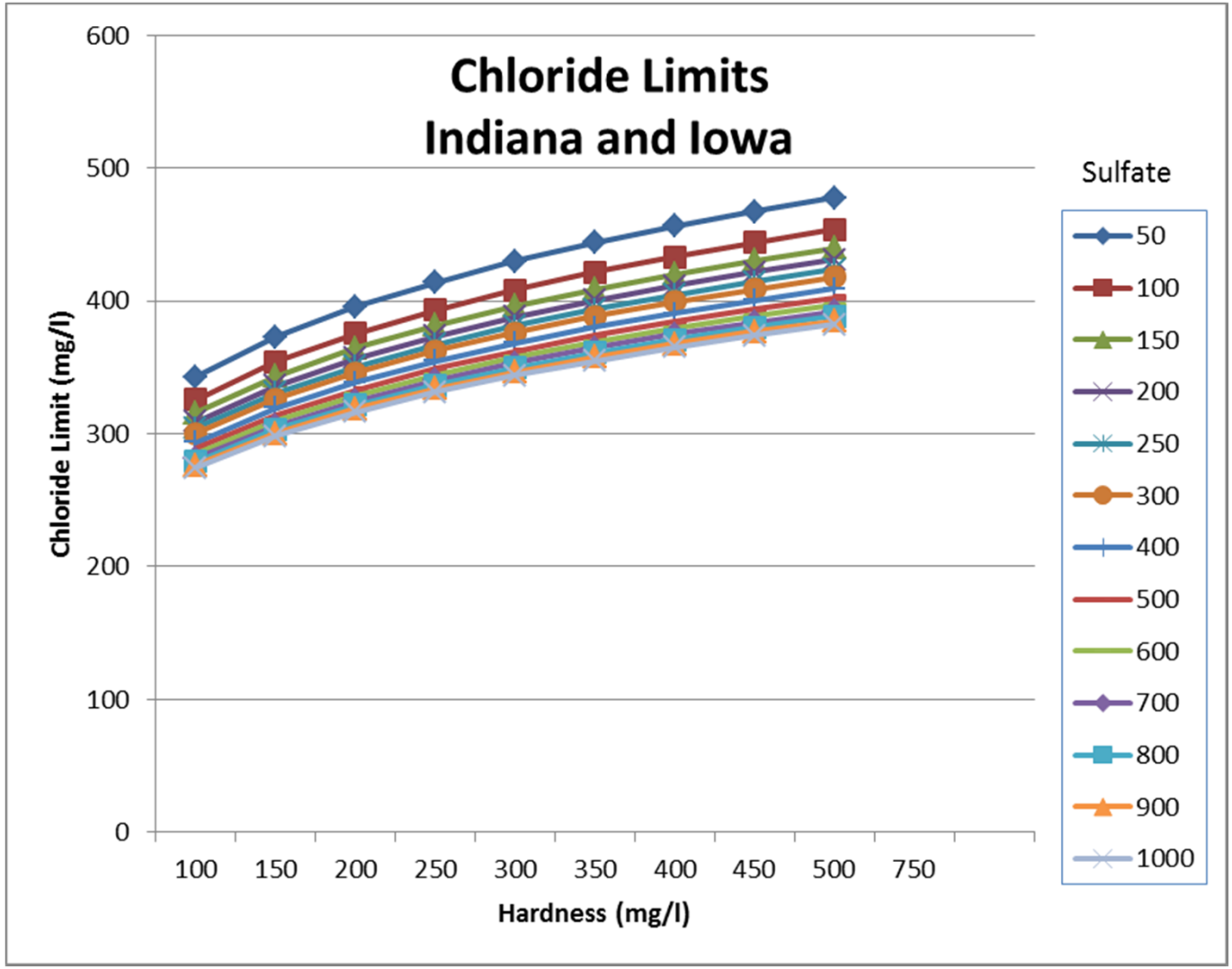
- Future TDS criteria for Ohio <u>might</u> be:
  - Ion specific
  - Ecoregion specific
  - A function of alkalinity
- Equations have been developed by Ohio EPA and are currently under internal and USEPA review

(while not official, the equations do seem to "allow" higher TDS concentrations than recent discussions of 600-800 mg/l)

Other States – Revised Approach



Other States – Revised Approach



Case Study - Pickerington, Ohio

- **Water Treatment Plant**:
  - 3.5 MGD – Iron / Mn Removal
  - Oxidation, Filtration, Ion Exchange Softening
- **Wastewater Treatment Plant**:
  - 3.2 MGD – Activated Sludge

WWTP TDS Compliance Issues

TDS Reduction Alternatives

A total of 13 alternatives were identified to reduce the TDS concentration at the WWTP (8 were considered feasible)

1. Adjustment of Softener Operation
2. Replacement or cleaning of Softener Media
3. Replace Ion Exchange Softeners with Reverse Osmosis
4. Reduce Level of Softening (to 195 mg/l)
5. Dilution Well at WWTP (flow augmentation)
6. Public Relations Strategies (Reduce In-home Softening)
7. Alt. Water Supply for Unsewered Customers
8. Purchasing Water during Peak Months

TDS Alternatives Ruled Out

The following alternatives were ruled out due to cost, technical, or political reasons

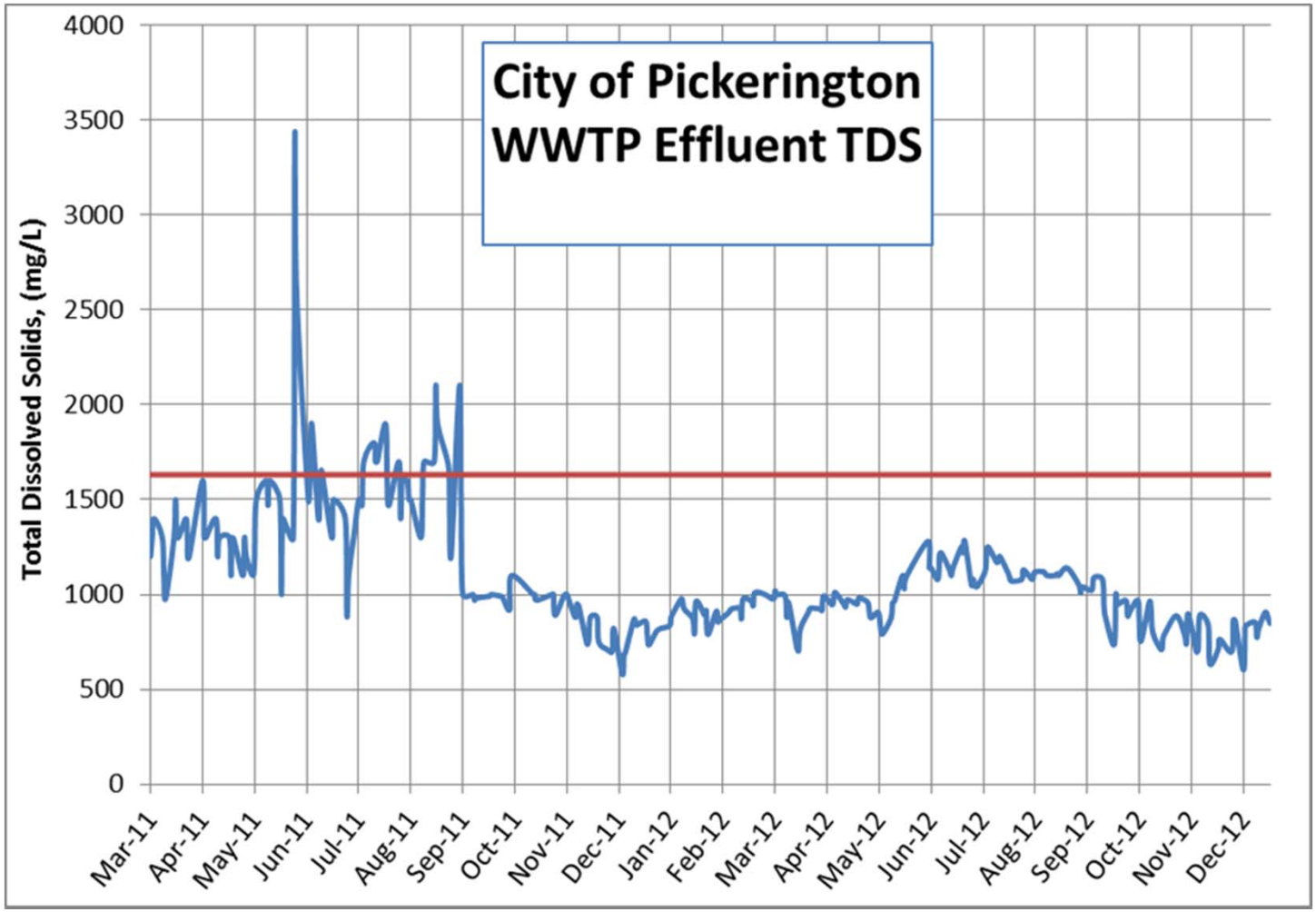
9. Deep Well Injection
10. Evaporation Ponds (not feasible in Ohio)
11. Land Application of Ion Exchange Residuals
12. Relocation of WWTP Effluent
13. Bypassing Softening During Peak Months

Pickerington WTP

New Reverse Osmosis Treatment Installed in place of some existing filter/softening equipment – in 5 months!

Pickerington WTP

Immediate WWTP TDS Compliance



Case Study - Delaware, Ohio WTP

- Proposed Integrated Membrane Plant (Bin 2 classification)
- Olentangy River, USGS Gauge

Magnitude and frequency of low flow for indicated periods

Period	Number of consecutive days	Streamflow (ft^3/s) for indicated recurrence interval (years)				
		2	5	10	20	50
Apr.-Mar.	1	9.2	5.0	3.5	2.5	1.7
	7	13	7.6	5.7	4.4	3.3
	30	19	12	10	8.9	7.9
	90	35	19	15	12	10
May-Nov.	1	12	7.1	5.2	3.9	2.7
	7	15	9.4	7.2	5.7	4.3
	30	19	13	11	9.3	8.3
	90	36	20	16	14	12

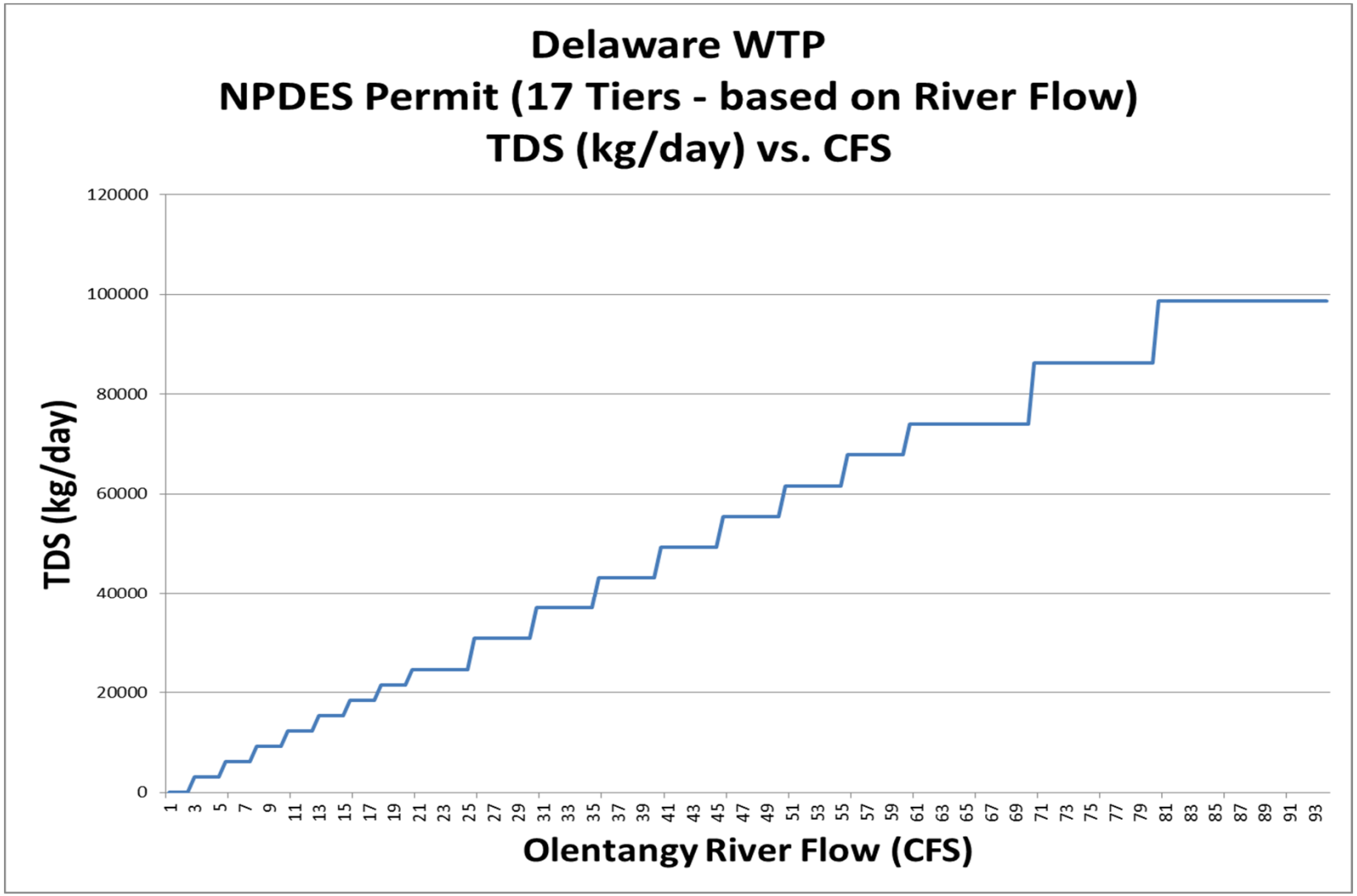
Period	Number of consecutive days	Streamflow (ft^3/s) for indicated recurrence interval (years)				
		2	5	10	20	50
Dec.-Feb.	1	31	14	8.8	5.9	3.6
	7	48	22	14	8.9	5.4
	30	116	43	25	15	8.8
	90	529	244	138	79	38
Sep.-Nov.	1	16	9.4	6.8	5.0	3.4
	7	17	12	9.4	8.0	6.6
	30	21	14	12	11	9.8
	90	85	38	26	19	13

- **$7Q_{10}$ is 5.7 ft^3/sec in this case in critical quarter**

Case Study: Delaware WTP RO Discharge Control Strategy

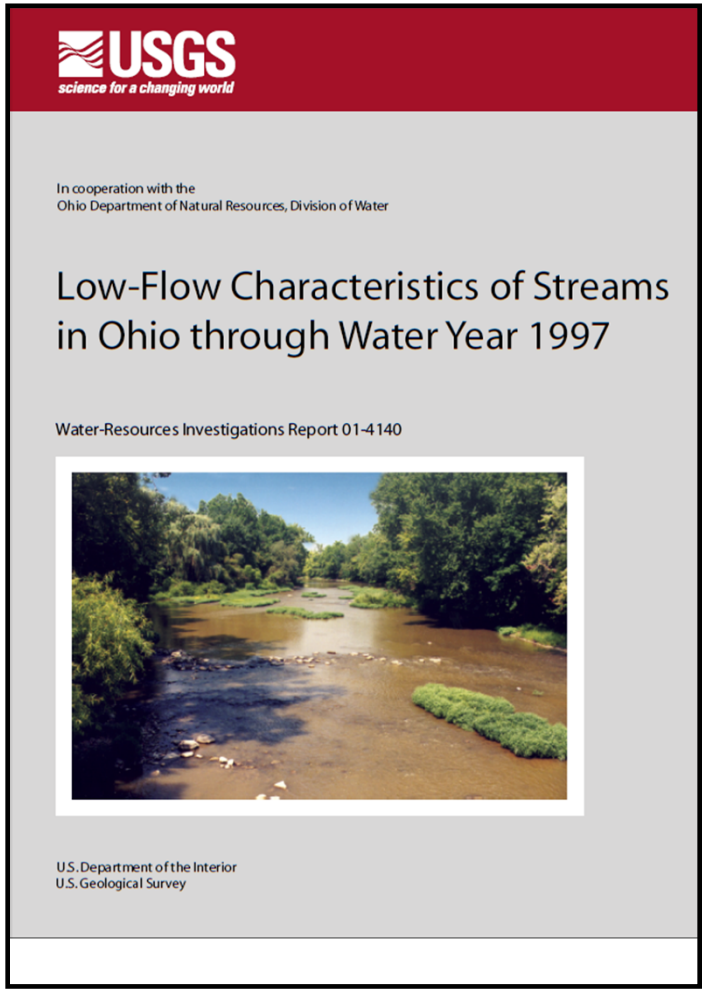
- Obtained approval for a Hydrograph-Controlled discharge permit (rarely approved by Ohio EPA)
- The in-stream concentrations could only be met when the river flow was > 24 cfs ($7Q_{10}$ = 5.7 cfs).
- If river is < 24 cfs:
  - Divert concentrate to old lagoons (19 days of storage).
  - Then, pump to sanitary sewer via an existing unused 16" waterline saving the City $$.
  - Finally, reduce or stop softening of GW
- Used USGS gauging station, inline conductivity meters and custom SCADA programming to optimize discharge flow to river at all times.

Case Study - Delaware WTP



Case Study – Industrial WWTP (NE)

- WWTP discharged to a tributary to a small creek ($7Q_{10} = 0$). Therefore, TDS "limit" is 1,500 mg/l (unattainable for this WWTP)
- Solution: Relocate the outfall to larger stream (4,500 lf force main)
- Complication: $7Q_{10}$ was available from Ohio EPA for a location <u>upstream</u> of proposed discharge [0.38 cfs based on 5.6 mi^2 area]
  - Measured new drainage area and got new $7Q_{10}$ (i.e. twice the area is twice the base minimum flow (say 11.2 mi^2 ~ 0.76 cfs)


USGS
science for a changing world

In cooperation with the
Ohio Department of Natural Resources, Division of Water

Low-Flow Characteristics of Streams in Ohio through Water Year 1997

Water-Resources Investigations Report 01-4140

U.S. Department of the Interior
U.S. Geological Survey

Case Study – Industrial WWTP

- More compliance strategies used for TDS compliance (same WWTP as previous slide):

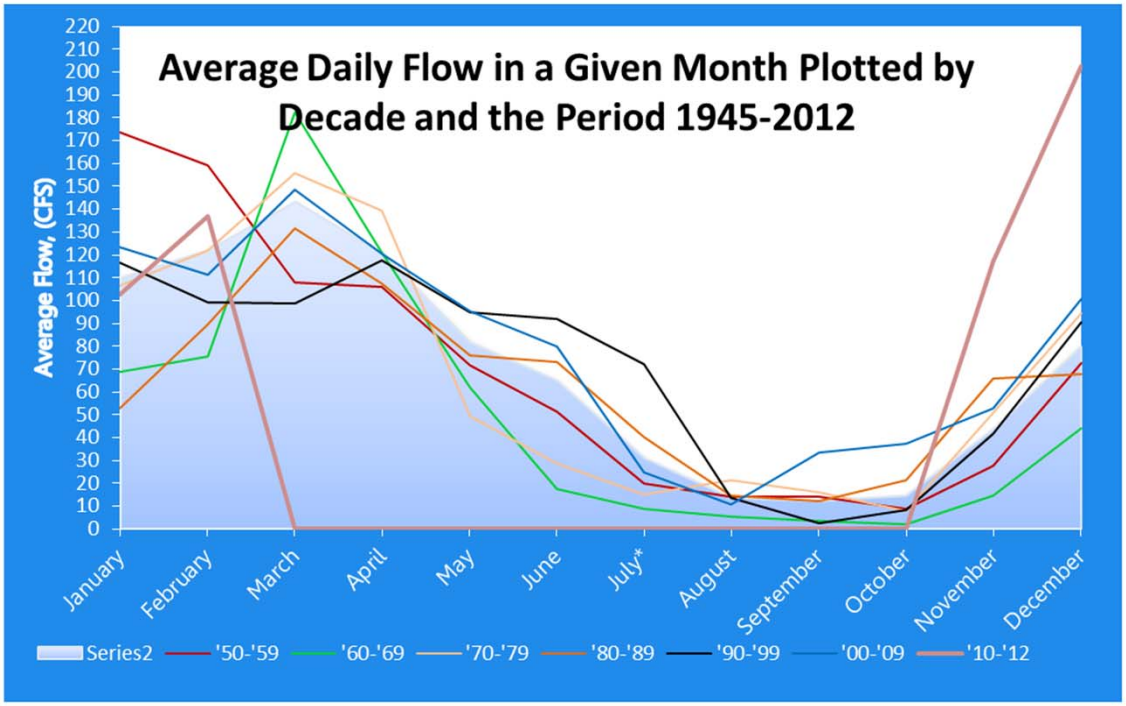
1. Flow augmentation:
   a) Well was constructed to dilute TDS discharge
   b) Compliance for TDS (and Temperature)
2. In-Stream Conductivity Monitoring
3. Reduction of TDS in Process
4. Replacing ion exchange with reverse osmosis (for water supply)

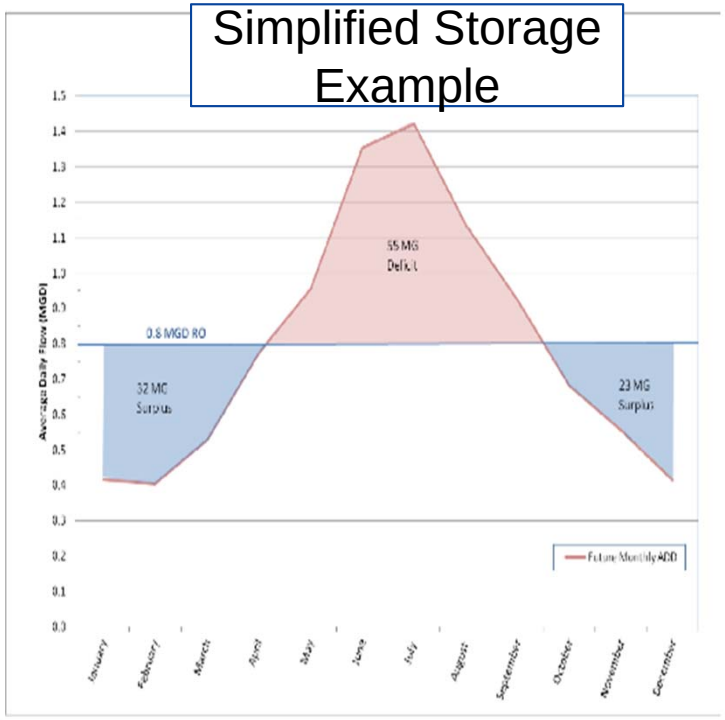
Case Study – Marysville, OH WTP

- New RO WTP Proposed
- Low Flows in Mill Creek ($7Q_{10}$: 0.26 CFS)
- Integrated Solutions
  - Dilute RO Concentrate with Raw Reservoir Water
  - Dilute RO Concentrate with Well Water (but high hardness)
  - Alternative RO System Design (treat most SW water, minimize RO treatment of high TDS (1,200 mg/l) GW)
  - Site Specific Criteria: OAC 3745-1-35 allows site specific limits
  - Other alternatives (perhaps future)
    1. Treatment of RO Concentrate (Lime softening, etc)
    2. Match Production when stream flow can handle (ASR)

Case Study – Marysville, OH WTP

If only could make most of the water when the stream could handle the RO concentrate……





Aquifer Storage and Recovery (ASR) could be a viable solution..

Case Study – Marysville, OH WTP

Site Specific Criteria: OAC 3745-1-35 allows site specific limits.

- URS Estimated Proposed RO concentrate using "worst case" cocktail (using higher sulfate water)
- GLEC, with assistance from University of Illinois (Dr. David Riecks-Soucek) showed that IC_{25} of the lab-produced concentrate was toxic above 1,412 mg/l (approximately what the current law mandates)
- Further testing using actual RO concentrate expected to yield IC25 above 1,800 mg/l or higher

Other Test Results - Inconsistent

- RO concentrates with TDS > 3,000 mg/l have passed the acute toxicity standards in cases
- RO concentrates with lower TDS (<1800 mg/l) have "failed" acute toxicity testing (i.e. TU_a > 1.0)

Table 5. Percent cumulative mortality, LC_{50}, EC_{50}, and 95% confidence intervals for acute toxicity tests using *Ceriodaphnia dubia* and *Pimephales promelas* using effluent collected from **Outfall 001.**

Concentration	***C. dubia* (water flea)** 06/18/14 to 06/20/14		***P. promelas* (fathead minnow)** 06/18/14 to 06/22/14			
	24-hours % mortality (% affected)	48-hours % mortality (% affected)	24-hours % mortality (% affected)	48-hours % mortality (% affected)	72-hours % mortality (% affected)	96-hours % mortality (% affected)
MHRW, **diluent**	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
DMW	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6.25% effluent	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
12.5% effluent	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
25% effluent	0 (0)	0 (0)	5 (5)	5 (5)	5 (5)	5 (5)
50% effluent	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
100% effluent	0 (0)	95 (95)	0 (0)	0 (0)	0 (0)	5 (5)
LC_{50}	>100% effluent	72.01% effluent	>100% effluent	>100% effluent	>100% effluent	>100% effluent
95% C.I.		NR				
EC_{50}	>100% effluent	72.01% effluent	>100% effluent	>100% effluent	>100% effluent	>100% effluent
95% C.I.		NR				
TUa (100÷LC50)		**1.39**				**AA**
Methods:	CT-TOX. Spearman-Karber.					

Summary

- Some states (Iowa, Illinois, Indiana) have rescinded TDS regulations for ion specific limits
- Ohio's current "TDS" limits are <u>still</u> 1,500 mg/l (in-stream)
- Acute and Chronic toxicity will likely end up in future permits for certain dischargers
- Mayfly (*Centroptilum triangulifer*) toxicity may be utilized in future
- University of Illinois, US EPA Region V and others still studying toxicity with GREAT interest
- There are still many techniques to maintain compliance with TDS regulations (in Ohio)

Any Questions?

Robert T. Shoaf, PE – URS
Columbus, OH
614.464.4500

robert.shoaf@urs.com