2015 NJWEA Conference

Technical Advances in Water Reuse: **Groundwater Recharge without Membranes**

May 9, 2015

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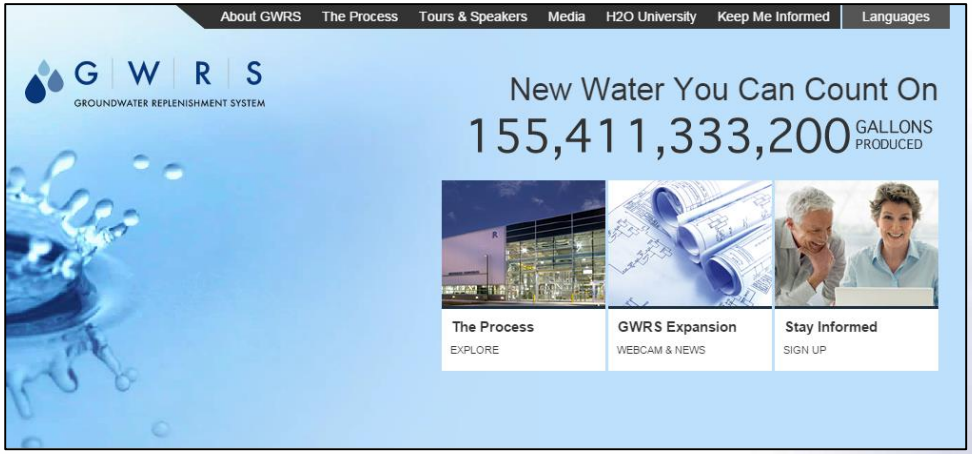
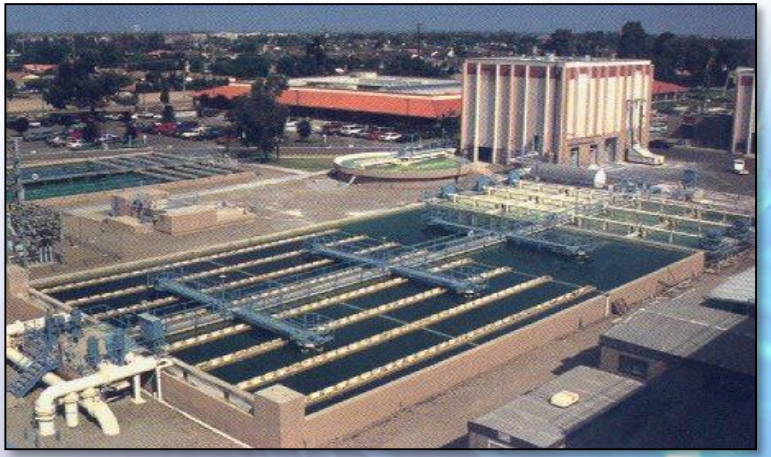
Acknowledgments

- Tara VanEyk, PE
- Jayson Page, PE
- Enrique Vadiveloo, PE
- Phil Cook, PE
- Erik Rosenfeldt, PhD
- Wendell Khunjar, PhD
- David Hernandez

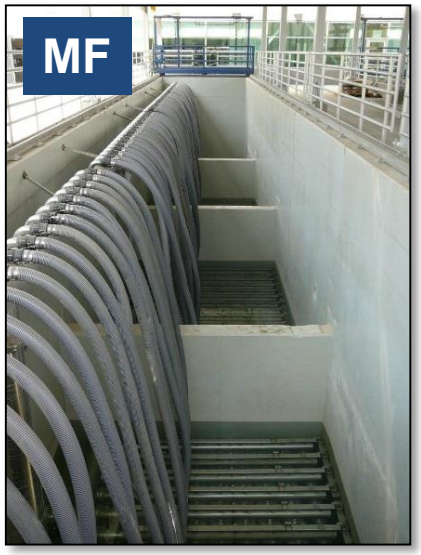
GW Recharge Has been Practiced for Years:
Water Factory 21 (1975 – 2004) and GWRS (2004-Present)

- OCWD built Water Factory 21 in 1975 (15 MGD)
  - First large-scale use of RO to treat wastewater for GW recharge and seawater intrusion barrier
  - 2 years earlier than first large-scale membrane seawater RO (3.2 MGD)
- 1991- California Dept. of Health granted first permit to inject 100% recycled water without blending
- Replaced by Groundwater Replenishment System in 2004





GWRS uses Desalting RO Treatment + UV/AOP



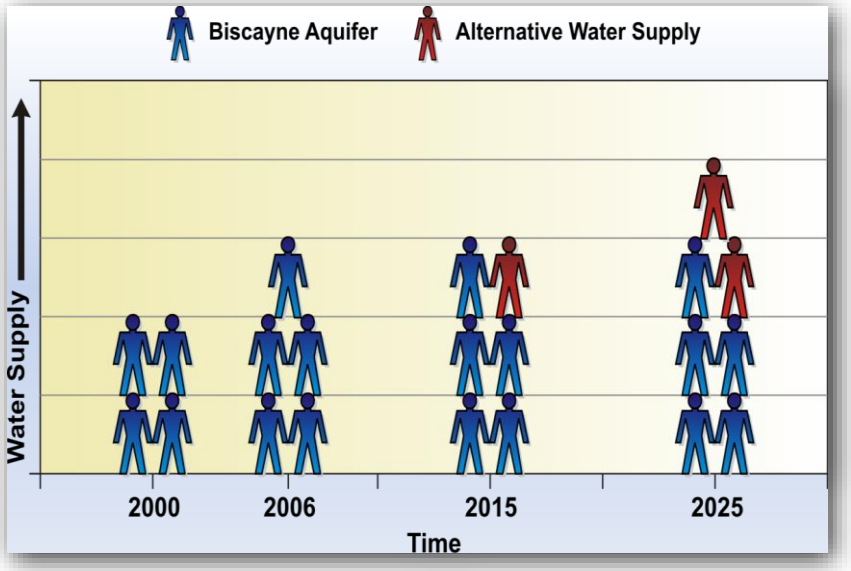
- But for groundwater recharge, are membranes needed?
- What about emerging contaminants?

Case Study: Groundwater Recharge Without Membranes in Florida

High Salinity Wastewater without Needing Desalting (RO membranes)

Florida Regulatory Drivers for Reuse

Regional Water Availability Rule



No additional withdrawal from the Biscayne Aquifer over levels that existed prior to April 2006

Ocean Outfall Rule

Shutdown outfall by 2025

Institute "Reuse" – 60% of outfall flow

Several Reuse Alternatives are Available, but Feasible Options are Limited

Large User Spray Irrigation

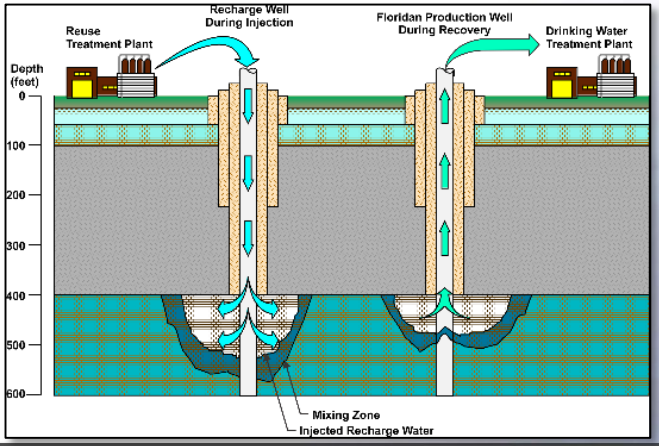
- High chloride, urban landscape

Biscayne Aquifer Recharge (IPR)

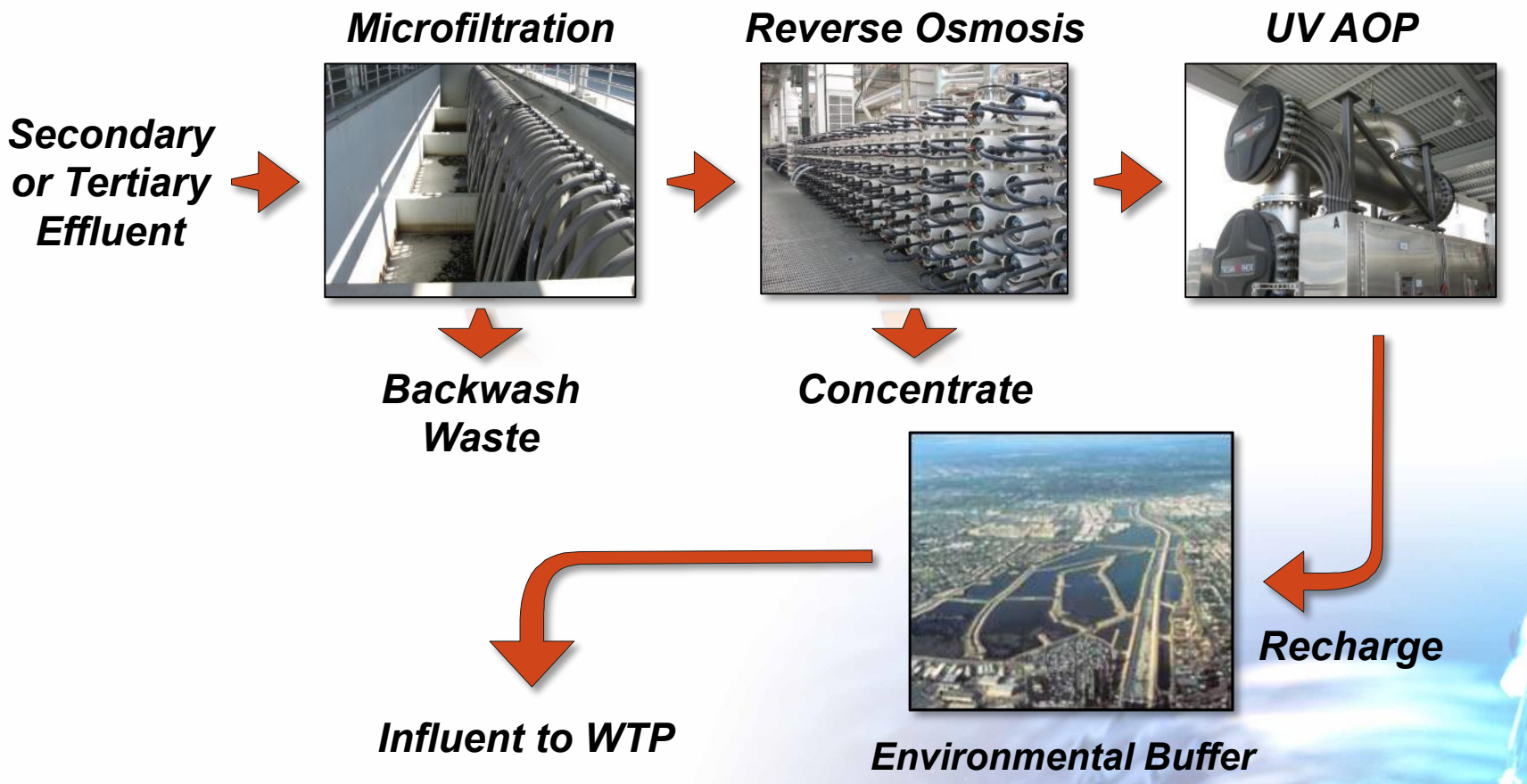
- Stringent nutrient limits

Floridan Aquifer Recharge (IPR)

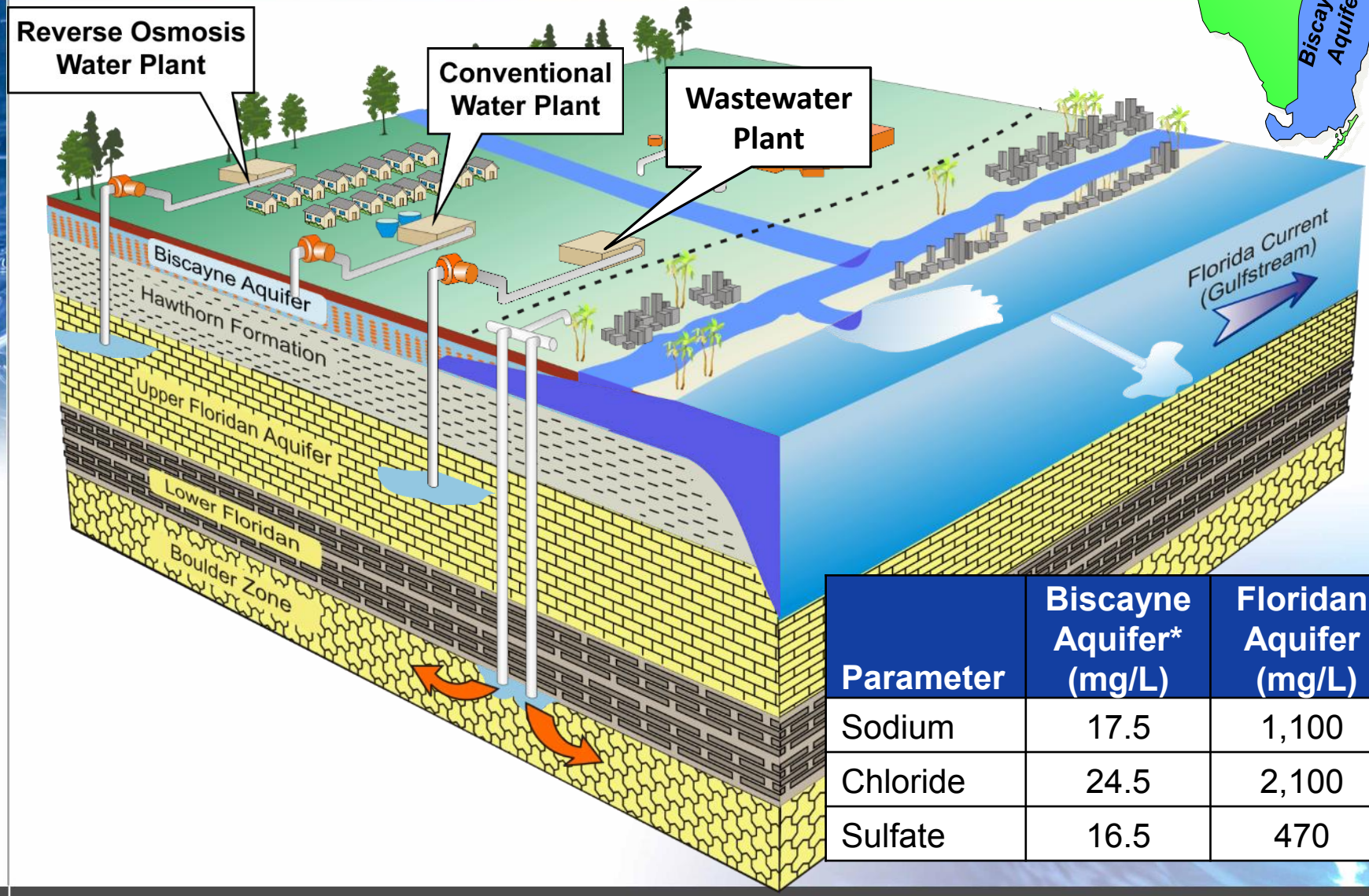
- Uncertain Regulatory Requirements



California Established IPR Treatment Approach – "Desalting with RO"



SE Florida's Unique Hydrogeology May Facilitate an Alternative Approach



Parameter	Biscayne Aquifer* (mg/L)	Floridan Aquifer (mg/L)
Sodium	17.5	1,100
Chloride	24.5	2,100
Sulfate	16.5	470

Opportunity for a Revised Recharge Treatment Approach

Secondary or Tertiary Effluent

Microfiltration

Reverse Osmosis

Advanced Oxidation Process

Backwash Waste

Concentrate

Reverse Osmosis WTP

Environmental Buffer

Recharge

However, Regulatory Challenges Exist for Floridan Aquifer Recharge

Parameter	FDEP (Less than 3,000 mg/L of TDS)	FDEP (Greater than 3,000 mg/L of TDS)	Broward County (Both)
$CBOD_5$	20 mg/L[1]	20 mg/L[1]	5 mg/L[2]
COD	---	---	**10 mg/L[2,3]**
TSS	5 mg/L[2]	5 mg/L[2]	5 mg/L[2]
Total Nitrogen	10 mg/L[1]	10 mg/L[1]	---
Phosphate (as P)	---	---	**0.01 mg/L[2,3]**
TOC	3 mg/L[1]	---	---
TOX	200 mg/L[1]	---	---
Chloride	250 mg/L	250 mg/L[4]	**250 mg/L[2,3]**
TDS	500 mg/L	500 mg/L[4]	**500 mg/L[2,3]**
Primary Drinking Water	Yes	Yes	Yes
Secondary Drinking Water	Yes	Yes[4]	Yes
Emerging Contaminants	**No**	**No**	**?**

1. Annual Average
2. Maximum Single Sample
3. Waiver *may be* needed
4. Subject to zone of discharge or background water quality

Approached Broward County Regulators Regarding Alternative Treatment

- Waivers for certain parameters may be possible
- Demonstrate removal of *"emerging contaminants"*
- Compare quality to Best Available Technology

However, *"emerging contaminants"* are not regulated…

- No Federal standards exist
- No State standards exist
- No County standards exist

Approach to Evaluating Undefined Contaminant Removal

We used California's Draft Title 22 Groundwater Replenishment Functional Group Framework

- Shifts away from 1,4-dioxane and NDMA approach
- Relies upon a "group" approach to contaminant removal
  - Similar chemistries → similar removal
  - 9 functional groups defined;
    - Requires demonstrated removal of surrogates from 5 of 9 groups
- Provides framework for the use of surrogates (e.g., UV254) for process monitoring and control
- Opens the door for non-RO based approach

Demonstrate >0.5 log (69%) Removal of Surrogates from A - G

Functional Group	Example Compounds
(A) Hydroxy Aromatic	Acetominophen, Bisphenol A, Estrone, Triclosan
(B) Amino/Acylamino Aromatic	Atorvastatin, Sulfamethoxazole
(C) Nonaromatic C=C	Carbamazepine, Codeine, OTNE
(D) Deprotonated Amine	Fluoxetine, Caffeine, Trimethoprim
(E) Alkoxy Polyaromatic	Naproxen, Propranolol
(F) Alkoxy Aromatic	Gemfibrozil, Hydrocodone
(G) Alkyl Aromatic	DEET, Dilantin, Ibuprofen, Primidone

Demonstrate >0.3 log (50%) Removal of Surrogates from H or I

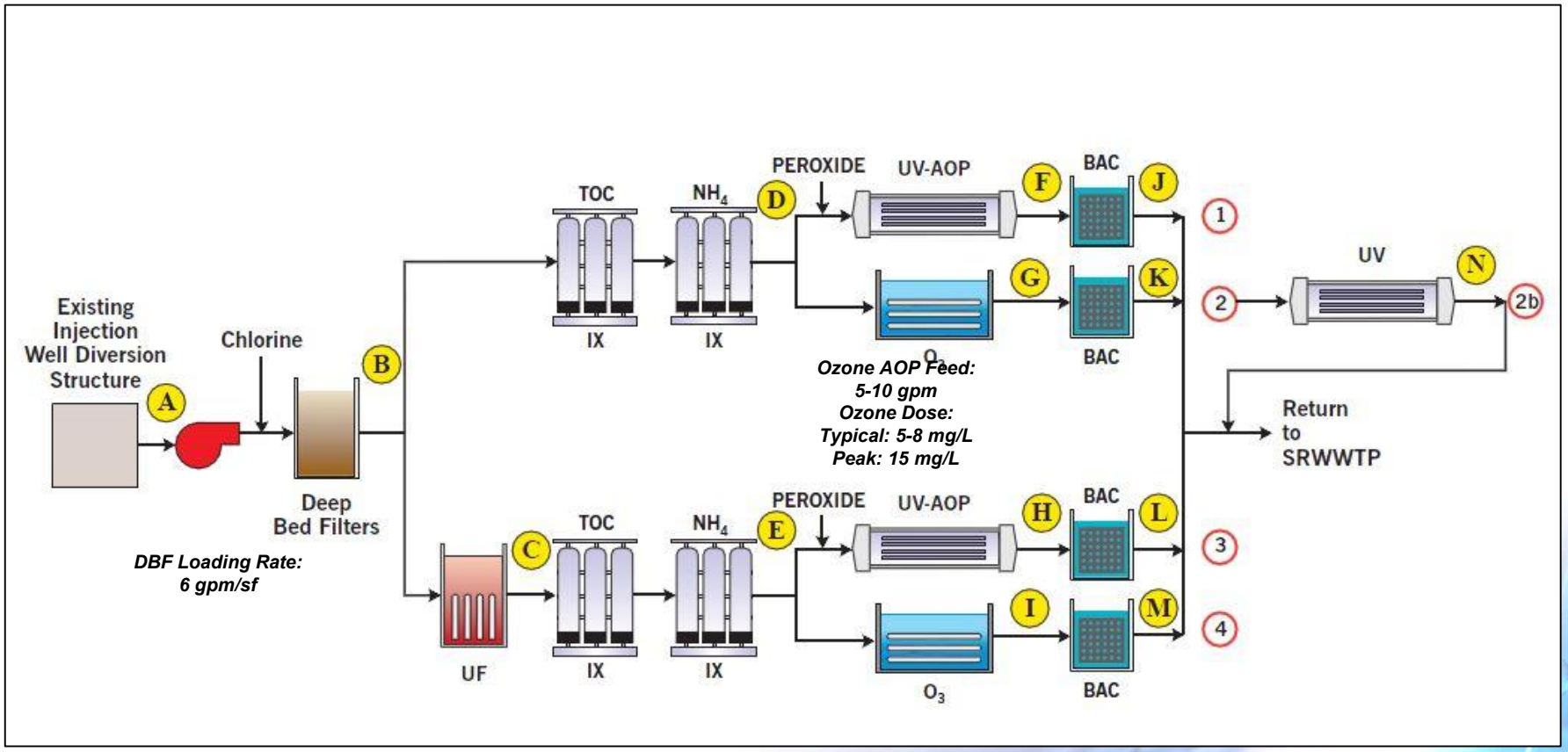
Functional Group	Example Compounds
(H) Saturated Aliphatic	Iopromide, Meprobamate
(I) Nitro Aromatic	Atrazine, Musk ketone, Musk xylene

In addition to Log Removal, Drinking Water Guidelines also used to Verify Treatment Efficacy

Compound	Functional Group	Guideline Value
1,4-Dioxane	---	3 µg/L
Atrazine	(I) Nitro Aromatic	3,500 ng/L
Carbamazepine	(C) Nonaromatic w/ carbon double bonds	73.5 ng/L
Dilantin	(G) Aklyl Aromatic	73.5 ng/L
Fluoxetine	(D) Deprotonated Amine	3,395 ng/L
Gemfibrozil	(F) Alkoxy Aromatic	15,050 ng/L
Iopromide	(H) Saturated Aliphatic	1,750,000 ng/L
Naproxen	(E) Alkoxy Polyaromatic	45,500 ng/L
NDMA	---	10 ng/L
Sulfamethoxazole	(B) Amino/Acylamino Aromatic	150,500 ng/L
Triclosan	(A) Hydroxy Aromatic	105,000 ng/L

Pilot Testing and Results

County Government Wanted System Designed for Emerging Contaminant Oxidation



Acronyms
UF = Ultrafilter
IX = Ion Exchange for TOC & NH_4 Treatment
AOP = Advanced Oxidation Process
BAC = Biological Activated Carbon Filter

Pilot Setup at SRWWTP

Pilot Setup at SRWWTP

Secondary Effluent

DBF

IX

UV AOP (Scheme 1)
or
Ozone (Scheme 2)

BAC

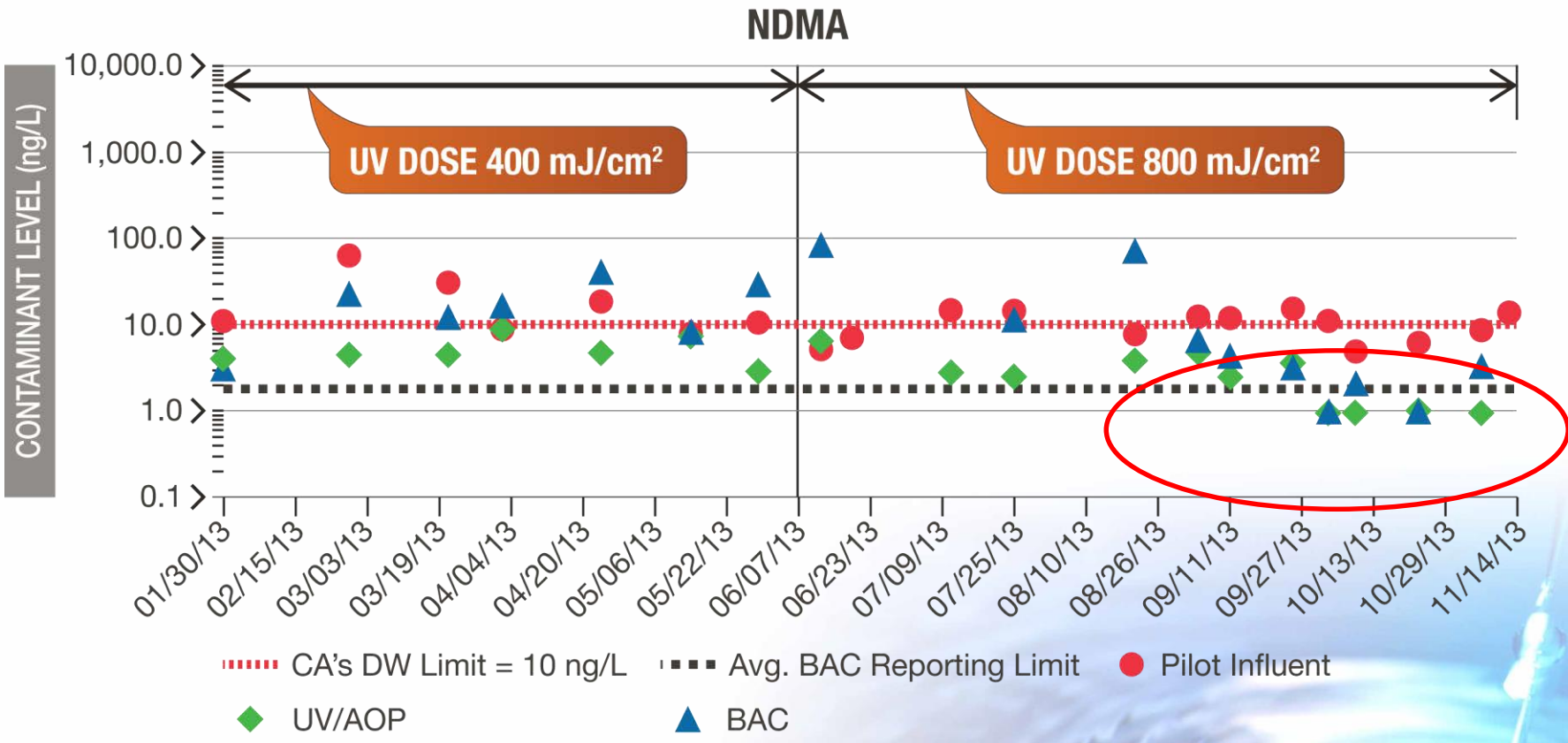
As expected, waivers would be needed for certain parameters

Parameter	Anticipated Limit (mg/L)	Pilot Effluent Averages (mg/L)	
		Scheme 1 (UV-AOP)	Scheme 2 (Ozone)
BOD_5	5	2.0	3.4
TSS	5	3.4	3.5
TN	10	7.3	7.9
Nitrite	1	0.7	0.7
Phosphates	**0.01**	**1.2**	**1.2**
COD	**10**	**14**	**16**
TOC	3	0.8	0.6
TOX	200	69	69
Chloride	**250**	**1,400**	**1,400**
TDS	**500**	**3,480**	**3,460**

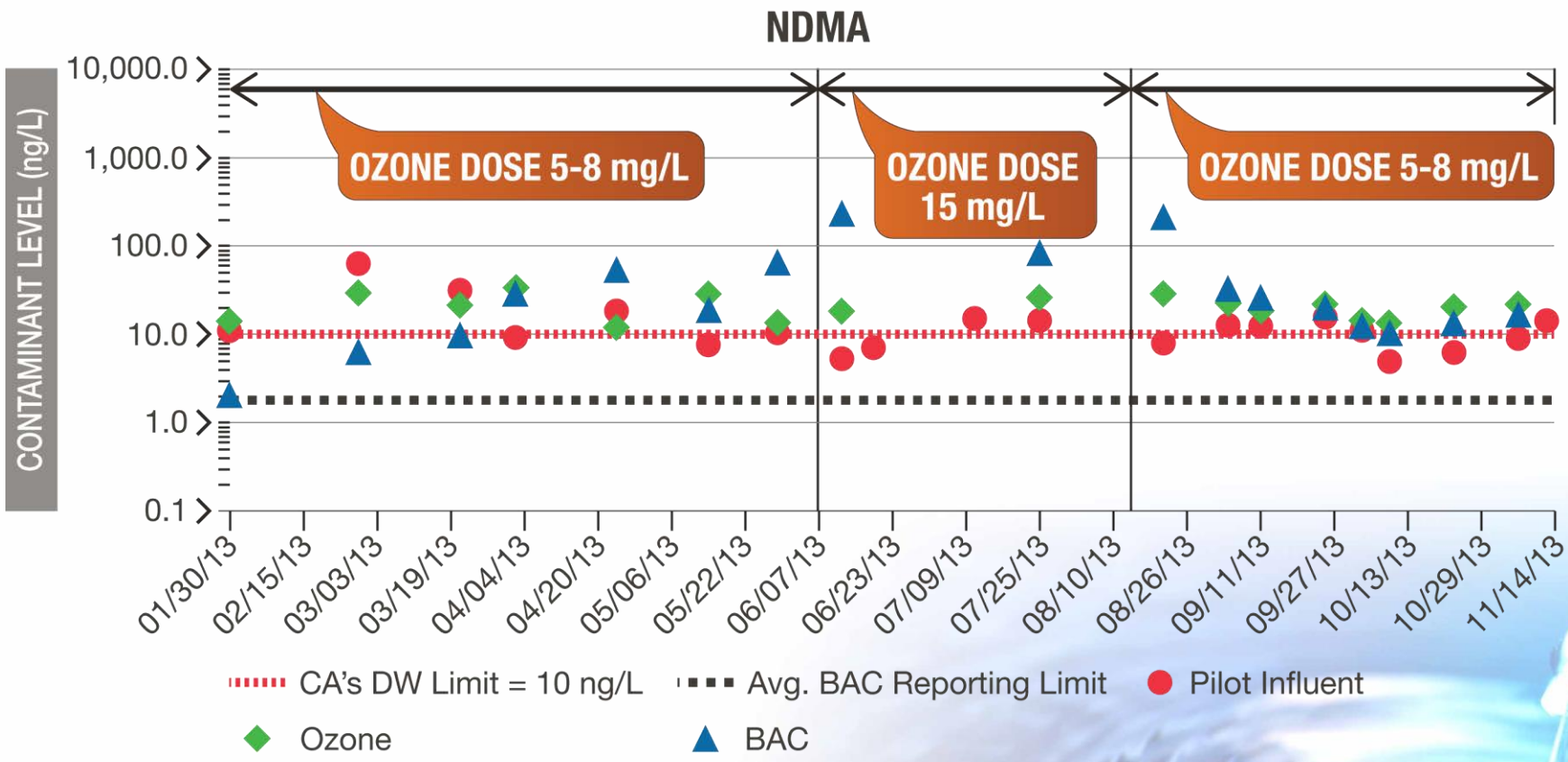
Pilot Demonstrated Appropriate Emerging Contaminant Oxidation for Key Parameters Except NDMA

Emerging Contaminant	Functional Group	Anticipated Drinking Water Guideline	Pilot Influent	Scheme 1 UV Dose of 400 mJ/cm^2	Scheme 2 Ozone Dose of 5-8 mg/L
1,4 Dioxane	-	3.0	< 2.0(2)	< 2.0(2)	< 2.0(2)
Atrazine	I	3,500	15	< 1.3(2)	< 1.6(2)
Carbamazepine	C	73.5	170	< 10(2)	< 10(2)
Dilantin	G	73.5	130	< 103(2)	< 103(2)
Fluoxetine	D	3,400	34	< 26(2)	< 26(2)
Gemfibrozil	F	15,000	1190	< 26(2)	< 26(2)
Iopromide	H	1,750,000	< 51(2)	< 51(2)	<115(2)
Naproxen	E	45,500	< 51(2)	< 51(2)	< 51(2)
Sulfamethoxazole	B	151,000	760	< 10(2)	< 16(2)
Triclosan	A	105,000	200	< 52(2)	< 52(2)
NDMA	-	10	23	18	33

Process Scheme 1: NDMA Formation in BAC



Process Scheme 2: NDMA Limit Not Met



Additional Process Scheme 2b Tested for NDMA Oxidation Post BAC Filters

DBF

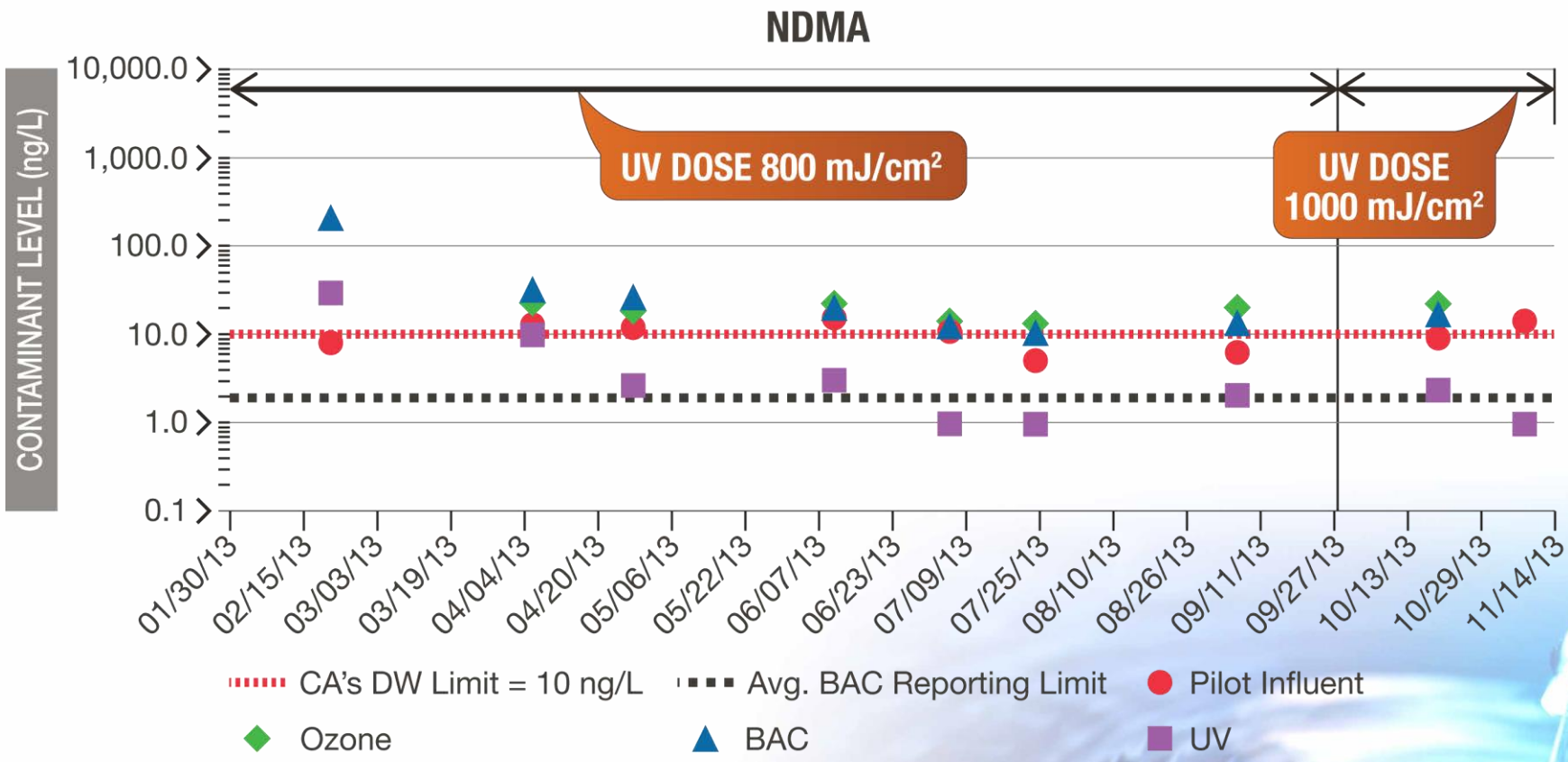
IX

OZONE

BAC

UV

Process Scheme 2b:
NDMA limit met with High Energy UV Dose



(Not UV disinfection dose)

Emerging Contaminant Summary

Emerging Contaminant	Functional Group	CA Log Removal	Scheme 1	Scheme 2
1,4 Dioxane	–	–	Not found	Not found
Atrazine	I	0.3	Yes	Yes
Carbamazepine	C	0.5	Yes	Yes
Dilantin	G	0.5	Yes	Yes
Fluoxetine	D	0.5	Yes	Yes
Gemfibrozil	F	0.5	Yes	Yes
Iopromide	H	0.3	Yes	Yes
Naproxen	E	0.5	Yes	Yes
Sulfamethoxazole	B	0.5	Yes	Yes
Triclosan	A	0.5	Yes	Yes
NDMA	–	–	Yes After BAC Stabilization	Yes With Process Scheme 2B

Representative of pilot operation sampling data from Jan. 2013 to Nov. 2013

Further discussions with Broward County were undertaken regarding a waiver / variance for certain parameters

- **Waiver/Variance pursued for:**
  - COD, Chloride, TDS, Sodium, Phosphates

- **Waiver/Variance Conditions:**
  1) Discharge “will not cause pollution or otherwise damage to the natural resources in contravention with regulations”
  2) “Undue hardship” must be evident
     - Need to evaluate “hardship” of meeting standards, specifically phosphates limit of 0.01 mg/L
  3) Present results at public hearing

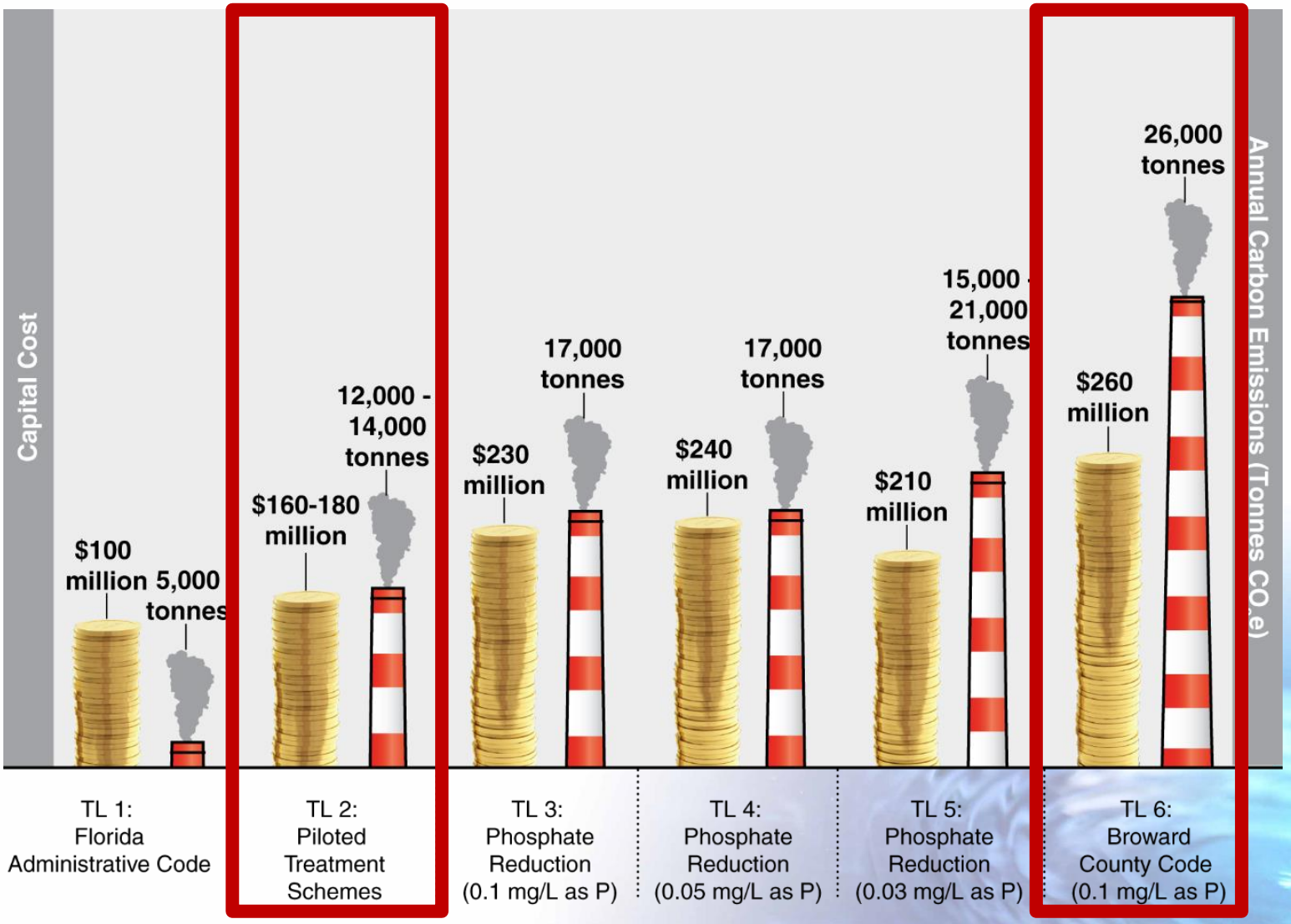
“Hardship” Evaluation

Treatment Alternatives Evaluated:

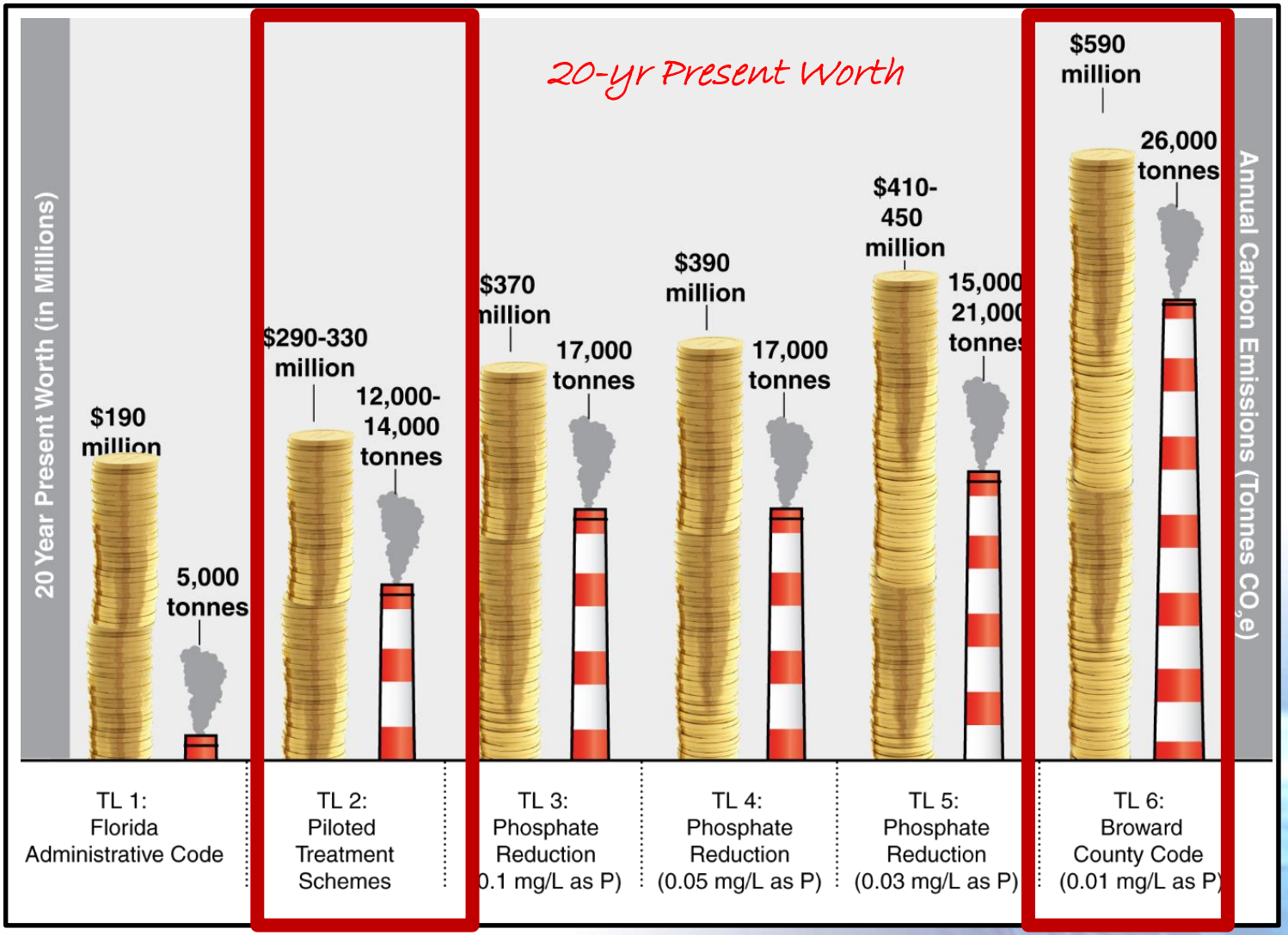
TL 2 was piloted; TL 3 – 5 required additional P removal; TL 6 was membrane-based

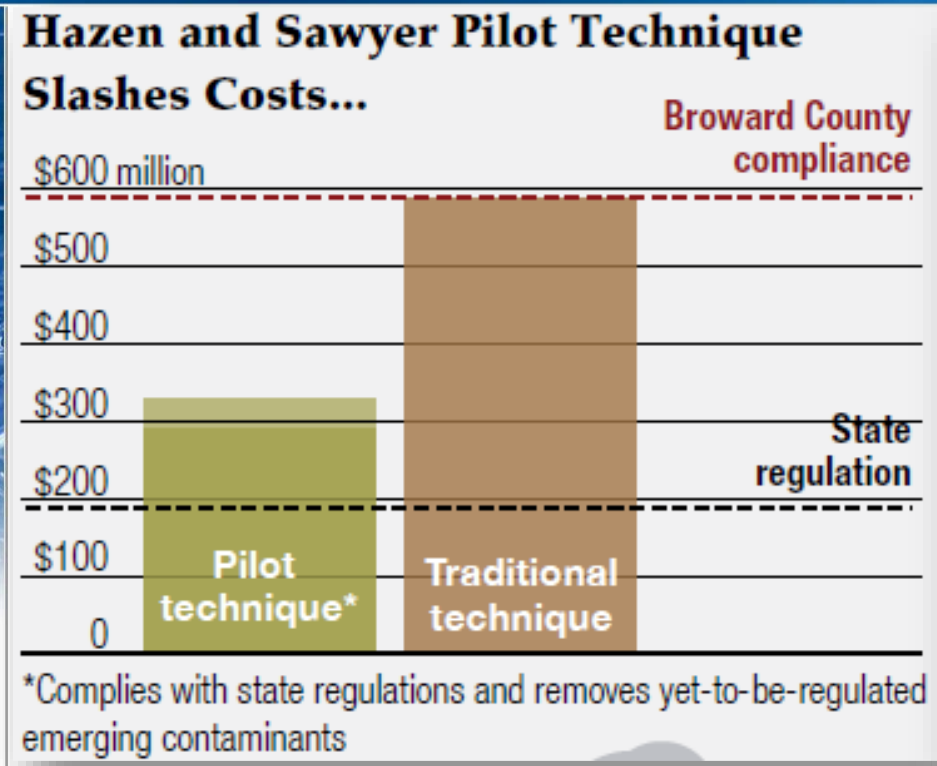
Description	Effluent Concentration (mg/L)				
	TN	Phosphates	COD	TDS	Emerging Contaminant Oxidation
TL 1: FDEP Standards DBF, IX for TN, Disinfection	< 10	> 1	> 10	> 3,000	No
TL 2: Piloted Schemes DBF, IX for TN and TOC, UV AOP and BAC	< 10	> 1	> 10	> 3,000	Yes
TL 3: Phosphate Removal Level 1 5 Stage BNR, Alum, DBF, IX for TOC, Ozone, BAC and UV	< 10	> 0.1	> 10	> 3,000	Yes
TL 4: Phosphate Removal Level 2 5 Stage BNR, Alum, High Rate Clarification, DBF, IX for TOC, Ozone, BAC and UV	< 10	> 0.03	> 10	> 3,000	Yes
TL 5: Phosphate Removal Level 3 Electrocoagulation and/or IX, High Rate Clarification, IX for TN, UV AOP and BAC	< 10	0.01 - 0.03	> 10	> 3,000	Yes
TL 6: Broward County Standards MF, RO and UV AOP	< 10	< 0.01	< 10	< 500	Yes

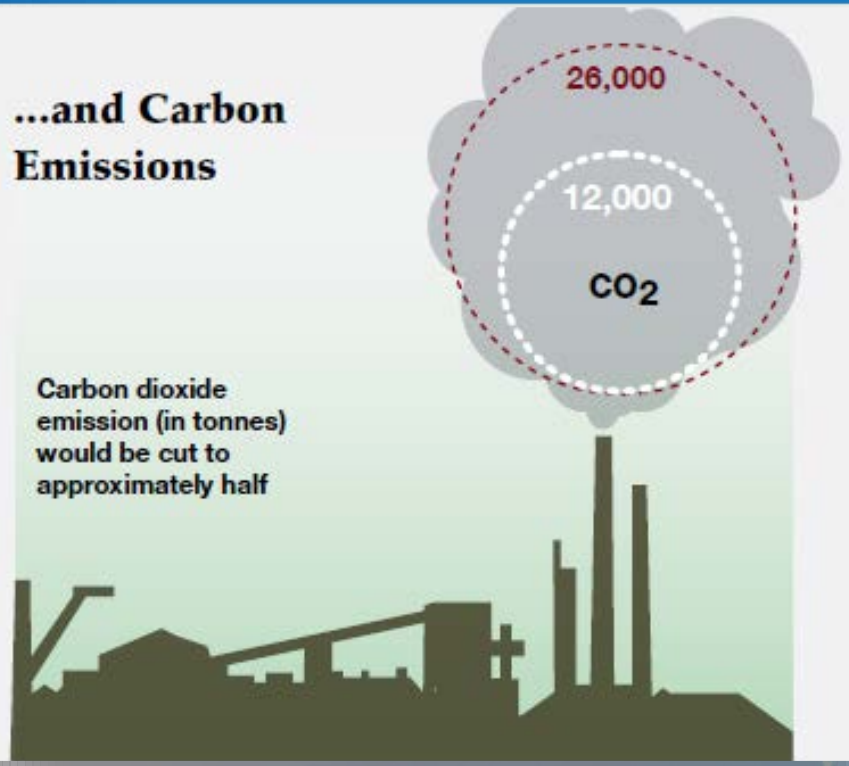
Economical and Environmental "hardship" demonstrated



Additional Phosphorus Treatment Would Result in Economic and Environmental Hardship







Discussions with County regulators is ongoing along with legislative revisions to further reduce costs.

Summary

- Successful demonstration of the use of non-membrane based treatment for IPR via groundwater recharge
- Emerging contaminant goals were met
- NDMA formation across BAC decreased after microbial community stabilized
  - Full scale implication: Need to plan for GAC to BAC conversion and stabilization period when NDMA may not be adequately managed
  - This may require additional treatment or further evaluation of risks and potential action levels since NDMA is not currently regulated
  - CA action level for NDMA is 300 ng/L (notification level is 10 ng/L)

Questions?

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