FUTURE SUPPLY ACTIONS PROGRAM
WEBINAR SERIES

One Water

THE METROPOLITAN WATER DISTRICT *of* SOUTHERN CALIFORNIA

Chloramines Feasibility Study

September 15, 2021

Our Region's Trusted Water Leader
San Diego County Water Authority

PADRE DAM
Municipal Water District

Trussell
TECHNOLOGIES INC

Agenda

Speaker Spotlight

Seval Sen, P.E.

AWP Engineering Manager

Padre Dam Municipal Water District

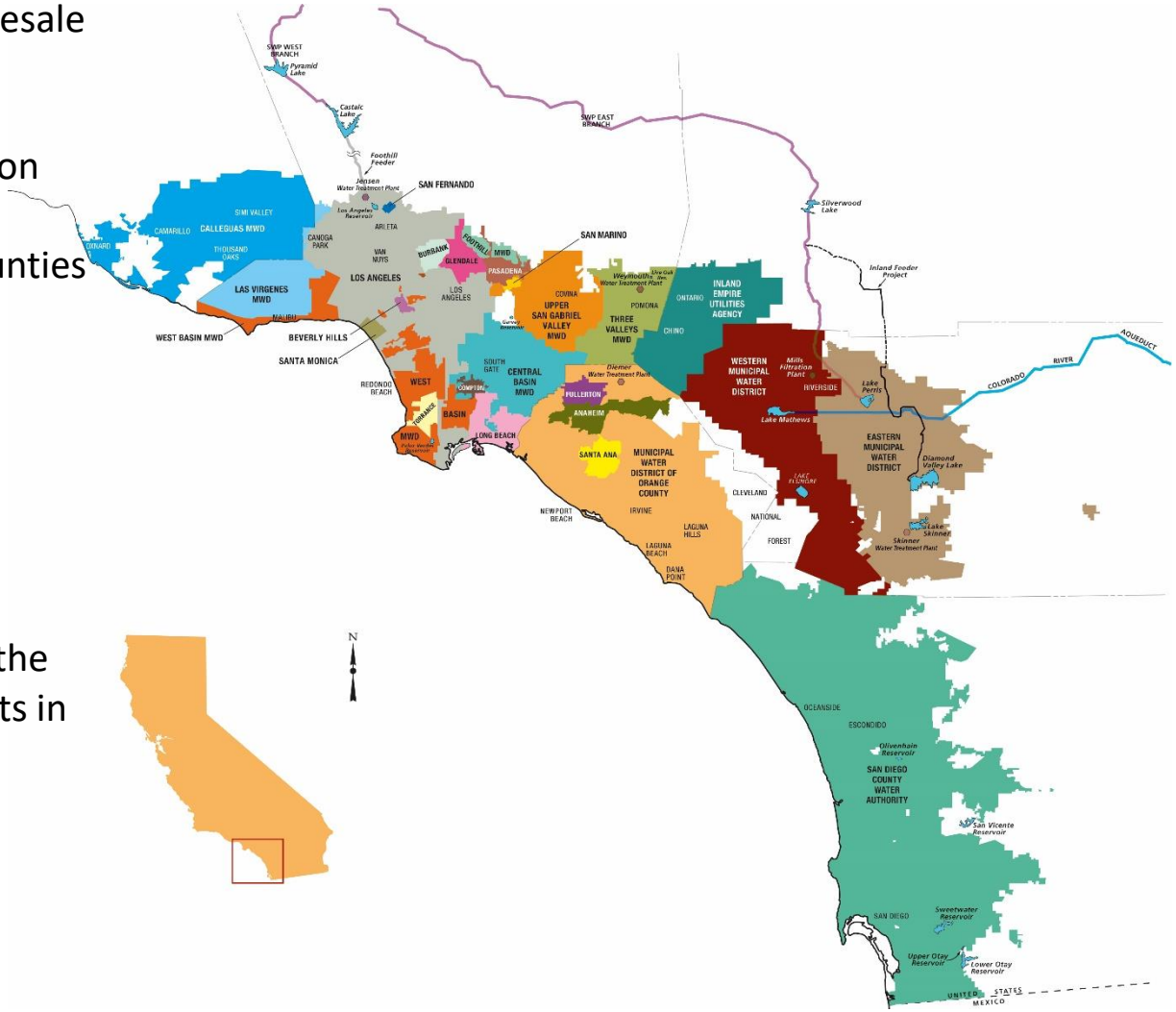
Luciana Pereyra, Ph.D.

Engineer

Trussell Technologies

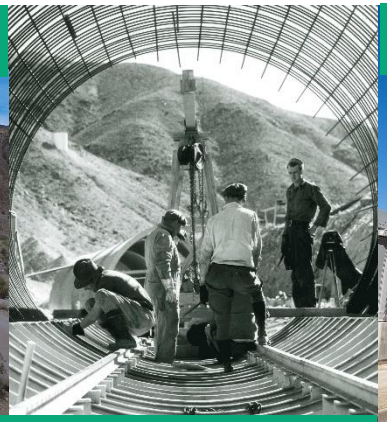
The Metropolitan Water District of Southern California

- Nation's largest wholesale water provider
- Service area: 19 million people/5,200 square miles/parts of six counties
- 26 member agencies
- Supports $1 trillion regional economy
- Imports water from Northern Sierra and the Colorado River, invests in local projects



Metropolitan's Role for Southern CA

REGIONAL PROVIDER

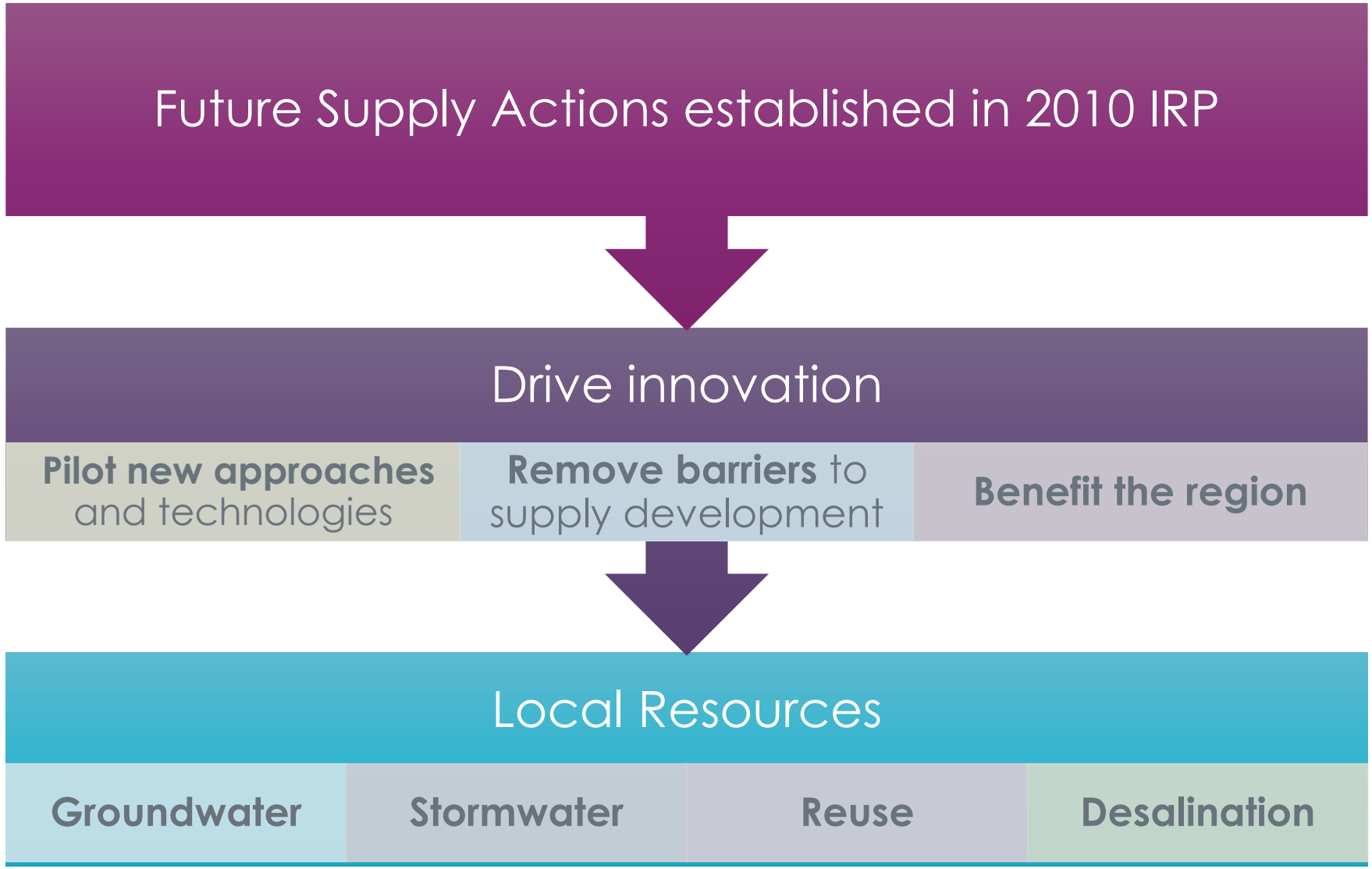


INNOVATION

VISION

SAFE & RELIABLE

Future Supply Actions Funding Program



Current Program

Member Agency

- 14 studies
- $3.1 million

Water Research Foundation

- 6 potable reuse studies
- 1 agricultural reuse study
- $975k

ECAWP Project Background

Seval Sen, P.E.
Padre Dam Municipal Water District

East County AWP Project

4 Participating Agencies

PADRE DAM Municipal Water District

Helix WATER DISTRICT

EL CAJON The Valley of Opportunity

Padre Dam

Helix

Water Purchase Agreements

East County Advanced Water Purification Joint Powers Authority

Wastewater Services Agreements

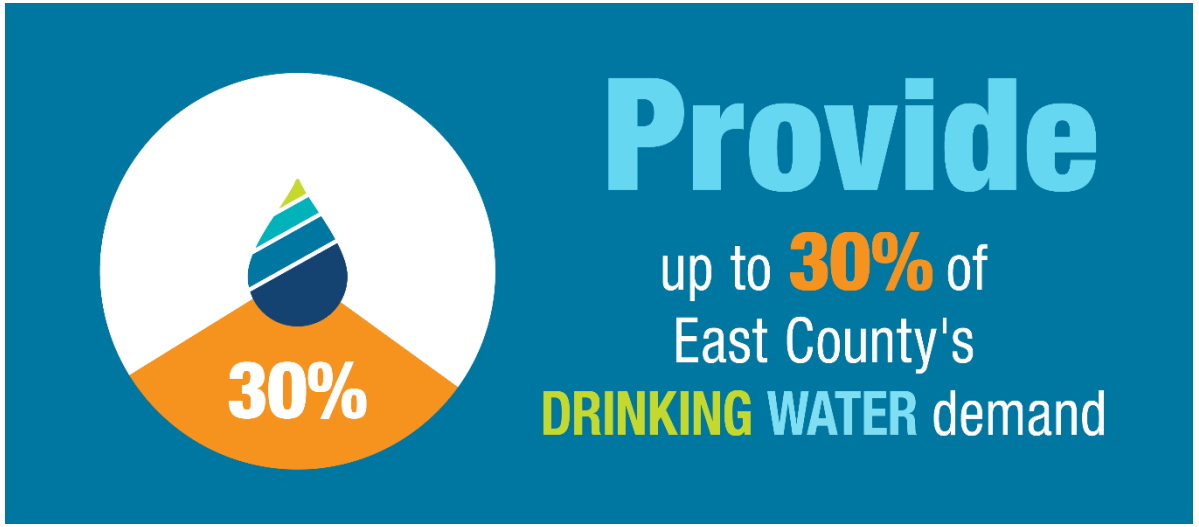
County

El Cajon

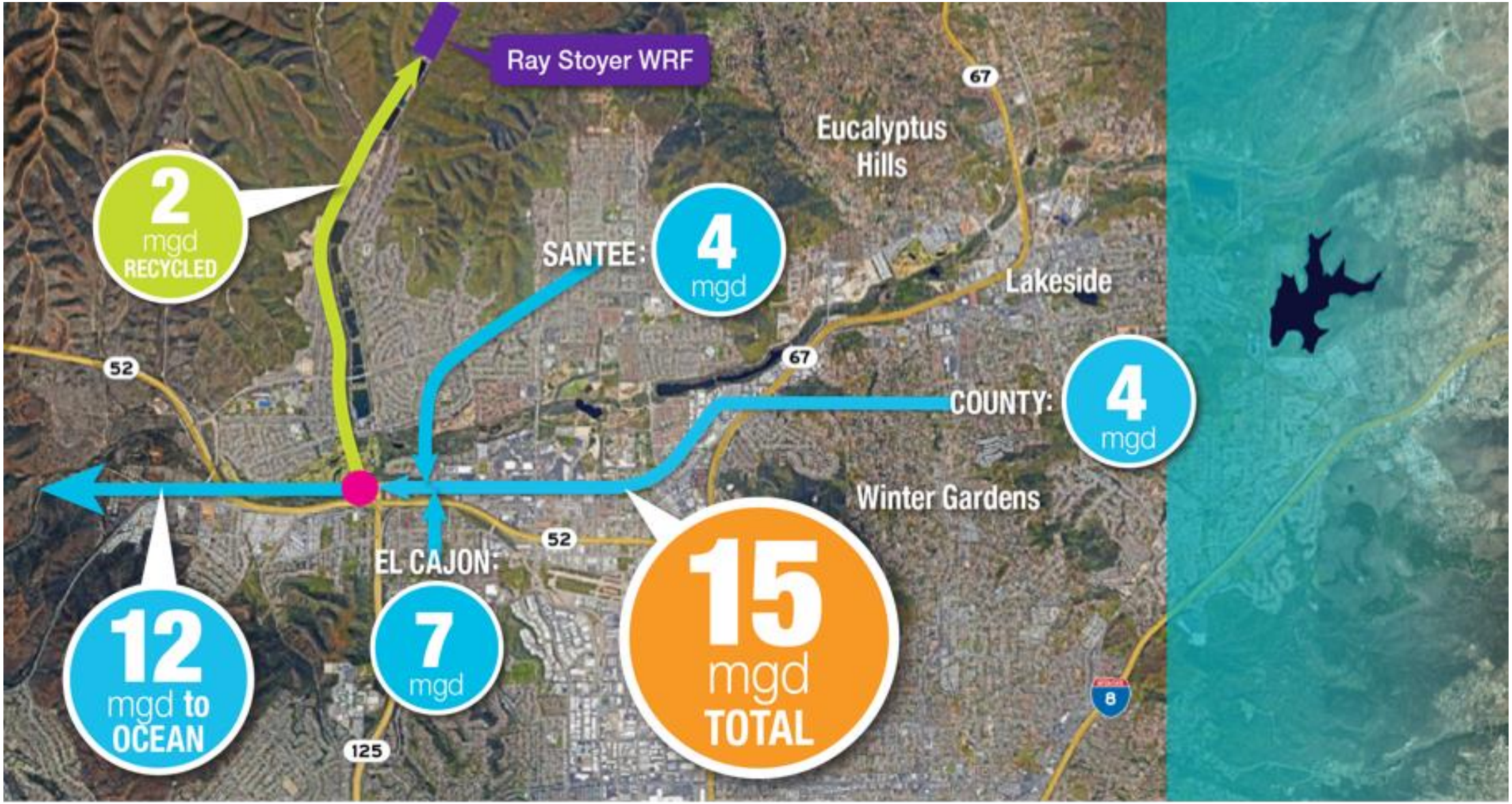
Padre Dam

East County AWP JPA formed on Nov. 1, 2020

Goals and Objectives

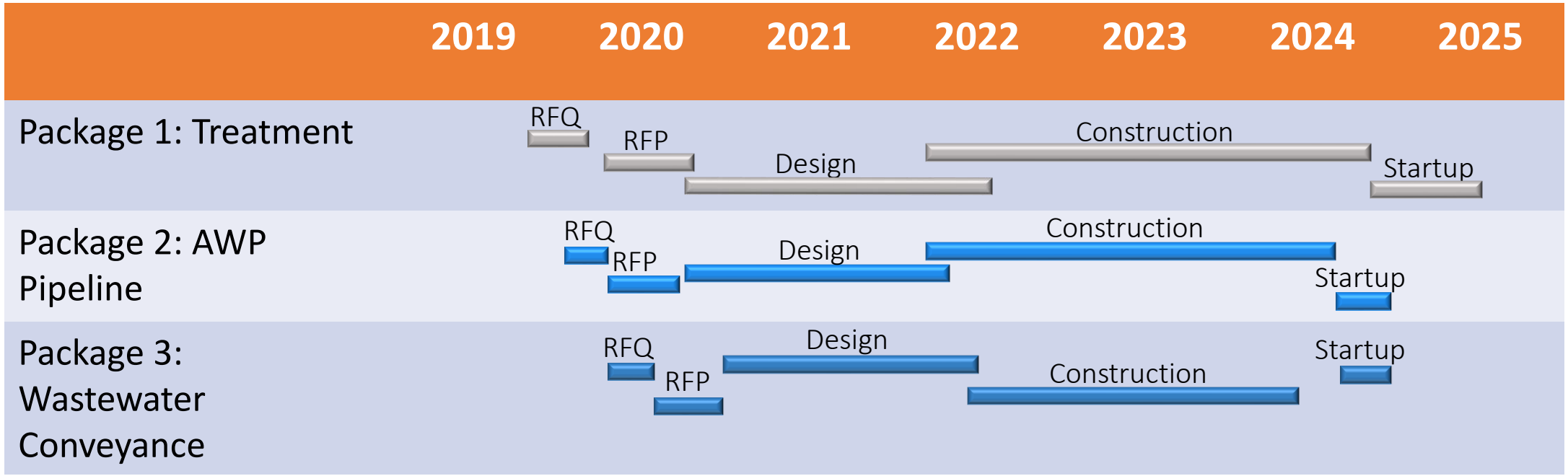


East County AWP Project Overview



East County AWP Project Overview

ECAWP Project Implementation Schedule



AWP Demonstration Project Overview

- Gain regulatory approval – using minimum aquifer storage
- Operator experience in advanced water treatment
- Demonstrate treatment performance at critical control points
- Public outreach

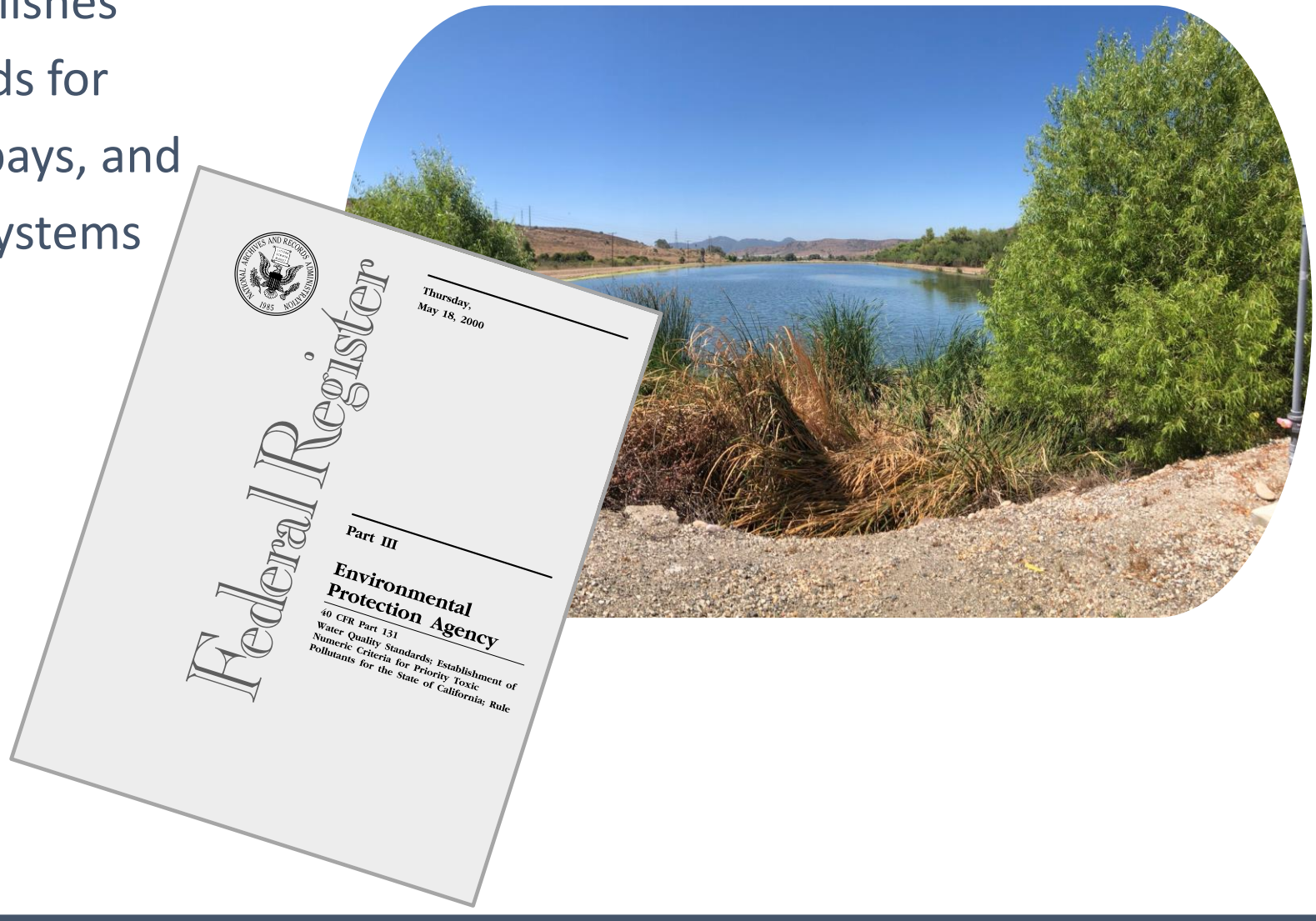
Construction Completed	Testing Started	Final Testing	Final Report
March 2015	**April 2015**	**February 2016**	**March 2016**

California Toxics Rule Compliance

Luciana Pereyra, Ph.D.
Trussell Technologies, Inc.

Regulatory Context

California Toxics Rule (CTR) establishes state-wide water quality standards for inland surface waters, enclosed bays, and estuaries to protect aquatic ecosystems and human health.



Regulatory Context

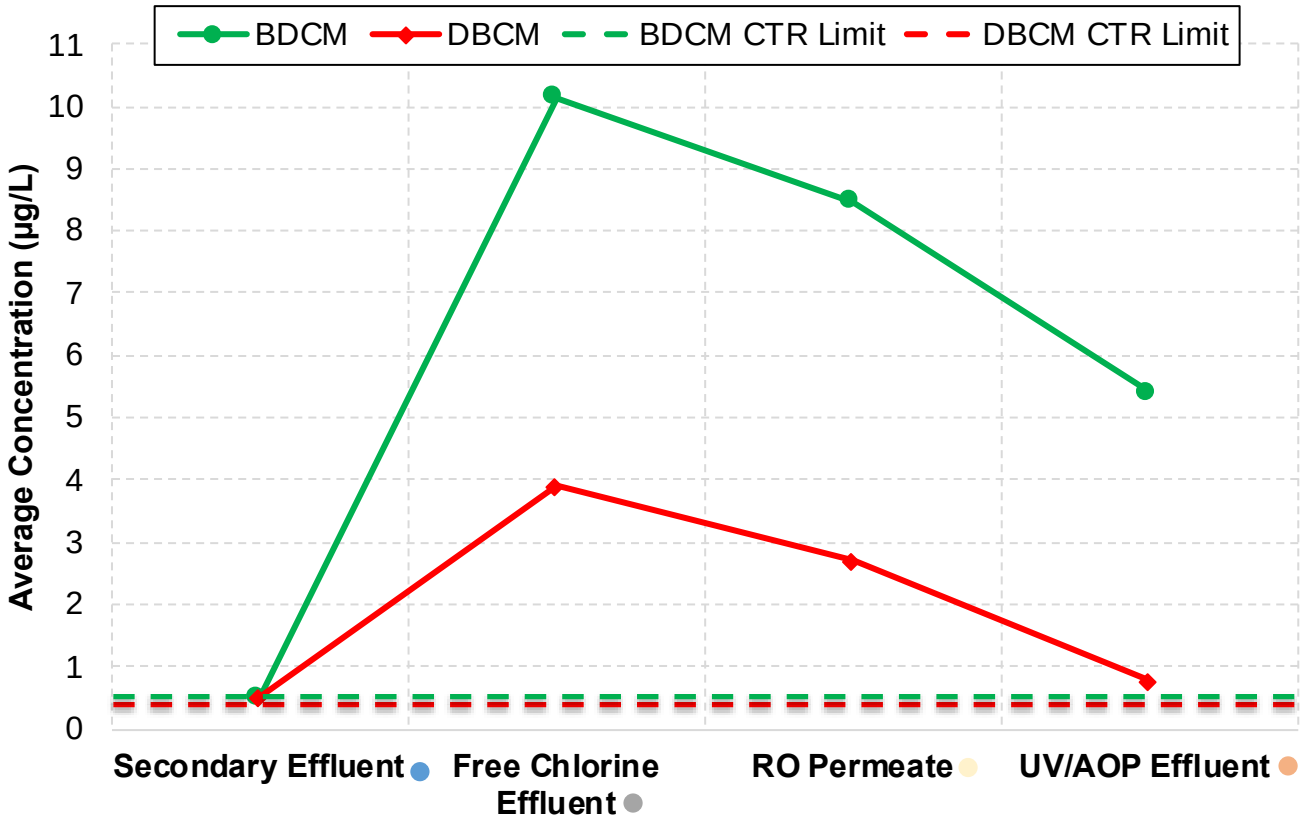
- CTR establishes limits for disinfection byproducts (DBPs) such as trihalomethanes (THMs)
- Strict limits for BDCM and DBCM

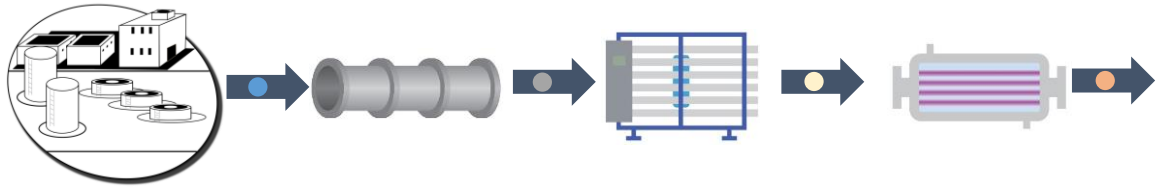
THM	CTR Limit	MCL
BDCM	0.56 µg/L	80 µg/L as total THM*
DBCM	0.41 µg/L	
Bromoform	4.3 µg/L	
Chloroform	Reserved	

$* Total\ THM = BDCM + DBCM + Chloroform + Bromoform$

THM Monitoring at Demonstration Facility

BDCM and DBCM above CTR limits in AWP demonstration facility UV/AOP effluent (2015-2016 study)

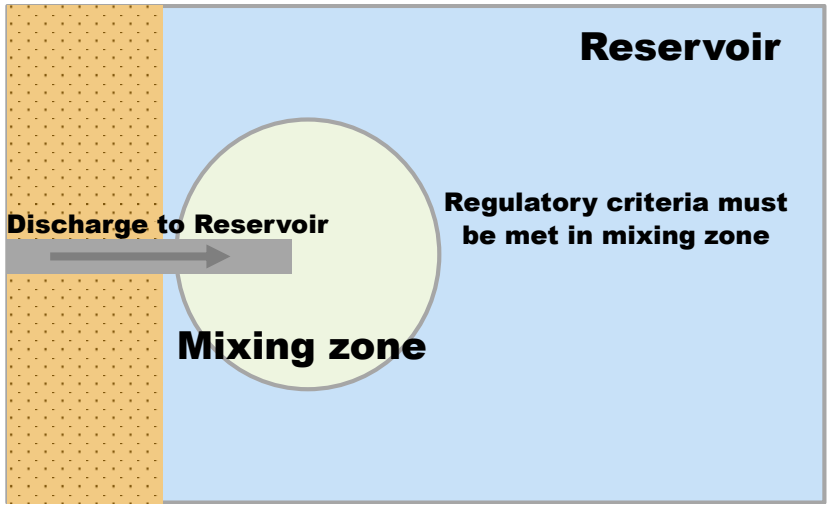




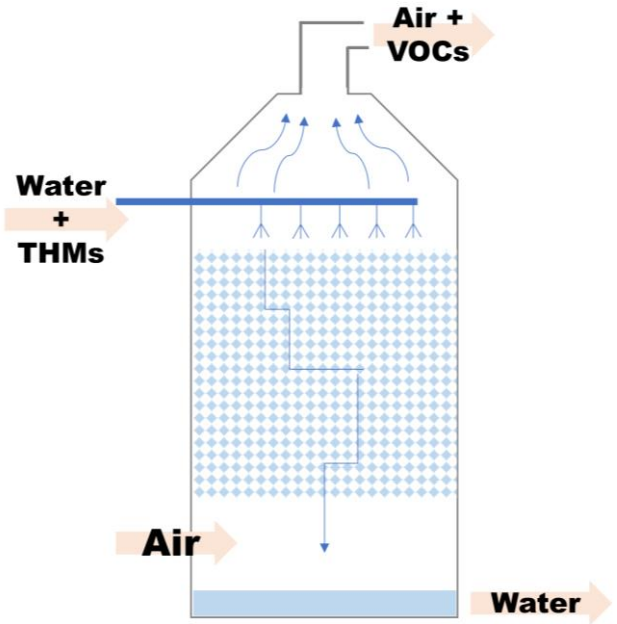
CTR Compliance Options

- Desktop evaluation of CTR compliance options
- Preformed chloramines selected as cost-effective & proactive strategy

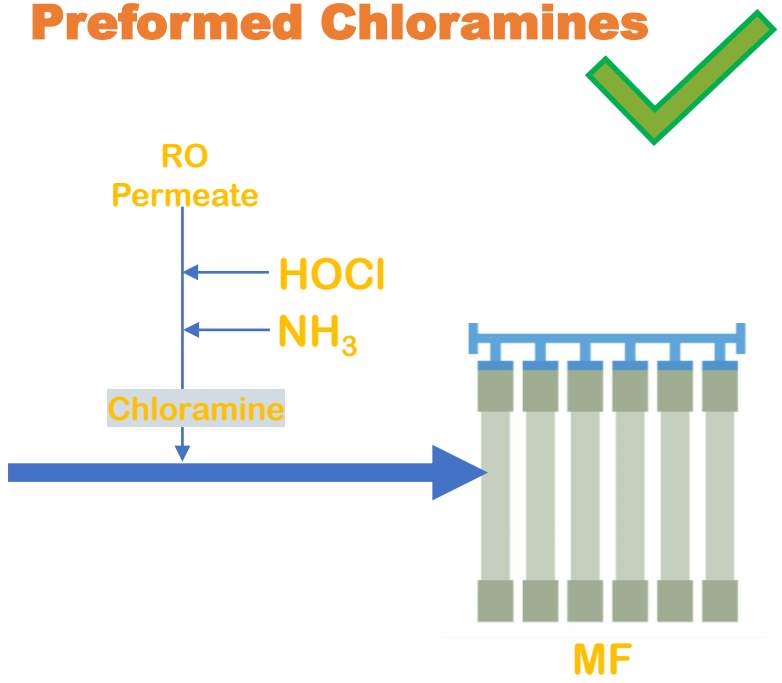
Establishment of a mixing zone



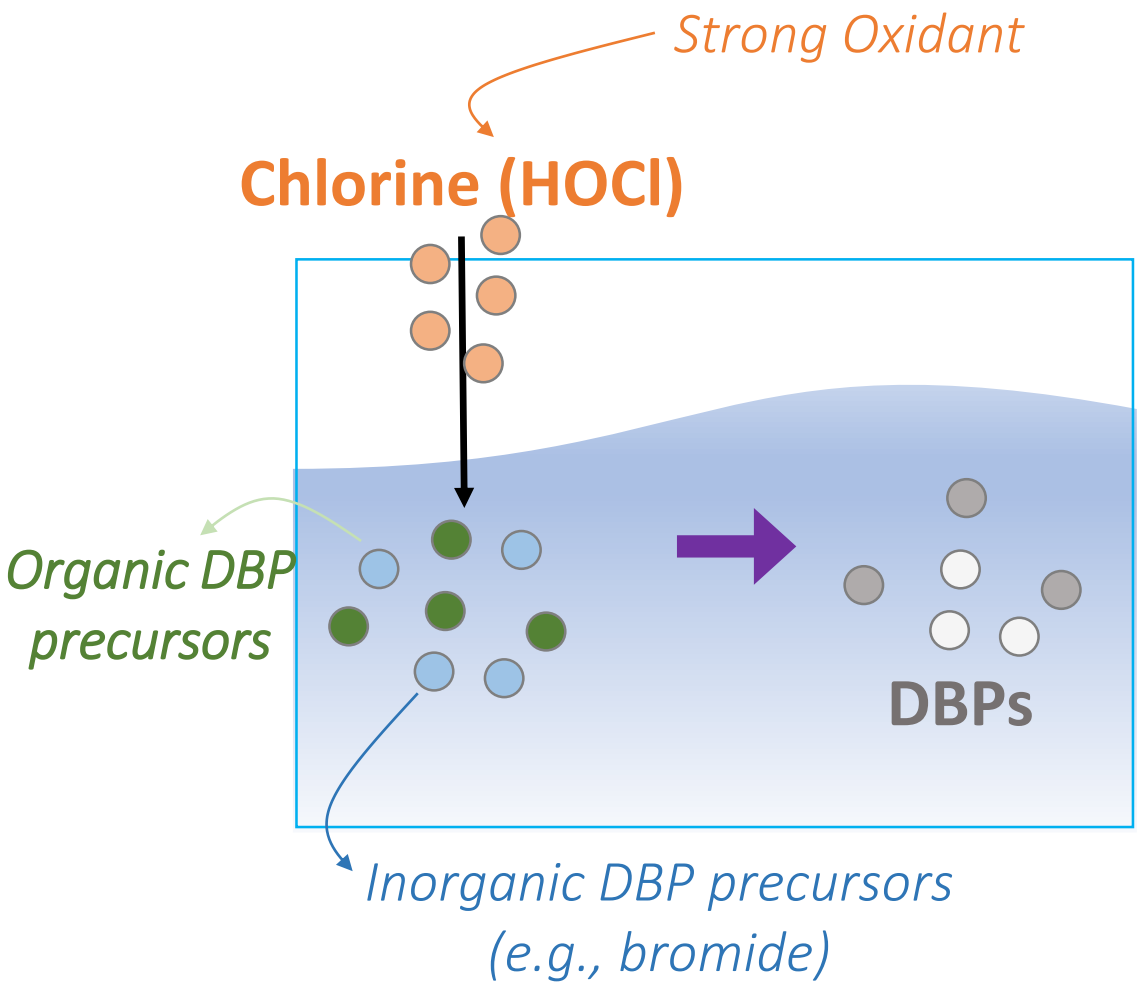
Air Stripping



Preformed Chloramines



How are THMs Formed?

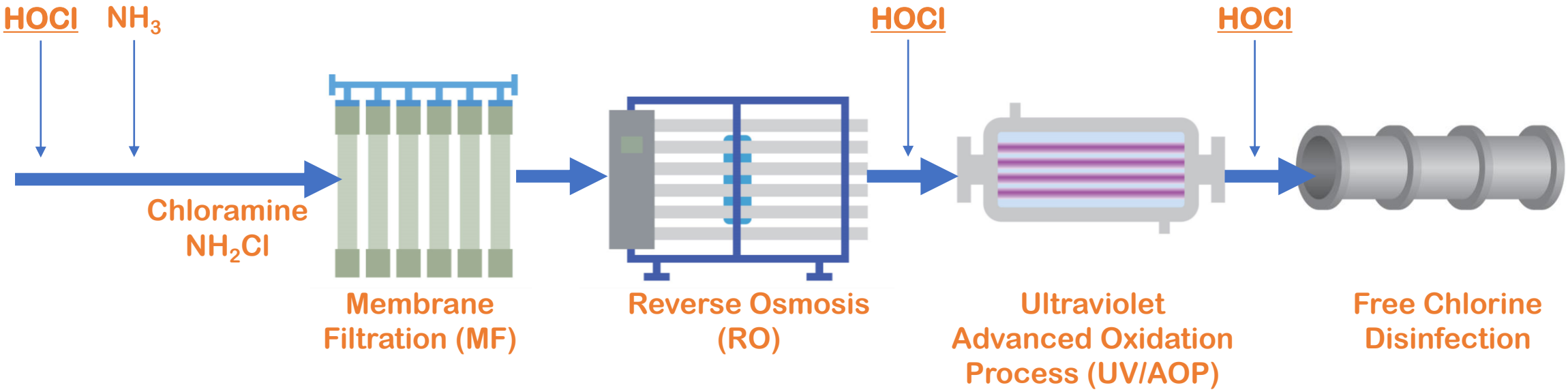


- THMs are a group of DBPs that contain one carbon and three halogens
- Regulated THMs:
  - Bromodichloromethane (BDCM)
  - Dibromochloromethane (DBCM)
  - Chloroform
  - Bromoform

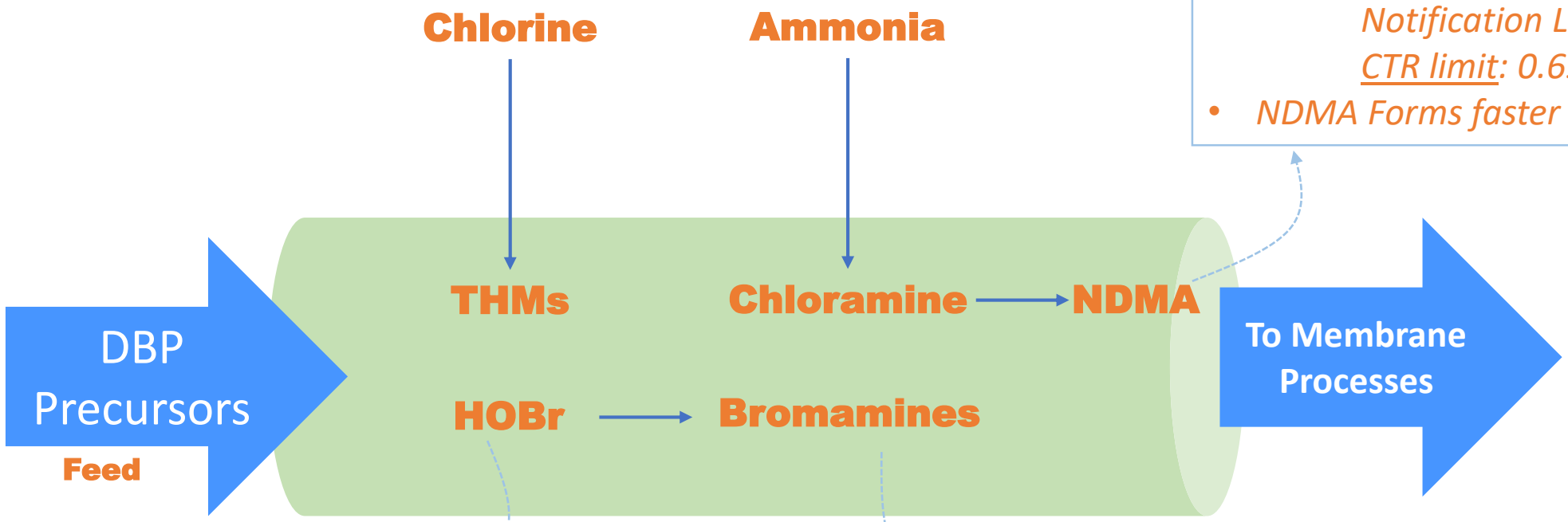
Advanced Water Treatment

- Applications of chlorine in advanced water treatment
  - Biofouling control (as chloramines)
  - Advanced Oxidation
  - Disinfection

In-Line Chloramination



What Happens During In-Line Chloramination?



- *Regulated Constituent:*
  Notification Level: 10 ng/L
  CTR limit: 0.69 ng/L
- *NDMA Forms faster with dichloramine*

During UV treatment:

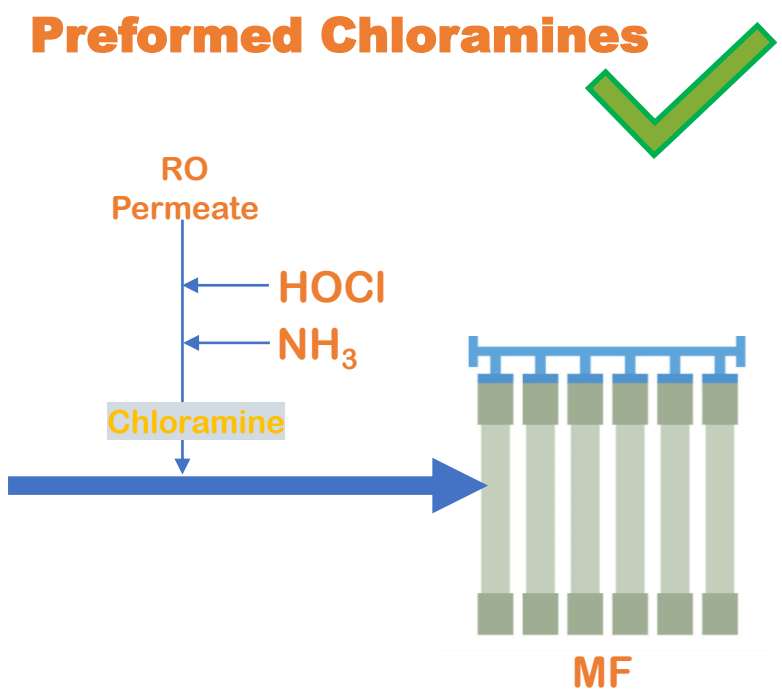
HOBr —UV→ Bromate (regulated)

Membrane Damage

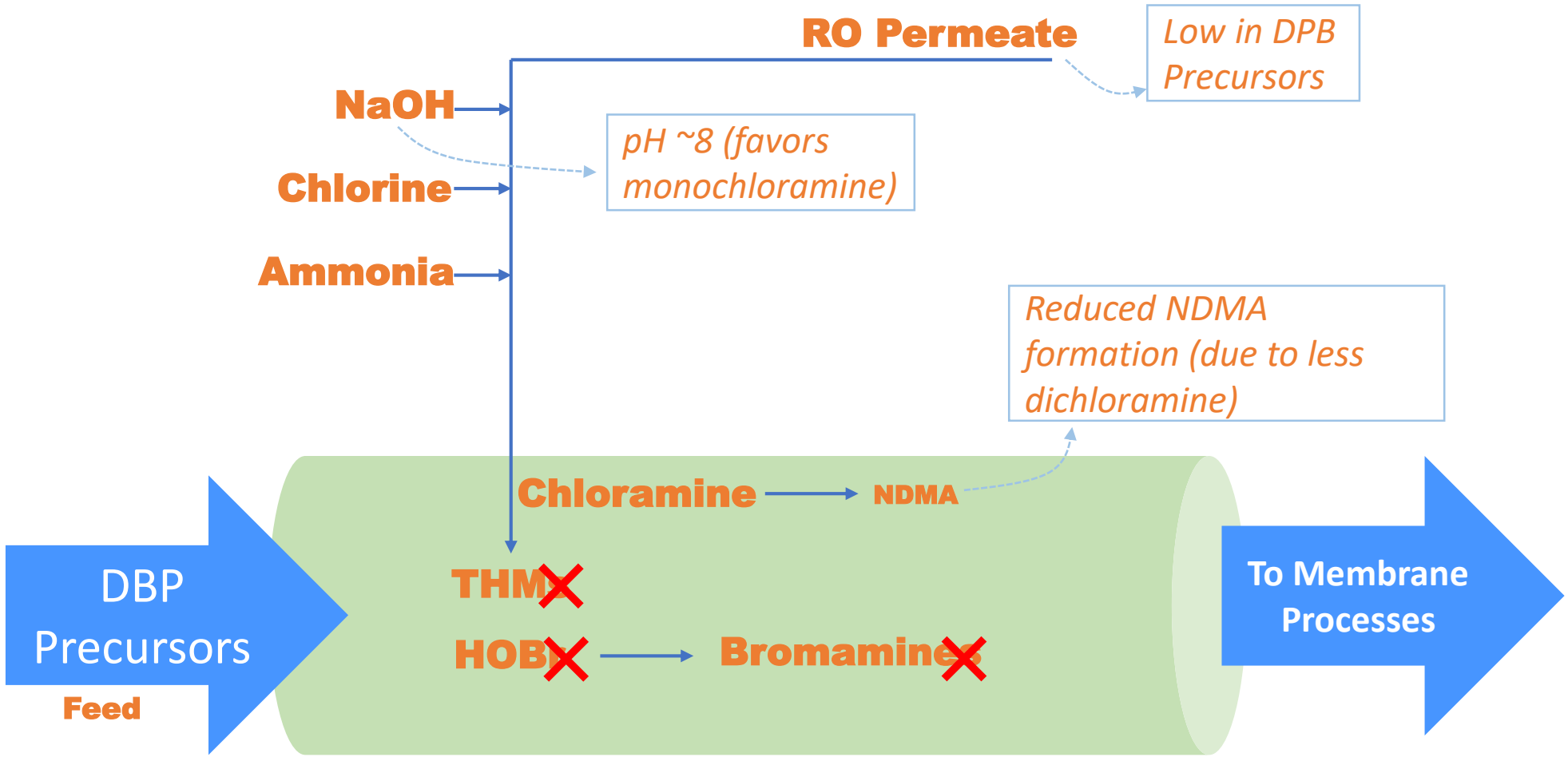
NDMA = N-nitrosodimethylamine

CTR Compliance Options

- Preformed Chloramines
  - Contact of free chlorine with feed is avoided by preforming chloramines in RO permeate (low in THM precursors).
  - Pros:
    - Avoids formation of BDCM and DBCM.
    - Low capital and O&M costs.
  - Cons:
    - Requires additional infrastructure at AWPF.

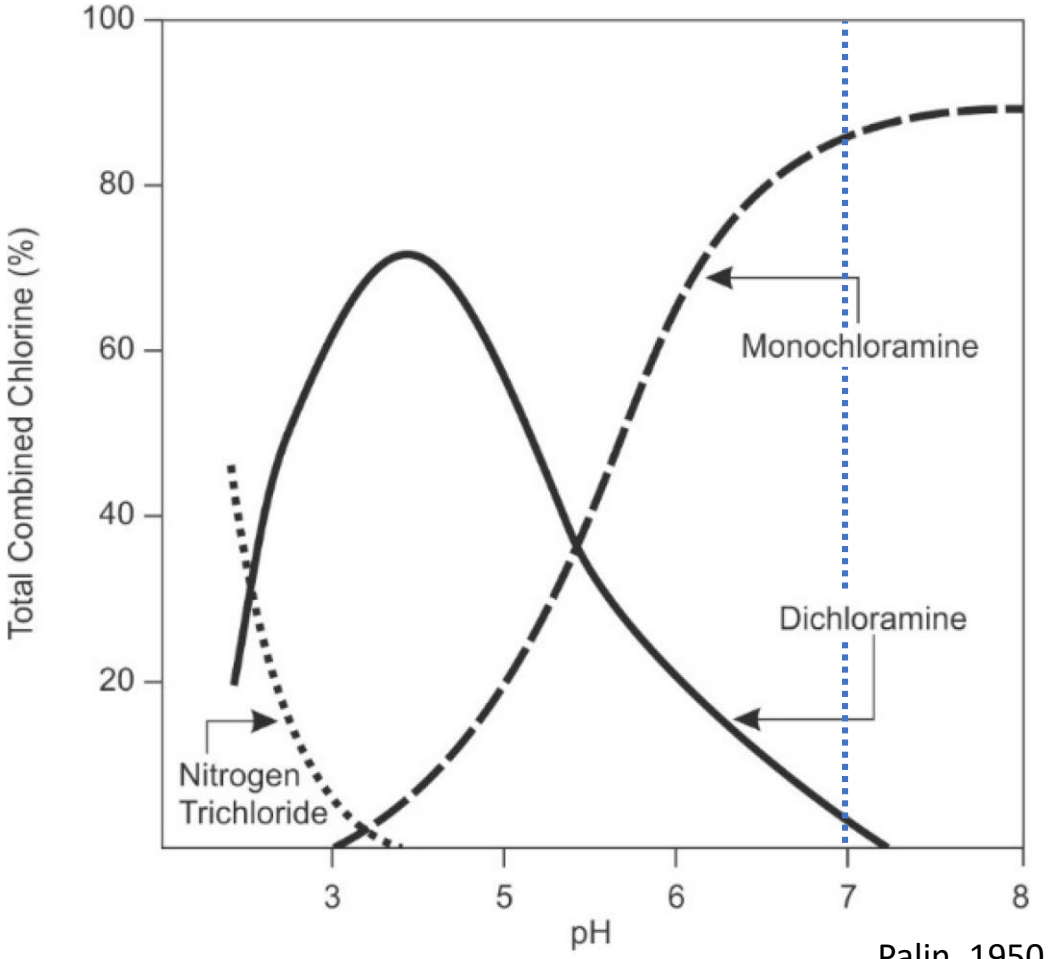


Preformed Chloramines Strategy



Preformed Chloramines Strategy

- pH
  - Monochloramine is favored (over dichloramin at pH >7
  - Reaction of N-OM with dichloramine to form NDMA is fast.
- Order of Addition
  - Chlorine first to avoid localized high chlorine concentrations that favor dichloramine upon ammonia addition.



Palin, 1950

Preformed Chloramines in Full- and Pilot- Scale

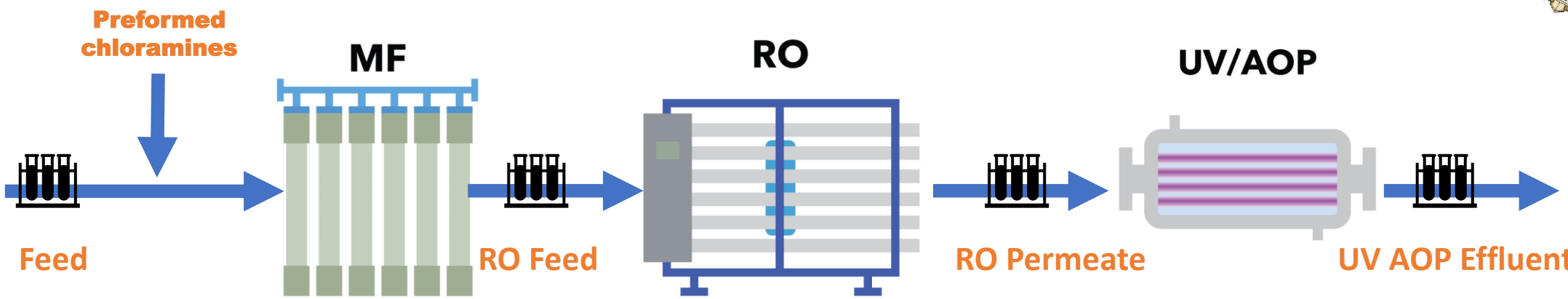
- In-line ("conventional") chloramination common in drinking water treatment and groundwater recharge
- Preformed chloramines gaining traction in the US and/or for potable reuse
- Pilot Scale:
  - West Basin Desalination Demonstration (to reduce bromamine formation)
  - DC Tilman (Los Angeles) Groundwater Replenishment AWP (NDMA formation)
  - Pure Water San Diego Phase 1 – control of bromamines
- Full Scale
  - Beenyup AWPF, Perth Australia – DBP control
  - NEWater facilities, Singapore

Preformed Chloramines Study at AWP Demonstration Facility

Evaluate the effectiveness of using preformed chloramines to achieve levels of THMs in the AWP product water below CTR thresholds.

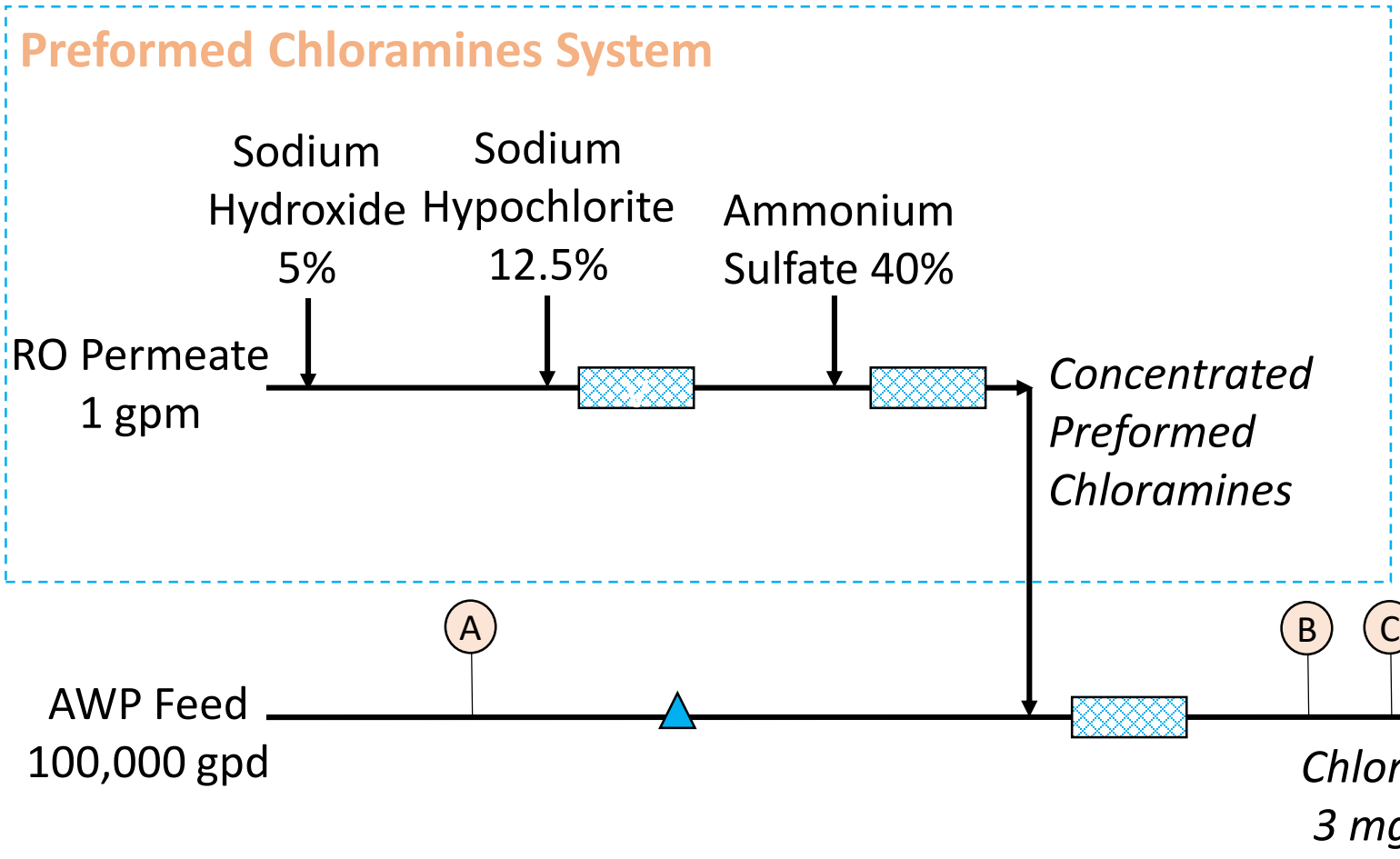
Test Plan → **Installation of Preformed Chloramines System** → **Monitoring 12 months**

Test Plan

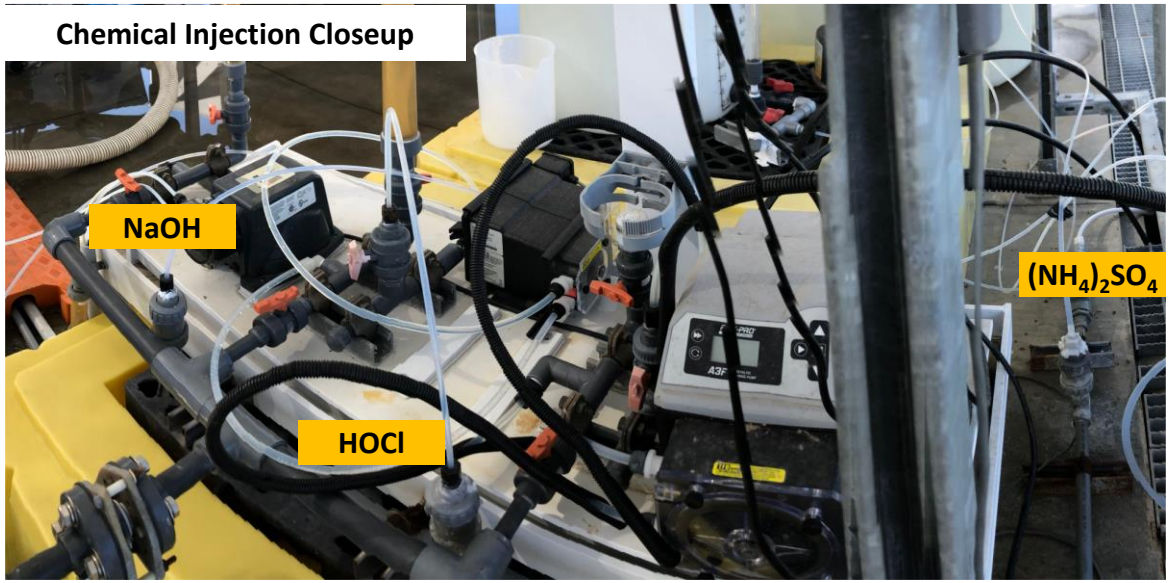


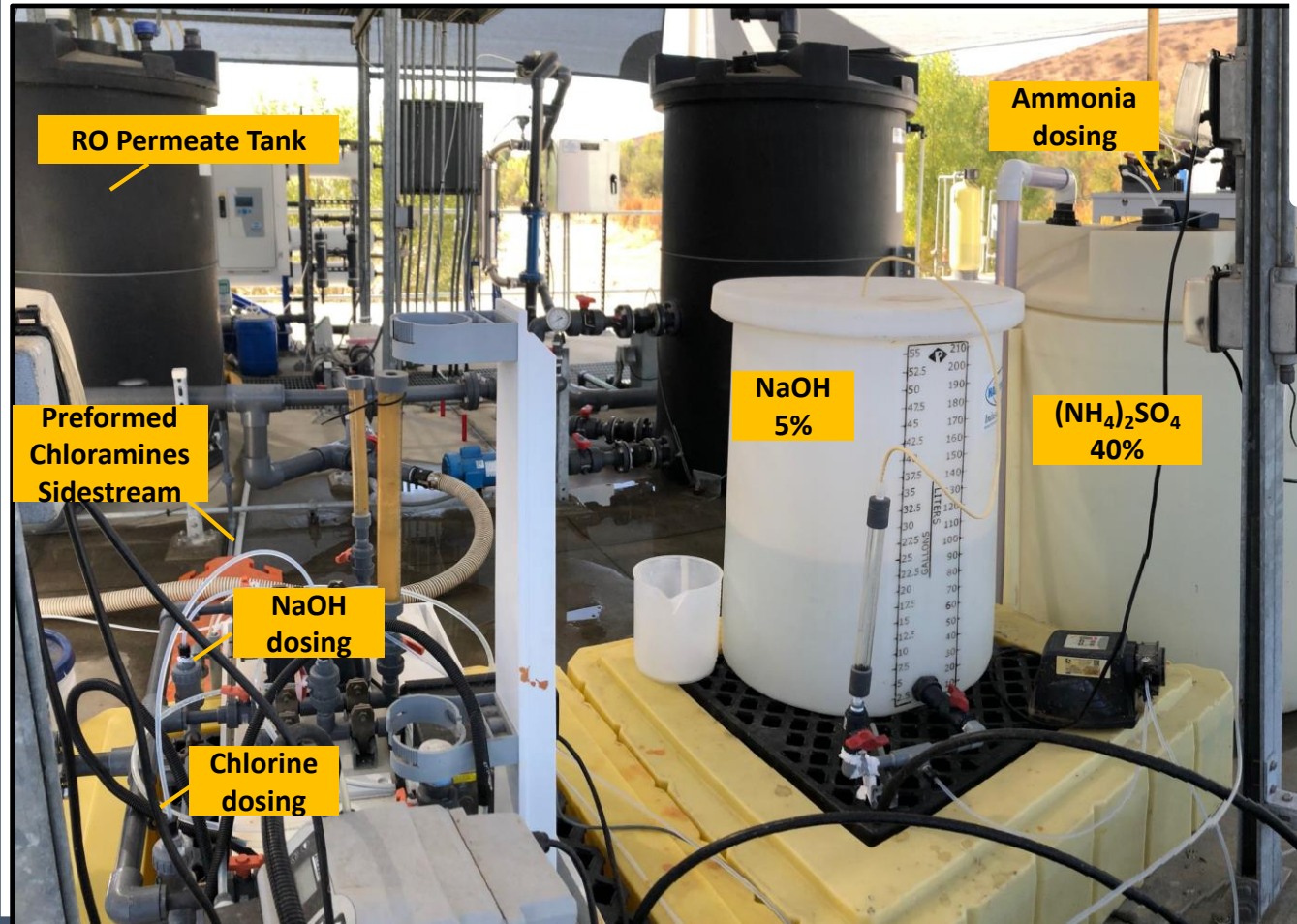
Analyte	Method	MRL (µg/L)
NDMA	EPA 521	0.002
THMs (BDCM, DBCM, bromoform, chloroform)	EPA 524.2	0.5
DEHP	EPA 525.2	0.6
Bromide	EPA 300.0	5.0

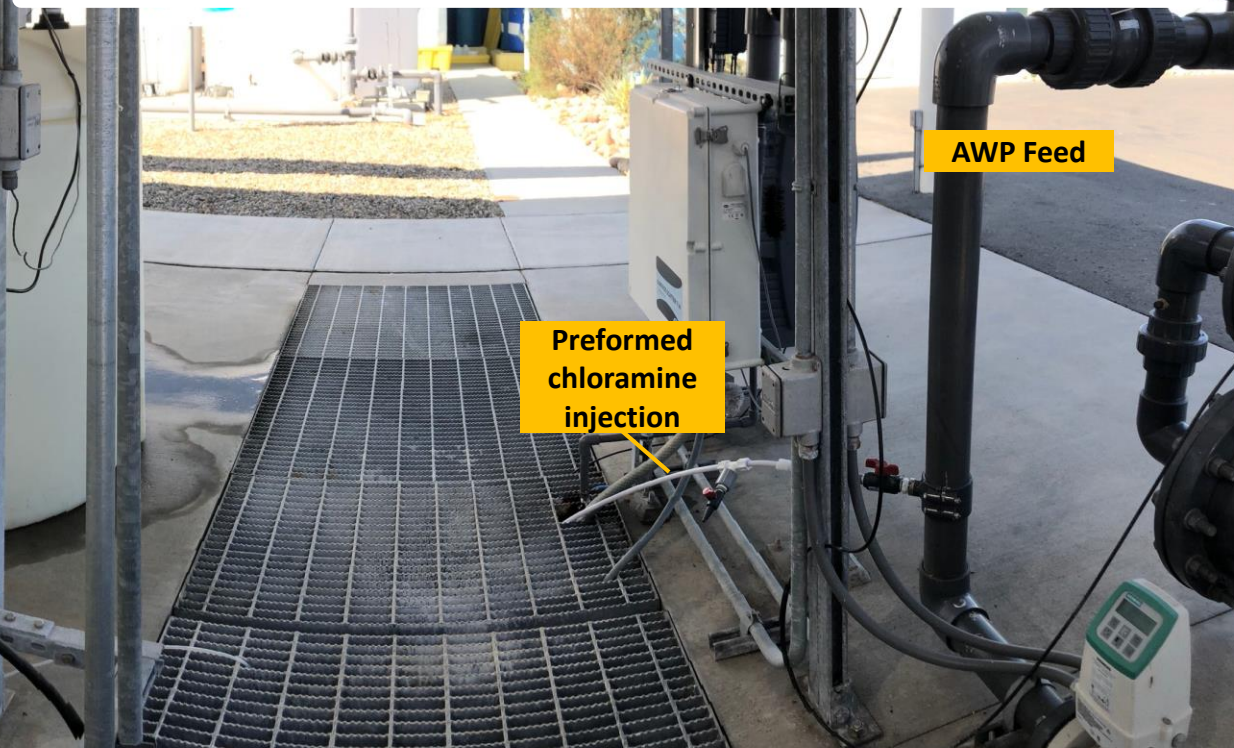
Preformed Chloramines System at AWP Demonstration Facility



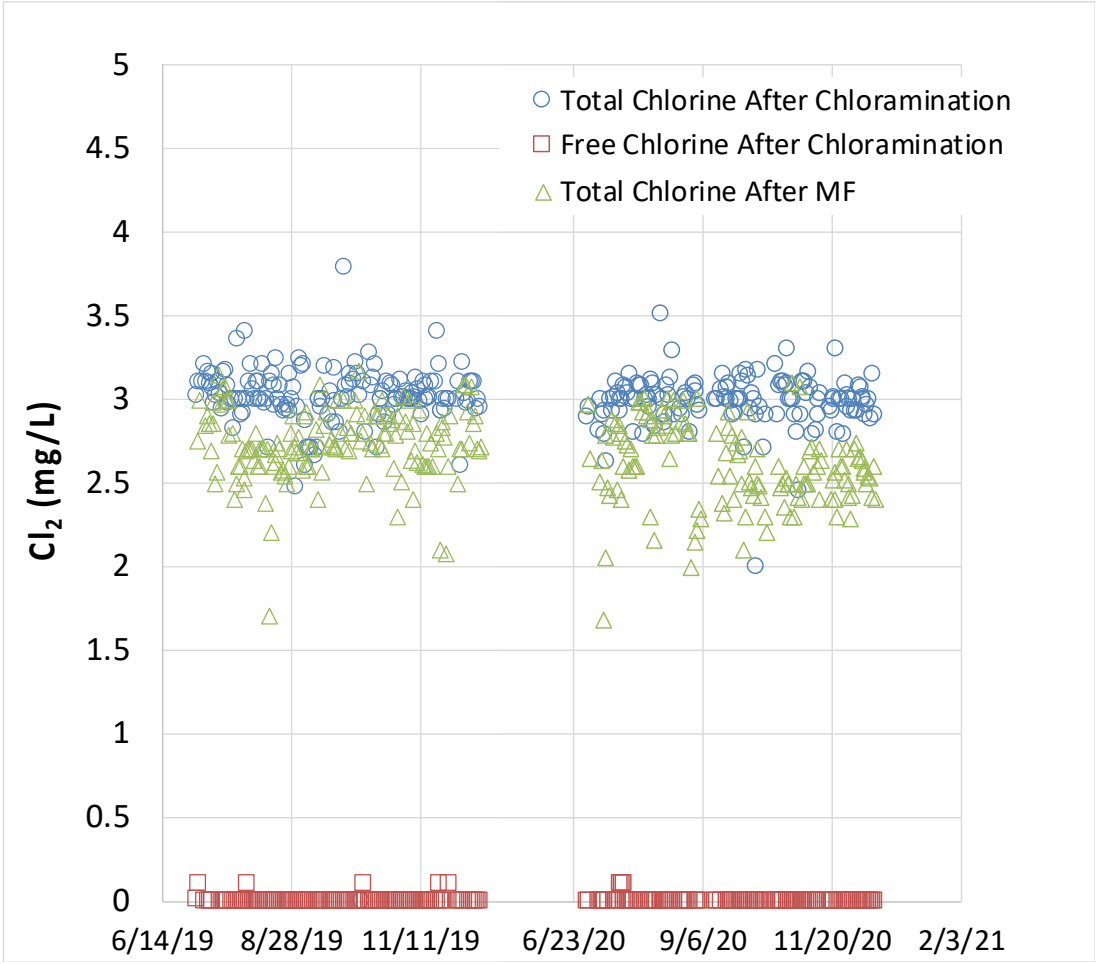
Preformed Chloramines System at AWP Demonstration Facility

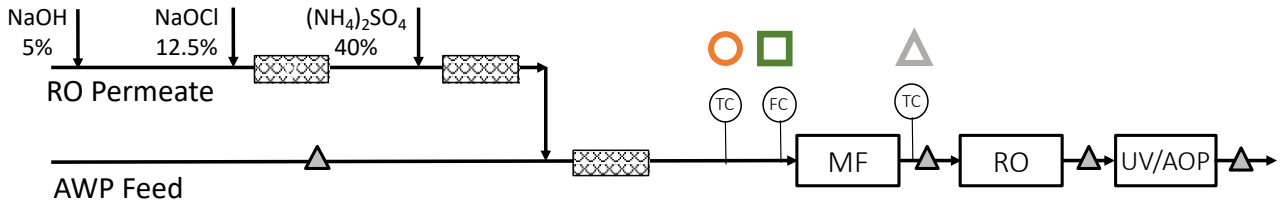






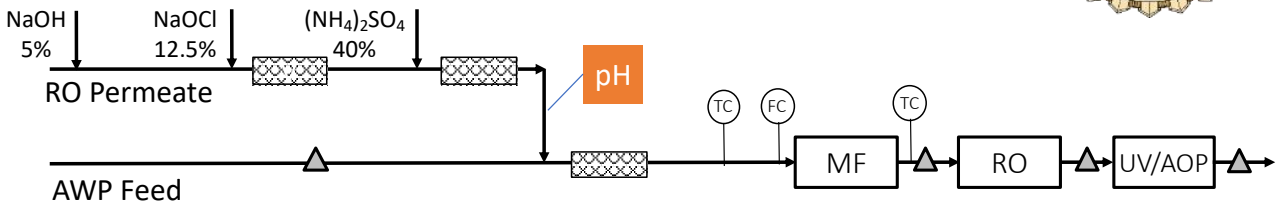
Preformed Chloramines System - Performance



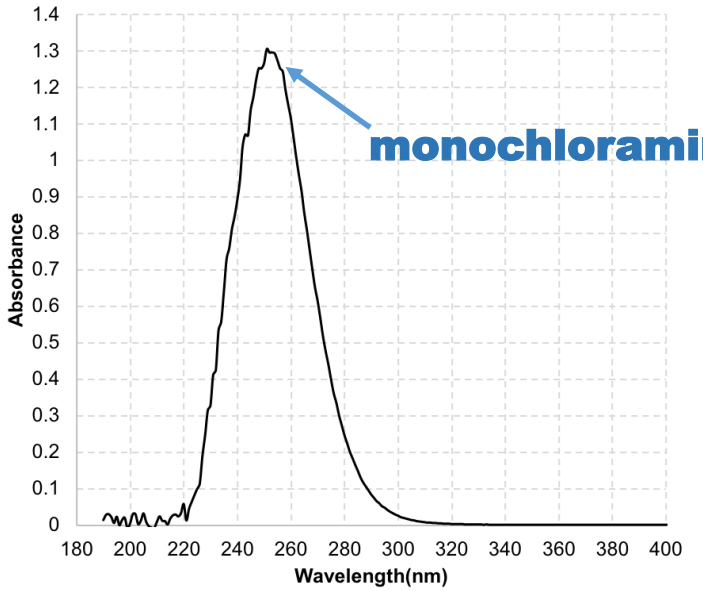


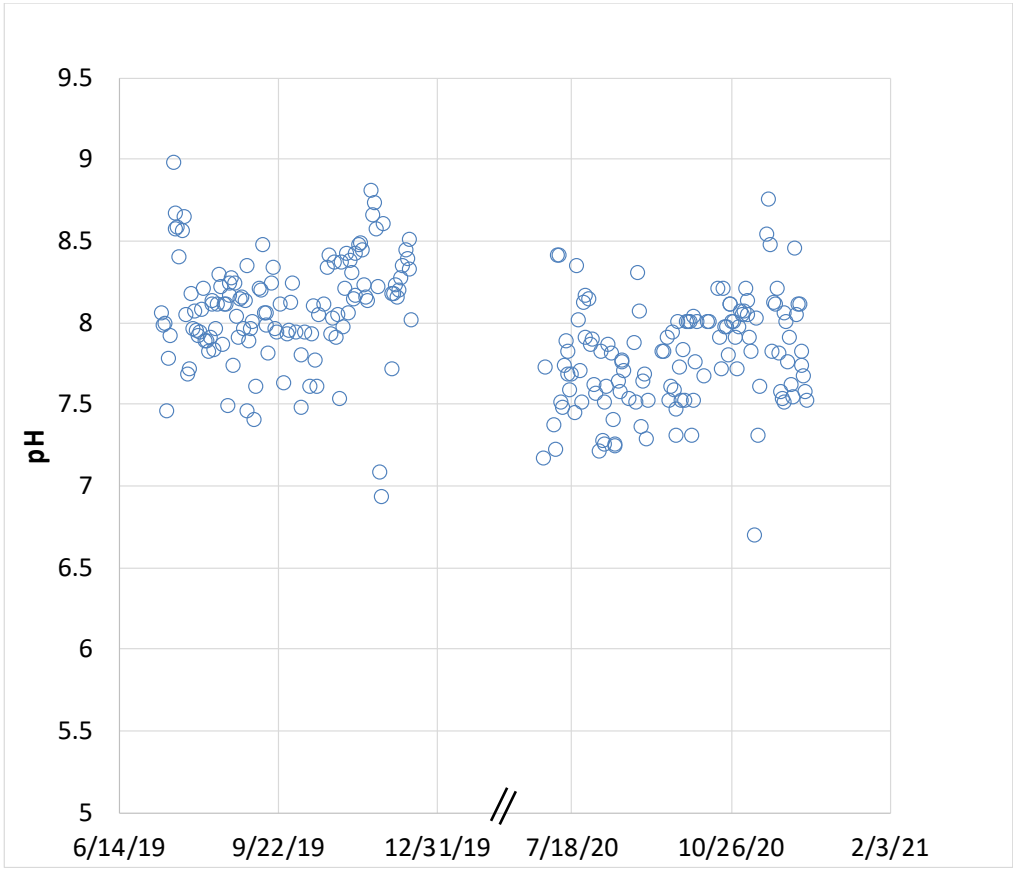
- Target chloramine: 3 mg/L Cl_2
- Monitored in-line with a total chlorine analyzer
- Free chlorine monitored prior to MF to ensure that no free chlorine reached the membranes.

Preformed Chloramines System - Performance



- pH checked daily with handheld probe
- UV scan (200 nm – 400 nm) of the concentrated chloramines confirmed presence of monochloramine only.



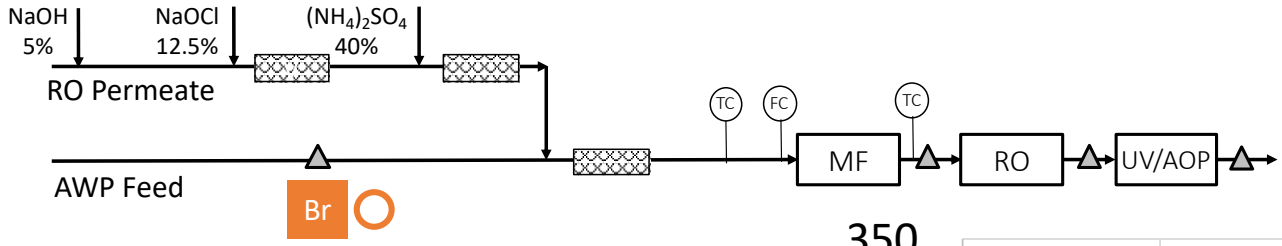


Preformed Chloramines System – Water Quality

- AWP Feed characterized at the beginning of the study.
- Well nitrified-denitrified tertiary effluent.

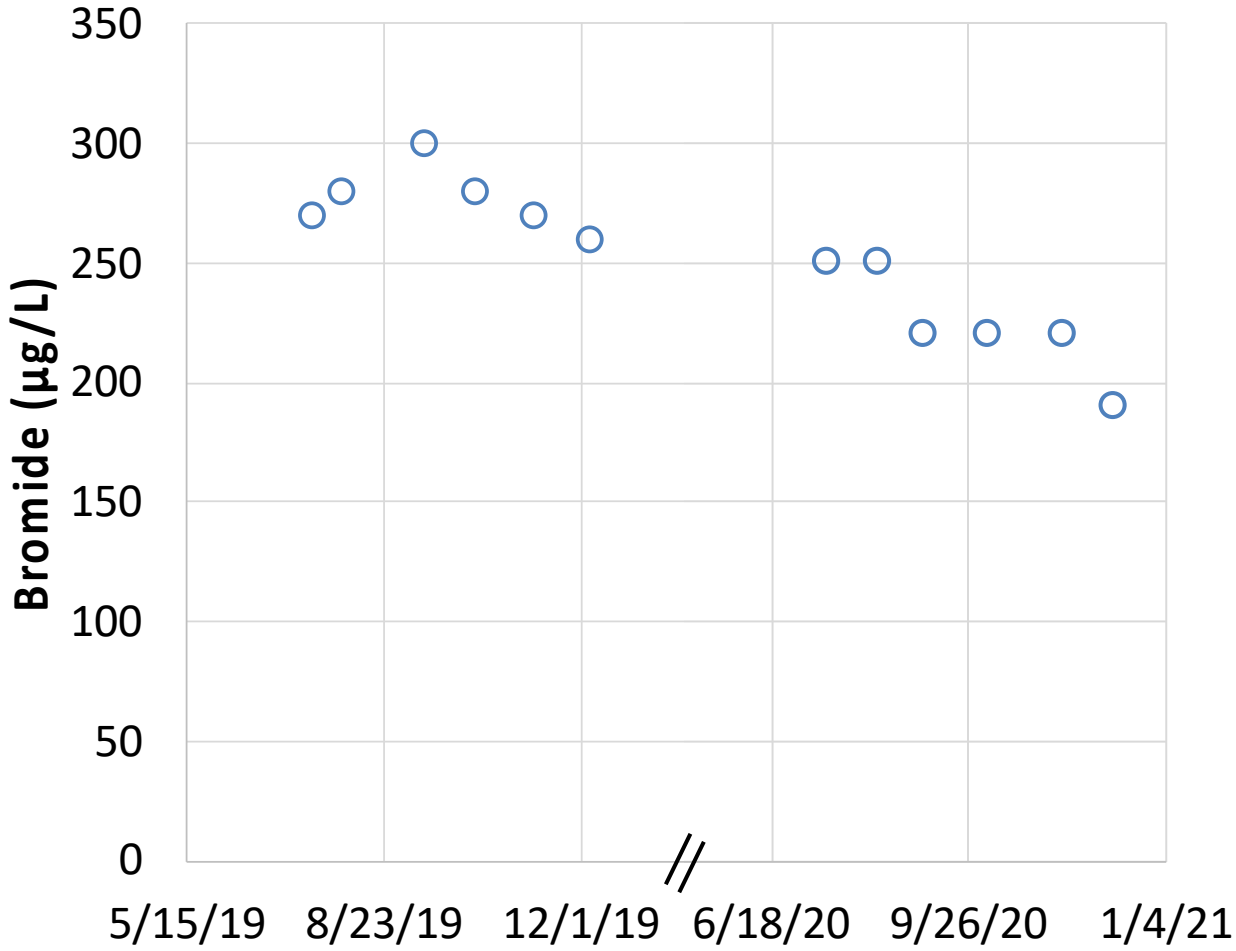
Constituent	Units	Value	Range
Nitrate	mg-N/L	8.7	2.7 - 12.4
Bromide	µg/L	270	260 - 300
Alkalinity	mg/L as $CaCO_3$	100	--
Ammonia Nitrogen	mg-N/L	0.058	< 1
Total Dissolved Solids	mg/L	580	560 – 660
Total Organic Carbon	mg/L	8.8	6.3 - 8.8

Preformed Chloramines System – Water Quality

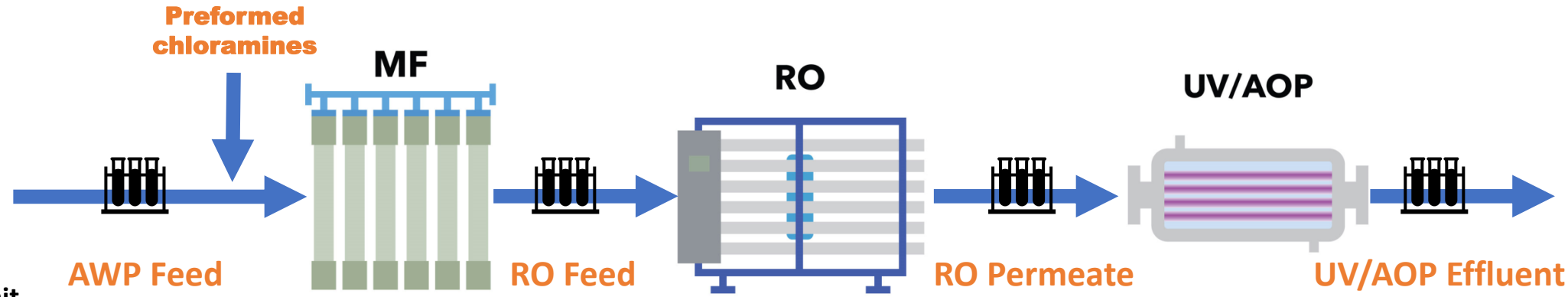


Bromide

- Concentration in the feed between 190 and 300 µg/L
- Expected to be <100 µg/L in RO permeate
- Comparable to U.S. water sources



Preformed Chloramines System – Water Quality

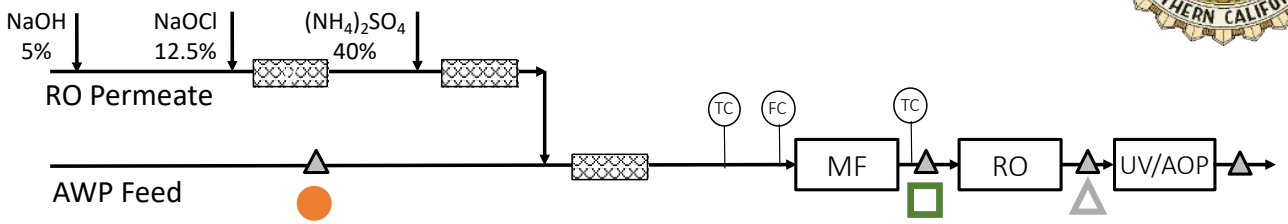


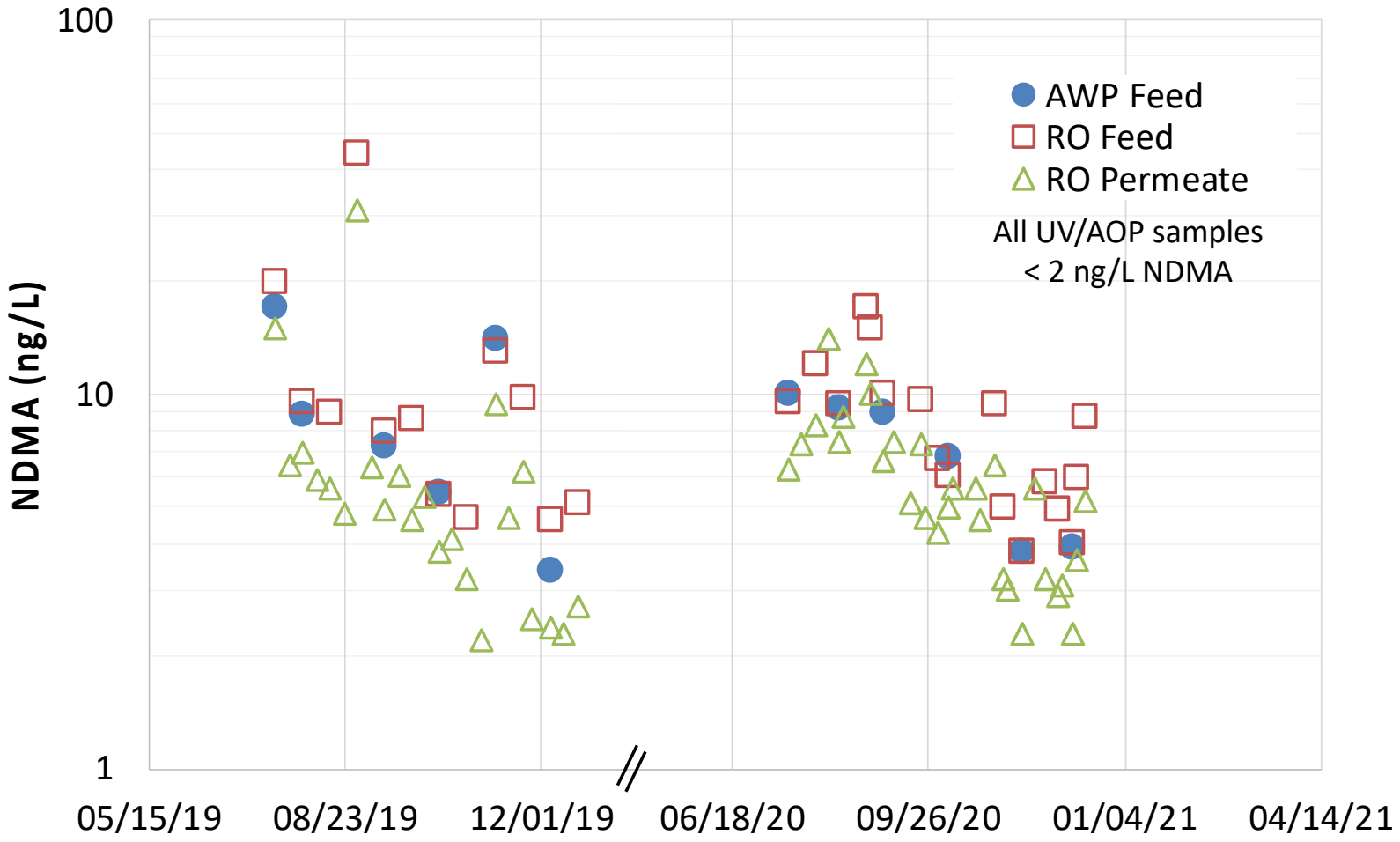
	CTR Limit	AWP Feed	RO Feed	RO Permeate	UV/AOP Effluent
BDCM	**0.56**	**<0.50**	**<0.50**	**<0.50**	**<0.50**
DBCM	**0.41**	**<0.50**	**<0.50**	**<0.50**	**<0.50**
Bromoform	**4.3**	**<0.50**	**<0.50**	**<0.50**	**<0.50**
Chloroform	Reserved	**<0.50**	**0.87** (<0.50-21)	**<0.50** (<0.50-3.6)	**<0.50** (<0.50-2.6)

All values in µg/L
Total THM MCL 80 µg/L

Preformed Chloramines System – Water Quality

NDMA





- NDMA detected in Feed
- Partially removed by RO
- Consistently not detected in UV/AOP effluent

Preformed Chloramines System – Water Quality

- NDMA and THM reformation
  - Reactions in UV/AOP could form NDMA/THM precursors
  - If there is a chloramine residual in the pipeline to the reservoir, NDMA and THMs could be formed
  - Reformation studied in UV/AOP effluent
  - No evidence of NDMA or THM reformation (all samples below detection)

Preformed Chloramines System – Water Quality

DEHP

	RO Feed	RO Permeate	UV/AOP Effluent
Average (µg/L)	< 0.60	< 0.60	< 0.60
Range (µg/L)	< 0.60 – 0.80	< 0.60 – 0.66	< 0.60
No Data Points	12	12	12

- DEHP consistently below detection in UV/AOP effluent
- DEHP CTR limit: 1.8 µg/L

Conclusions

- Preforming chloramines in RO permeate helps maintain DBP levels below CTR thresholds.
  - BDCM and DBCM consistently below detection in UV/AOP effluent.
  - NDMA partially removed through RO.
  - NDMA consistently below detection in UV/AOP effluent.
- Study demonstrates preformed chloramines are a cost-effective solution for compliance with CTR limits for DBPs
- Implementing preformed chloramines makes surface water augmentation more attainable in CA.

Acknowledgments

- Padre Dam Municipal Water District
- San Diego County Water Authority
- Metropolitan Water District of Southern California - FSA Funding Program
- United States Department of the Interior, Bureau of Reclamation- WaterSMART: Water Reclamation and Reuse Research under the Title XVI Program

Questions?