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GARVER

How do you get the salt out of Water?

APPROACHES FOR MITIGATION OF TDS IN TREATED WASTEWATER

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Today we will discuss the following TDS topics

- Rationale for TDS removal in treated wastewater
- TDS reduction strategies
- Case study

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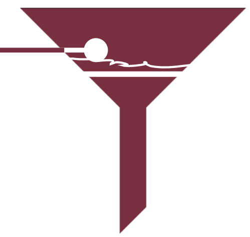
TDS stands for total dissolved solids

Total Solids (TS)

- Volatile
- Fixed

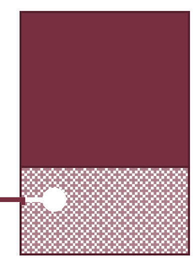
Suspended Solids (SS)

- Retained on 0.45 μm filter paper
- Fixed or Volatile
- Fixed

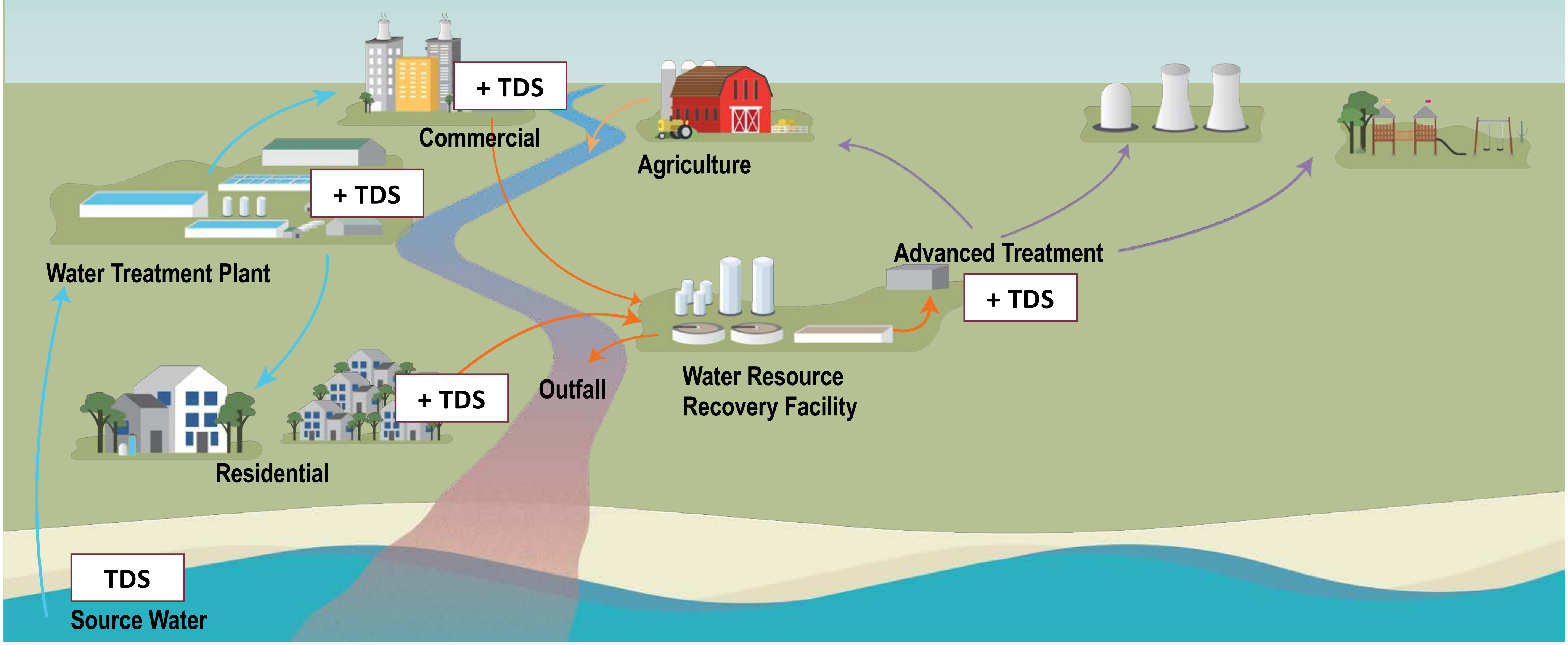


Total Dissolved Solids (TDS)

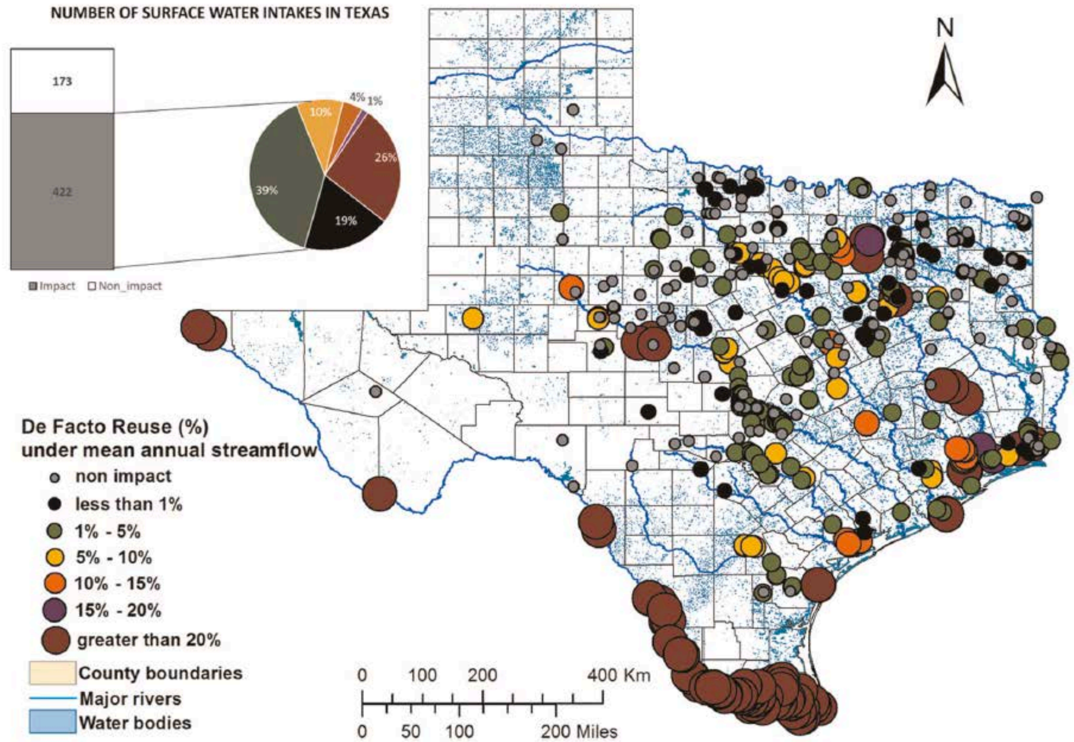
- Also called Filterable Solids
- Passing through 0.45 μm
- Fixed or Volatile



How does TDS get into wastewater?



Discharged treated wastewater ends up contributing to source water TDS for downstream communities



De-facto water reuse in TX

Source: Nguyen and Westerhoff, 2019

There are two main reasons we should worry about TDS

Too much salt in the water makes it unpalatable (i.e., brackish water)

↓

Treatment may be needed for drinking water applications

High TDS in treated wastewater could harm water quality in receiving bodies and aquifer

↓

Treatment may be needed prior to discharge

There is a national secondary drinking water standard for TDS removal

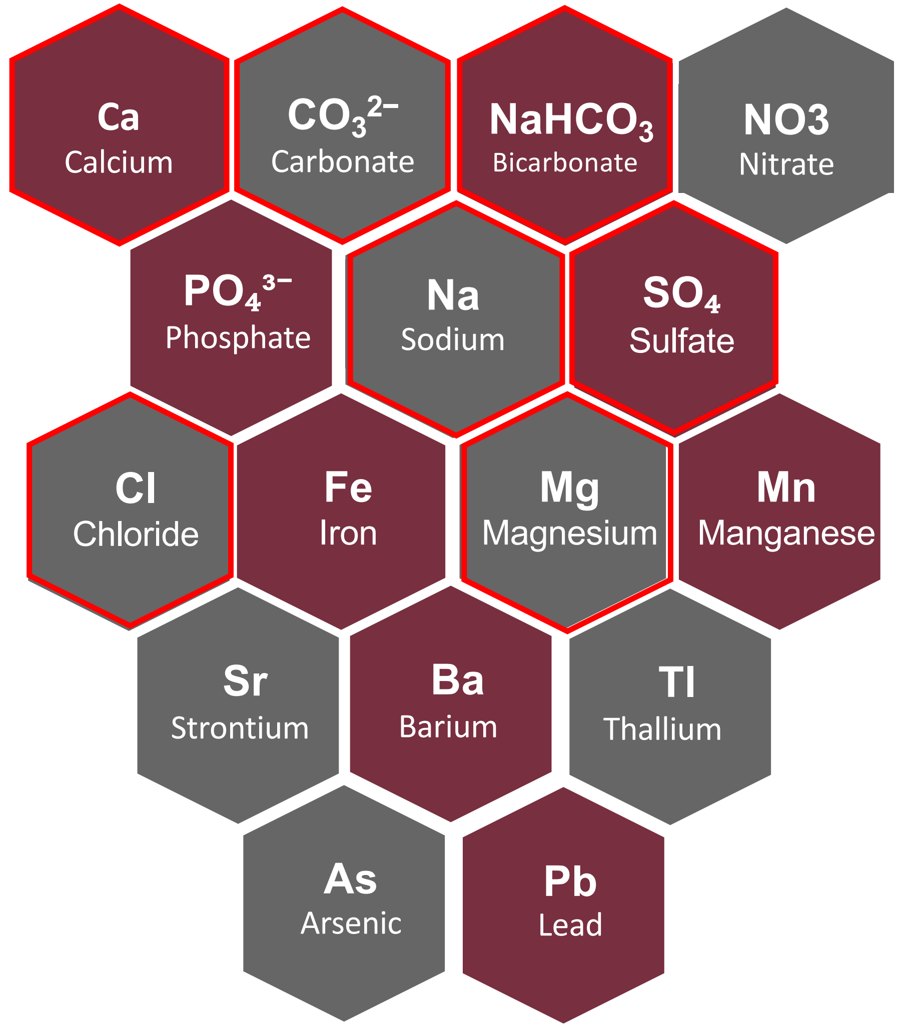
Contaminant	Secondary MCL	Noticeable Effects above the Secondary MCL
Aluminum	0.05 to 0.2 mg/L	Colored water
Chloride	250 mg/L	Salty taste
Color	15 color units	Visible tint
Copper	1.0 mg/L	Metallic taste; blue-green staining
Corrosivity	Non-corrosive	Metallic taste; corroded pipes/fixtures staining
Fluoride	2.0 mg/L	Tooth discoloration
Foaming Agents	0.5 mg/L	Frothy; cloudy; bitter taste; odor
Iron	0.3 mg/L	Rusty color; sediment; metallic taste; reddish or orange staining
Manganese	0.05 mg/L	Black to brown color; black staining; bitter metallic taste
Odor	(threshold odor number)	“rotten egg”; musty or chemical smell
pH	6.5-8.5	Low pH; slippery feet; soda taste; deposits
Silver	0.1 mg/L	Skin discoloration; graying of the white part of the eye
Sulfate	250 mg/L	Salty taste
Total Dissolved Solids (TDS)	500 mg/L	Hardness deposits; colored water; staining; salty taste
Zinc	5 mg/L	Metallic taste

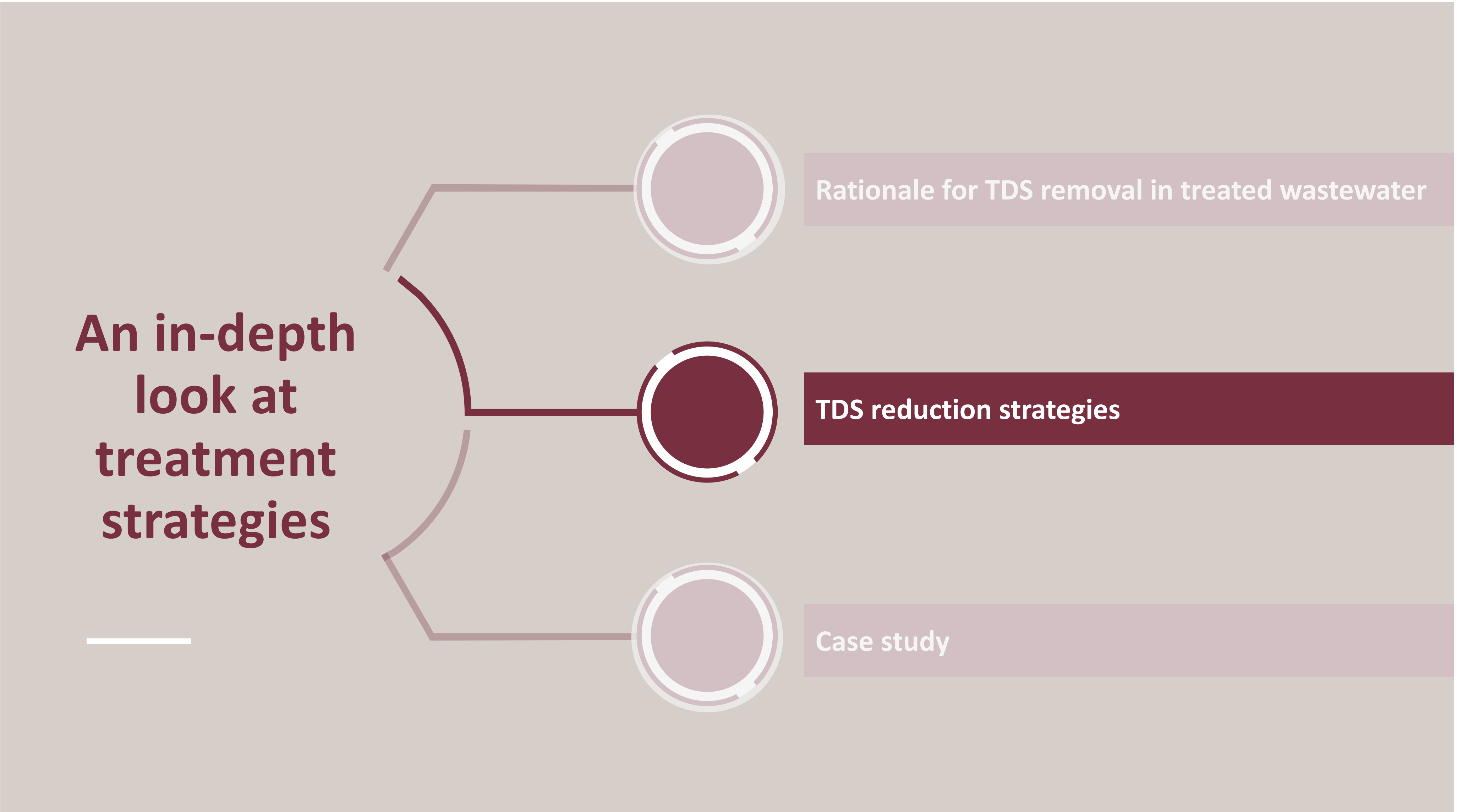
Principles for removing the ions from water include the following

Water softening removes some TDS from hardness

Divalent ions are easier to remove compared to monovalent ions

Reverse Osmossis is needed for the removal of monovalent ions




An in-depth look at treatment strategies
Rationale for TDS removal in treated wastewater
TDS reduction strategies
Case study

Reducing TDS in treated wastewater discharge must be holistically considered

What drives the need for removing TDS?

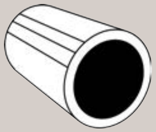
What approaches are available?

Which technologies make practical and financial sense?

TDS reduction reduction can be achieved at the source, in the system, or prior to discharge

At the source

- TDS levels in source water in relation to acceptable water quality
- Centralized vs distributed source water entry points
- Groundwater vs surface water
- Technology options Capital and operational costs



In the system

- Incremental load from the system
- Domestic versus industrial
- Communication and enforcement

Prior to discharge

- Discharge options
- Technology options
- Capital and operational costs

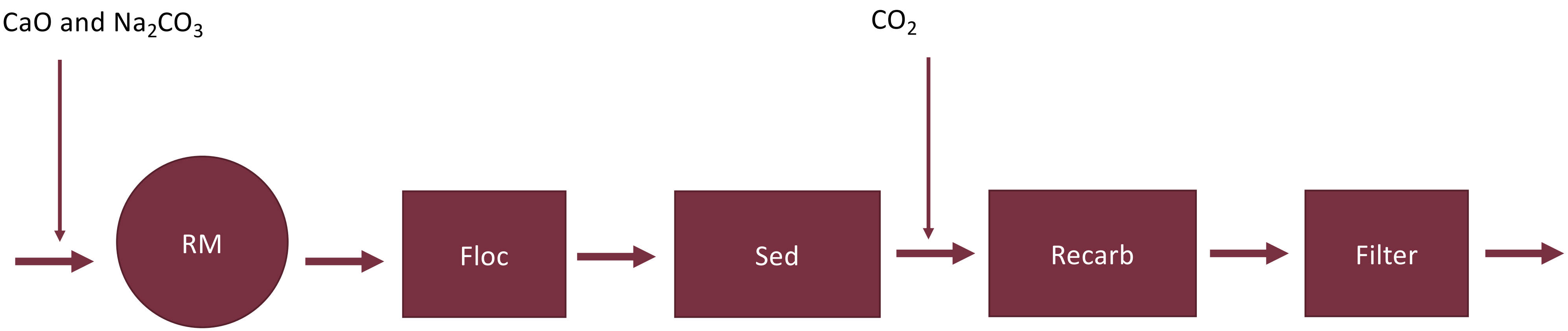
There are many technology alternatives for TDS reduction

1. **Precipitative softening**

2. **Electrocoagulation**

3. **Membrane Softening**
    - Nanofiltration Membranes
    - Reverse Osmosis Membranes

Precipitative softening process removes hardness/TDS by getting calcium and magnesium out of the water



Chemical transformation during softening ends up getting some hardness and TDS of of the water

Lime Addition

Hardness	Lime		Precipitate
CO_2	$Ca(OH)_2$	→	$CaCO_{3(s)} + H_20$
$Ca(HCO_3)_2$	$Ca(OH)_2$	→	$2CaCO_{3(s)} + 2H_20$
$Mg(HCO_3)_2$	$Ca(OH)_2$	→	$CaCO_{3(s)} + MgCO_3 + 2H_20$
$MgCO_3$	$Ca(OH)_2$	→	$CaCO_{3(s)} + Mg(OH)_{2(s)}$

Lime & Soda Ash Addition

$MgSO_4$	+	$Ca(OH)_2$	↔	$Mg(OH)_{2(s)}$	+	$Ca(SO)_4$
$CaSO_4$	+	Na_2CO_3	↔	$CaCO_{3(s)}$	+	$Na_2(SO)_4$
$MgCl_2$	+	$Ca(OH)_2$	↔	$Mg(OH)_{2(s)}$	+	$CaCl_2$
$CaCl_2$	+	Na_2CO_3	↔	$CaCO_{3(s)}$	+	$2NaCl$

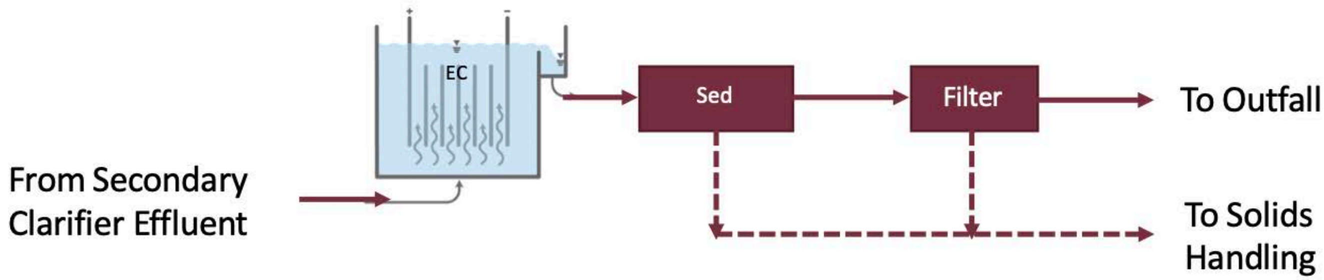
Recarbonation

$Mg(OH)_2 + CO_2 \rightarrow MgCO_3 + H_20$

$MgCO_3 + CO_2 + H_20 \rightarrow Mg(HCO_3)_2$

$CaCO_3 + CO_2 + H_20 \rightarrow Ca(HCO_3)_2$

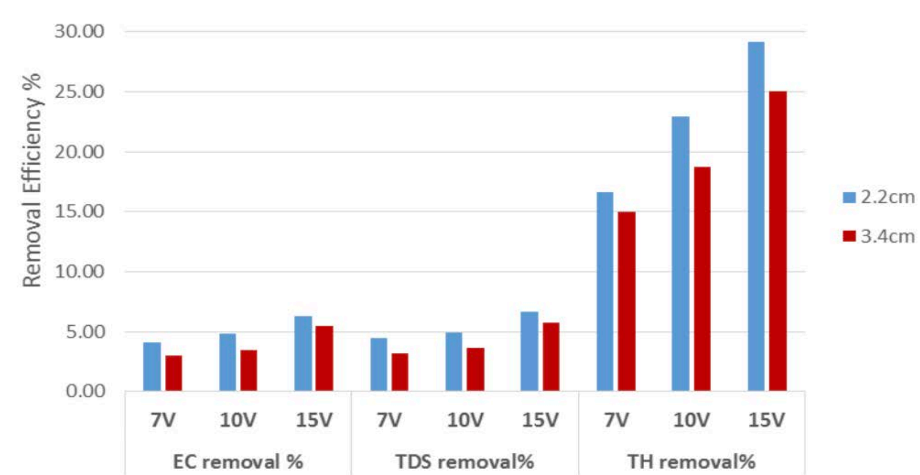
Electrocoagulation applies electrical current across metal electrodes causing coagulation



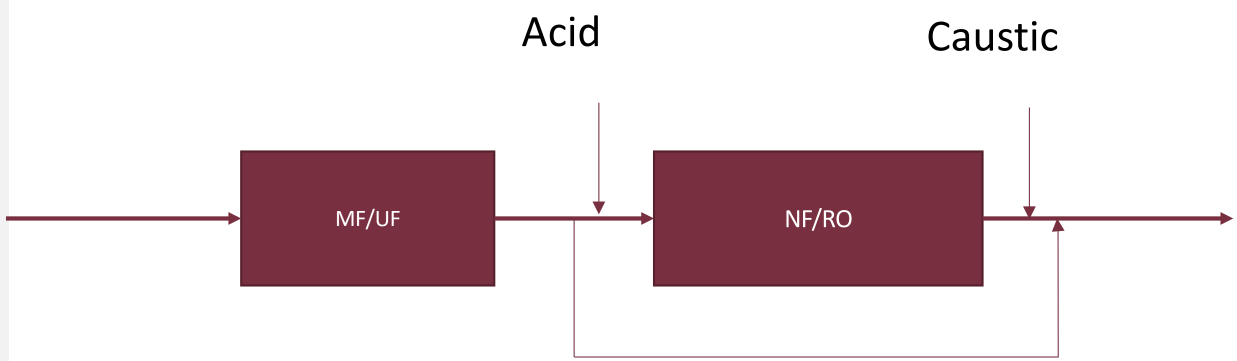
Electro-coagulation process causes co-precipitation of certain ions

Divalent ions (e.g. Ca and Mg) are influenced preferentially by this process

Monovalent ions (e.g., Cl) are not impacted much by electro-coagulation



Membrane softening achieves TDS removal by directly removing the dissolved ions



Concentrates dissolved ions in the concentrate stream

Treated water is typically very low in TDS, partial stream treatment is often adequate

Residual stream has high concentration of removed salt

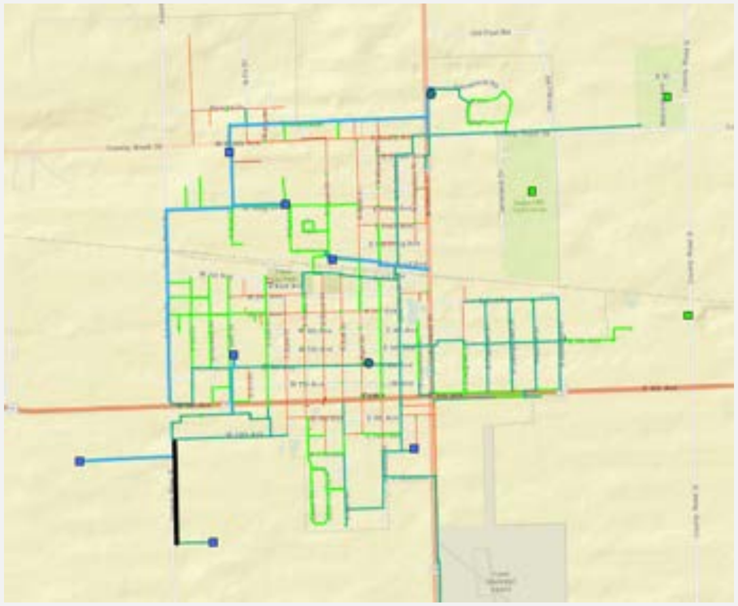
Selection of appropriate TDS removal technology depends on many factors

Technology	TDS is primarily caused by divalent ions	TDS is primarily caused by monovalent ions	Liquid residual stream	Solids residual stream	Technology Experience
Precipitative Softening	✓	X	X	✓	✓
Electro Coagulation	✓	X	X	✓	X
Nanofiltration	✓	X	✓	X	✓
Reverse Osmosis	✓	✓	✓	X	✓

I recently developed solutions for addressing elevated TDS in the treated wastewater discharge from the City of Yuma's treatment facility

- Rationale for TDS removal in treated wastewater
- TDS reduction strategies
- **Case study**

The City of Yuma has seven potable wells and one wastewater treatment facility



- No treatment of drinking water except disinfection
- Widespread use of water softeners within the system
- Wastewater is treated with a conventional BNR process
- Treated wastewater is discharged to ultimately end up in aquifer
- Under order from CDPHE to reduce TDS in treated wastewater discharge

TDS concentration increases as the water passes through municipal use and advanced wastewater treatment

Water and Wastewater Quality
(Samples collected between January and March, 2020)

		Potable Water		Wastewater Influent	
Parameter	**Unit**	**Average**	**Maximum**	**Average**	**Maximum**
TDS	Mg/L	268	295	553	611
pH	s.u.	7.5	8.0	8.0	8.6
Alkalinity	Mg/L as CaCO3	141	157	300	348
Calcium	Mg/L	105	121	135	229
Magnesium	Mg/L	35	50	38	60
Hardness	mg/L as CaCO3	407	506	493	819
Sulfate	Mg/L	11	14	13	27
Chloride	Mg/L	10	12	95	135

We evaluated various options to lower TDS in the treated wastewater discharge

At the source

- Distributed wells
- Relatively low TDS in groundwater
- Centralization will be expensive

In the System

- Significant increase through domestic use
- Protracted educational campaign with questionable results
- Long term and expensive solution

After wastewater treatment

- Single location for all water
- Space available to install additional treatment
- Will meet CDPHE requirements in an expeditious manner

Each technology has distinct advantages and disadvantages

Technology	Advantages	Disadvantages	Cost
Precipitative Softening	Proven technology	Chemical intensive process	$
	Solids residual stream	Large amounts of solids will be generated	
	Solids generated could assist stabilization of biosolids		
	Lower equipment cost		
Electro-coagulation	Very little to no chemicals needed	High equipment cost	$$$
	Residual stream is in solid form that can be disposed similar to the biosolids	Solids are not expected to assist stabilization of biosolids	
Membrane Softening	High degree of process automation	High electricity use	$$
	Ability to turn-down/adjust treatment side stream		
	Lower equipment cost	Liquid brine stream needs disposal via deep well injection	

The main points of our case study include..

There are multiple ways to get salt out of water

Technology selection depends on the make up of the TDS

All TDS removal technologies are expensive

If TDS removal technologies can be avoided by lowering the TDS before waters enter the WWTP then that is the most prudent solution

Questions?

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