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Strategies for removing contaminants of emerging concern at municipal wastewater treatment facilities

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Agenda

- Background
  - What are CECs
  - Regulating Contaminants of Emerging Concern in Wastewater
  - Technologies to Remove CECs
- Case Studies
  - Oak Bluffs
  - HRSD Virginia
- Questions

Background

What are CECs?

Contaminants of Emerging Concern (CECs) or Microconstituents

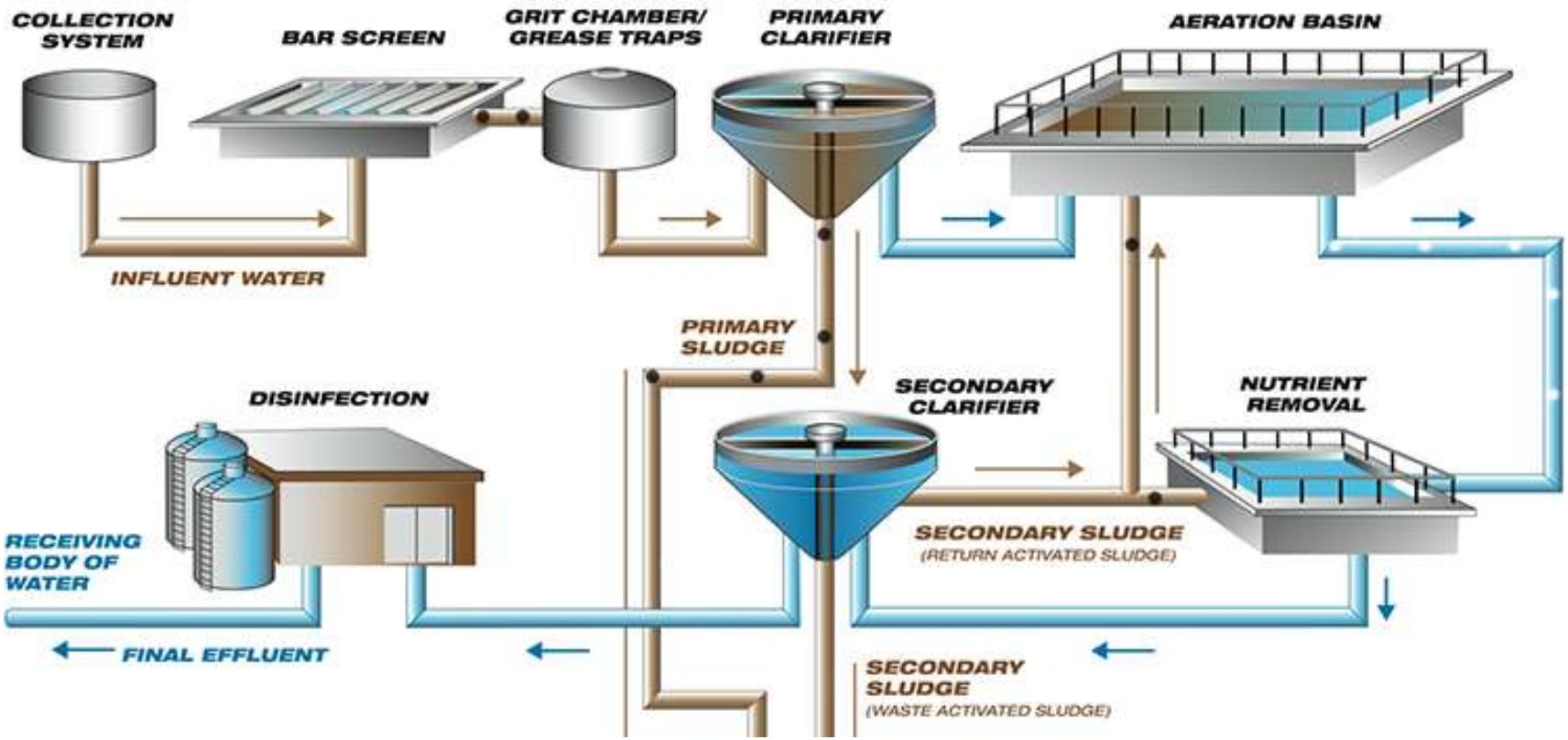
- 31 million organic and inorganic substances documented
- 14 million commercially available
- < 250,000 inventoried or regulated
- Domestic, industrial & agricultural compounds:
  - Pharmaceuticals: prescription & non-prescription
  - Personal care products
  - Industrial & commercial products (detergents & metabolites, plasticizers, flame retardants, pesticides)
- Potential Health Effects
  - EDCs
  - Carcinogens
  - Developmental toxicants

Regulating Contaminants of Emerging Concern in Wastewater

- Requirements released by State of Massachusetts in March, 2009 include limitations for total organic carbon (TOC)
  - 3.0 mg/L for discharge within a Zone II drinking water protection area and >2-year travel time to source
  - 1.0 mg/L for discharge within a Zone II area and <2-year travel time to source
  - 1.0 mg/L for discharge within a Zone II area without soil aquifer treatment
- TOC is a surrogate for many contaminants of emerging concern (CEC)

- Other states target specific CECs

Centralized Wastewater Treatment



TOC Removal in Secondary Treatment

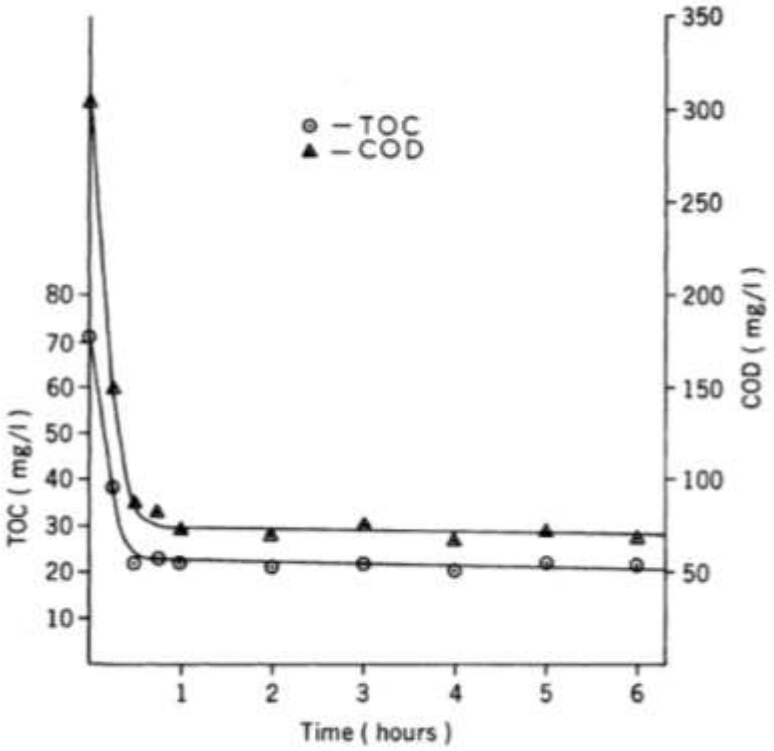


FIGURE 1.—Effect of aeration time on soluble TOC and COD (data of 1/14/69).

Rickert and Hunter: Effects of Aeration Tim on Soluble Organics During Activated Sludge Treatment (1971)

Technologies to Remove CECs (Post-Tertiary) – alone or in conjunction with others

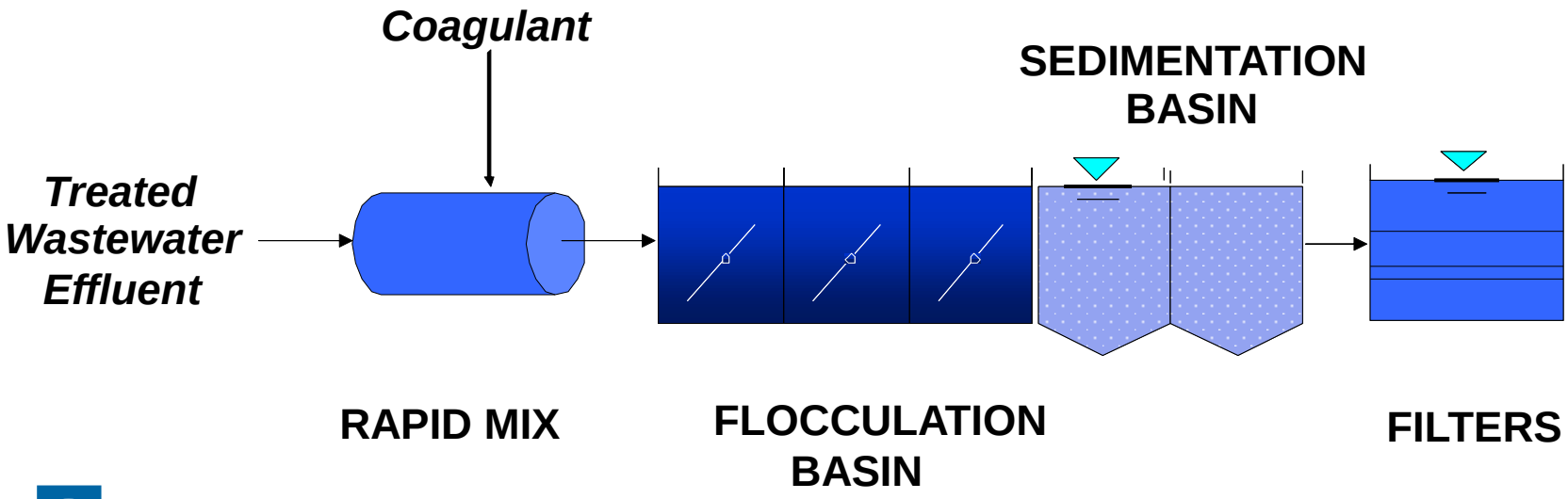
- Membrane Filtration

(Ultrafiltration, Nanofiltration, Reverse Osmosis)

- Ion Exchange
- Adsorption (GAC)
- Advanced Oxidation Processes (AOPs)
- Coagulation and Filtration

Coagulation

- Alter physical / chemical properties of suspended particles to increase agglomeration (create larger flocs)
- Chemical coagulants include aluminum sulfate (alum), ferric chloride, and ferric or ferrous sulfate
- *Pretreatment step*

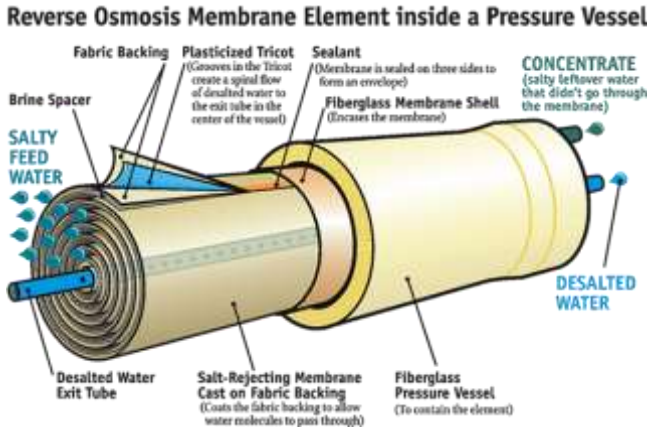


Membranes

- Fine membranes require pretreatment to minimize fouling

- May require post-treatment for water chemistry stabilization

- Concentrate disposal required (high salinity RO concentrate) – possible big hurdle

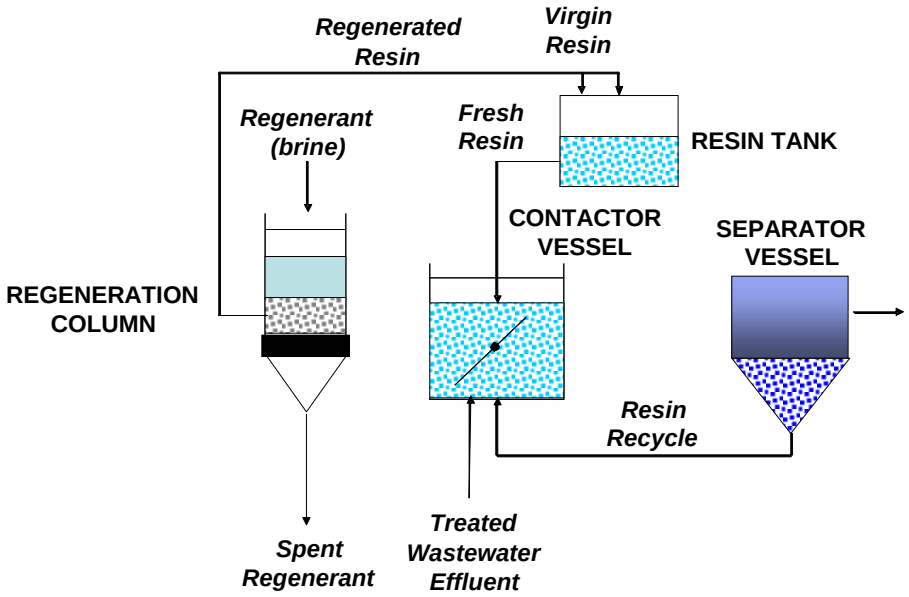


Excellent TOC and CEC removal

Ion Exchange

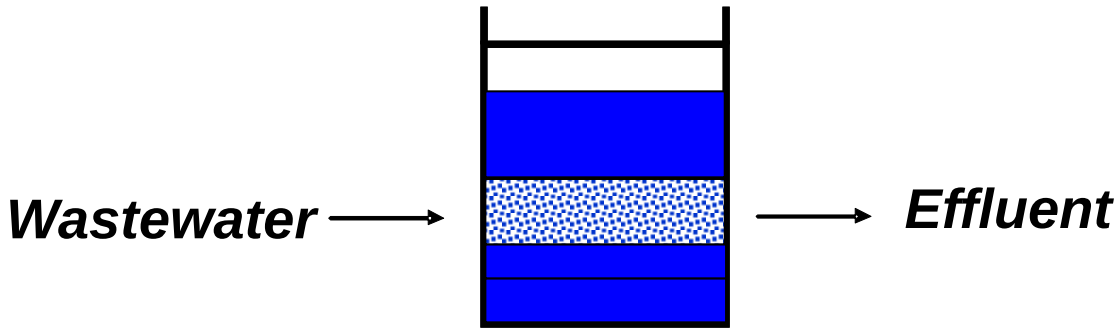
- Continuous process with magnetized anionic exchange resin designed for dissolved organic carbon (DOC) removal
- DOC exchanged with chloride ions on the MIEX resin surface
- Resin regenerated by contacting with concentrated brine solution
- Brine disposal required

Potential for good DOC and CEC removal



Adsorption – Granular Activated Carbon (GAC)

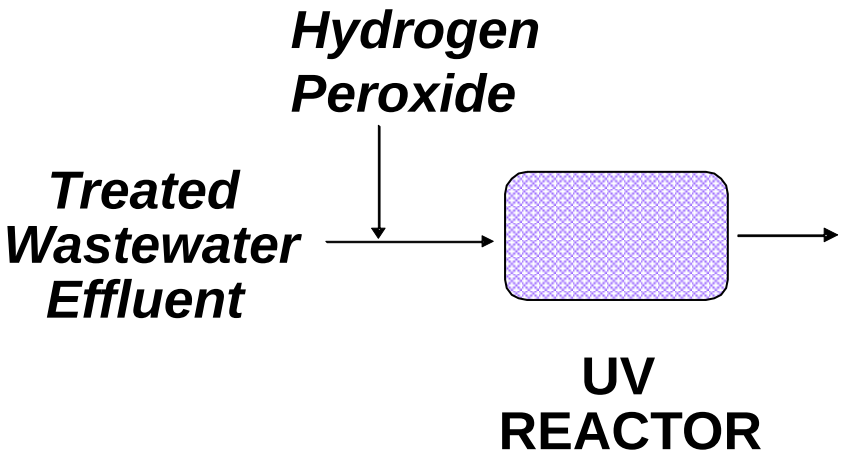
- TOC adsorbed in a downflow or upflow contactor
- Requires pretreatment and disposal / regeneration of spent GAC once breakthrough occurs



- *Good TOC and CEC removal*

Advanced Oxidation

- Oxidation by hydroxyl radicals
- Typically used as polishing step following membrane filtration
- Risk of creating more toxic compounds



- *Good CEC destruction*

Case Studies

Case Study: **Oak Bluffs MA**

The Problem: need for more treated effluent disposal area

- Issues with existing disposal area
- Need for future expansion

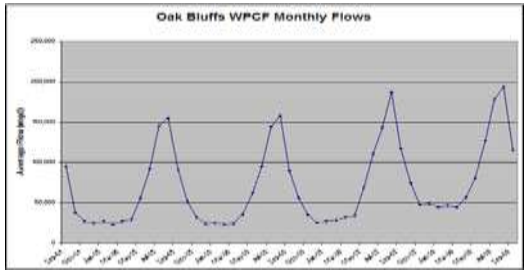
Wastewater treatment facility

Existing Facilities

- SBRs with primary clarifier, effluent filters, and UV
- Seasonal flows
- Wastewater: municipal and hospital flow
- Discharge to Ocean Park

Expansion of Effluent Disposal Area

- Town purchased property adjacent to existing facility in 2007/8
- Ideal setting, except …..




FARM NECK RD. WELLFIELD
Proposed Treated Water
Disposal (Leonardo Property)

Challenges at Oak Bluff

- Requirement for a high level of treatment
  - Need to achieve levels below 3 mg/L
  - Desire to be as low as 1 mg/L (Water District)
- A hospital contributes in the order of 10% of the flow to the plant
- Small user base with median income (year round population) at or below state median
- Piloting likely needed to determine optimum process
- Limited options for waste stream disposal

Investigation of processes and challenges

Water quality testing

- Standard in-plant
- Specialty testing

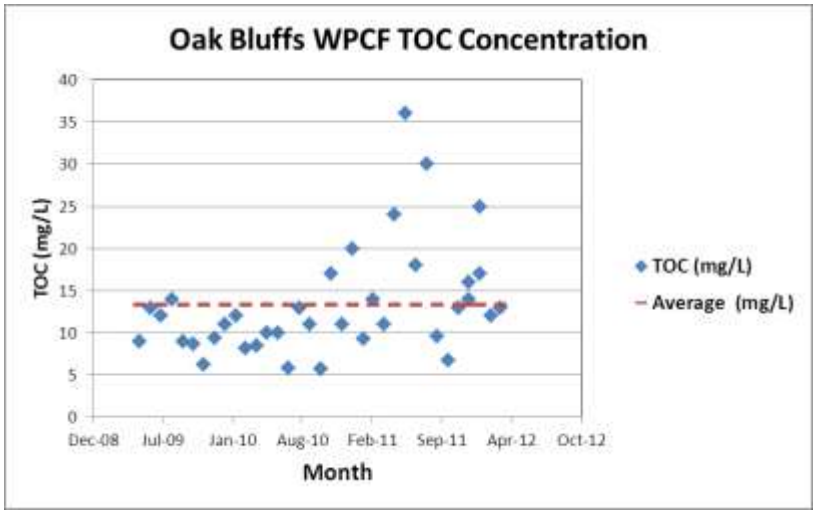
Desktop Evaluations

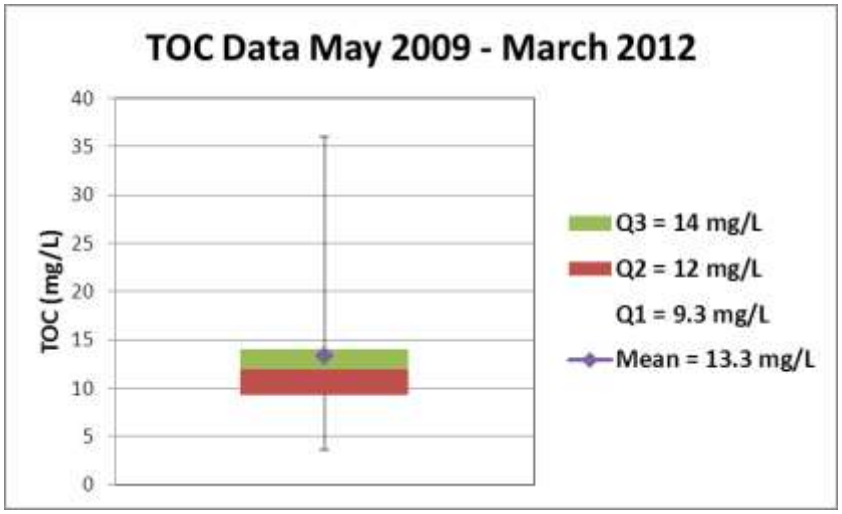
- Reverse Osmosis – cost and reject water
- Ion Exchange – cost and reject water
- Granular Activated Carbon – high usage rate, O&M costs

Bench-scale tests

- Coagulation/GAC
- Coagulation alone (manufacturers and GHD)
- BioMag
- Ion Exchange/Coagulation

Historical Effluent TOC data

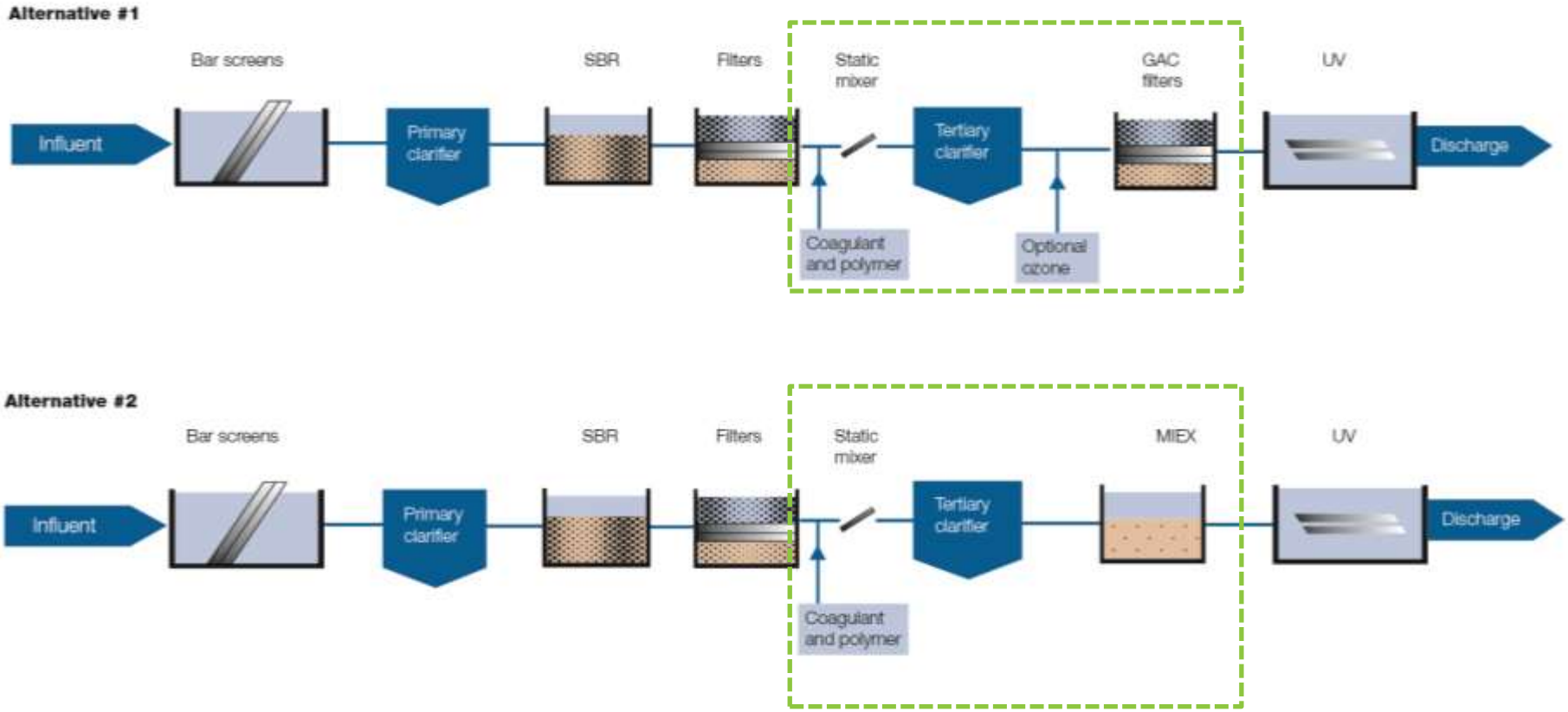




Water quality data

Water Quality Parameter	Unit	Influent	Effluent
pH	SU	6.6	7.16
Alkalinity	mg/L	190	90
Ammonia (unionized)	mg/L	26	2.7
Total Nitrogen	mg/L	45	5.3
Total Phosphorous	mg/L	6.7	4.8
$CBOD_5$	mg/L	200	3
COD	mg/L	550	55
TSS	mg/L	94	3
UV Absorbance	(1/cm)	0.41	0.22
TOC	mg/L	81	12
DOC	mg/L	81	11

Process alternatives



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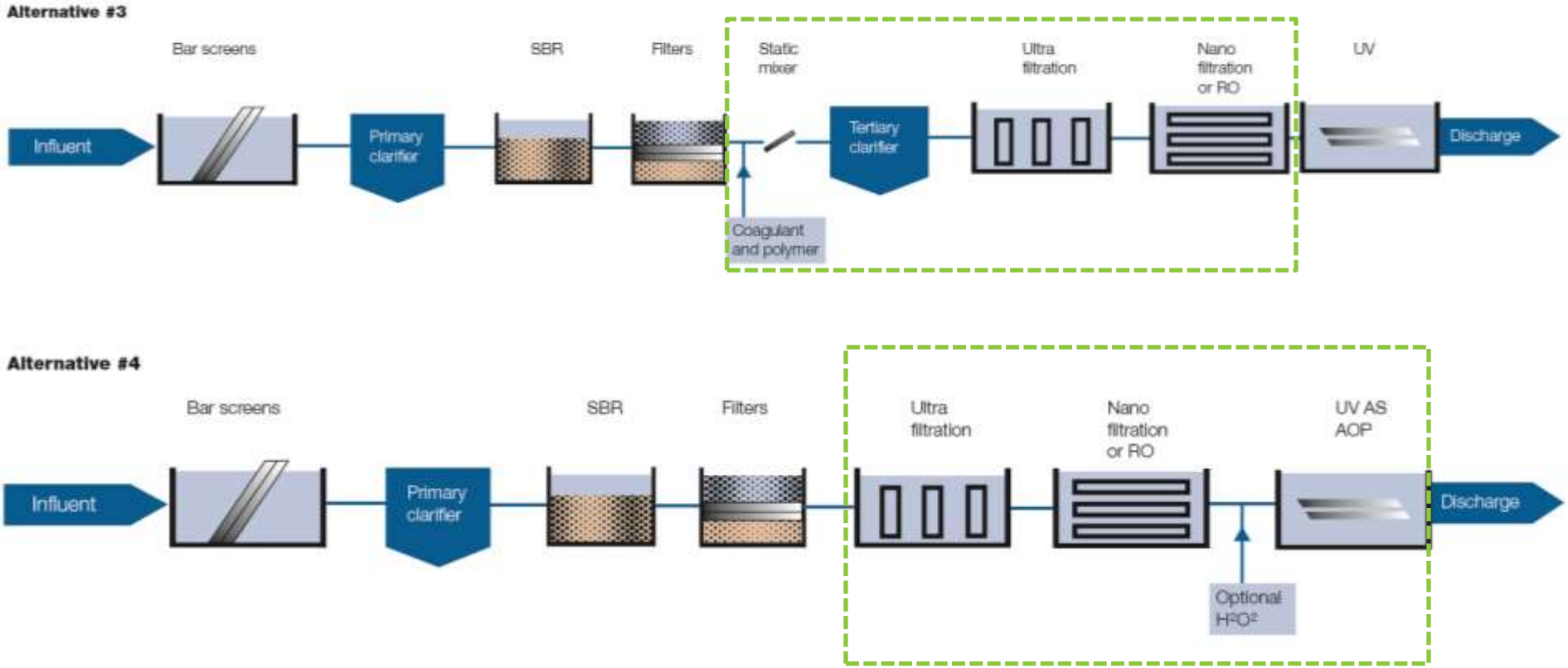
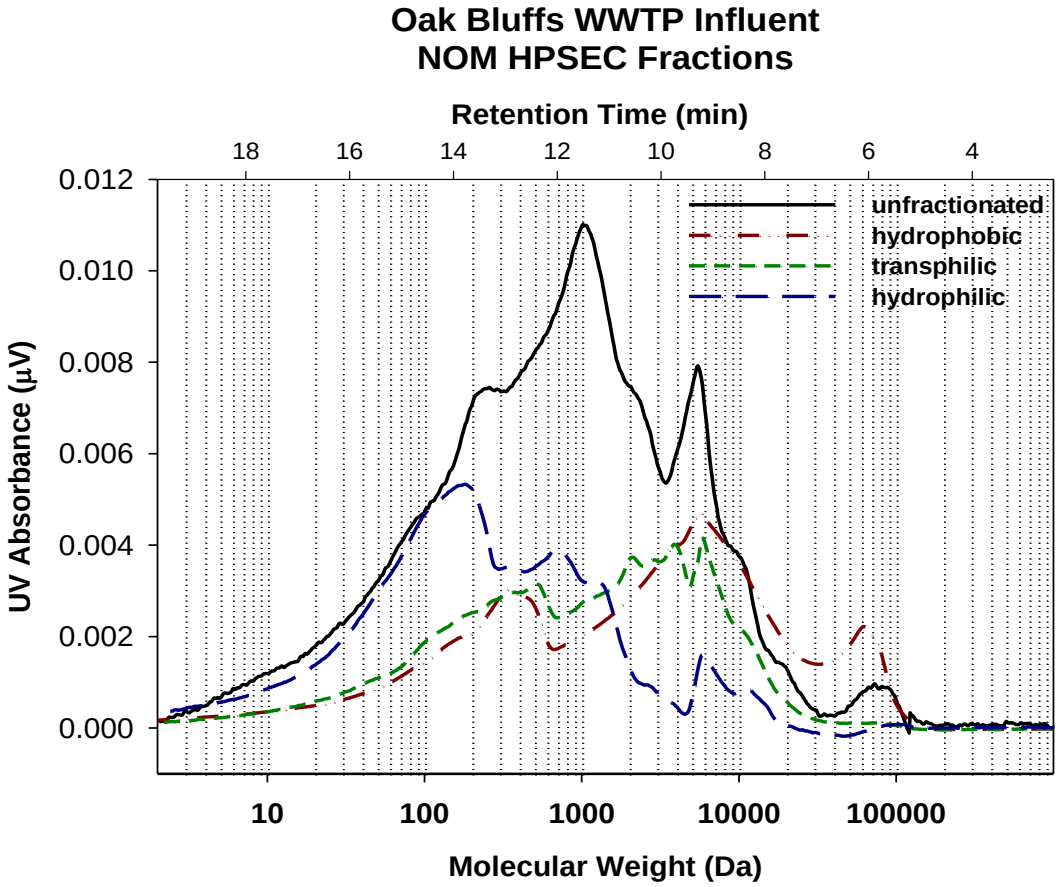


Influent organic matter characterization



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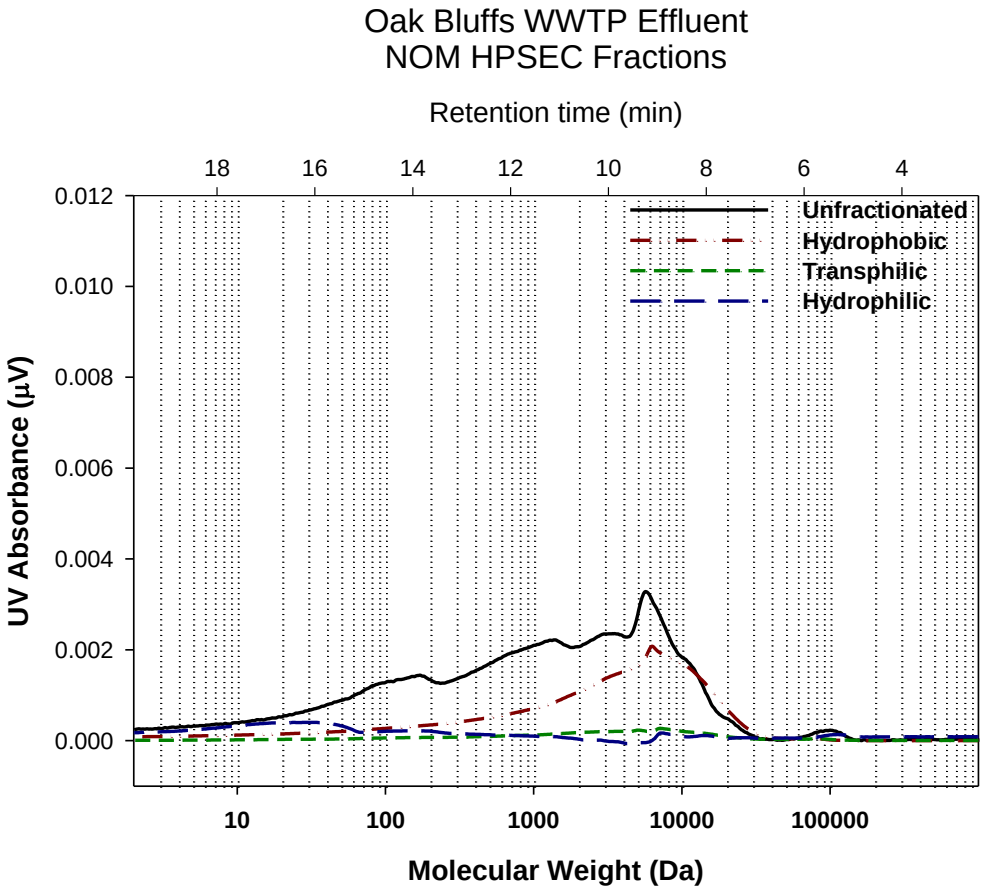
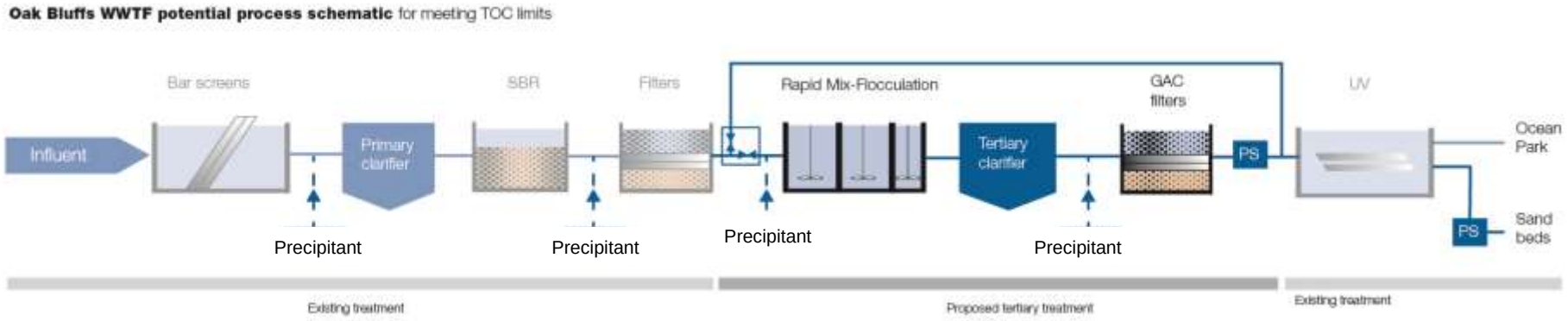


Results of evaluation

Considered many factors:

- Type of plant
- Makeup of contaminants
- Results of many bench scale tests

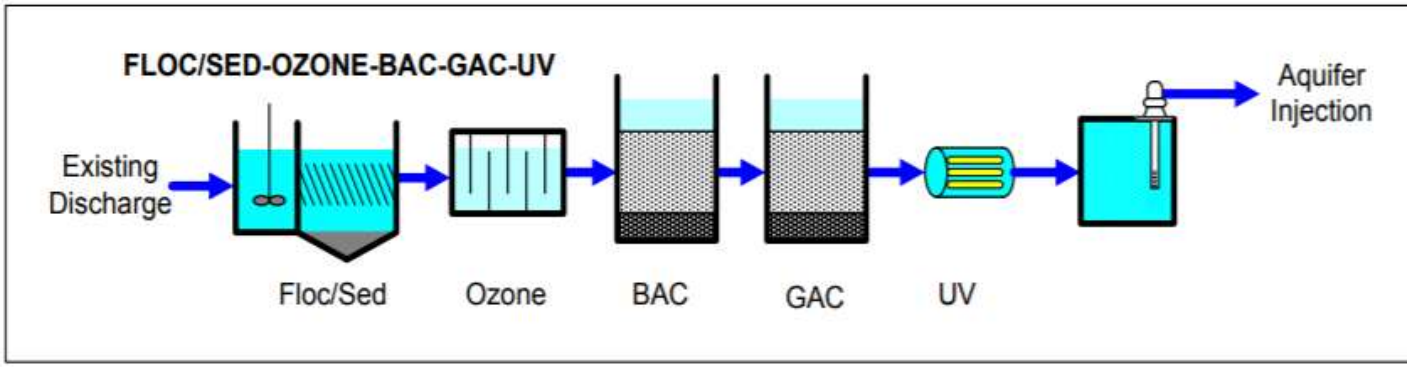


Hampton Roads Sanitary District (HRSD)

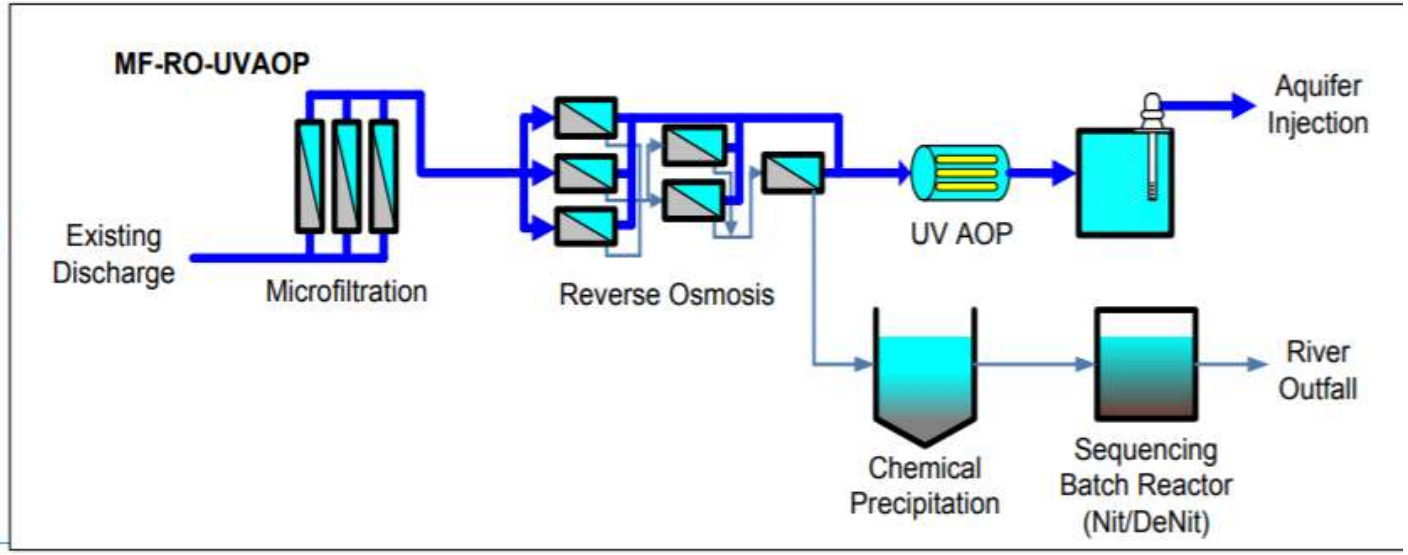
- In about 100 years groundwater levels have gone from 31 feet above sea level to 200± feet below sea level.
- Coastal land is subsiding due to over-pumping of groundwater
- Effort underway to replenish groundwater
- Project called Sustainable Water Initiative for Tomorrow (SWIFT)
- Piloting and testing
- Evaluating TOC removal and specific CEC removal

Advanced Water Treatment Alternatives

Carbon Based



Membrane Based



CEC monitoring

Pilot Evaluation: Carbon vs Membrane Contaminants of Emerging Concern

- A suite of 96 CECs analyzed in both treatment processes
- Treatment case study for 8/31/16
  - Only constituents detected by analysis are displayed in chart
- Multi-barrier approach is shown by decrease in concentration through the treatment process
- All values shown in ng/L (parts per trillion)

		Carbon Train			Membrane Train	
Contaminant	Pilot Feed	O3 Eff	BAC Low	GAC Low	RO Eff	UVAOP Eff
4-nonylphenol	1100	320	<100	<100	100	<100
Acesulfame-K	1100	360	290	<20	<20	<20
Iohexal	7500	4000	1400	<10	31	<10
Sucralose	43000	28000	12000	<100	140	130
Primidone	130	46	21	<5	<5	<5
TCEP	140	130	45	<10	<10	<10

Questions?

www.ghd.com