

Boron Removal and Reverse Osmosis

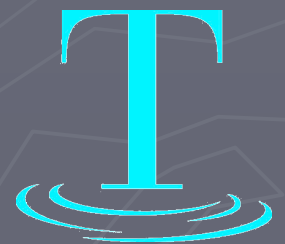
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OUTLINE

- ▶ Boron concentrations and guidelines
- ▶ Why is boron hard to remove?
- ▶ What is the boron removal of a typical RO membrane?
 - Types of membranes
 - ▶ Seawater membrane
 - ▶ Brackish water membrane
- ▶ What is being done in other projects?
- ▶ Can we cost effectively reduce boron concentrations?



Boron Concentrations

- ▶ Seawater = 4.5 mg/L
- ▶ San Diego Wastewater = 0.5 mg/L
- ▶ Colorado River Water = 0.1 mg/L
- ▶ WHO 1998 guidelines = 0.5 mg/L
- ▶ Cal DHS Action Level = 1 mg/L
- ▶ USEPA “Maximum Lifetime Exposure” = 0.6 mg/L



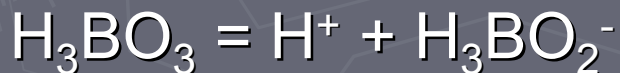
Why is Boron Hard to Remove?

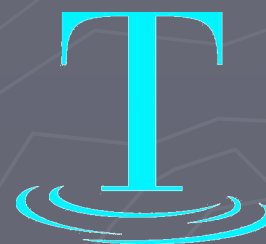
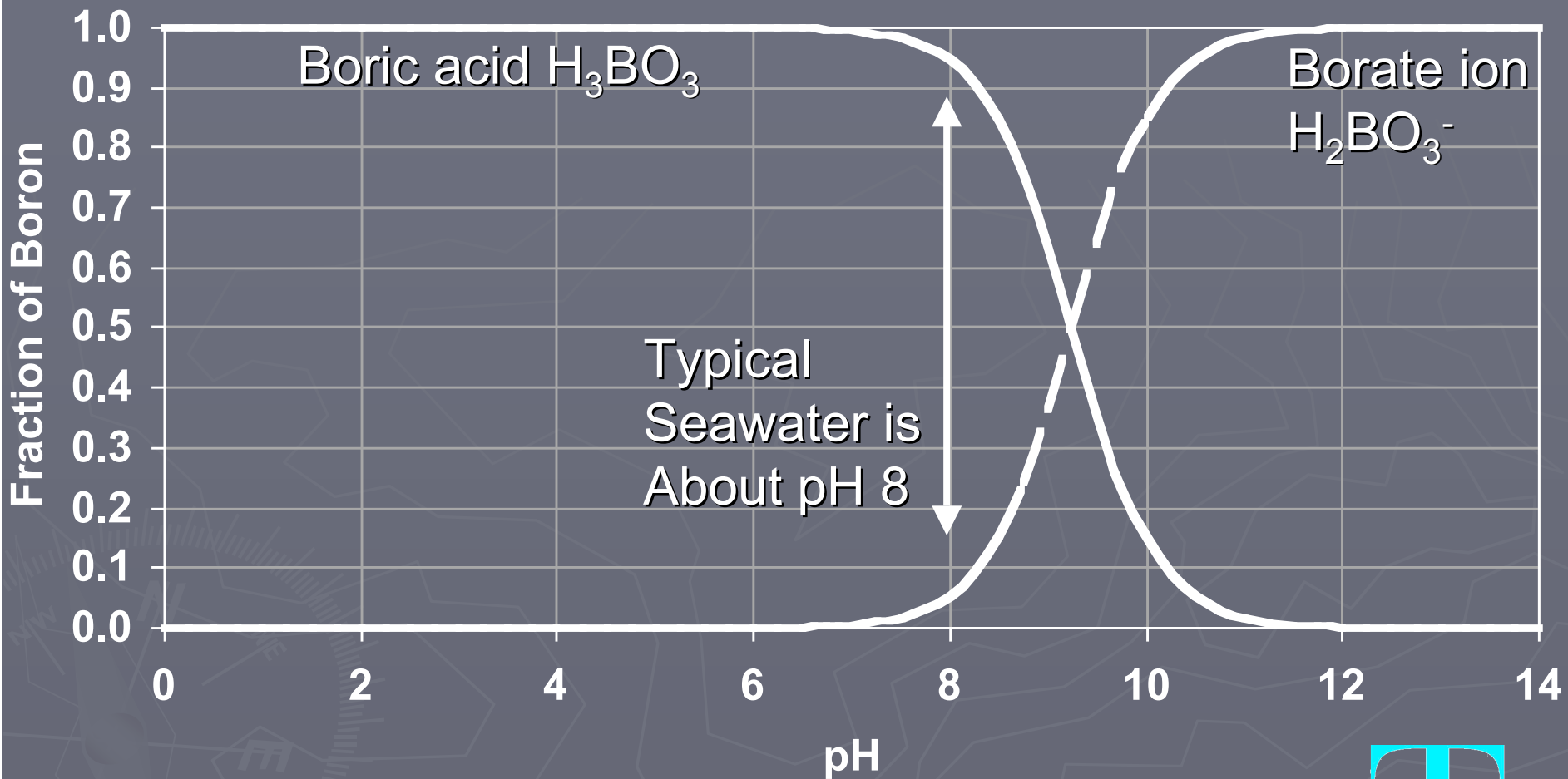
- ▶ Unlike most of the elements in seawater, boron is not ionized (i.e. it has no charge)
- ▶ Boron takes two forms in drinking water (or seawater):

Boric Acid: H_3BO_3

Borate Ion: H_3BO_2^-

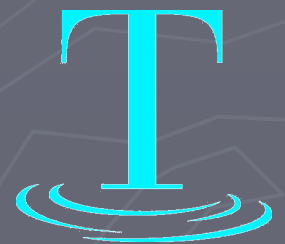
- ▶ RO is much better at removing charged ions. Hence the removal of borate ion is much better than the removal of boric acid.
- ▶ The dominant form (borate or boric acid) depends on the pH:





Boron Removal by Seawater Reverse Osmosis

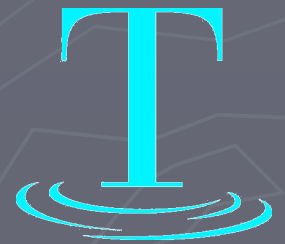
- ▶ Dow FILMTEC at pH 8:
 - SW30-380 = 88% (85-90%) 0.78 mg/L
 - SW30HR-380 = 90% (88-92%) 0.66 mg/L
- ▶ Toray at pH 8:
 - TM820-370 = 92% (91-93%) 0.53 mg/L
 - TM820A-370 = 95% (94-96%) 0.33 mg/L
- ▶ Hydranautics at pH 8:
 - SWC3 = 89% (NA) 0.72 mg/L
 - SWC4 = 92% (NA) 0.53 mg/L



Boron Removal by Brackish Reverse Osmosis

[assuming 0.5 mg/L 1st pass]

- ▶ Dow FILMTEC at pH 8:
 - BW30-400 = 65% (55-75%) 0.31 mg/L
 - BW30LE-440 = 55% (45-65%) 0.36 mg/L
- ▶ Hydranautics at pH 8:
 - CPA3 = 40% (NA) 0.41 mg/L
 - ESPA1 = 38% (37%-40%) 0.42 mg/L



Operating Seawater RO Plants

- ▶ Trinidad - 2 pass system
- ▶ Tampa - 2 pass system
- ▶ Larnaca, Cyprus (14 MGD)
 - Partial 2 pass system (25% flow from 1st pass)
 - SWC3 - claim ≤ 1 mg/L Boron after 2 years of operation



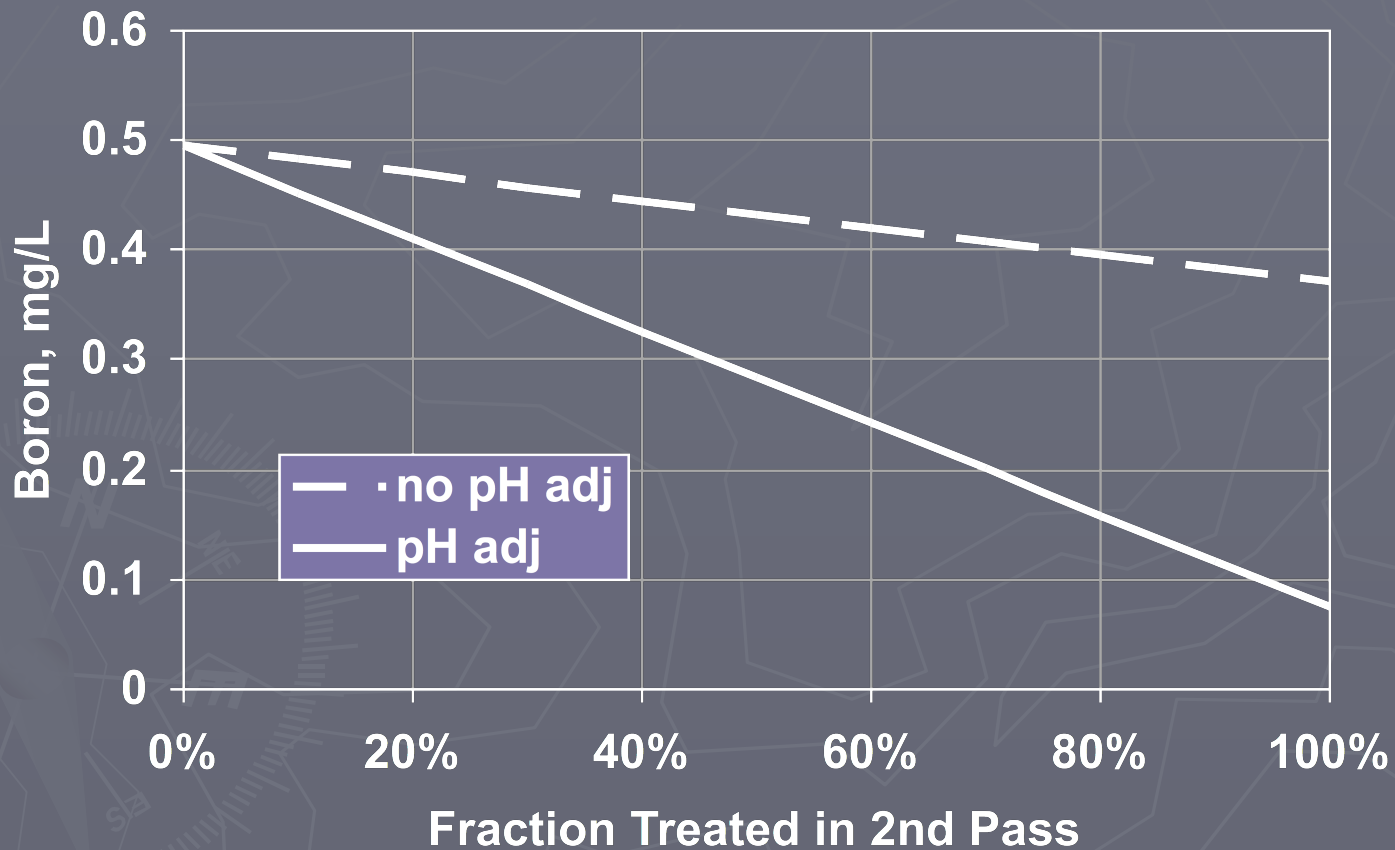
Can We Economically Meet a Low Boron Concentration

YES! By doing one or more of the following:

- ▶ Choose good SWRO Membranes
- ▶ Partial 2nd Pass
- ▶ Possible pH adjustment in the 2nd Pass



Effect of 2nd Pass with and without pH adjustment



Meeting a Low Boron Concentration

- ▶ The additional water cost for 2nd pass is estimated to be:
 - \$20 - 30/acre-ft

