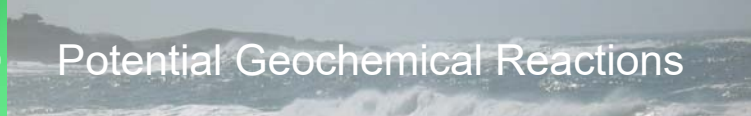



Potential Changes in Groundwater Quality Resulting from Introducing New Sources of Water into the Seaside Groundwater Basin

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Senior Hydrogeologist



Potential Geochemical Reactions

Presentation Overview

- Case study: Orange County Water District
- Mission to protect and augment water supplies
- Water Supply Gap
- Plan to use Seaside Basin as storage for all sources of supplemental “new” supplies
- Water quality differences
- Project operations
- Geochemical interactions between different water types and aquifer mineralogy

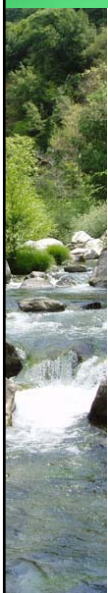


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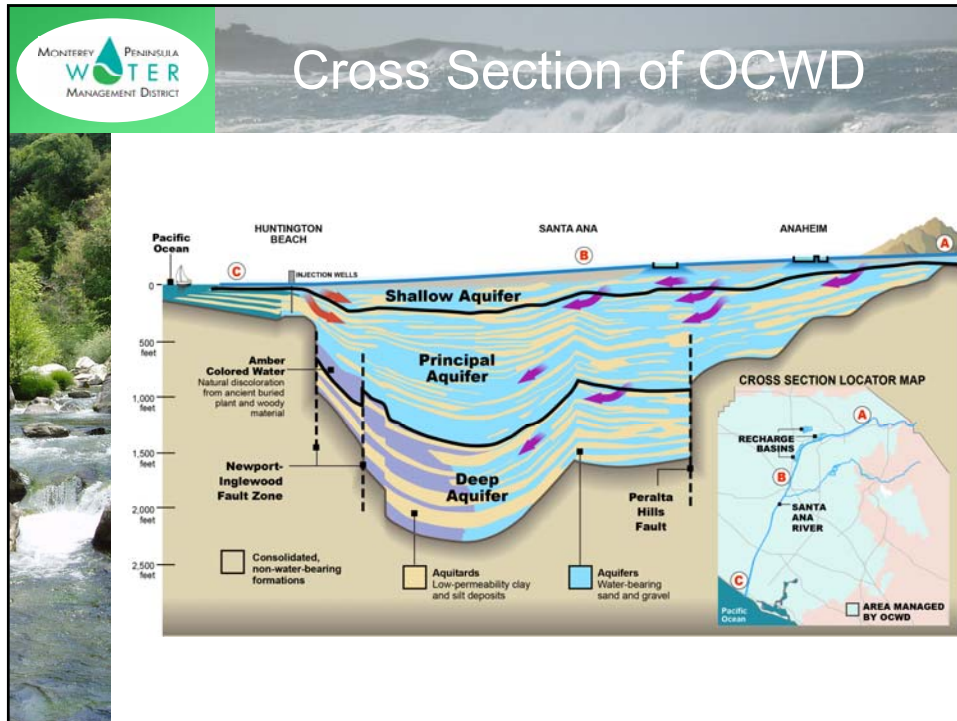
OCWD replenishes the aquifer using its recharge facilities along the Santa Ana River in Anaheim.

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Orange County Water District

- 1976 Water Factory 21 was constructed to inject recycled water as seawater intrusion barrier
- 2006 Water Factory 21 was shut down, expanded and upgraded to a reverse osmosis treatment facility.
- 2012 Miraloma Recharge Basin is the first Recharge facility to receive a blend of RO water and water imported from the State Water Project

EXHIBIT 2-A



Arsenic Occurrences in Groundwater

- Following mixing of water delivered from the State Water Project with Reverse Osmosis water produced at the upgraded Factory 21 plant, the Water District began to detect spikes of Arsenic in the groundwater.
- Arsenic spikes were transient and were later linked to the recharge of higher blend ratios of Reverse Osmosis water at the recharge facilities.
- Recharged water from Factory 21 had a residence time in the ground from 6 months to 2 years, but the Arsenic spikes were not related to residence time.
- Stanford Professor, Scott Fendorf, discovered that it was not the residence time creating the Arsenic spikes, but rather the initial geochemical interactions between the clays in the aquifer and the low TDS RO water.
- Naturally occurring Arsenic was locked in the clays by Calcium and Magnesium ions. Naturally recharging water was not able to unlock the Arsenic, but RO water low in Calcium dissolved the ions from the clays and released the Arsenic.



Take Home Message




"It only takes a little Arsenic or other elements to contaminate a big aquifer. In Orange County the contaminant was Arsenic, but in other areas it may be Uranium, Chromium, Selenium, or Boron, as other examples" – Scott Fendorf




Take Home Message:

Mixing different water types can cause unexpected changes in geochemistry when reacting with aquifer matrix minerals.



District Mission Statement



- The Monterey Peninsula Water Management District's mission is to promote or provide for a long-term sustainable water supply, and to manage and protect water resources for the benefit of the community and the environment.
- Seaside Adjudication – Water quality implications and Material Damage

EXHIBIT 2-A

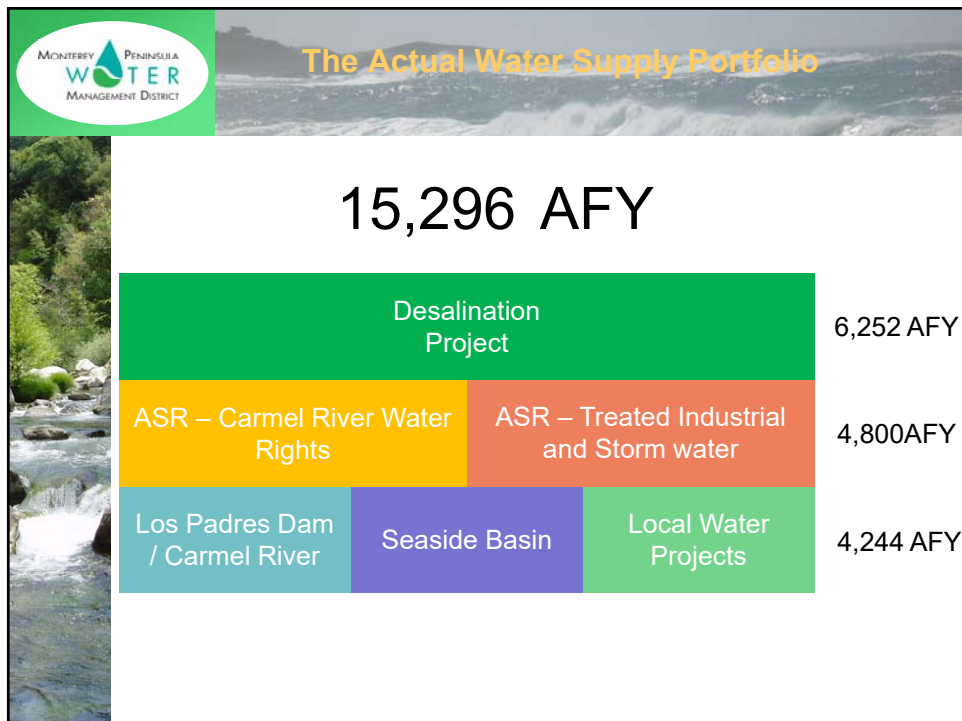
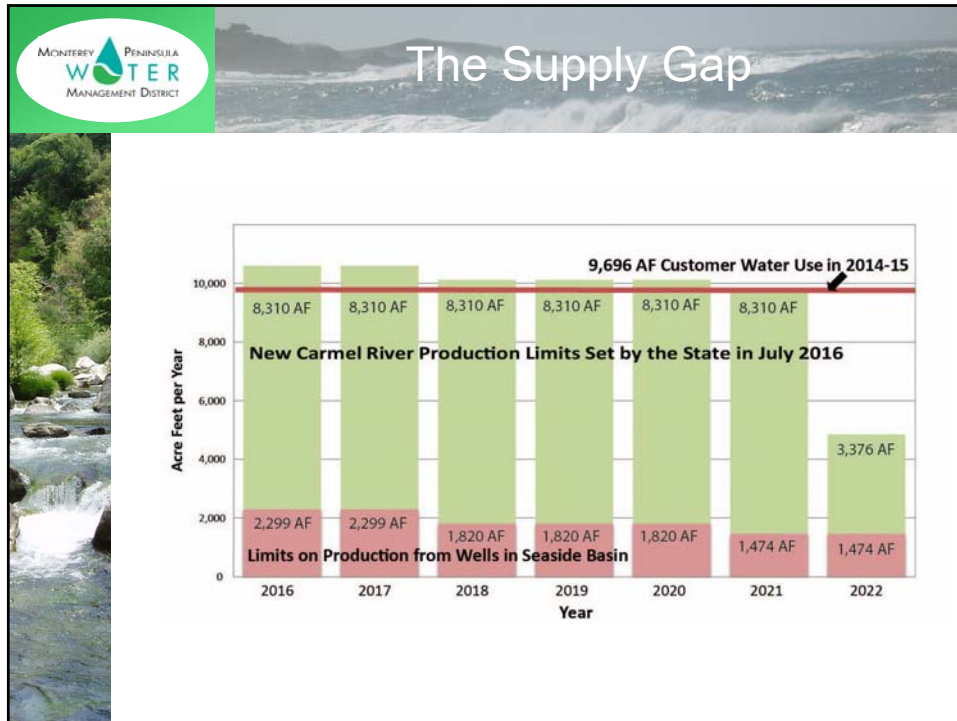


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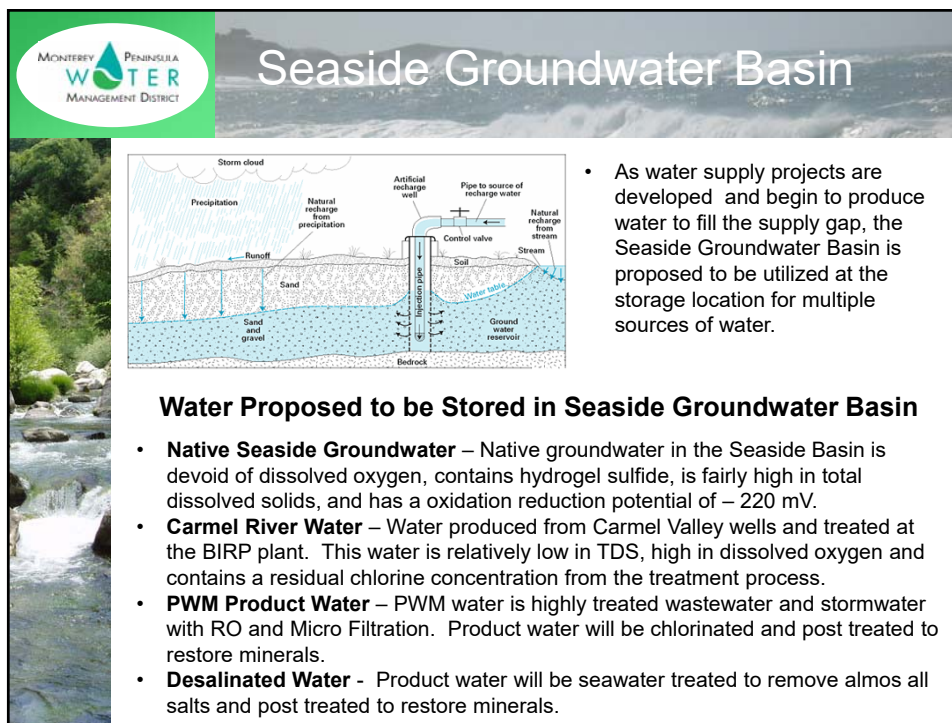
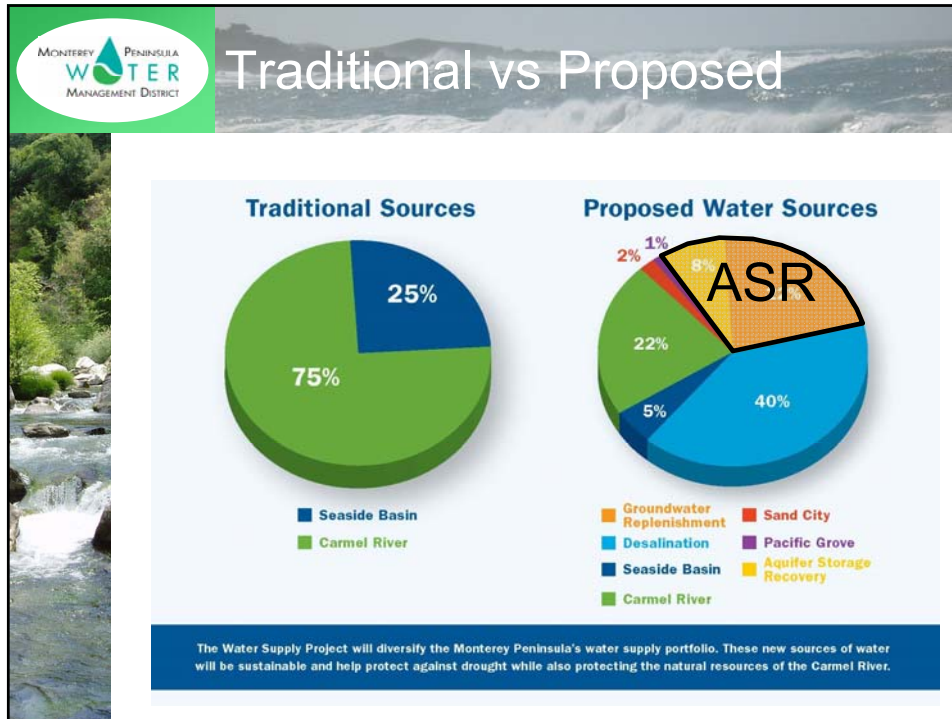


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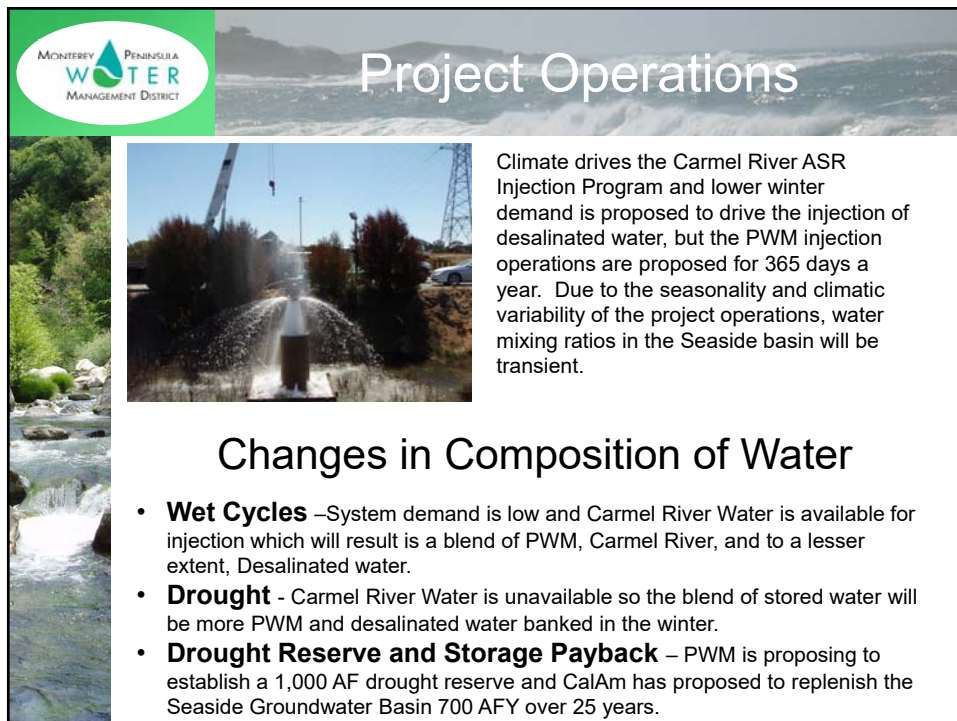
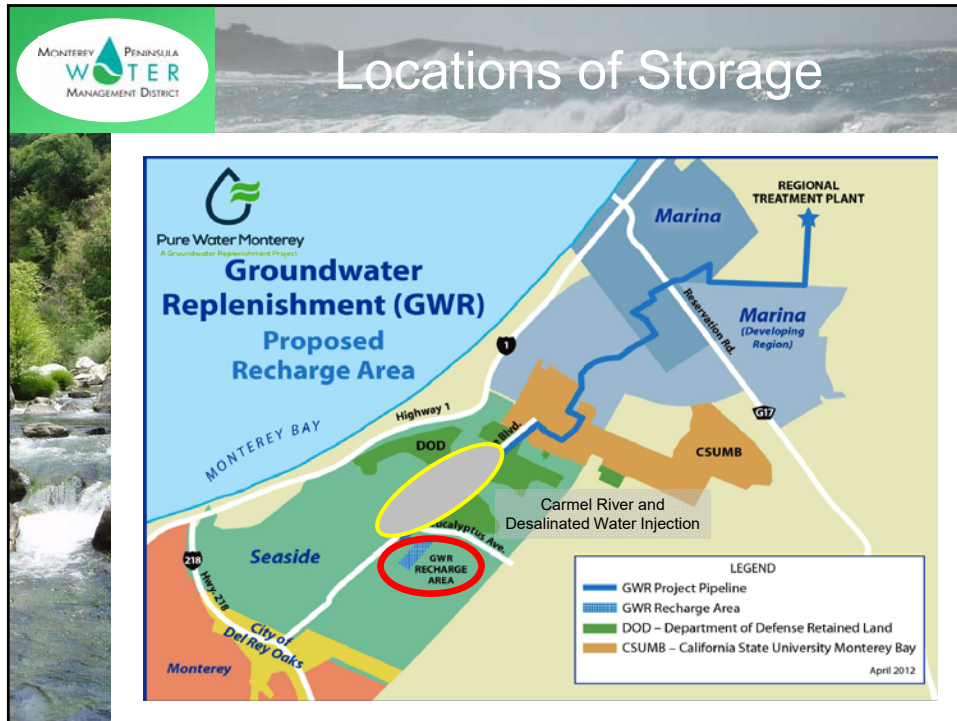


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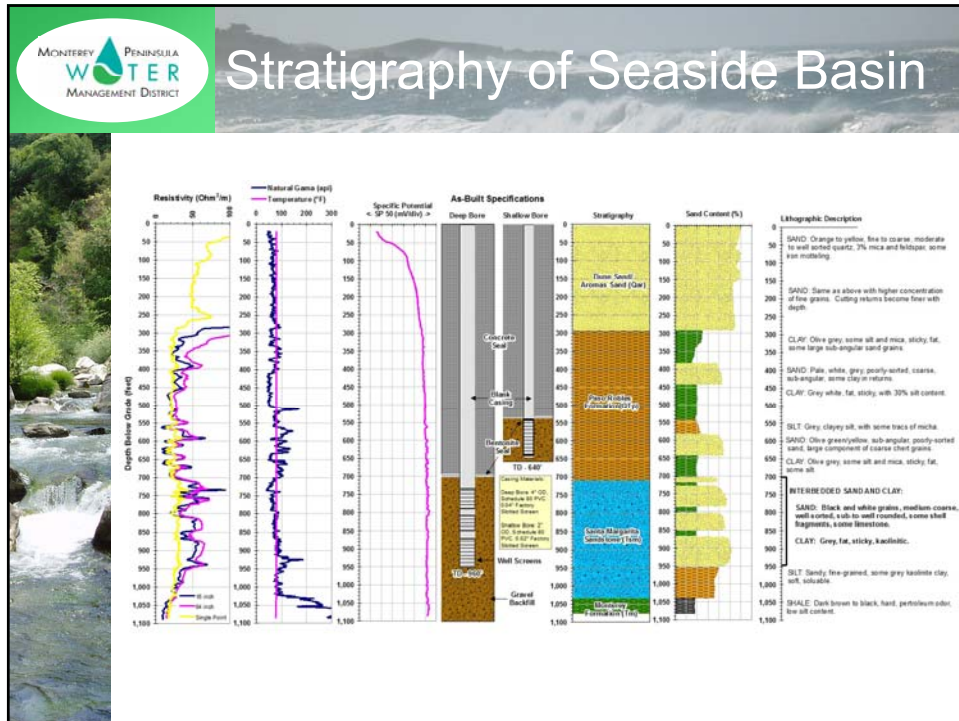
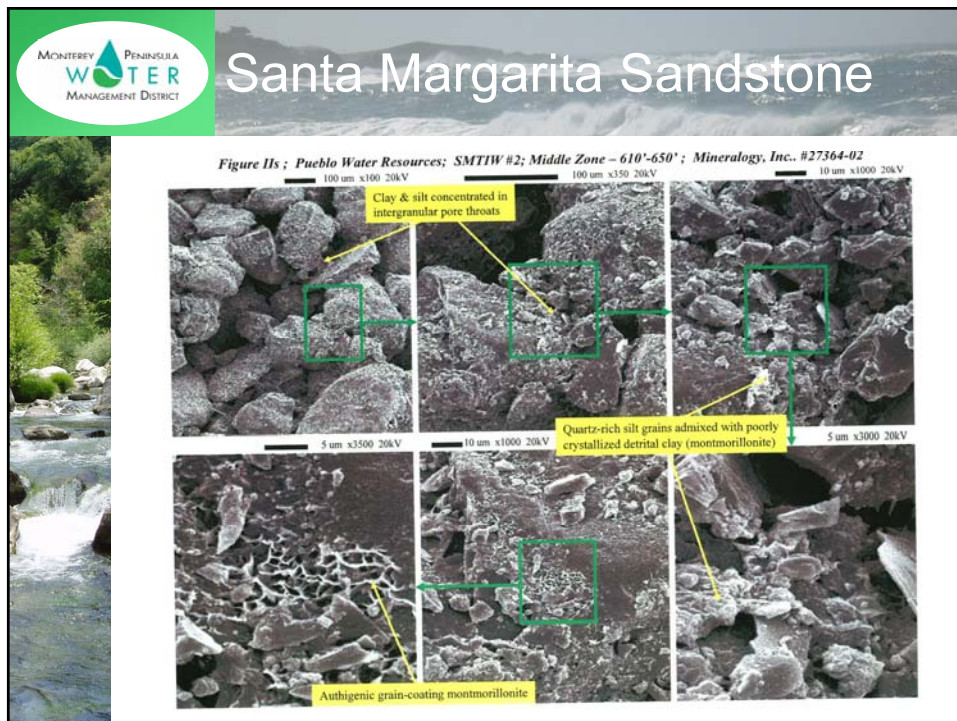

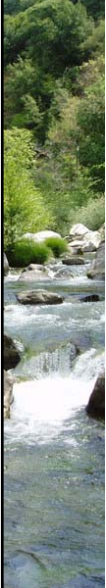


EXHIBIT 2-A






Geochemical Modeling

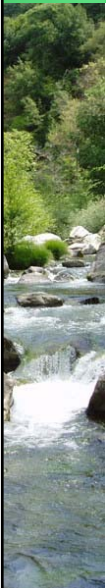


Defining Some Terms that Drive Geochemical Reactions

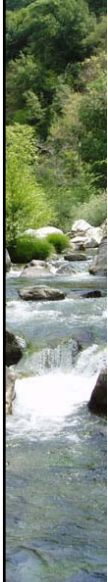

- **Aqueous speciation** – the distribution of individual ions and ion pairs in water
- **Saturation** – the state of an aqueous solution in chemical equilibrium with a particular solid phase
- **Undersaturation** – phase is thermodynamically favored to dissolve



Geochemical Modeling

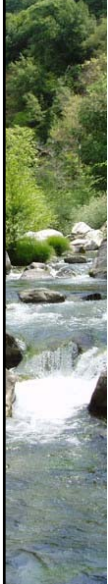



- **Supersaturation** – phase is thermodynamically favored to form
- **Kinetics** – the rates of geochemical reactions
- **Mass Transfer** – moving mass between phases (solid, aqueous, gas)
- **Reactive Transport** – coupling flow and chemical reactions



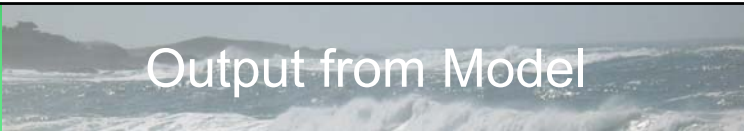

Geochemical Modeling

- Input Data – Good quality required!
- Water Chemistry - Use proper methods of filtration, preservation, and dilution
 - Measure field parameters (pH, Eh, D.O., temperature, alkalinity, specific conductance) at time of sample collection
 - Charge balance must be within acceptable limits
- Aquifer Material and Mineralogy
 - Thin section analysis
 - Electron scanning microscopy
 - Bench leaching tests




Modeling Process



- Reaction paths - solution composition as a function of reaction progress, quantities of secondary minerals formed, and composition of solid-solutions formed
- Time of reaction - kinetic rate laws and relative reaction rates based on temperatures and pressures




Output from Model



- Transport Processes – Advection, Hydrodynamic Dispersion and Diffusion
- Reactions on Mineral Surfaces, Adsorption, Ion exchange
- Mineral Dissolution and Precipitation, Thermodynamic model, Kinetic rate expressions
- Biochemical Processes




Tasks




- Identify the different water qualities, quantities, flow paths, and residence times
- Characterize mineralogy of Santa Margarita Sandstone
- Collect water quality data to populate geochemical model
- Construct geochemical model and evaluate the effects of mixing differing water types in the Seaside Groundwater Basin.

EXHIBIT 2-A



Goals

- Create a model to evaluate geochemical reactions between differing water types and aquifer mineralogy to forecast best post-treatment conditioning for RO water
- Create a tool to evaluate and model water quality issues and forecast solutions if they arise after project operations begin
- Create a tool to test options and assist with permitting water projects



ASR Water Quality Modeling

Questions?

