Mechanism for Arsenic Increase in Drawdown Cones

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In Proposed Project Impact Area

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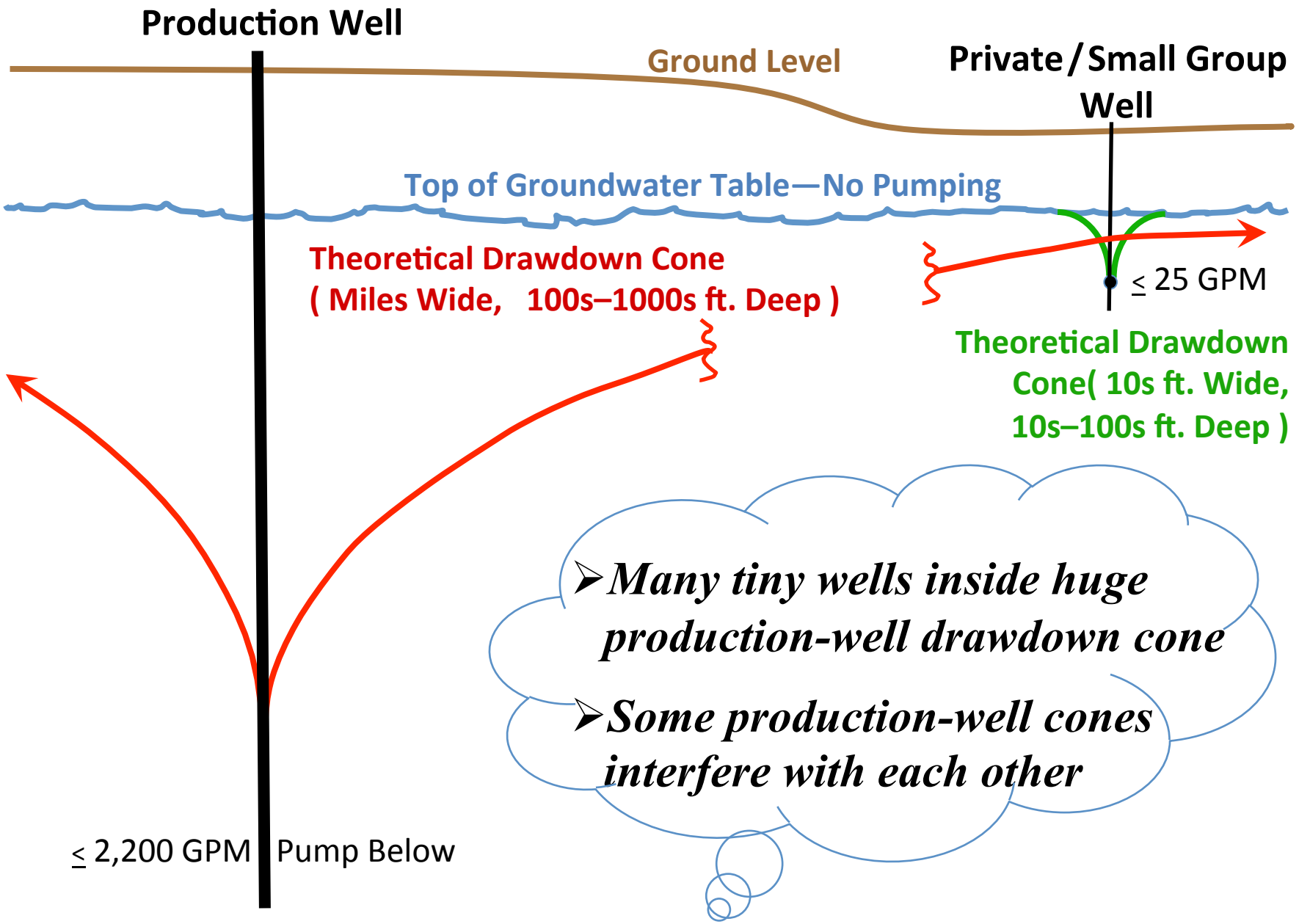
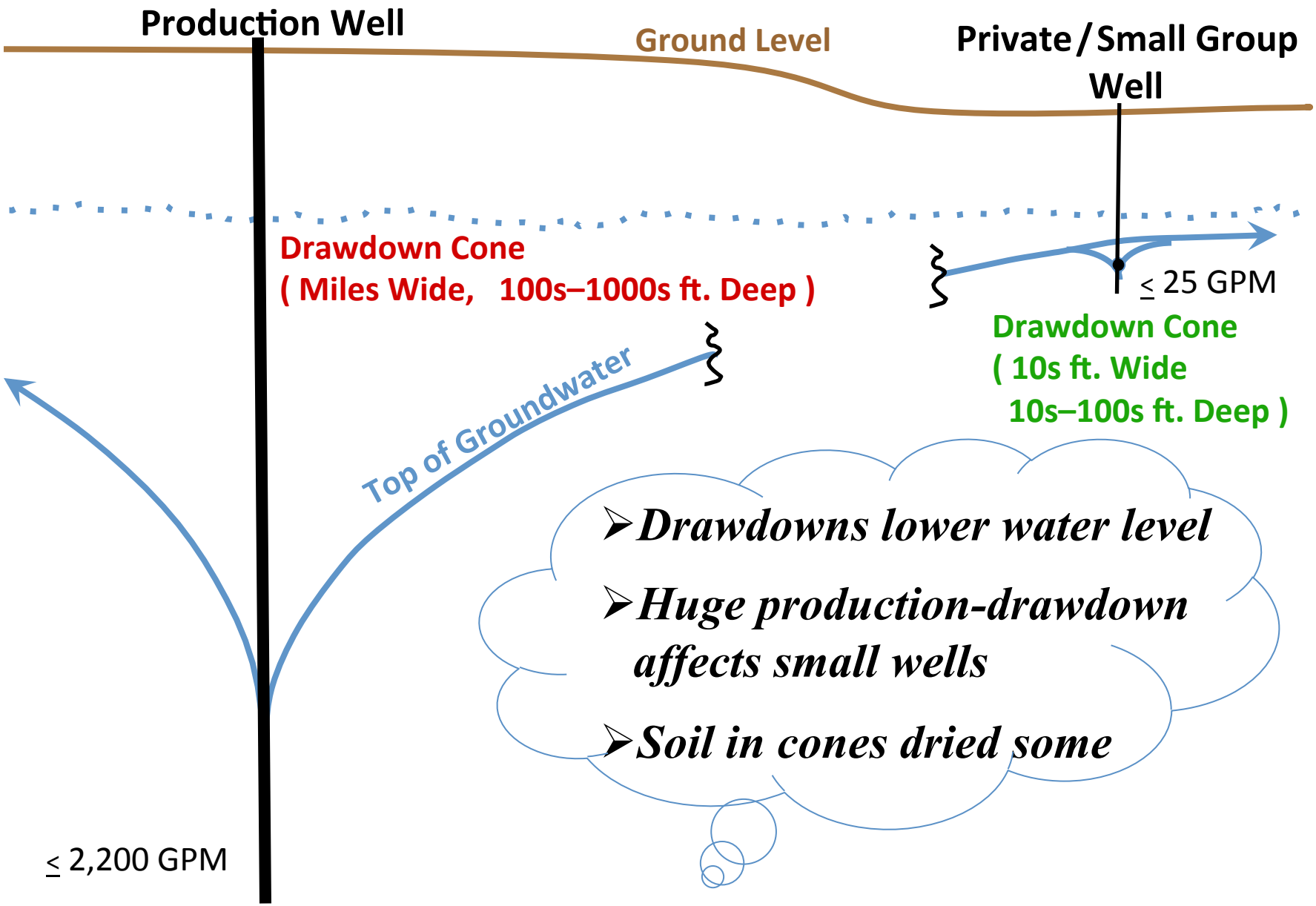
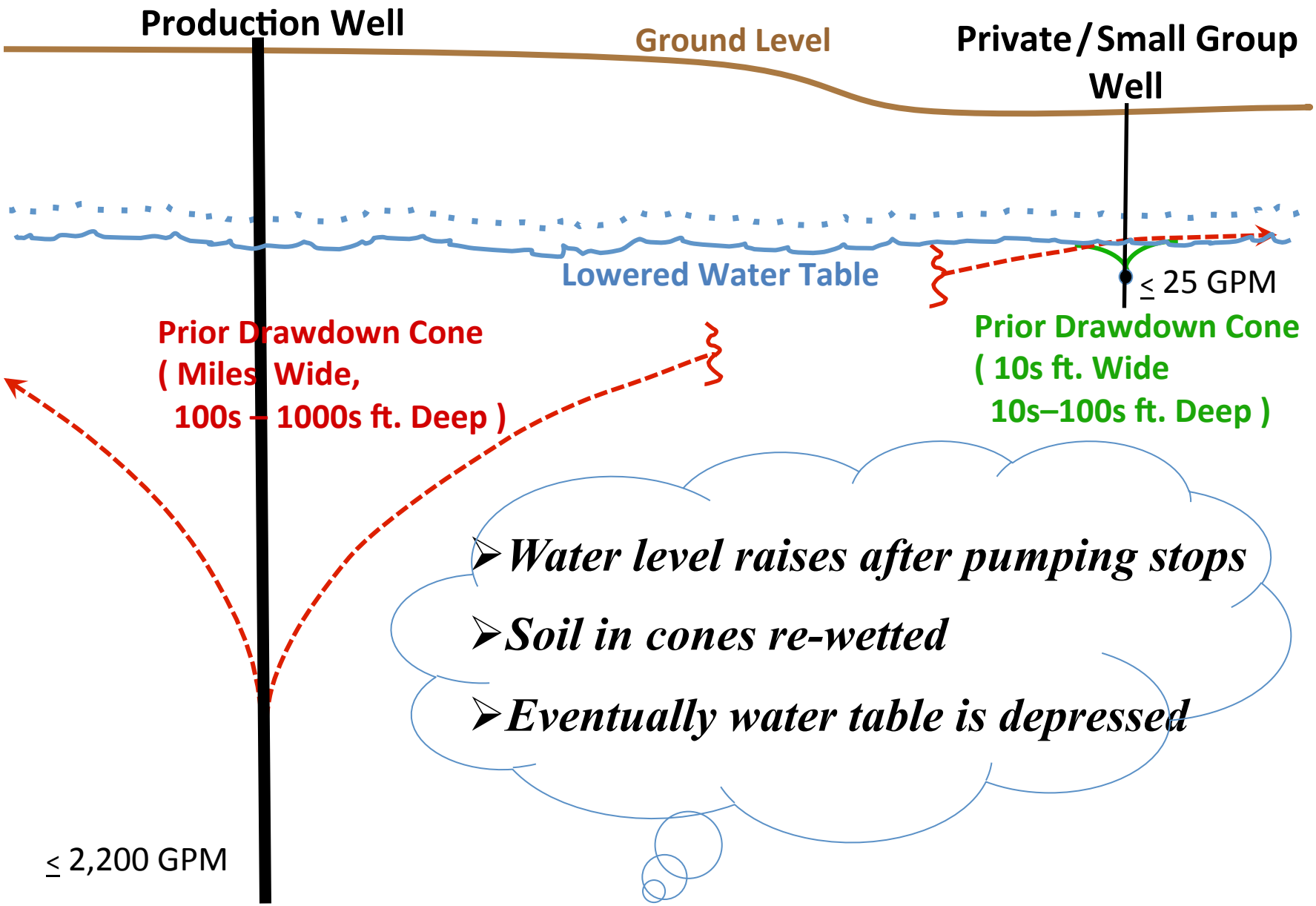
Big and Small Drawdown Cones

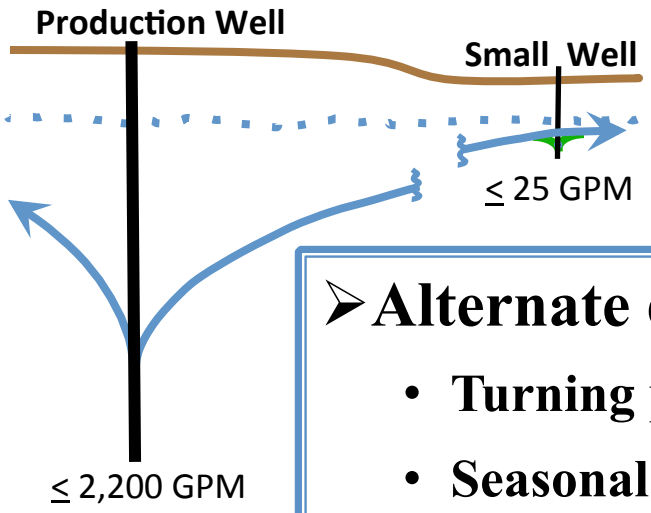


Drawdown Cones—*When Pumping*



Drawdown Cones—*Pumping Stopped*





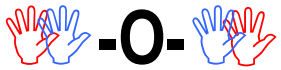
Alternate Wetting & Drying Changes Groundwater Chemistry

- **Alternate drying and wetting is due to**
  - **Turning pumps on and off**
  - **Seasonal pumping: 70-90% summer use vs. 20-40% winter use**
  - **Cumulative effects over years**
- **Alternate wetting and drying changes chemistry of soil and groundwater in cones**
- **Naturally occurring arsenic then dissolves in the water**
- **Depression from production pumping also pulls lower-quality groundwater to wells**

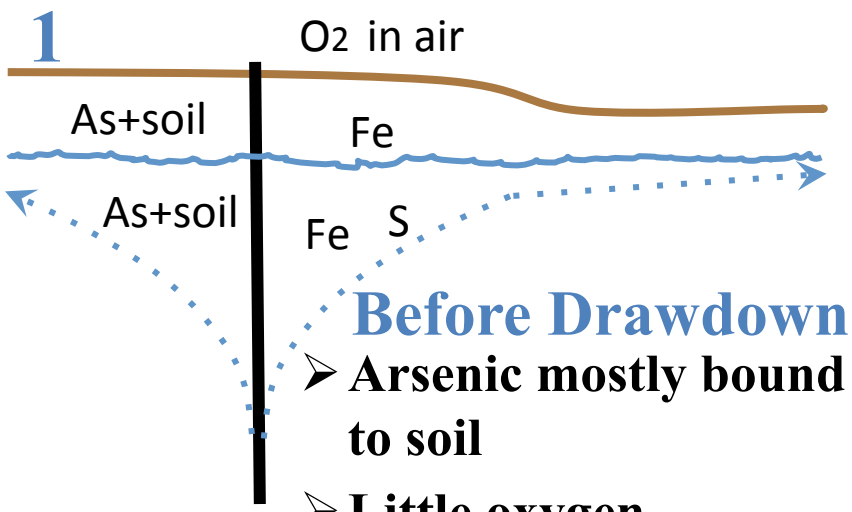
Chemicals Combine and Change By Binding and Unbinding

- ***Chemicals have different numbers of "chemical hands" that let them "hold hands"/bind with other chemicals***
  - ***H = Hydrogen has +1, O = Oxygen has -2, As = arsenic has -3 or +5***
  - ***"Hands" may be empty or differently occupied***

- ***Hydrogen and Oxygen Examples***

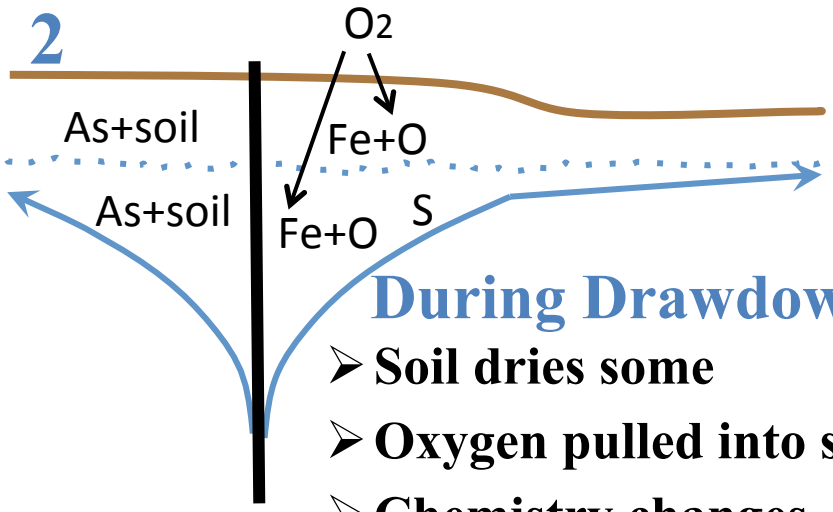
H+ 	*H unbound (empty hand)*
H+  -O-	*HO (1 oxygen bound to hydrogen)*
H+  -O- +H	*H_2O (2 hydrogens & 1 oxygen = water)*
H+  -O-	*HO (let go 1 hand)*

Chemical Changes Dissolve Arsenic in Water



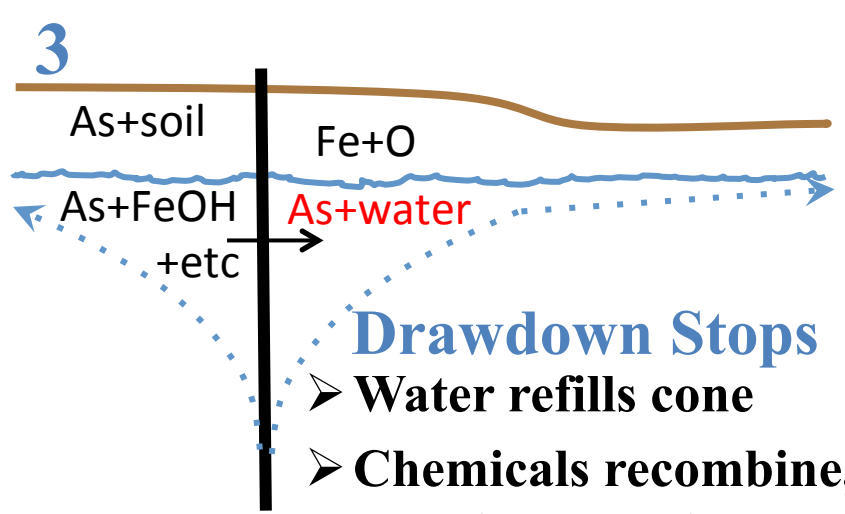
Before Drawdown

- Arsenic mostly bound to soil
- Little oxygen



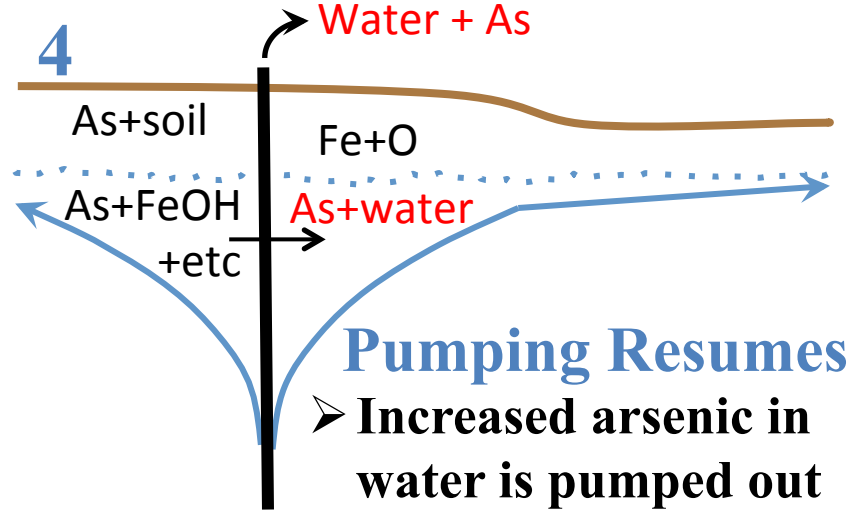
During Drawdown

- Soil dries some
- Oxygen pulled into soil
- Chemistry changes



Drawdown Stops

- Water refills cone
- Chemicals recombine, allowing arsenic to dissolve in water



Pumping Resumes

- Increased arsenic in water is pumped out

Chemical Sequences for Dissolving Arsenic

- Chemical sequence on previous slide is generally representative
  - Chemical oxidation and reduction are involved in various stages
  - "Oxidation" and "Reduction" have also become jargon for different sequences that dissolve arsenic
  - "S" for sulfides represents that other problem chemicals may also be involved

- Such chemical sequences are <u>initiated</u> by atmospheric O_2 being pulled into the drawdown cone

- Alkalinity, evaporation, and sulfides present challenges in western U.S. (including our area, per A. H. Welch)

- Acidity, organic matter, and bacteria worsen problem in eastern U.S. and elsewhere

Increasing vs. Removing Dissolved Arsenic

- Chemical sequences to increase or remove dissolved arsenic are essentially the same, both starting with addition of oxygen
  - Pulling oxygen into drawdown cones
  - Injecting oxygen (and iron) for faster reaction

- Remediation requires managing the process to ensure intentionally contaminated water is removed

- *Simplistically* letting oxygen enter a drawdown cone tends to increase an arsenic-in-water problem rather than reducing it.

Poor Science → Illogical Leap → Wrong Conclusion → Bad EIR ?

- Did poorly understood science lead to an illogical leap to an incorrect conclusion ?
- Final EIR Response 20-10 describes that simply letting oxygen enter drawdown cones would reduce dissolved arsenic *but science says the opposite*
- EIR also lacks other important arsenic information relevant to our microclimate
- Important arsenic issue is only 1 example of poor, minimal, or missing information in the Final EIR

Reject Inadequate EIR

- If water-quality and other issues are addressed in the true spirit of CEQA—based on good science, measuring, monitoring, mitigating, and acknowledging less urgency…

  alternative plans that include conservation policies are likely to be cheaper over the long haul

- Reject this inadequately developed EIR, as responsible water stewards who honor the intent and law of CEQA

References

- Alan H. Welch, et. al., "Arsenic in Ground Water of the United States: Occurrence and Geochemistry," USGS, GROUND WATER, Vol. 38. No. 4, Aug 2000. Pages 589-604.

- Alan H. Welch and Kenneth G. Stollenwerk eds., Arsenic in Ground Water Geochemistry and Occurrence, Ch. 9 and Ch. 15, Kluwer Academic Publishers, 2003.

- A. H. Welch and K. G. Stollenwerk, "In-situ remediation of arsenic in ground water," USGS NAWQA Program, in Arsenic in the Asia-Pacific Region, Adelaide, Australia, p. 67-68.

- J. G. Thundiyila, et.al., "Seasonal variation of arsenic concentration in wells in Nevada," Environmental Research 104 (2007) p. 367–373.

- Md. Safiuddin, "GROUNDWATER ARSENIC CONTAMINATION IN BANGLADESH: CAUSES, EFFECTS AND REMEDIATION," 2001 Proc of 1st IEB international conference, Bangladesh.

- Thomas E. Bridge and Meer T. Husain, "The Increased Draw Down And Recharge in Groundwater Aquifers And Their Relationship to the Arsenic Problem in Bangladesh," by Thomas E. Bridge, Professor of Geology(emeritus), Emporia State University, Kansas, USA & Meer T. Husain, Environmental Geologist, Kansas Department of Health And Environment, Kansas, USA.

- WATER SUPPLY IMPROVEMENT PROJECT FINAL ENVIRONMENTAL IMPACT REPORT, State Clearinghouse No. 2011071010, by ECORP Consulting Inc. for IWVWD, Ridgecrest, CA, FEBRUARY 2012