Mechanism for Arsenic Increase in Drawdown Cones

Annette F. DeMay
Ridgecrest, CA

In Proposed Project Impact Area
February 23, 2012
Big and Small Drawdown Cones

Many tiny wells inside huge production-well drawdown cone

Some production-well cones interfere with each other

< 2,200 GPM Pump Below

Theoretical Drawdown Cone
(Miles Wide, 100s–1000s ft. Deep)

Theoretical Drawdown Cone
(10s ft. Wide, 10s–100s ft. Deep)

< 25 GPM
Drawdown Cones—*When Pumping*

- **Drawdowns lower water level**
- **Huge production-drawdown affects small wells**
- **Soil in cones dried some**
Drawdown Cones—*Pumping Stopped*

- Production Well
- Ground Level
- Private/Small Group Well
- Lowered Water Table
- Prior Drawdown Cone (Miles Wide, 100s – 1000s ft. Deep)
- Prior Drawdown Cone (10s ft. Wide, 10s–100s ft. Deep)

- Water level raises after pumping stops
- Soil in cones re-wetted
- Eventually water table is depressed

< 2,200 GPM

≤ 25 GPM
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**
  - $H+$ [hand] $H$ unbound (empty hand)
  - $H+$ [hand] -O- [hand] $HO$ (1 oxygen bound to hydrogen)
  - $H+$ [hand] -O- [hand] +H $H_2O$ (2 hydrogens & 1 oxygen = water)
  - $H+$ [hand] -O- [hand] $HO$ (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

1. O₂ in air
   - As+soil
   - Fe
   - As+soil
   - Fe S

2. O₂
   - As+soil
   - Fe+O
   - As+soil
   - Fe+O S

3. Fe+O
   - As+FeOH +etc
   - As+water

4. Water + As
   - As+soil
   - Fe+O
   - As+soil
   - Fe+O +etc
   - As+water
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 initiated by atmospheric O2 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 $\rightarrow$ Illogical Leap $\rightarrow$ Wrong Conclusion $\rightarrow$ 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


- 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