Carson Valley and Arsenic

Distribution of Arsenic in Southern Carson Valley: What We Currently Know

Angela Paul
USGS, Nevada Water Science Center

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PROBLEM

- Water supply wells in northern Carson Valley were decommissioned due to elevated arsenic concentrations (*Carl Ruschmeyer, January 2013, Douglas County Public Works Director, verbal communication*).

- Town of Minden is currently providing water from their production wells to supply water lost to consumers by the decommissioning of the wells in northern Carson Valley

- Ultimate Question: Will increasing pumping rates from water supply wells in Minden mobilize arsenic toward them thereby degrading water quality?

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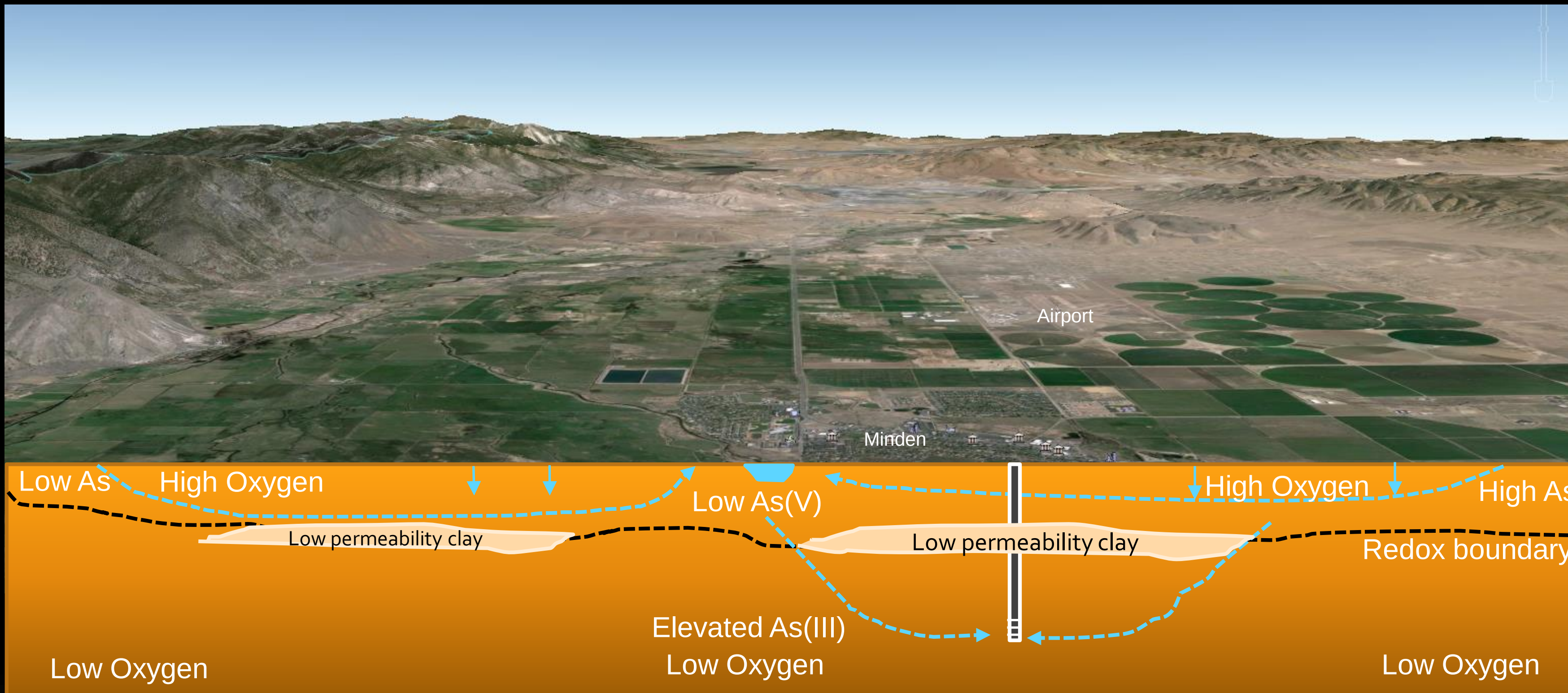
Conceptual Model: Arsenic in Groundwater



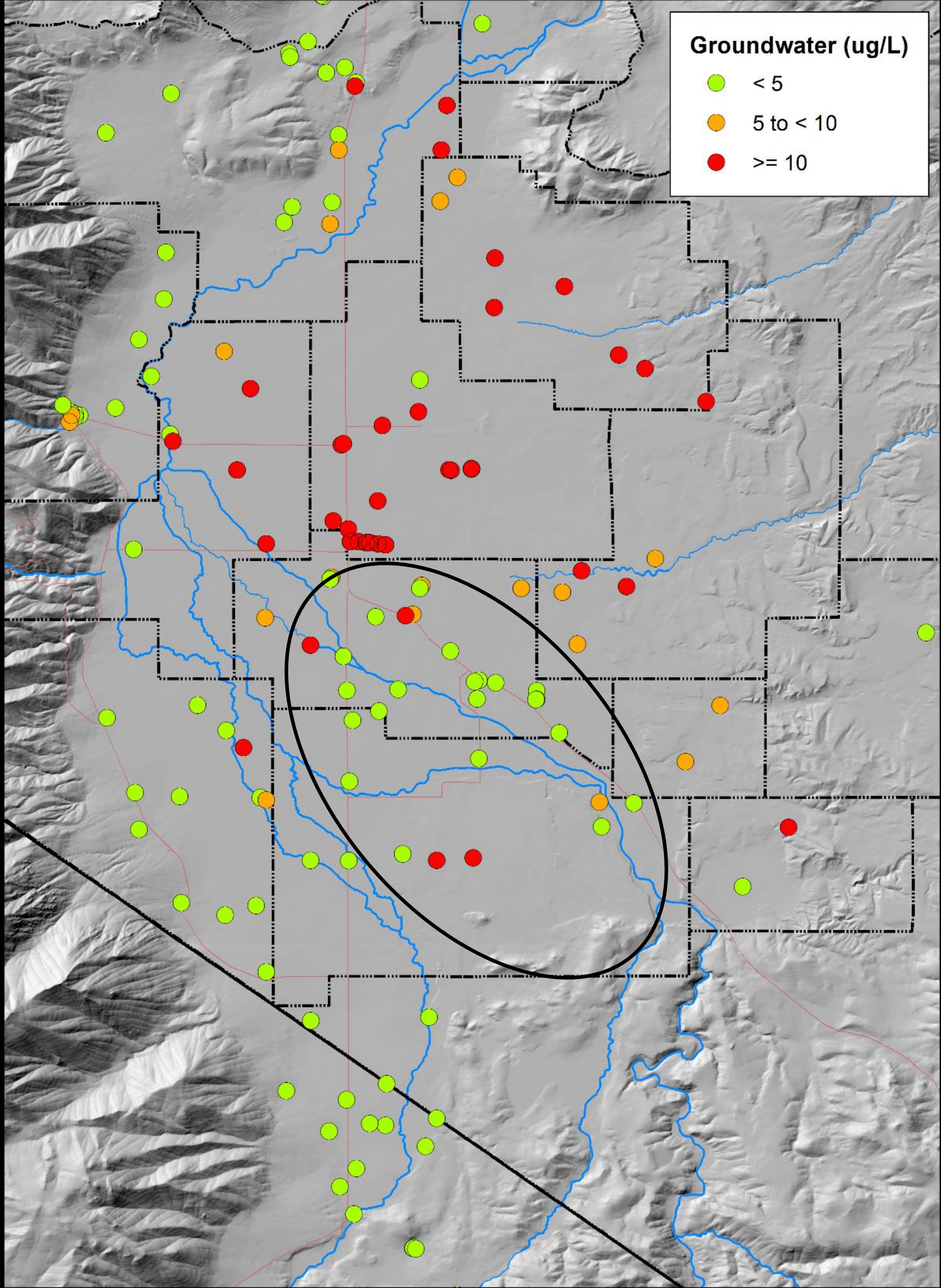
Arsenic is naturally occurring. Enrichment can occur due to favorable hydrogeology, geochemical conditions, and long flow paths

Deep wells can tap groundwater that can contain the reduced form of inorganic As(III) – the more mobile form

Water Years
1960 – 2015

Distribution of Arsenic Concentrations in Carson Valley

Filtered and Unfiltered

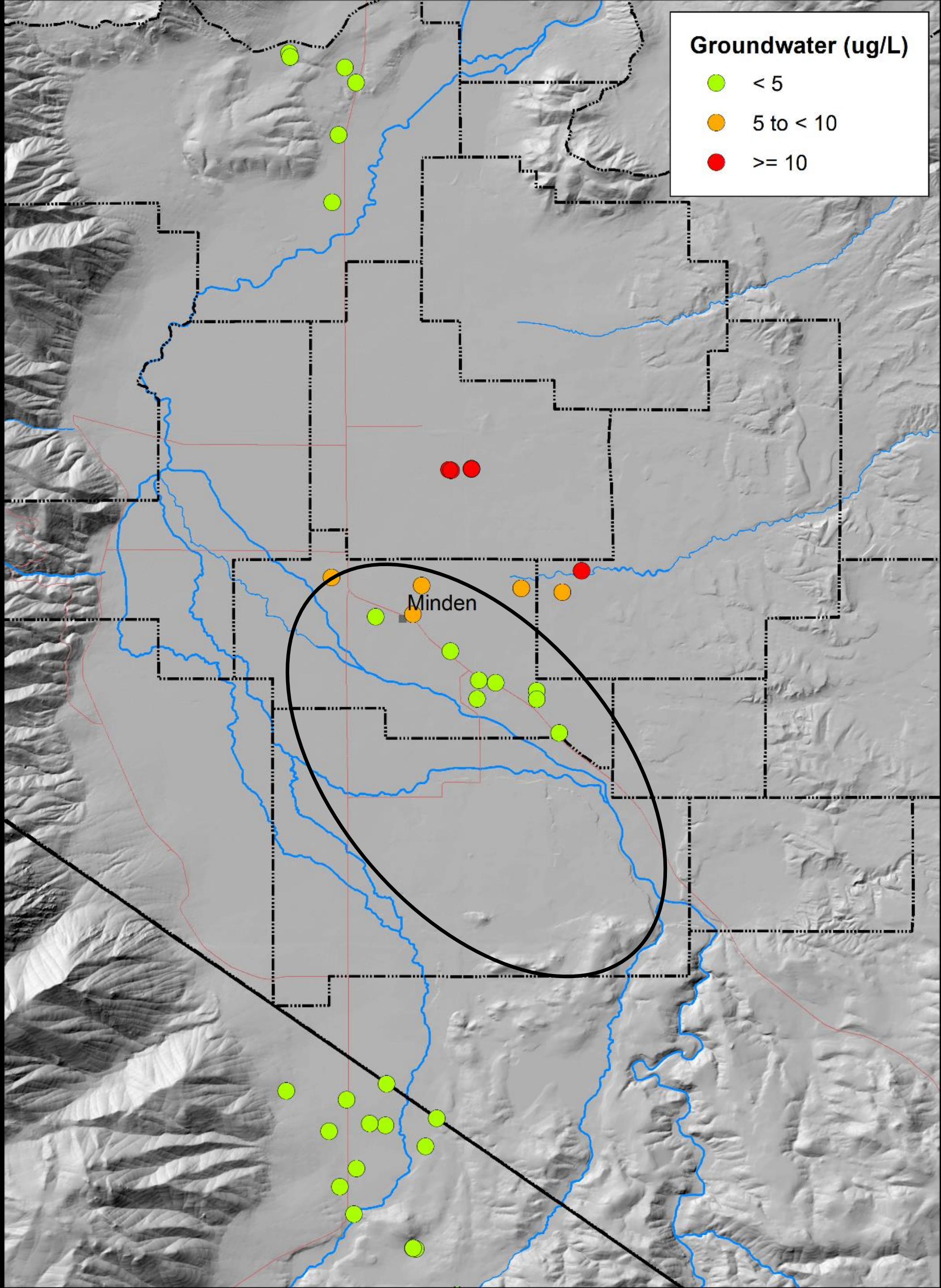


Water Years

2006 – 2015

Distribution of Arsenic Concentrations in Carson Valley

Filtered and Unfiltered



Status and Sampling Effort - 2019

- Limited arsenic concentration data exist over the past 10-20 years for areas upgradient and surrounding production wells: Update arsenic concentration distribution assessment within the target study area (*n = 9 wells*)

- Redox conditions may be mixed and above what might be reducing for arsenic but speciation data are unavailable: Analyzed each sample collected from domestic wells for redox chemistry (DO, N-species, Mn, Fe, As-species, SO_4-H_2S), DOC, and chloride

- Collect samples during minimal pumping pressure (*March/April 2019*)

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Minden Well #8

Collaboration with water purveyors (FY2018) –

Arsenic concentrations above 10 µg/L (MCL) before purge; after purge, concentrations fall below MCL (Jeff Cady, Town of Minden, Water Operations Manager)

Arsenic in-situ remediation study (2010) with speciation data just north of Well #8

Well #8 Sampled for a suite of analytes in 2013 as part of the USGS NAWQA Program

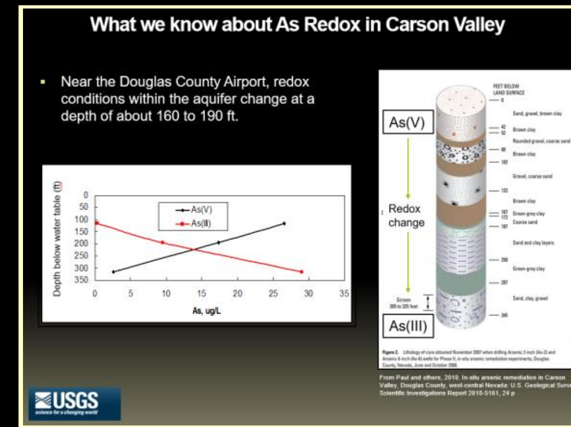
110 – 170
250 – 270
310 – 330
430 - 510

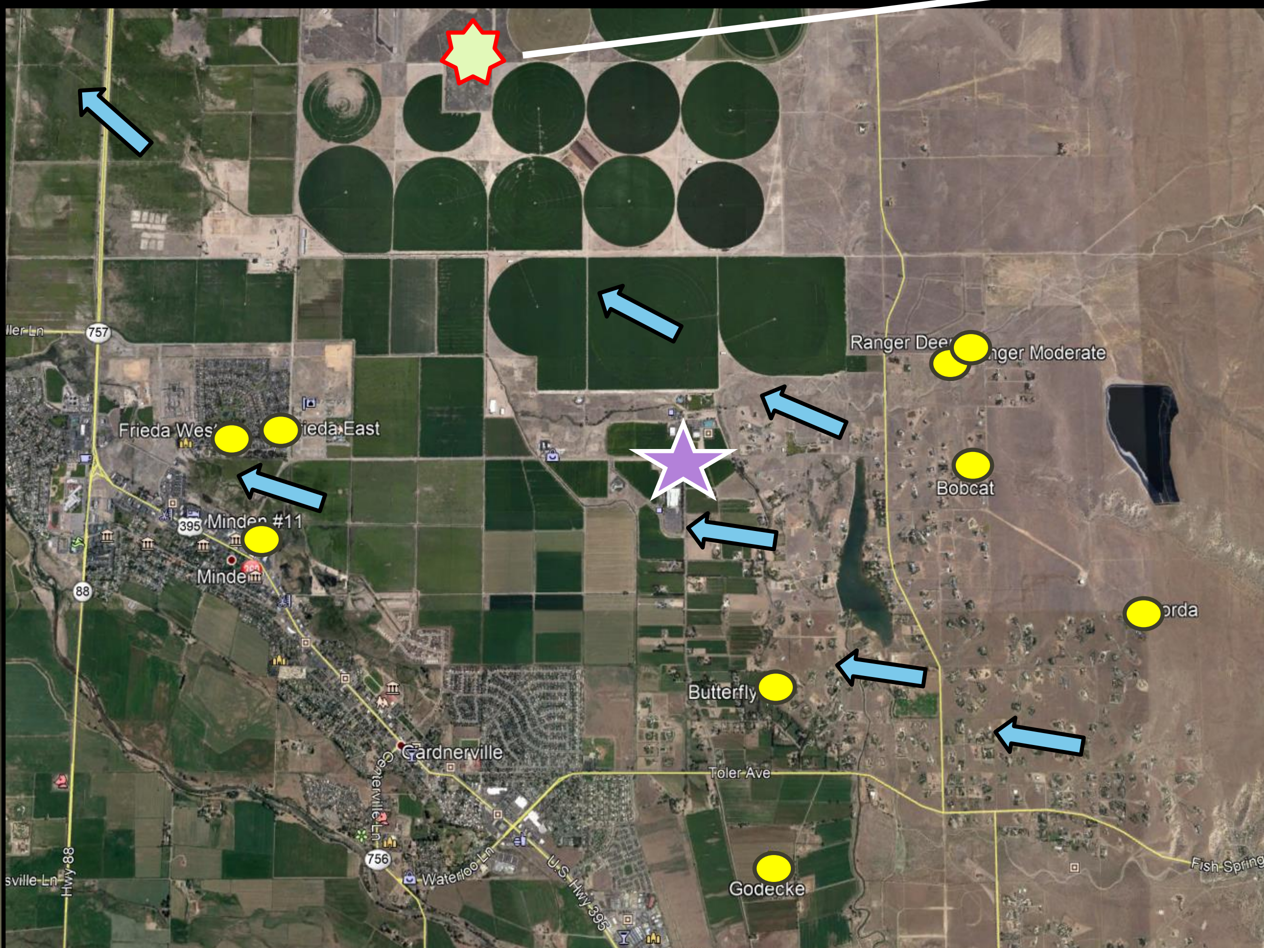
Screened intervals
(below land surface)

USGS 2013 (source water)
Arsenic = 9.0 µg/L

Domestic Well Selection Process

Aquifer Penetration Depth
Proximity to municipal supply well
Location within general groundwater flow path
Permission by well owner to sample well





Minden Well #8

General GW Flow
(Yager et al, 2012)

Sample Well

2010 In-situ remediation study

Depth Within Aquifer Representation

Target Aquifer Penetration Depth

Shallow: ≤100 ft
Moderate: 101 to 299 ft
Deep ≥300 ft

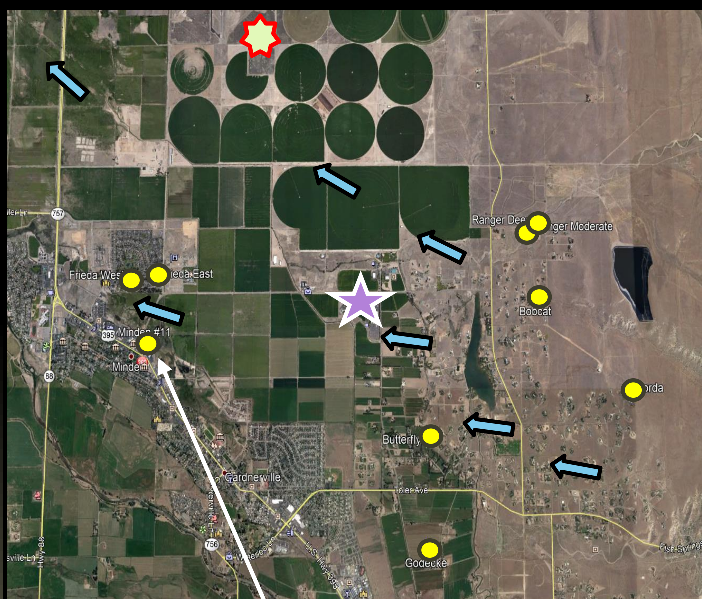
South End Douglas County Airport, 2010

49, 106, 107 ft

144 ft

143, 178, 200 ft

392 ft



Minden Well #11; Multiple Screened Intervals (100 to 397 ft) – Aquifer Pen. Depth = 289 ft

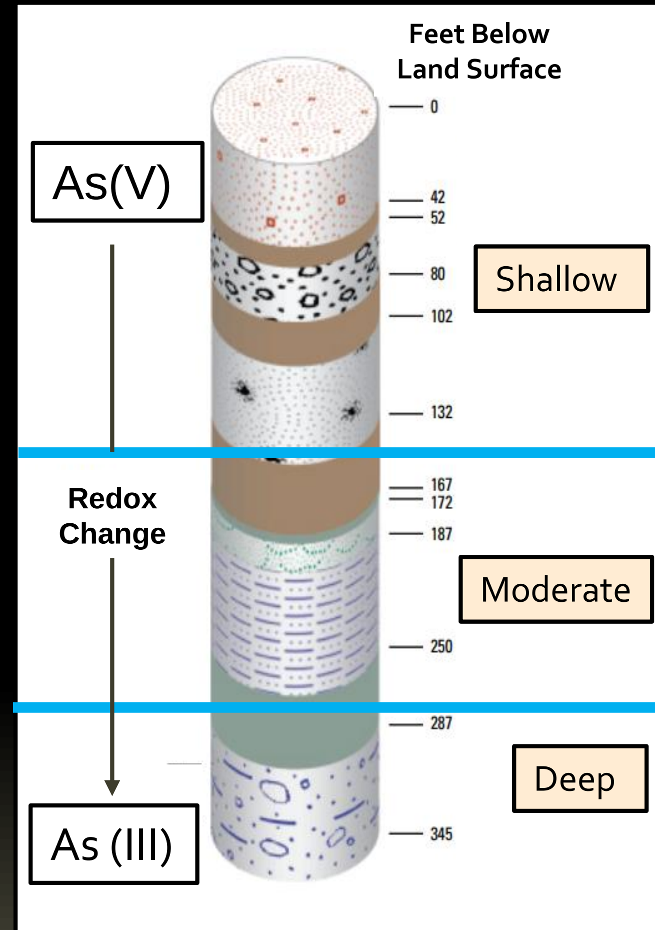


Figure 2. Lithology of core obtained November 2007 when drilling Arsenic 2-inch (As-2) and Arsenic 6-inch (As-6) wells for Phase II, in-situ arsenic remediation experiments, Douglas County, Nevada, June and October 2008.

From Paul and others, 2010. In-situ arsenic remediation in Carson Valley, Douglas County, west-central Nevada: U.S. Geological Survey Scientific Investigations Report 2010-5161, 24 p

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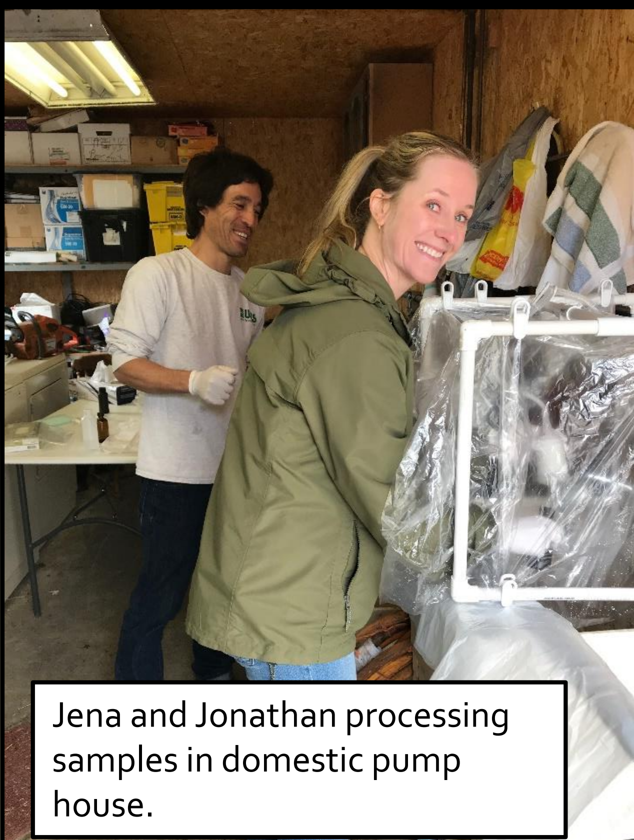
Samples Collected

9 Environmental Samples
1 Field Blank (no speciation)
3 Sequential Replicates (all parameters)
Arsenic Oxidizing Bacteria (Farah Ansari, Pakistan/CSU)

Farah



Jena and Jonathan processing samples in domestic pump house.

Jonathan preparing to sample for arsenic speciation. Septum used to preserve redox conditions during sampling.

Analyses

Field Parameters (DO, pH, SC, temp)

Nitrogen Species (NO_3/NO_2/NH_3)

Manganese and Iron

Arsenic Speciation (AsV/AsIII)

Sulfate (+H_2S sniff test)

Chloride, Phosphate, and DOC

Rinsing the sampling line

Samples were analyzed by USGS NWQL, USGS Trace Element Lab, and Brooks Applied Labs

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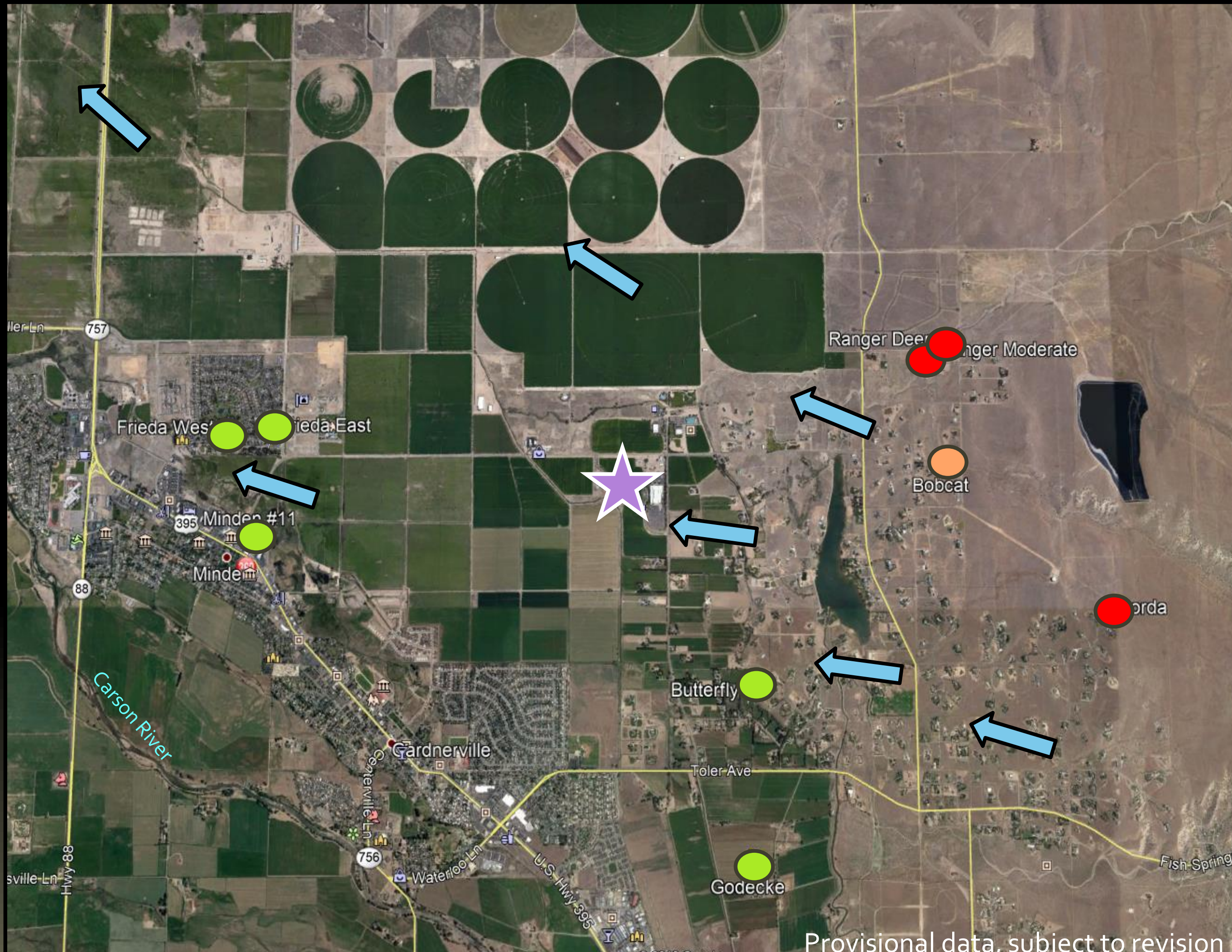
During the 2019 sampling effort, higher As along eastern edge of S. Carson Valley



Minden #8

General GW Flow
Yager and others, 2012

As < 5 ug/L

5 ug/L < As <10 ug/L

As ≥ 10 ug/L

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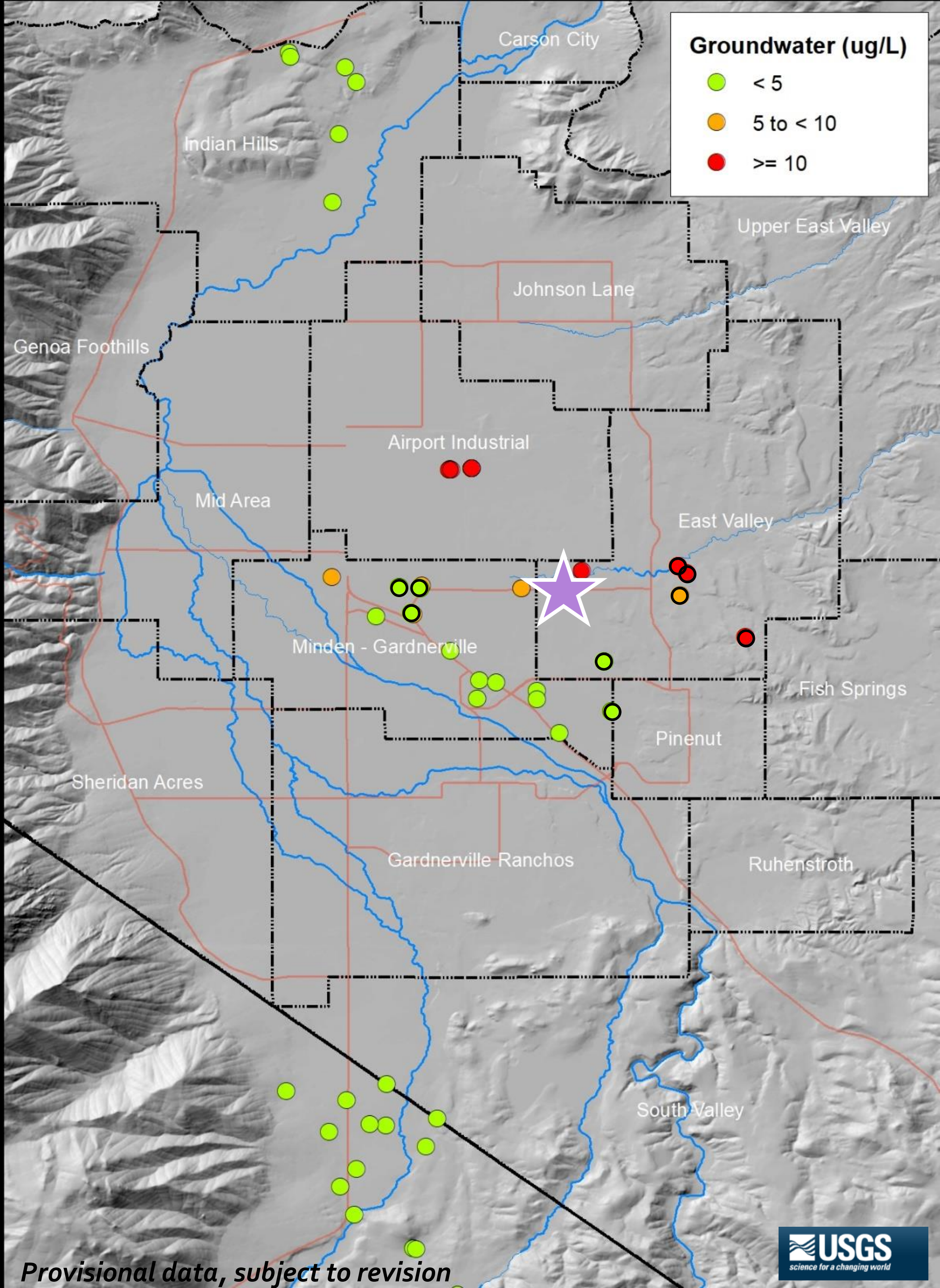
Water Years
2006 – 2019

Arsenic Concentrations

Filtered and Unfiltered

Municipality
and
USGS As Remediation Study and 2019 Data

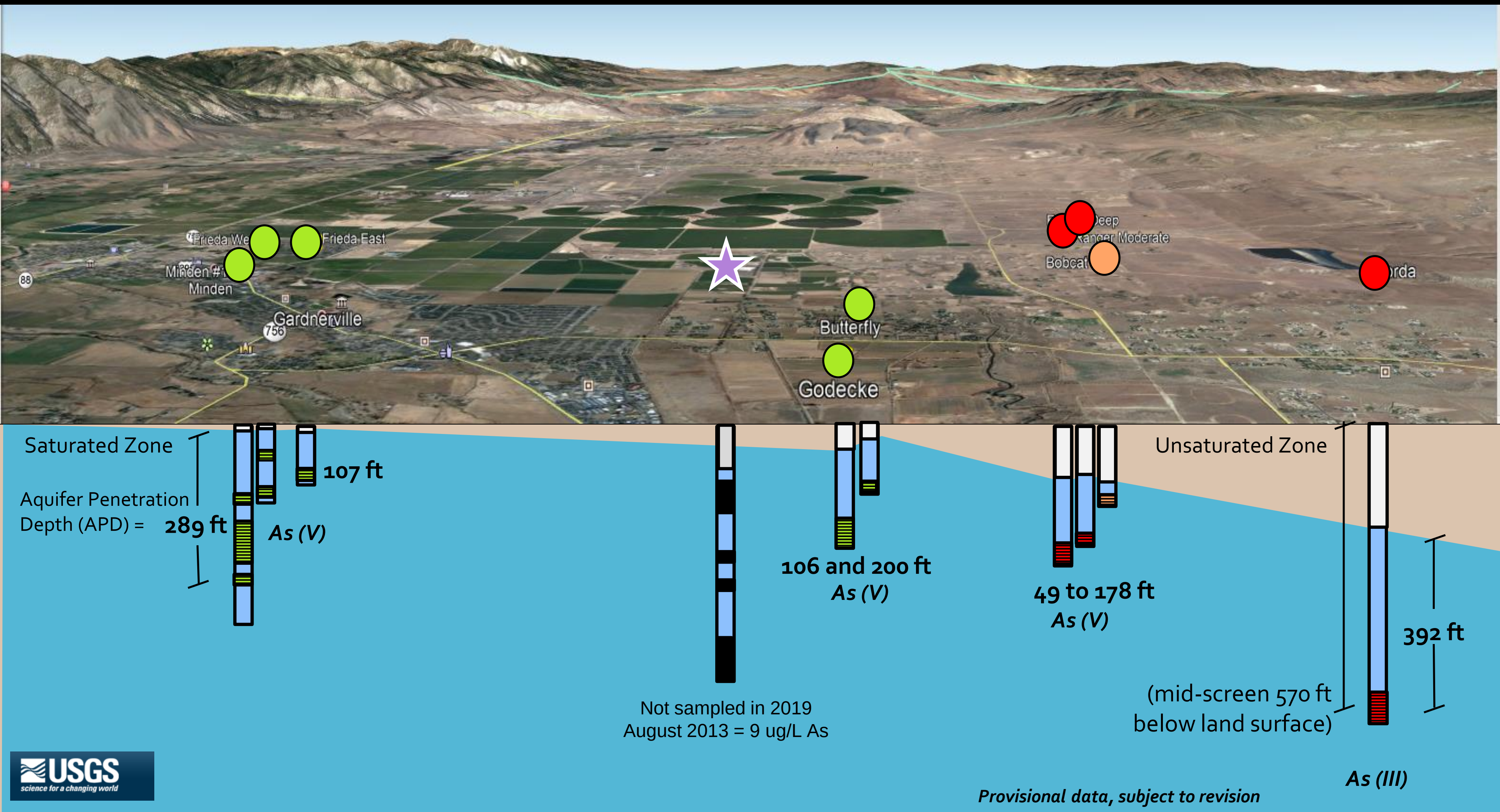
Minden Well #8



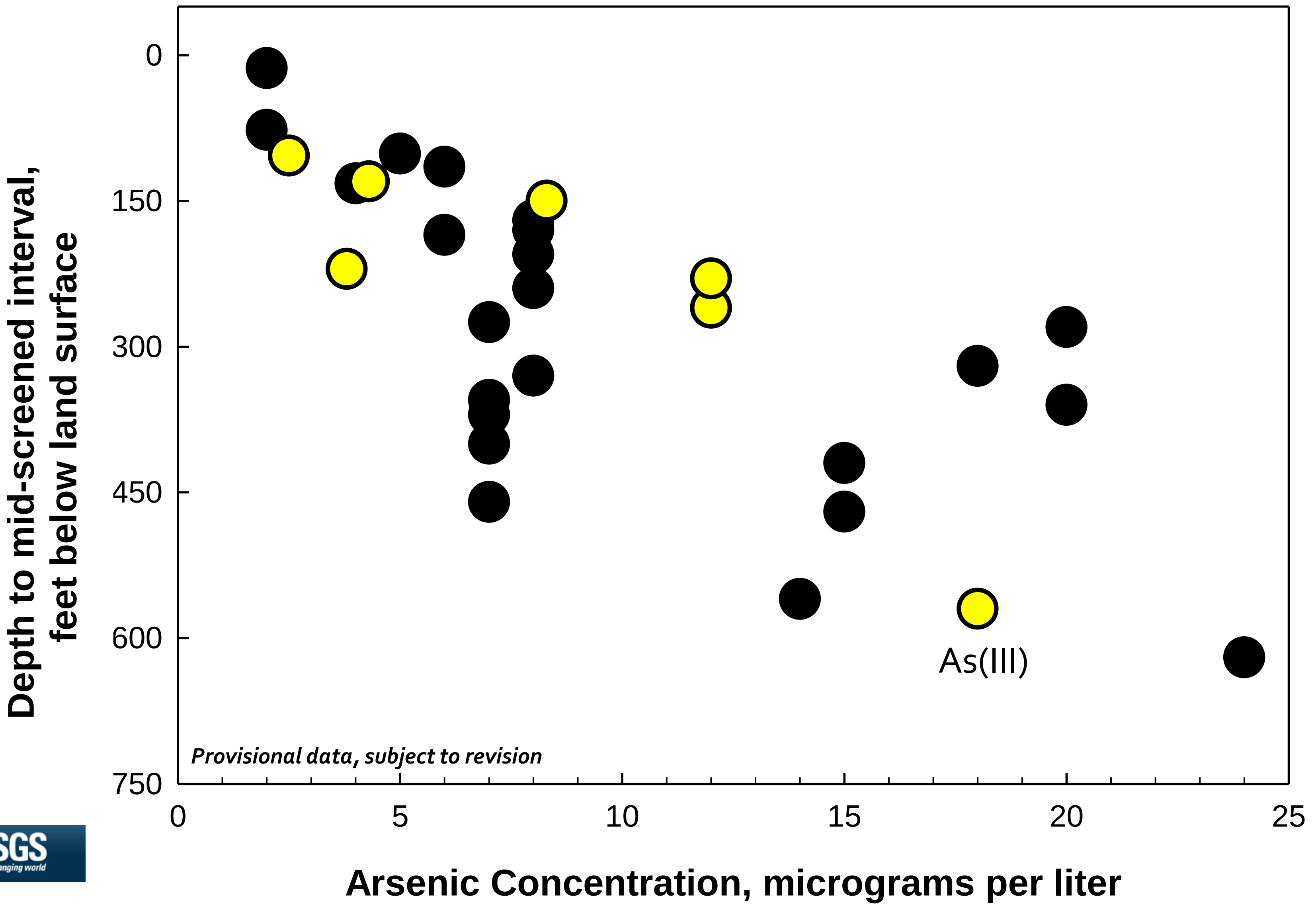
Higher arsenic concentrations observed along the east side of the valley (east of East Valley Road)

<5 ug/L As

>10 ug/L As



Arsenic Concentration with Depth – Phase I & II



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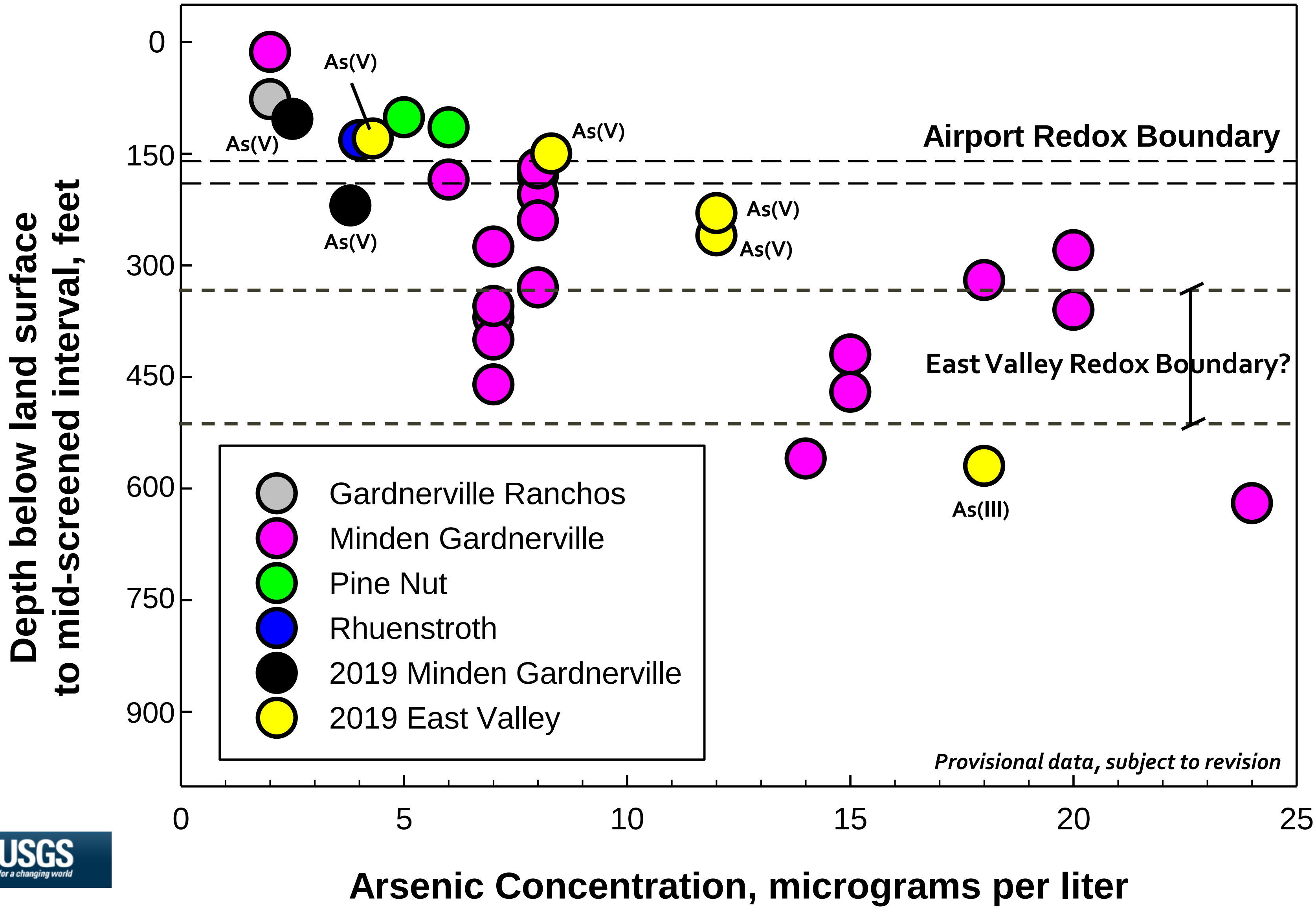
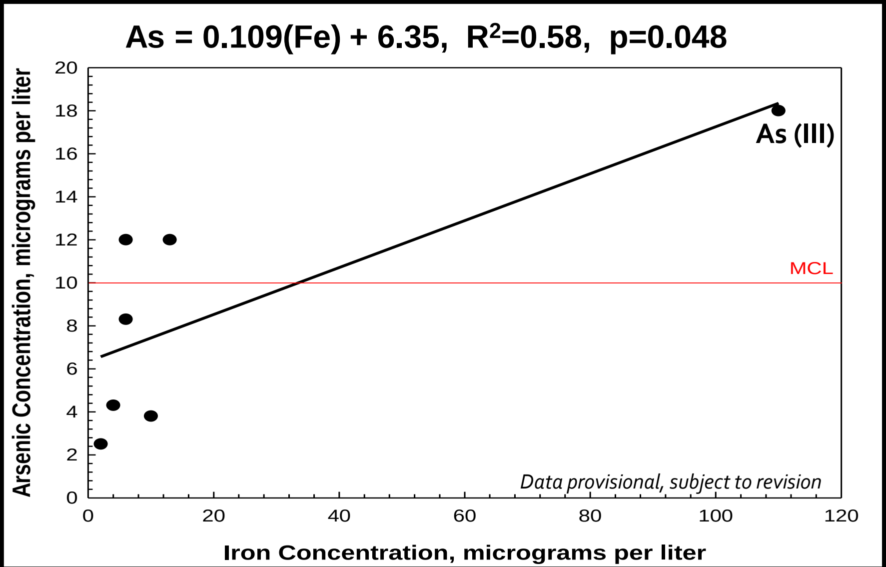
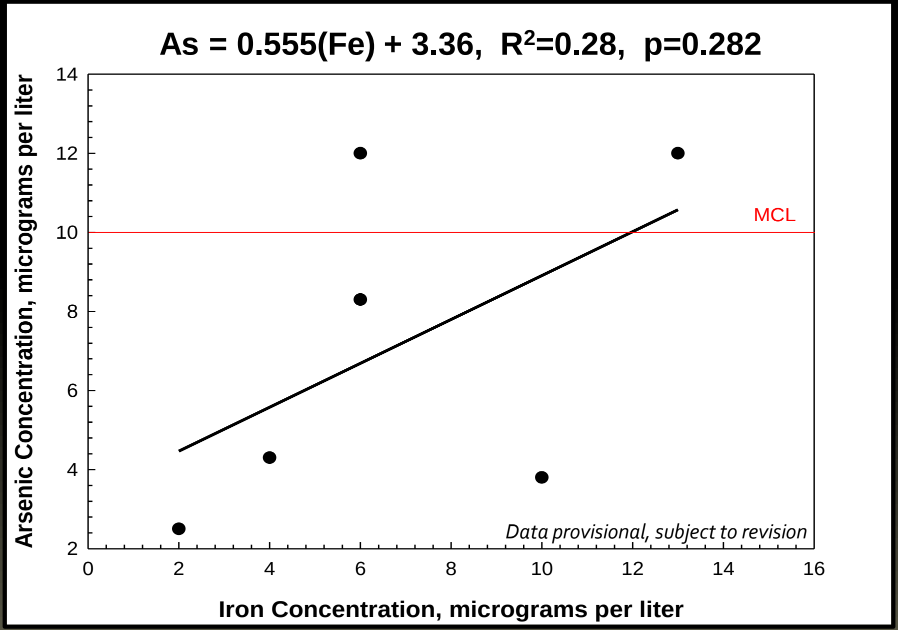
Arsenic Concentration with Depth – with 2019 Data



Arsenic and Iron (Fe)





Arsenic is attracted to iron oxide. Iron oxide is the rust colored material observed as a coating in basin-fill aquifer material (picture below). Under conditions oxidizing to iron, the arsenic will not be as mobile; under conditions that do not support iron rust, arsenic can have greater mobility in the groundwater (Thiros and others, 2014, USGS Circular 1358).

Photo Credit: Core of basin-fill sediment, Susan Thiros, USGS, 2014.

Note: Relation in top figure is dominated by As(III) data point; reductive dissolution of metal oxides is likely liberating As into groundwater. Relation in bottom figure is not significant ($p>0.05$) but suggests that iron may be undergoing some degree of dissolution and releasing As(V) into groundwater (further data needed to confirm hypothesis).

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Study Findings

- Higher arsenic concentrations appear to be occurring along east side of valley; upgradient from many public supply wells

- All samples collected were analyzed for parameters known to be important to the mobility of arsenic

    Iron may be influencing the mobility of arsenic in some areas/portions of the aquifer

- Arsenic primarily observed as As(V); except in the deepest well, screened below 500 ft below land surface, which was found to support As(III)

    - Importance: Generally, As(III) has greater mobility than As(V)