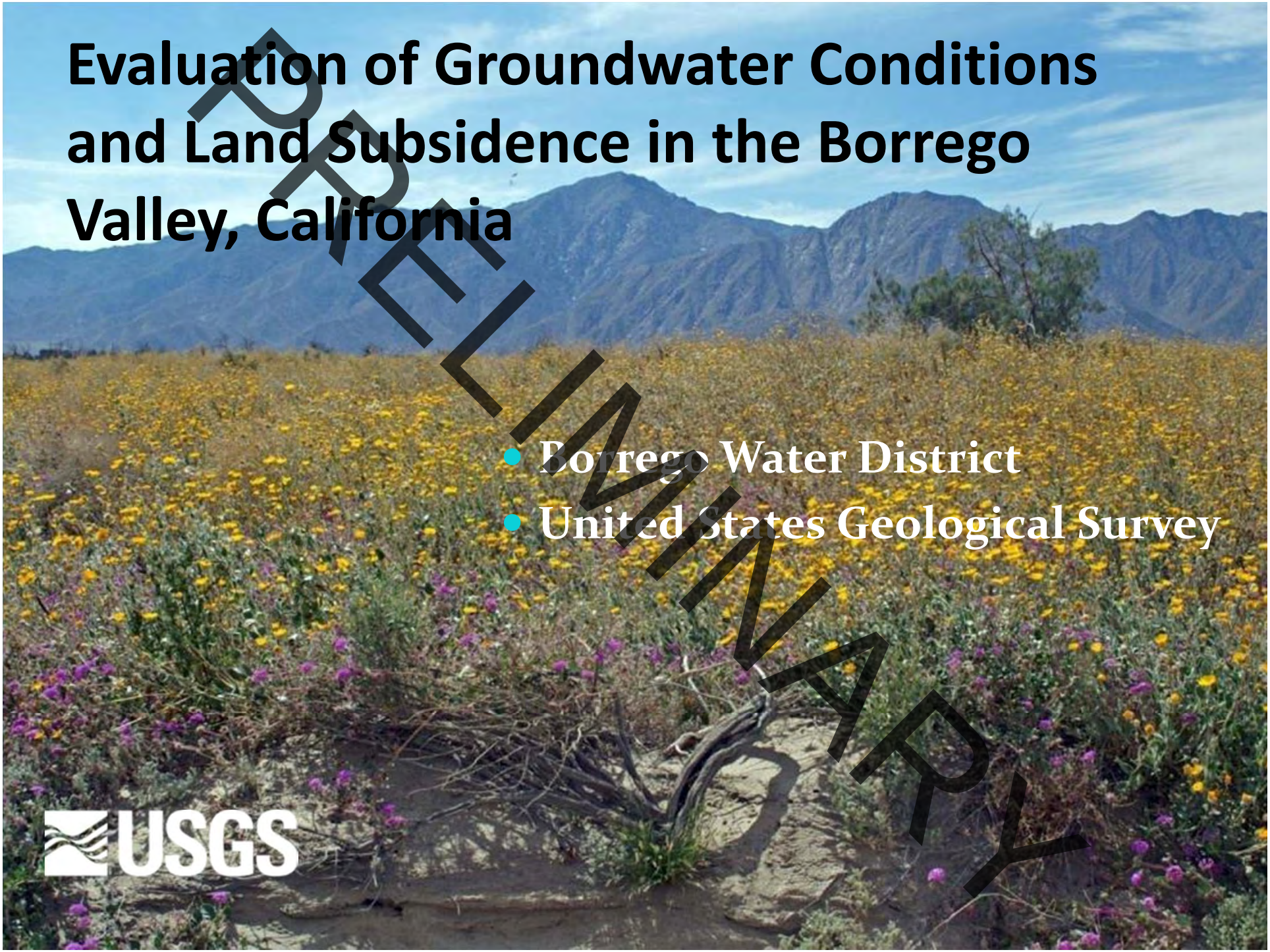
# Evaluation of Groundwater Conditions and Land Subsidence in the Borrego Valley, California




- Borrego Water District
- United States Geological Survey

USGS

# Problem:

- Groundwater is virtually the sole source of water in Borrego
- Annual groundwater pumping exceeds natural recharge by about four times
- Pumping has resulted in water levels dropping over two feet per year for the past twenty years
- Water-level declines in areas with significant clay deposits could result in land subsidence
- As the more permeable upper aquifer is dewatered, water-level declines may accelerate and water quality may deteriorate



USGS

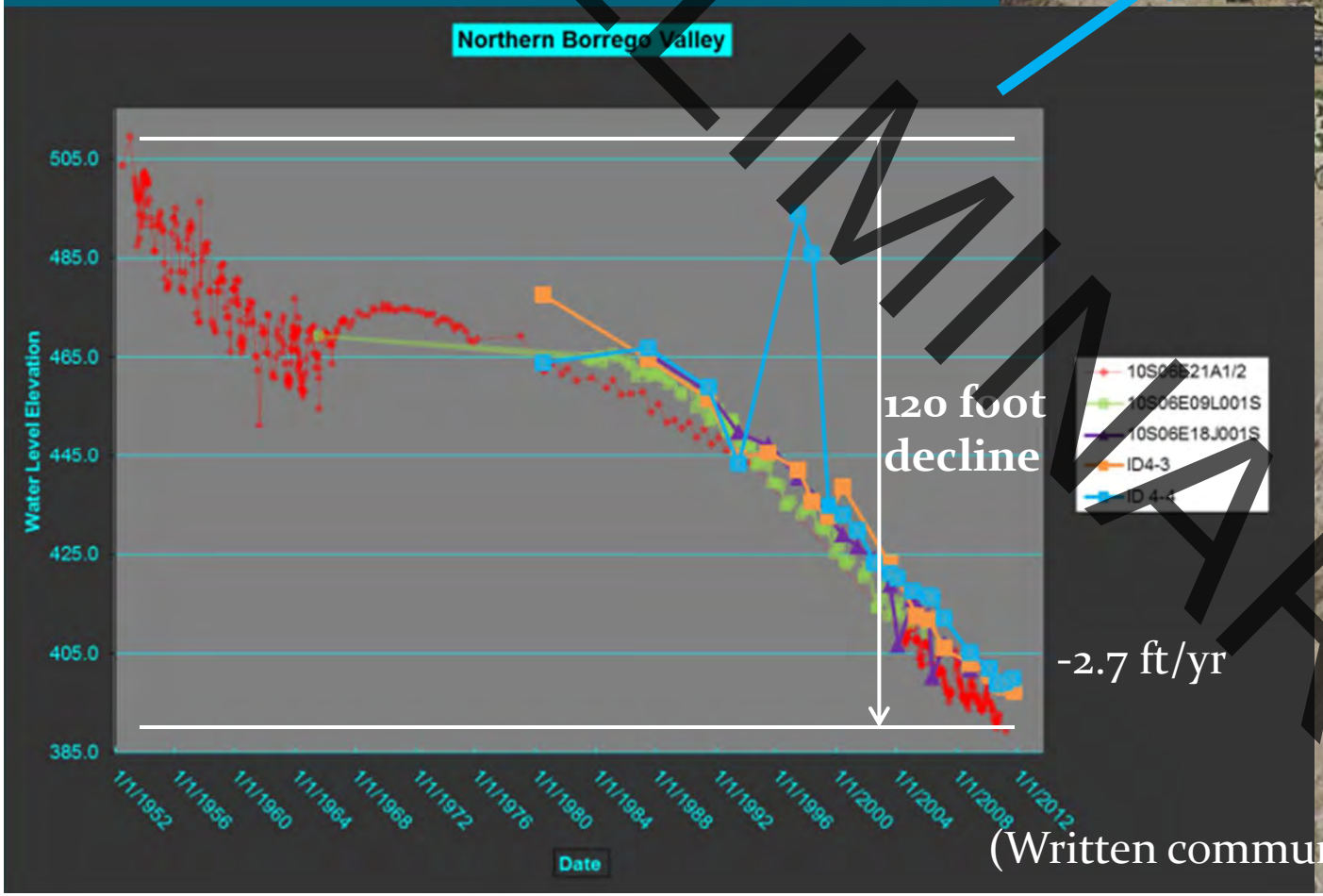
# Basic groundwater budget



| **Preliminary Groundwater Budget (acre-feet per year)** | | |
|---|---|---|
| **IN** | Pre-development | Current |
| Natural Recharge | 4,800 | 4,800 |
| **OUT** | | |
| Flow out southern end | 900 | 900 |
| Natural ET | 3,900 | 0 |
| Wells | | 19,000 |
| | | |
| **Storage Change** | 0 | -15,100 |

USGS

# Water level declines:

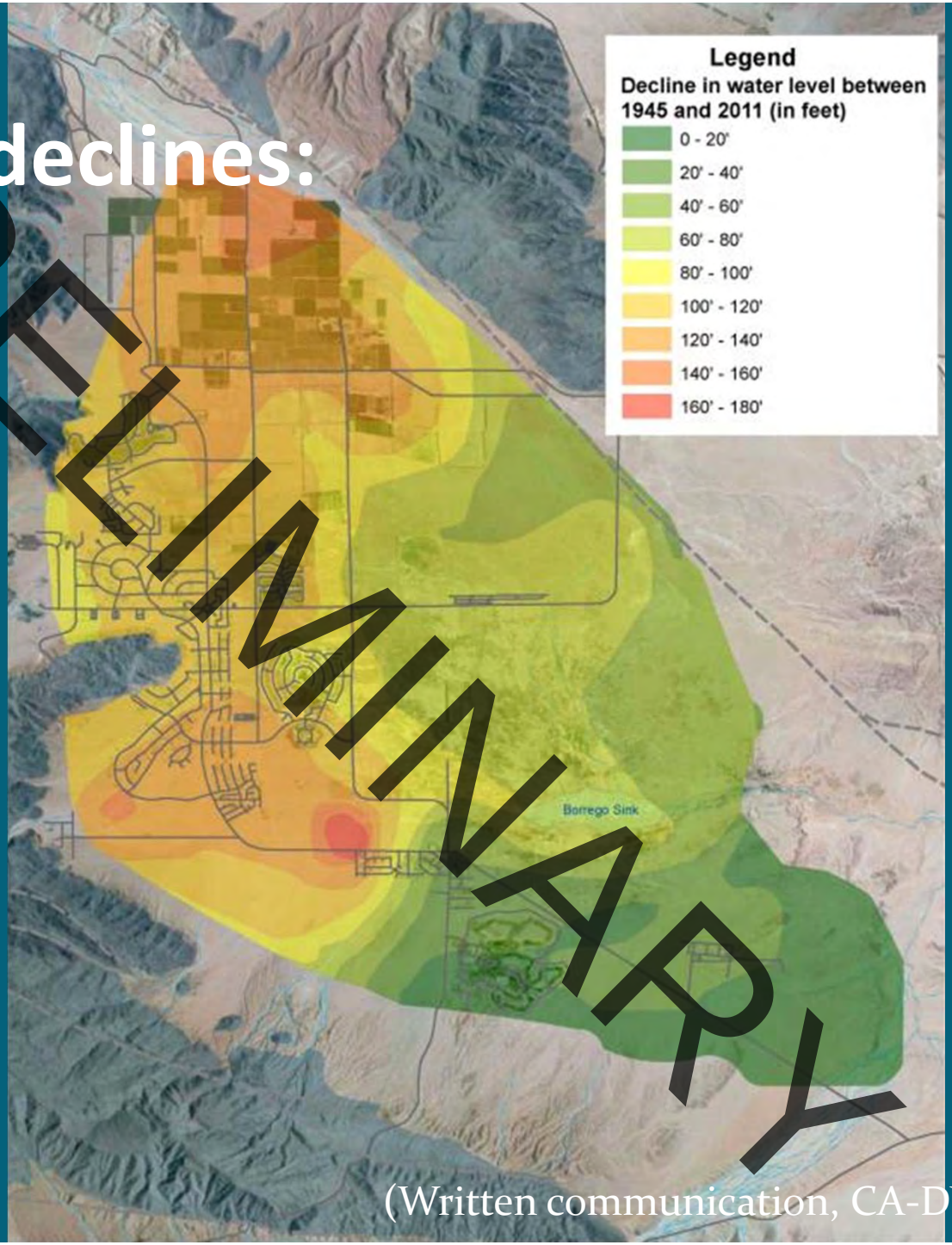





USGS

(Written communication, CA-DWR, 2012)

# Water level declines:






USGS

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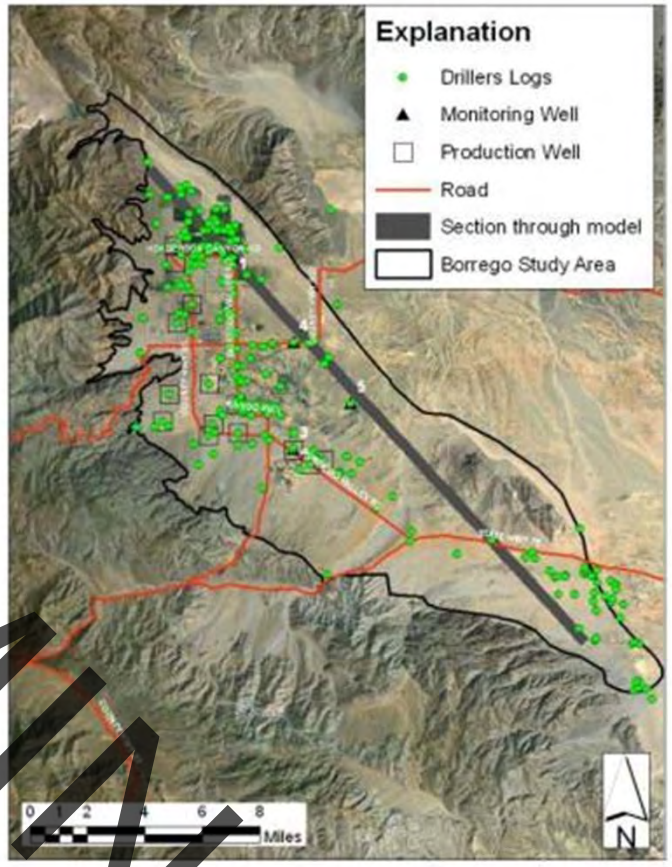
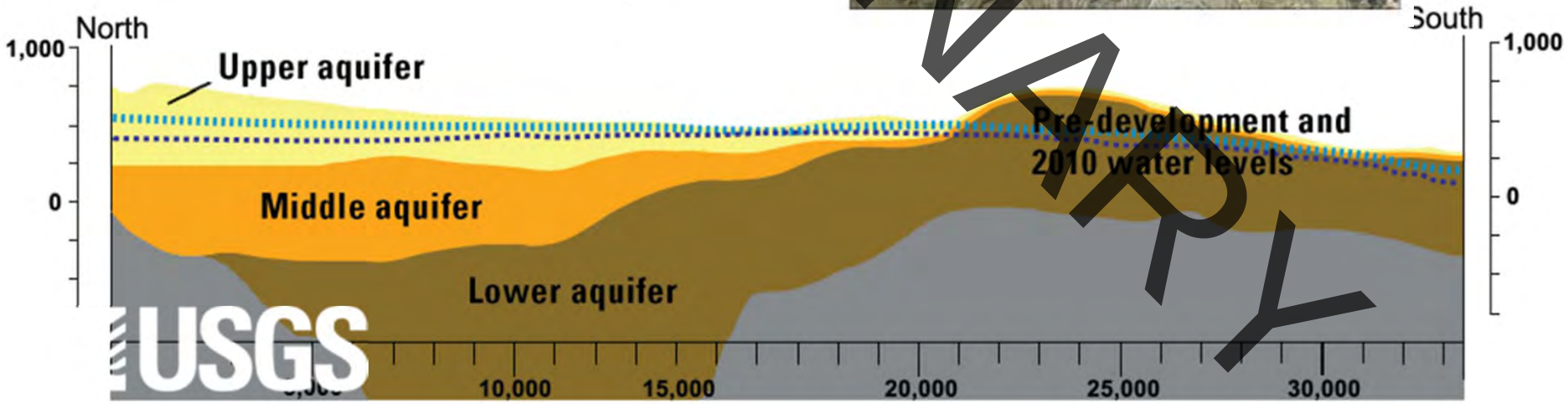
# Water level declines:





# Problem:

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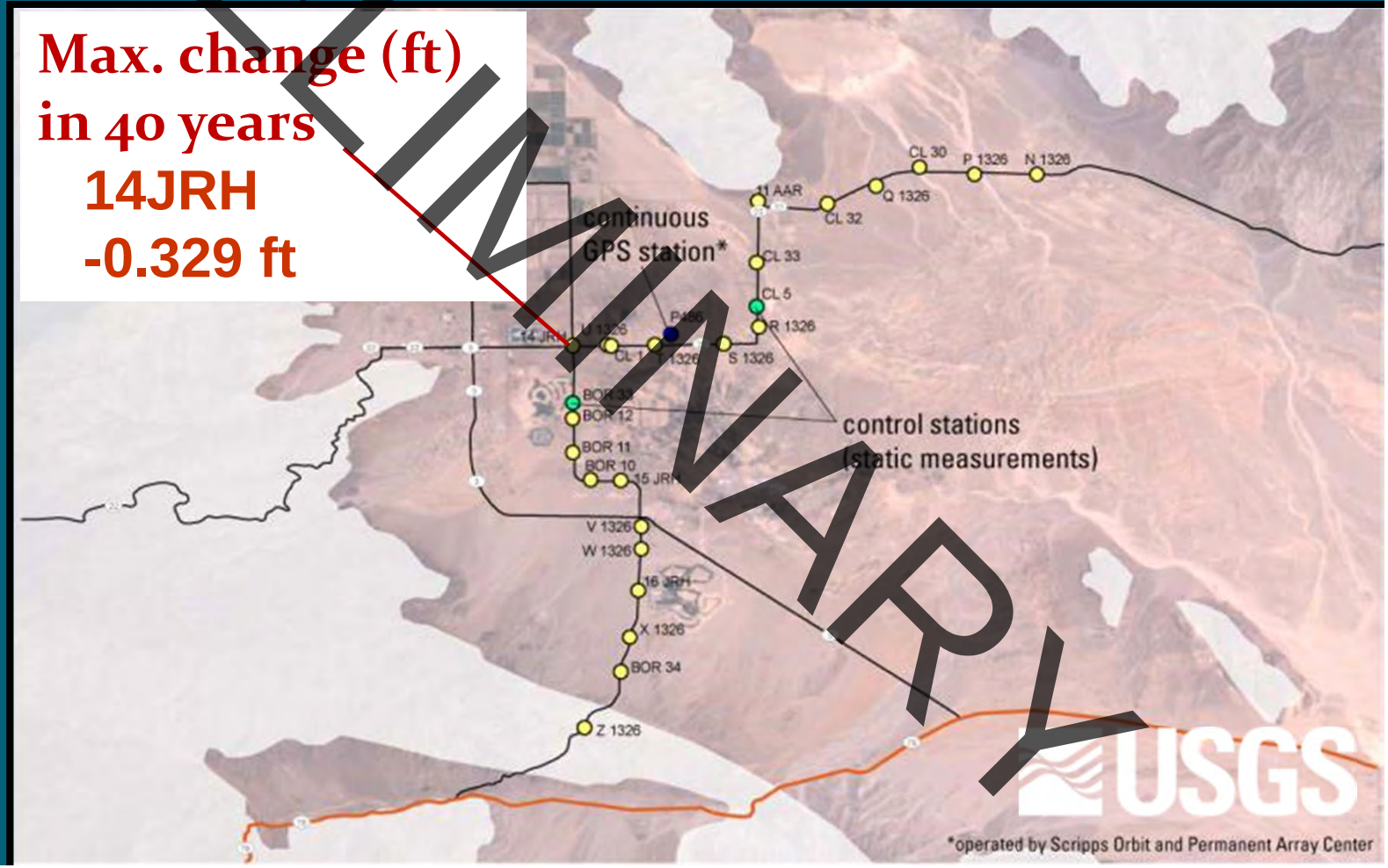
USGS

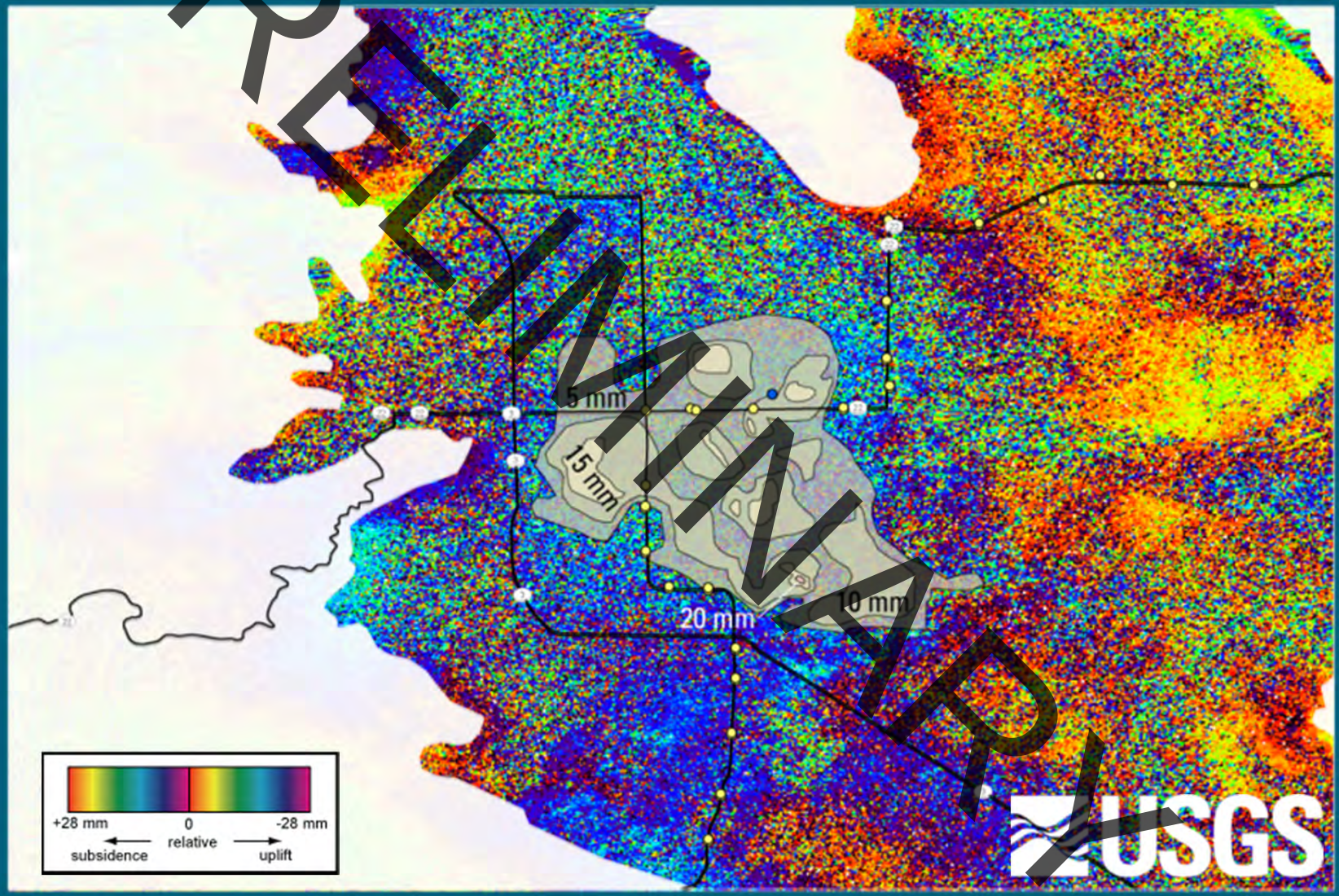
# Land Subsidence

- Elevations for all 25 benchmarks are stable (< 6”) compared to elevations derived from leveling measurements in 1978 (23 benchmarks) or 1969 (2 benchmarks)



# InSAR

- **Interferometric synthetic aperture radar**




4/3/05-9/30/07 (2.5 years) max. < 1 inch

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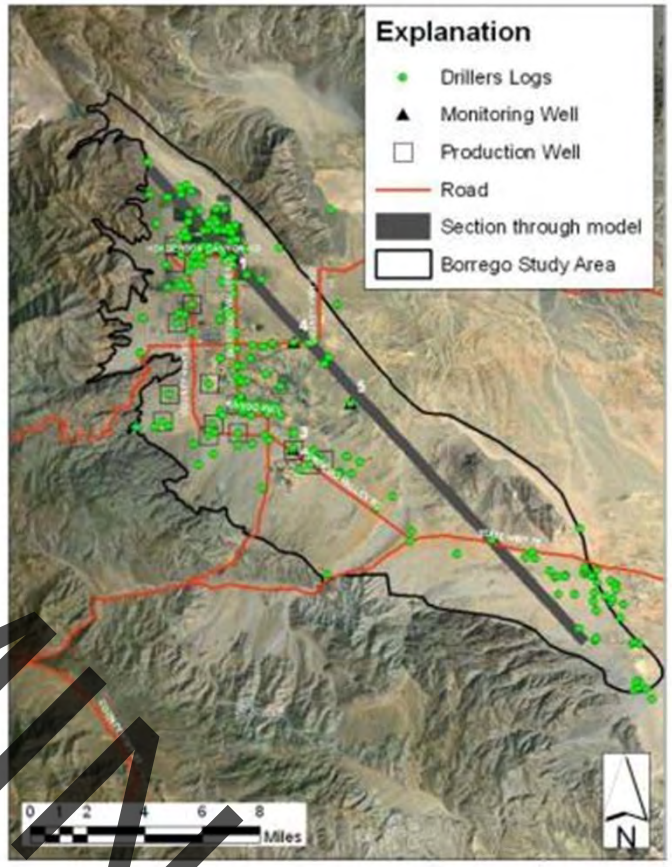
# Hydrogeologic characterization:

## Horizontal hydraulic conductivity (Permeability)

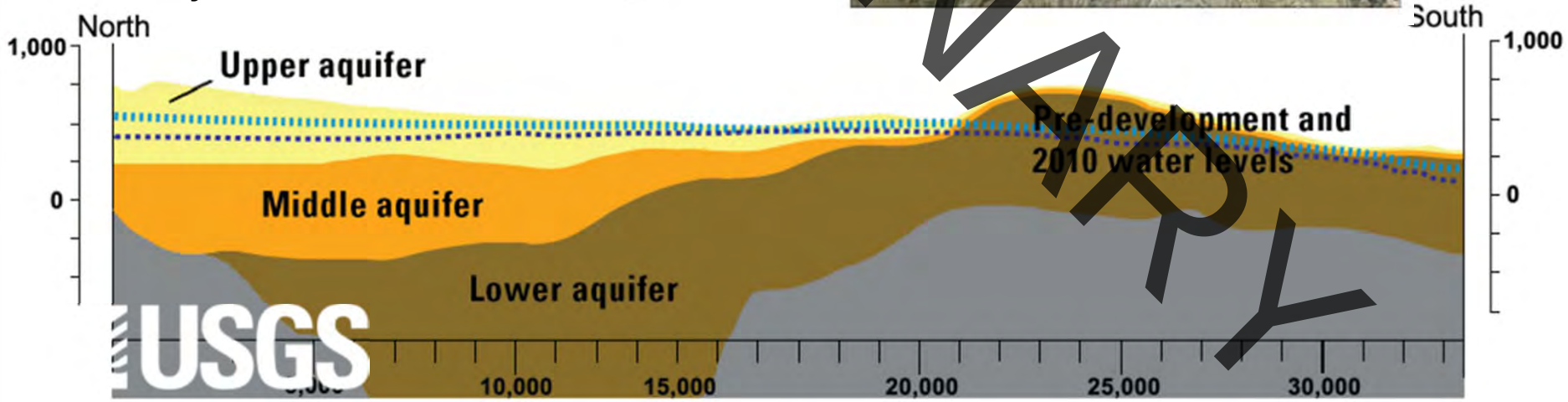
- Upper aquifer 43-81 feet/day
- Middle aquifer 1-10 feet/day
- Lower aquifer 0.1-2 feet/day

## Specific Yield (Storage)

- Upper aquifer 14%
- Middle aquifer 7%
- Lower aquifer 3%

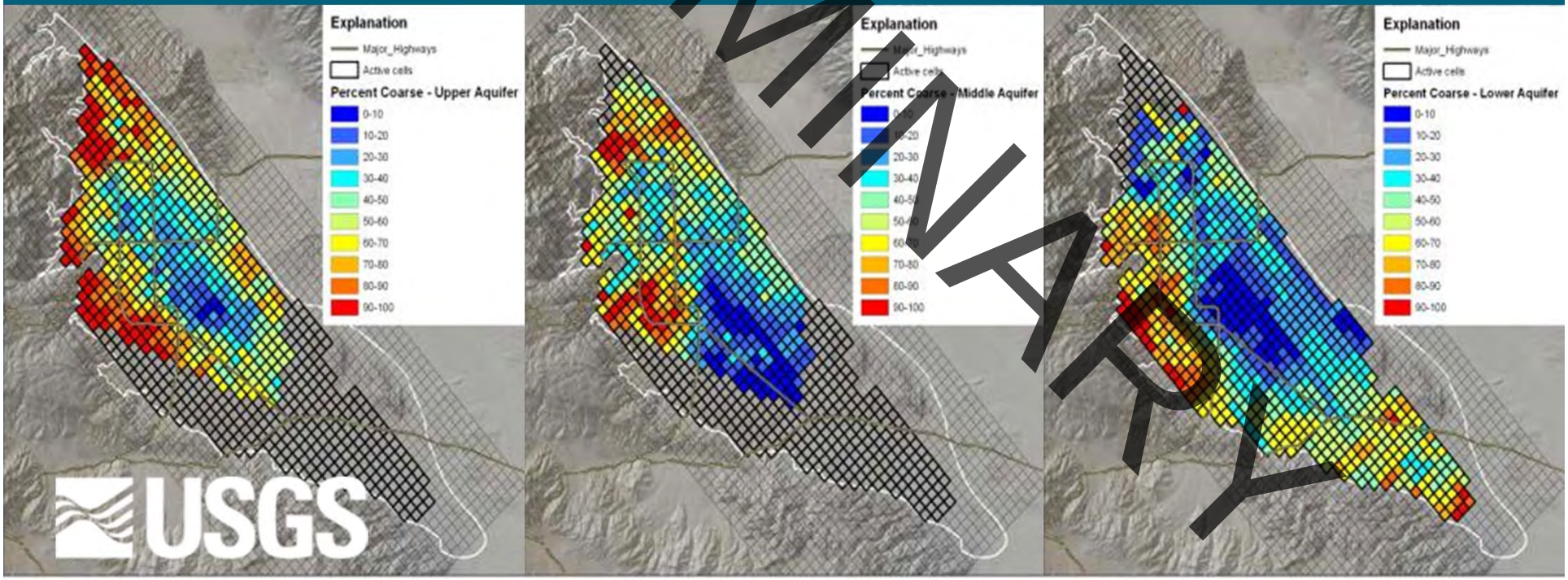



**Preliminary Estimates**



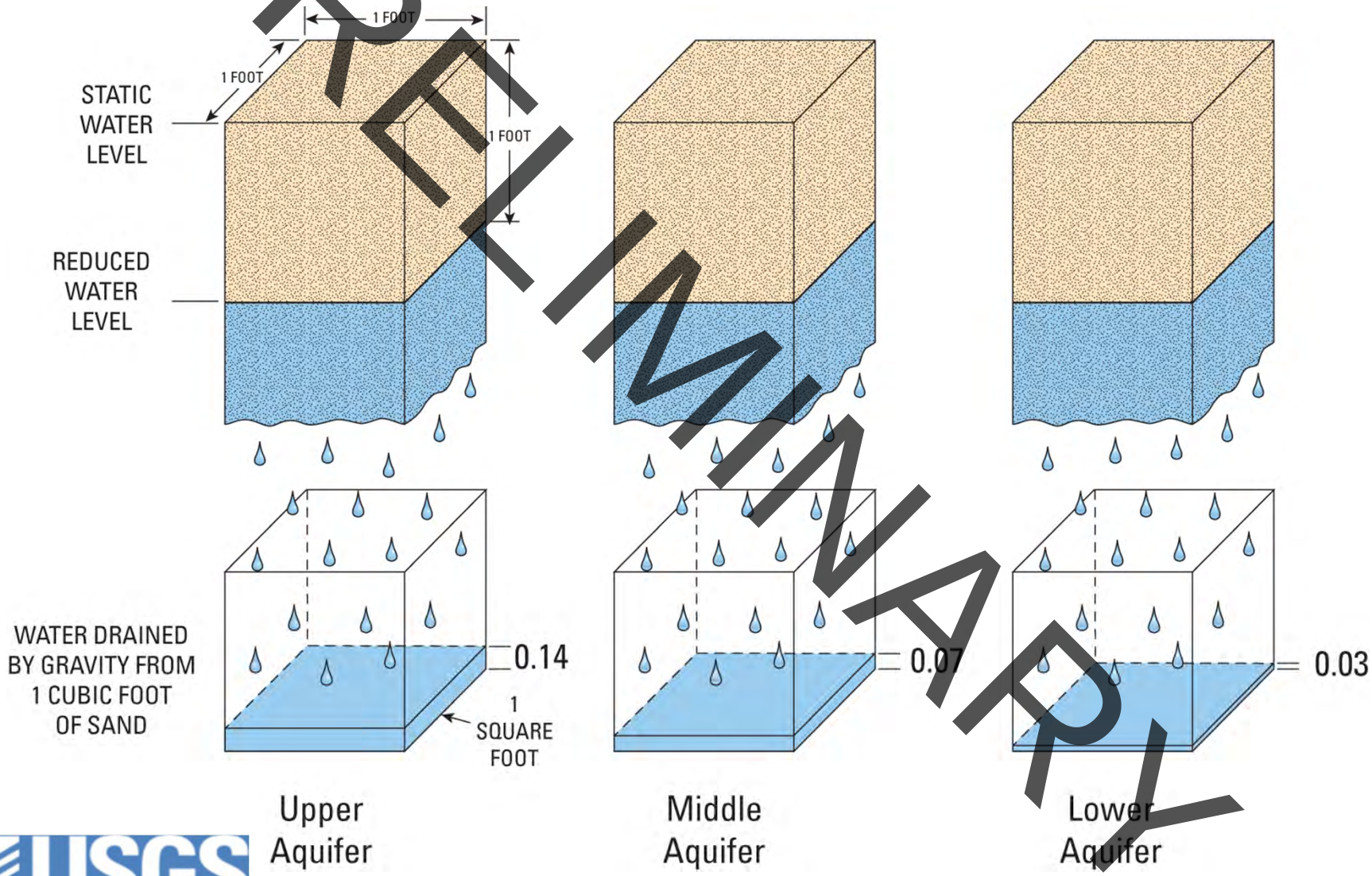
# Hydrogeologic characterization - permeability





# Specific yield of sediments



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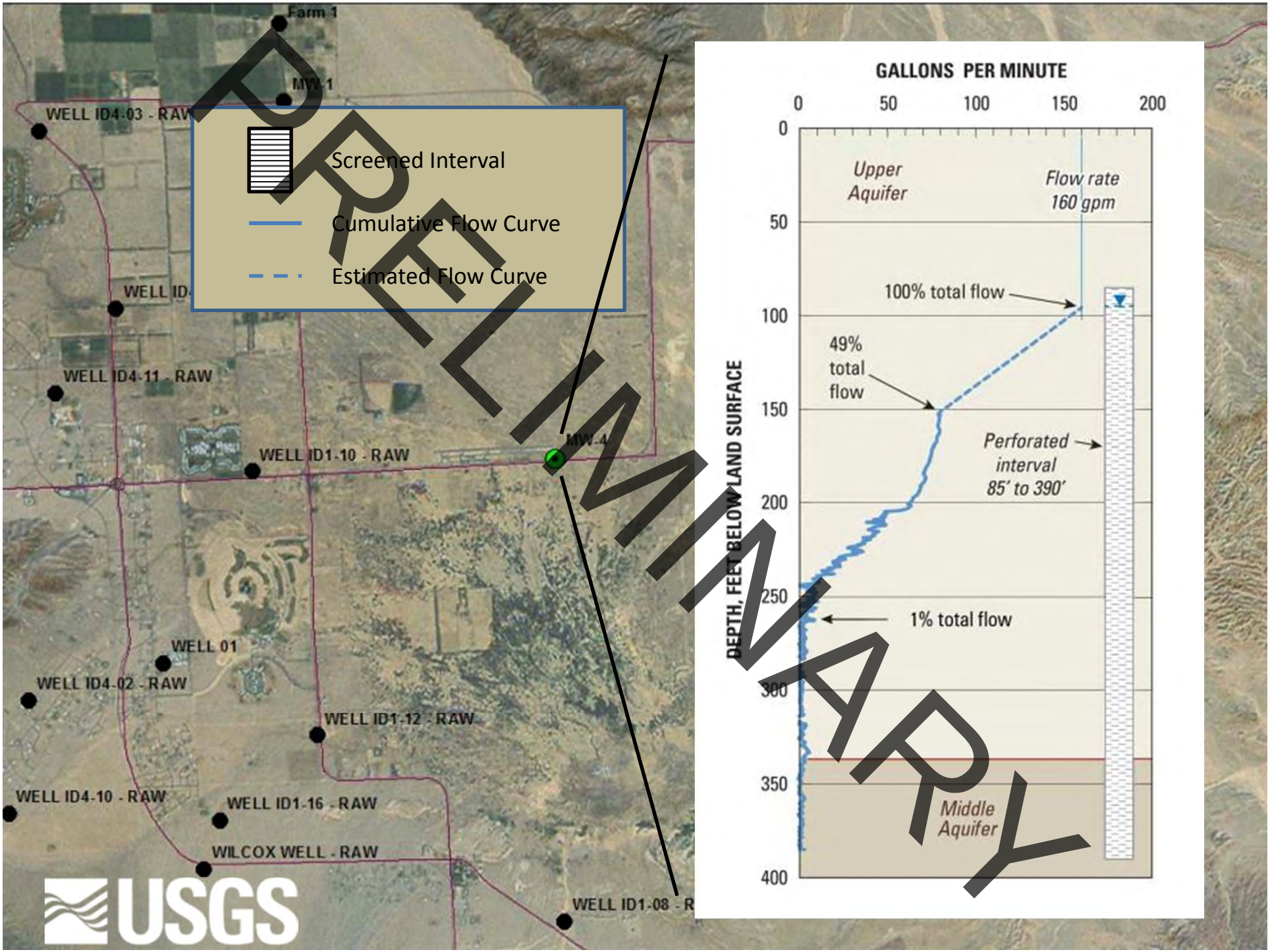
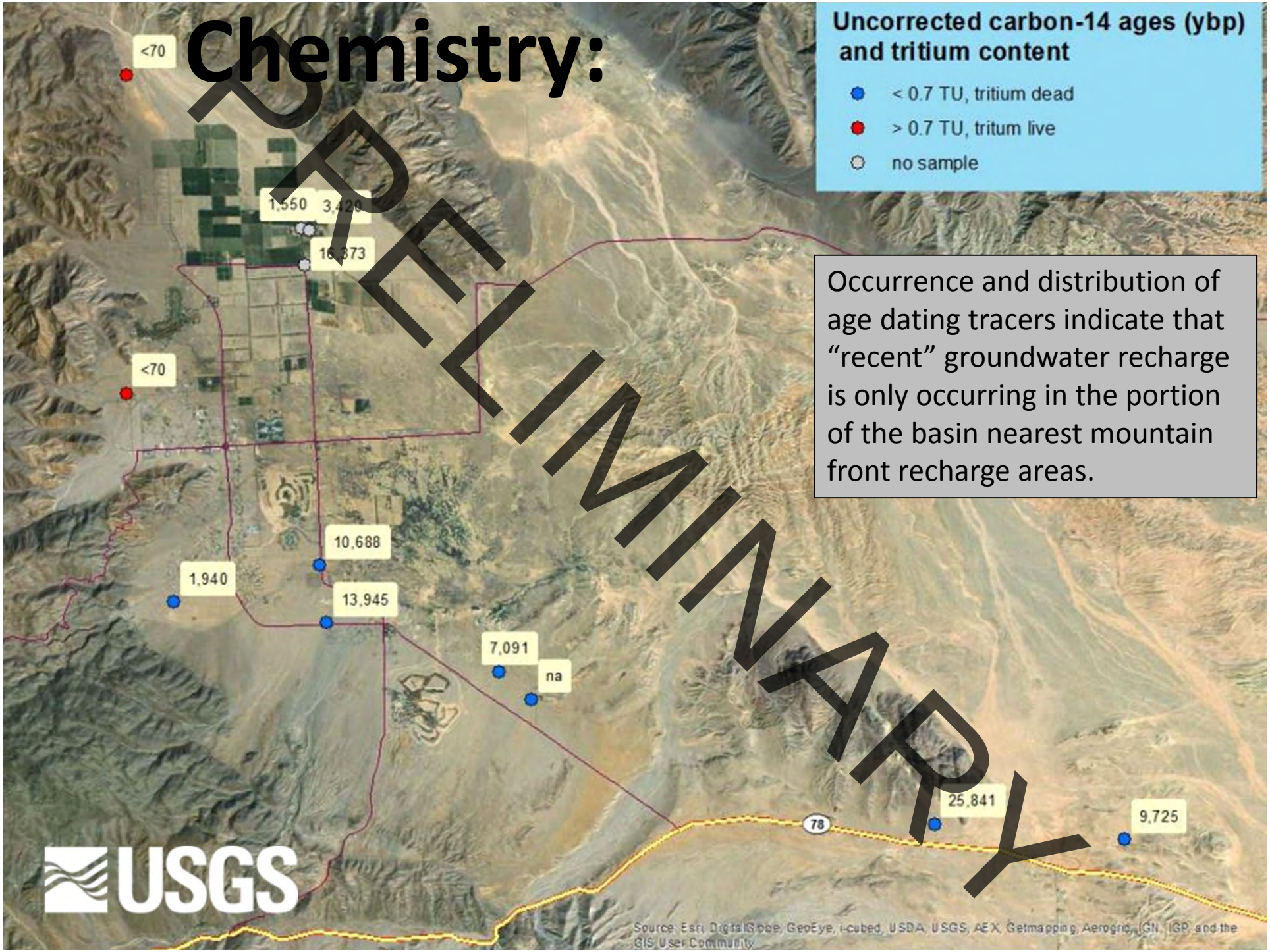
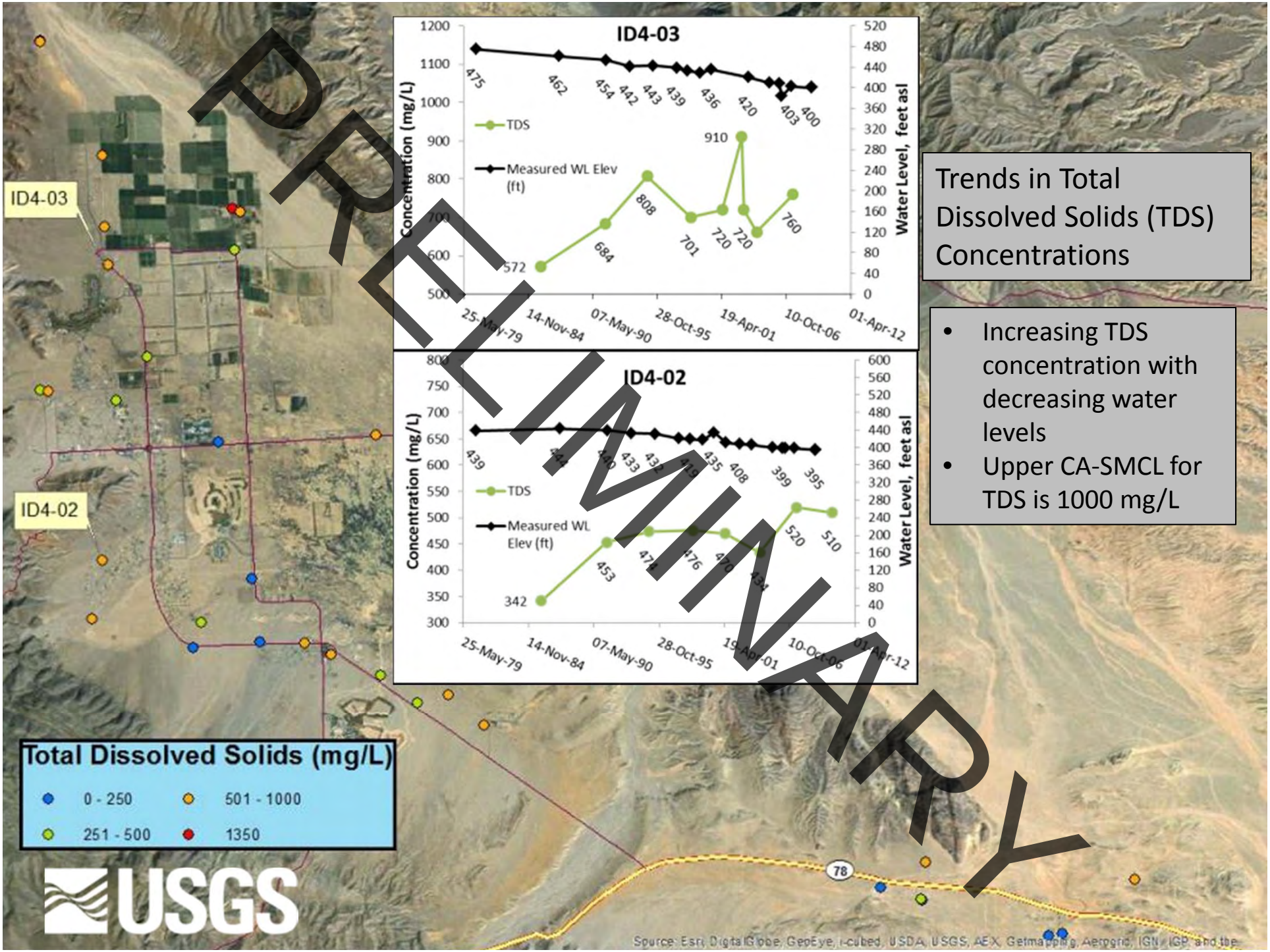

Farm 1
MW-1
WELL ID4-03 - RAW
WELL ID4-11 - RAW
WELL ID1-10 - RAW
MW-4
WELL 01
WELL ID4-02 - RAW
WELL ID1-12 - RAW
WELL ID4-10 - RAW
WELL ID1-16 - RAW
WILCOX WELL - RAW
WELL ID1-08 - R
Screened Interval
Cumulative Flow Curve
Estimated Flow Curve
GALLONS PER MINUTE
0
50
100
150
200
DEPTH, FEET BELOW LAND SURFACE
0
50
100
150
200
250
300
350
400
Upper Aquifer
Flow rate 160 gpm
100% total flow
49% total flow
Perforated interval 85' to 390'
1% total flow
Middle Aquifer
USGS
PRELIMINARY

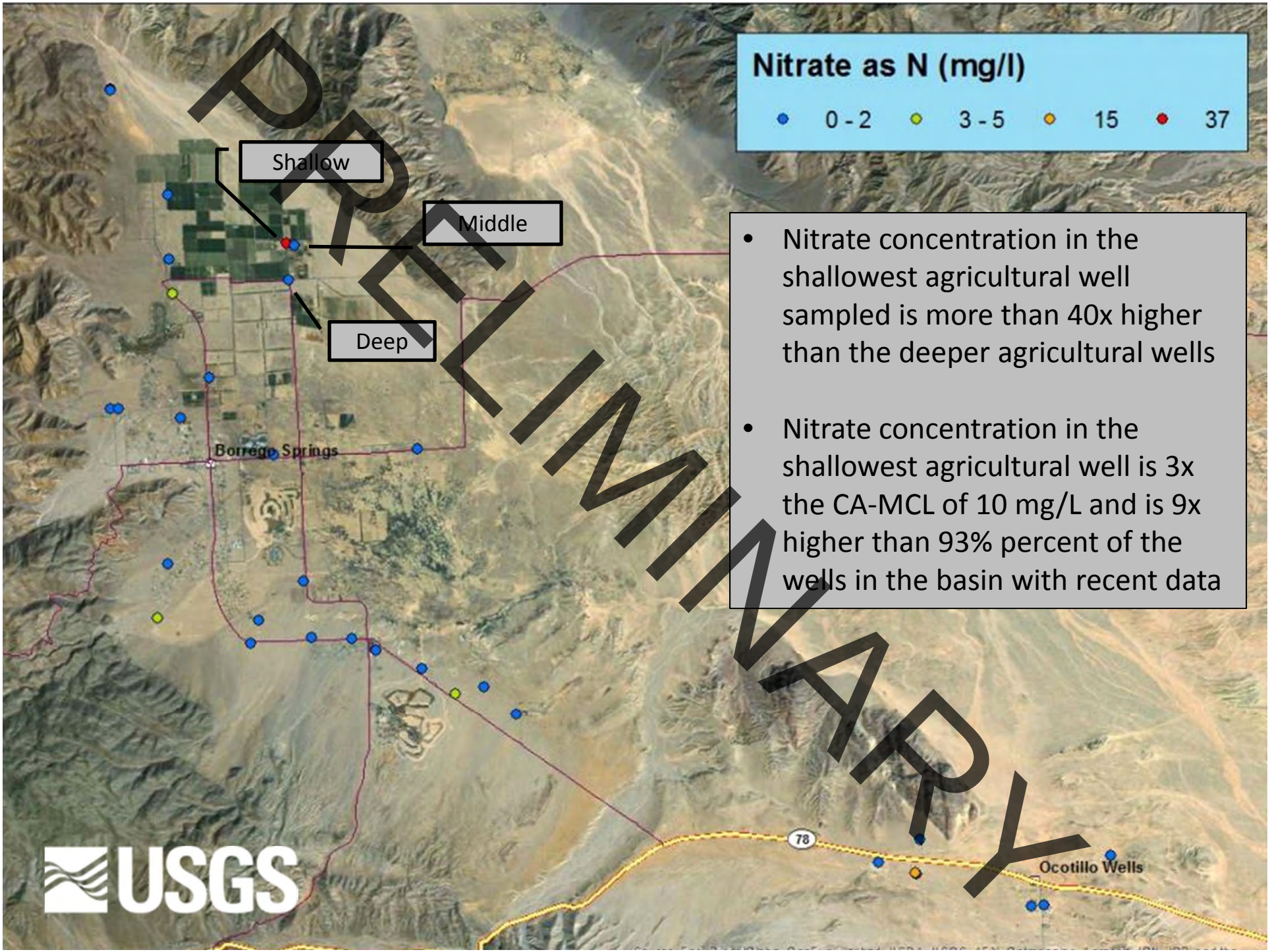
# Chemistry:




PRELIMINARY

Occurrence and distribution of age dating tracers indicate that “recent” groundwater recharge is only occurring in the portion of the basin nearest mountain front recharge areas.


ID4-03
ID4-02
ID4-03
Concentration (mg/L)
Water Level, feet asl
TDS
Measured WL Elev (ft)
475 462 454 442 443 439 436 420 403 400
572 684 808 701 720 720 910 760
25-May-79 14-Nov-84 07-May-90 28-Oct-95 19-Apr-01 10-Oct-06 01-Apr-12
ID4-02
Concentration (mg/L)
Water Level, feet asl
TDS
Measured WL Elev (ft)
439 433 435 408 399 395
342 453 474 476 470 520 510
25-May-79 14-Nov-84 07-May-90 28-Oct-95 19-Apr-01 10-Oct-06 01-Apr-12
Trends in Total Dissolved Solids (TDS) Concentrations
• Increasing TDS concentration with decreasing water levels
• Upper CA-SMCL for TDS is 1000 mg/L
Total Dissolved Solids (mg/L)
0 - 250
251 - 500
501 - 1000
1350
78
USGS
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the
PRELIMINARY



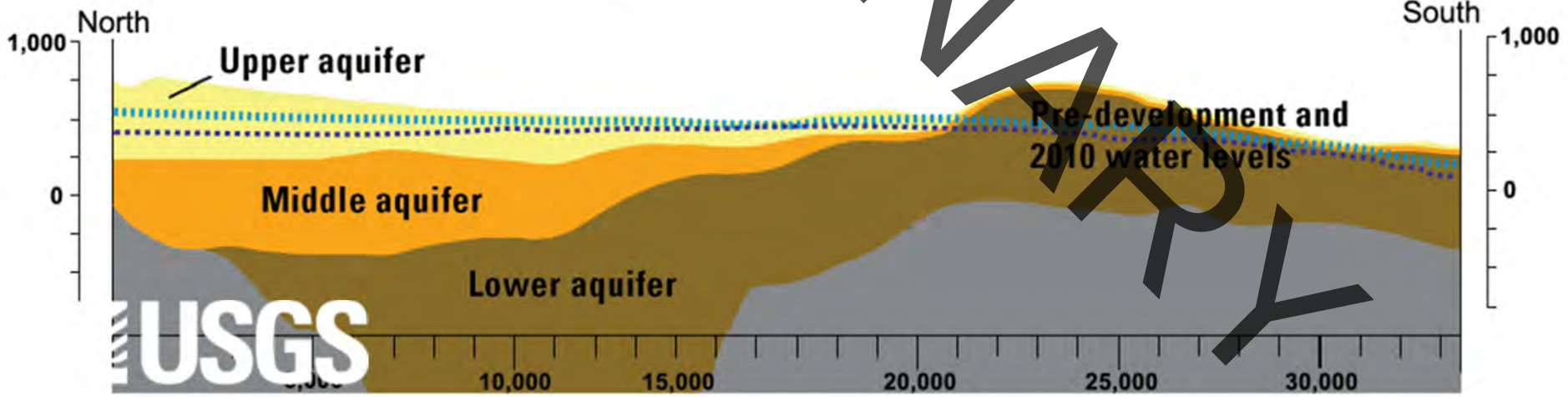

- Nitrate concentration in the shallowest agricultural well sampled is more than 40x higher than the deeper agricultural wells
- Nitrate concentration in the shallowest agricultural well is 3x the CA-MCL of 10 mg/L and is 9x higher than 93% percent of the wells in the basin with recent data

# Predictive simulations:

## 3 Scenarios

(1) No action 50 years
(2) 2013 SCENARIO (Ag red. 40%; Golf red. 40%; Muni red. 30%)
(3)WATER USAGE REDUCTION TO REACH SUSTAINABILITY
(Ag red. 80%; Golf red. 80%; Muni red. 48%)





# Basic groundwater budget

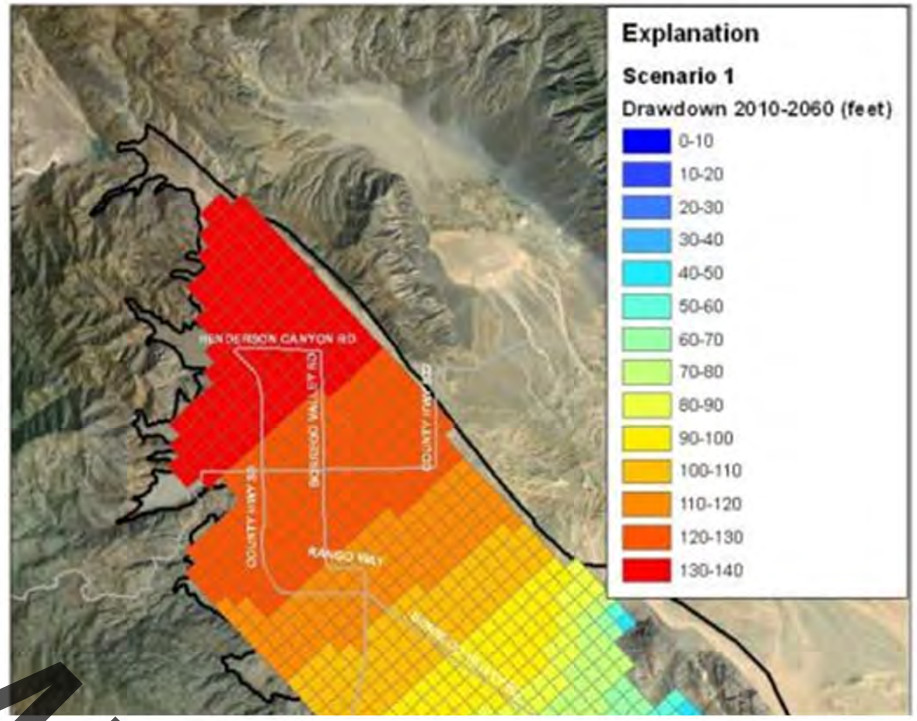


| **Preliminary Groundwater Budget (acre-feet per year)** | | | | |
|---|---|---|---|---|
| **IN** | **Pre-development** | **Current** | **Scenario** | **Sustainable** |
| Natural Recharge | 4,800 | 4,800 | 4,800 | 4,800 |
| **OUT** | | | | |
| Flow out southern end | 900 | 900 | 900 | 900 |
| Natural ET | 3,900 | 0 | 0 | 0 |
| Wells | | 19,000 | 12,000 | 3,900 |
| | | | | |
| **Storage Change** | 0 | -15,100 | -8,100 | 0 |

USGS

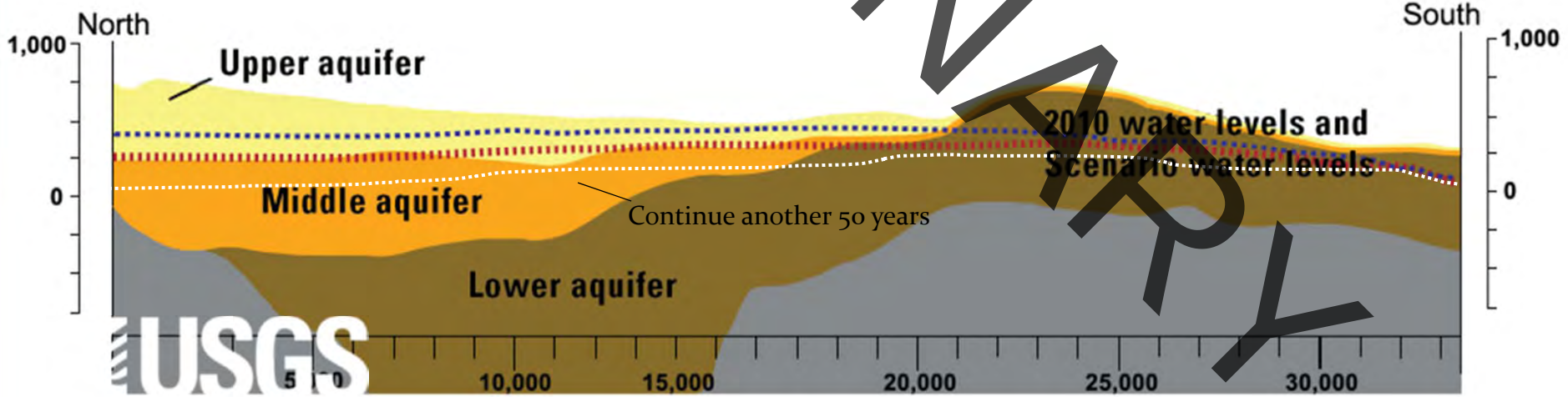
# Scenario 1:

## No action 50 years
Continue current pumping rates



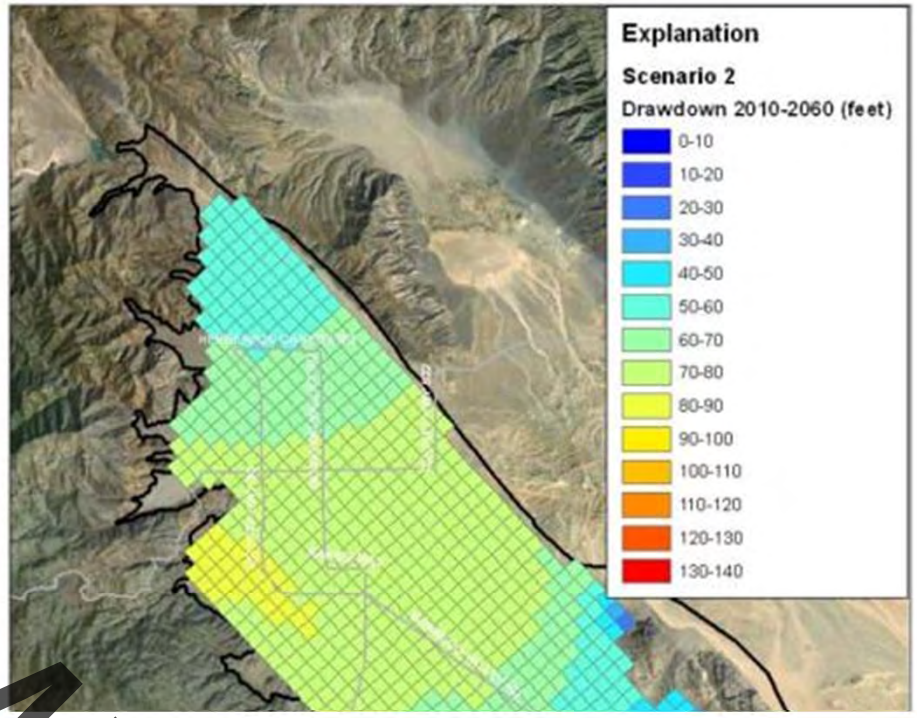


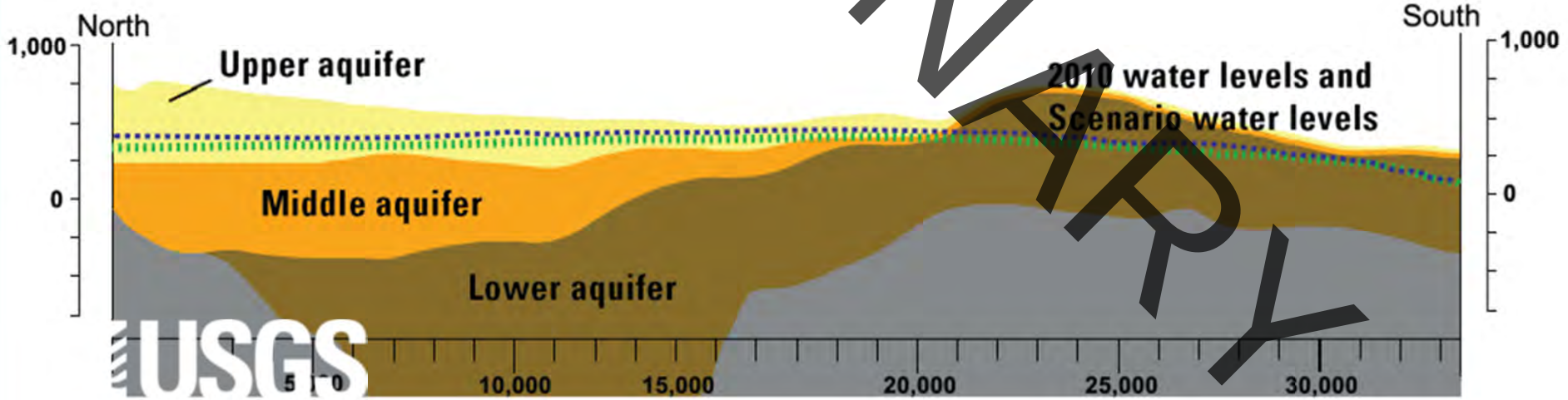

## Scenario 1



# 2013 Scenario:

- Agriculture reduced 40%
- Golf reduced 40%
- Municipal reduced 30%



# Change in storage through time

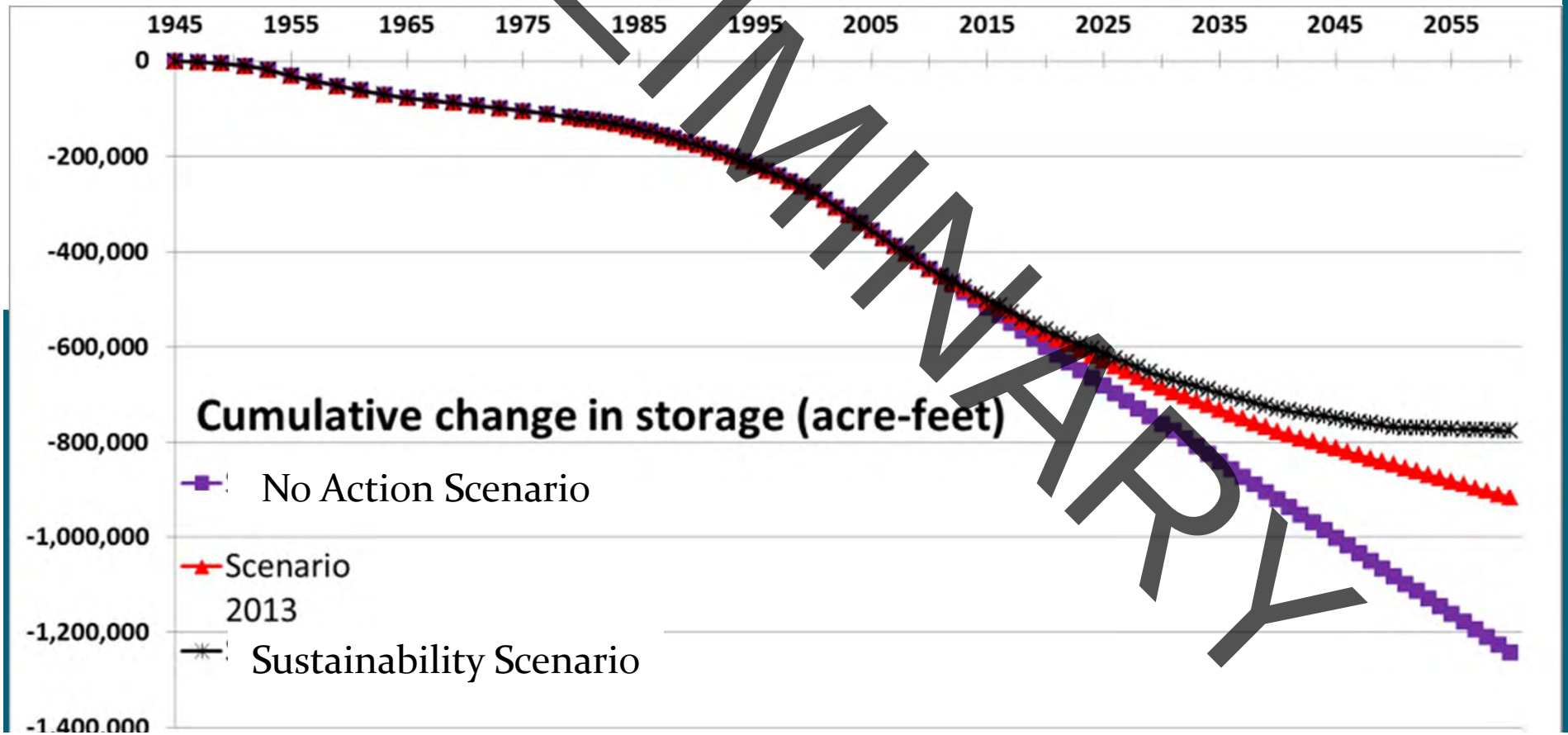
(1) No action 50 years

(2) 2013 Scenario

(Ag red. 40%; Golf red. 40%; Muni inc. 30%)

(3) WATER USAGE REDUCTION TO REACH SUSTAINABILITY

(Ag red. 80%; Golf red. 80%; Muni red. 48%)



# Conclusions:

## (1) Water Budget

- Currently, more water being pumped than recharging basin
- As a result, water levels are declining and will continue to decline until this changes
- The rate of decline may increase and the water quality may deteriorate with continual lowering of water levels

## (2) Subsidence

- Currently, small amount of subsidence is happening
- Not likely to be a big issue in this basin now or in the future

## (3) Water Quality

- "Recent" natural groundwater recharge is only reaching the basin near mountain front recharge areas
- TDS concentrations are increasing as water levels decrease indicating that TDS may be a water quality issue in the future
- The distribution of nitrate in groundwater indicates that agricultural operations are impacting "shallow" water quality in the northern portion of the basin

## (4) Final thought

- The issue isn't that the basin will run out of water, but that water is likely to become more expensive
  - Costs from deepening wells, increasing number of wells to get the same yield, treating for water quality issues, etc.

# Plans:

(1) Complete interpretive report,

(2) Construct and analyze any additional predictive simulations identified by Borrego Water District such as, and

- Artificial recharge
- Reduced municipal or recreational pumpage
- Fallow agriculture land
- Import water and change pumping patterns



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