Groundwater Quality Monitoring and Assessment in California

State Board Meeting
March 15, 2011

John Borkovich, PG
GAMA Program
State Water Resources Control Board

Water Boards

GAMA is:

Groundwater
Ambient
Monitoring and
Assessment

Water Boards

Why GAMA?

- California Relies Heavily on Groundwater
  - 35% of water for irrigation and public use is from groundwater
  - 43% of Californians are served by groundwater
  - Many communities rely 100% on groundwater
  - Contaminated groundwater results in treatment costs, well closures, and new well construction which increases costs for consumers

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Why GAMA?

- Water Quality Testing is Not Complete
  - Water quality from 16,000 wells used for public supply is regulated and regularly tested (36M people)
  - Water quality from 600K private domestic wells is not regulated and is rarely tested (1.4M people)

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Why GAMA?

- Legislature's concern about groundwater quality
- Budget Act of 2000
- Water Code Section 10780
  - Groundwater Quality Monitoring Act of 2001 - (AB 599, Liu)
  - Groundwater Quality Monitoring –

    (2008. AB 2222, Caballero)

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GAMA Program Functions

- Coordinate with water agencies
- Collect new data
- Combine new and existing data

  (water quality, water level, contaminant sources)
- Assess groundwater quality
- Serve information to the public

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GAMA Program

- Projects staffed by State Board, USGS, LLNL to assess CA groundwater quality
- Well owners volunteer wells to be sampled
- Over 4,000 wells sampled since 2000
- GAMA tests groundwater for:
  - Drinking water standard contaminants
  - Hundreds of contaminants for trace levels

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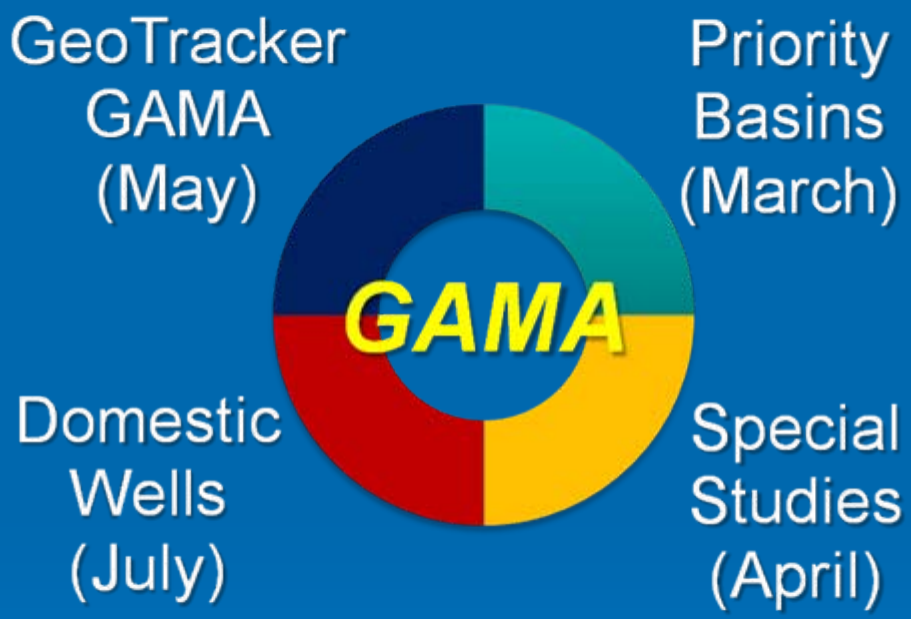
GAMA Program
Current Projects & Schedule for Board Meetings



Sampling conducted in *Voluntary Cooperation* with Participants

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Status: Priority Basins Project

- First statewide sampling cycle nearly complete
- 2,200 wells sampled
- Dozens of Reports, Fact Sheets published

- *USGS Presentation on Findings - NEXT*

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Status: Special Studies - LLNL

- Studies on nitrates from dairies, fertilizer, human wastewater
- Wastewater Indicator studies on effect of septic systems on shallow groundwater and areas influenced by recycled water
- Changes in chemistry of groundwater by recharge of surface water

LLNL Presentation on Findings – April 19

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Status: Domestic Well Project

- 1,067 Wells sampled by Board staff from 2003-09
- Key Results - *El Dorado, Yuba, Tehama, Tulare, San Diego Counties*
  - Total Coliform: 28% wells tested Positive
  - Nitrate: Average 10% wells tested above MCL
  - Nitrate: 41% Tulare County wells tested above MCL
  - Radionuclides: 33% San Diego above MCL
- Monterey County sampling to begin in April

Presentation on Findings – July 19

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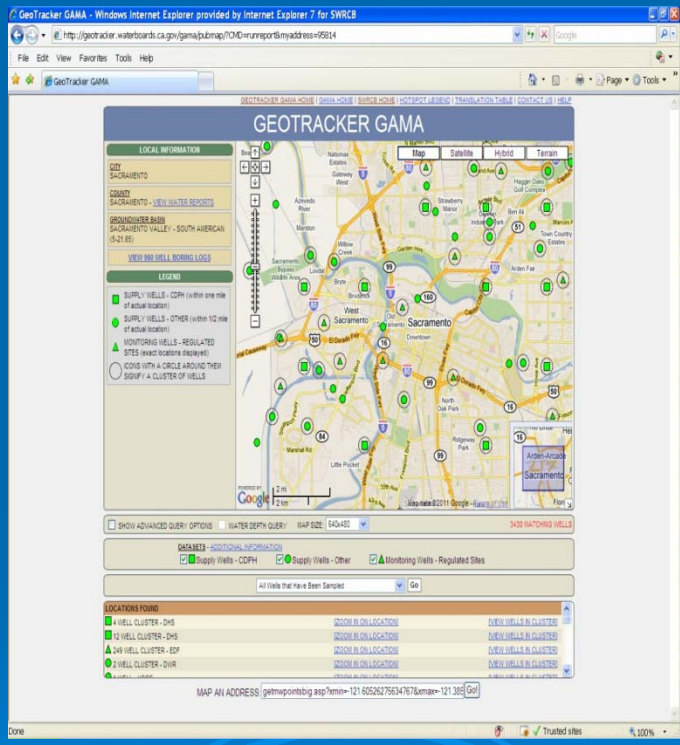
GeoTracker GAMA:
Groundwater Quality Data System

- Fulfills AB599 intent: Central Data Source
- Data from CDPH, USGS, LLNL, DWR, DPR, State and Regional Water Boards
- Water quality, water levels, contaminant sources, groundwater publications
- Groundwater quality data collected with State funds must comply with AB 599 - but electronic submittal not specified



Presentation of System – May 17

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In Summary:

- Most land uses negatively affect groundwater
- Shallow groundwater is poor in many areas
- Deeper water has better quality, but contains several contaminants-usually in trace amounts
- To sustain groundwater resource and reduce negative trend, action is needed
- Monitoring groundwater quality is critical to track impacts over time

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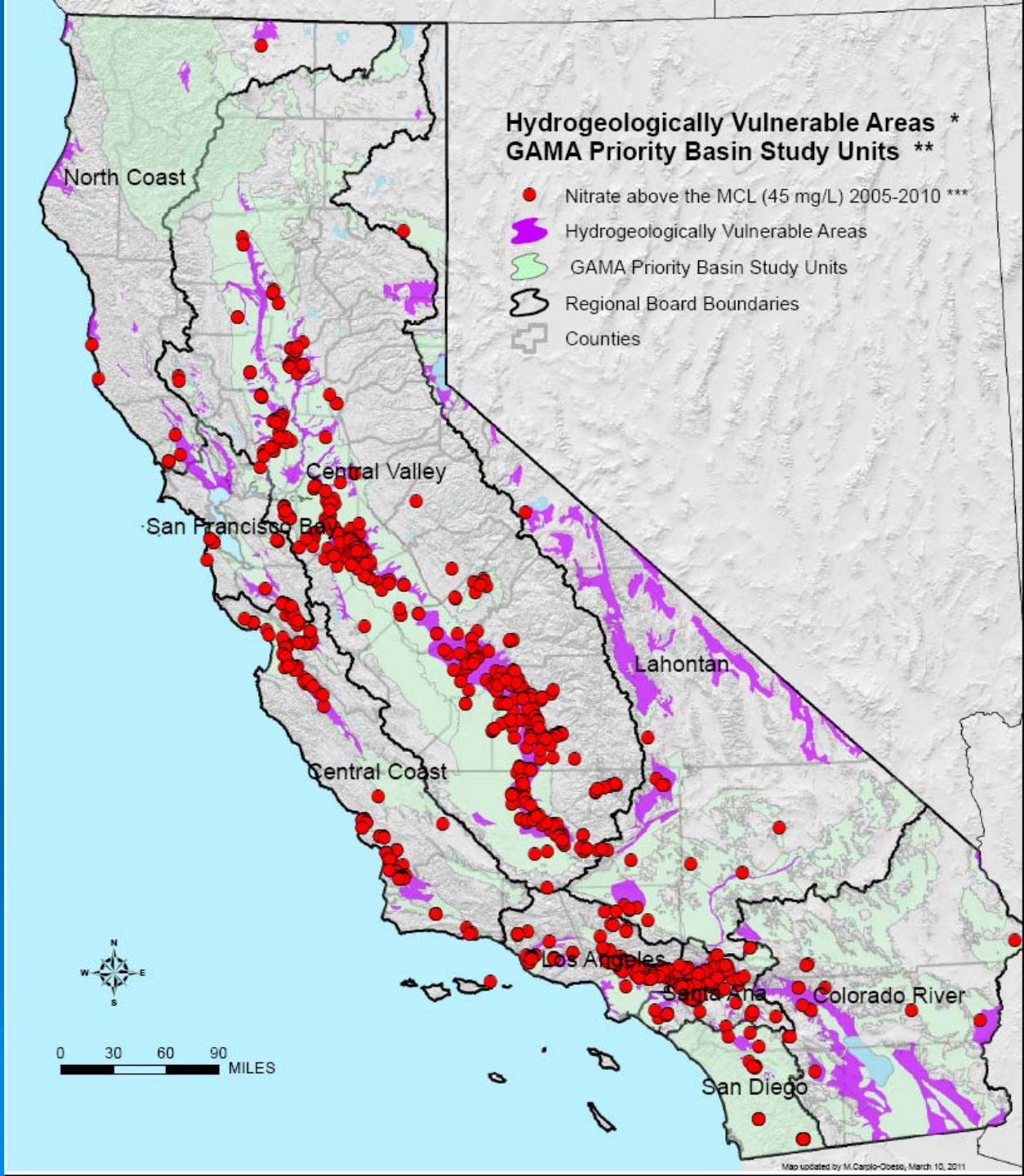
Hydrogeologically Vulnerable Areas and GAMA Priority Basins

Nitrate above MCL in Public Supply Wells



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Future Funding

- Bond Funds run out 2013
- Without replacement funding,
  Priority Basin Project funding will end
- AB 2222 Report to Legislature:
  Options to extend GAMA to 2024

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GAMA Priority Basins Project

Dr. Kenneth Belitz, USGS

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FINDINGS FROM IMPLEMENTATION OF STATE WATER BOARD GROUNDWATER AMBIENT MONITORING AND ASSESSMENT PROGRAM (GAMA) PRIORITY BASIN PROJECT

Kenneth Belitz, USGS

Presentation to

State Water Resources Control Board

Board Meeting Session – Division of Water Quality

March 15, 2011

ACKNOWLEGEMENTS

- 1600 well owners, voluntary participation
- Water resource agencies & purveyors
- USGS GAMA scientists and technicians
- Water Board GAMA staff

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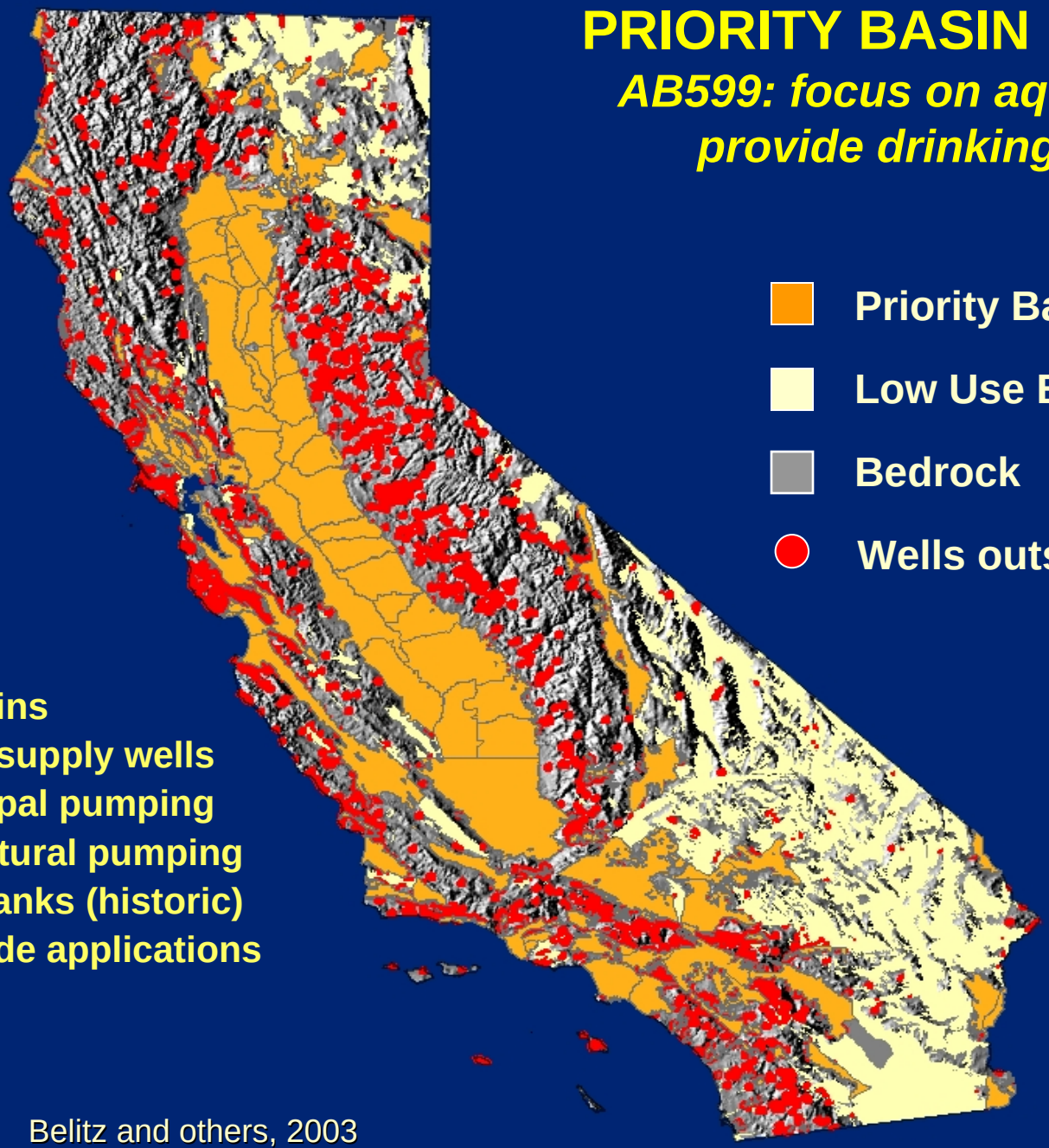
PRIORITY BASIN PROJECT

AB599: focus on aquifers that provide drinking water



- Priority Basins (116)
- Low Use Basins (356)
- Bedrock
- Wells outside basins

Priority basins
95% public supply wells
99% municipal pumping
90% agricultural pumping
90% leaky tanks (historic)
90% pesticide applications
60% area

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Belitz and others, 2003

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35 STUDY UNITS

May 2004 – February 2011

Priority Basins

Additional Study Areas

Sampling completed in

- 116 Priority Basins
- ~ 50 Low-Use Basins
- 6 areas outside of basins

Remaining sampling tasks

- 3 areas outside of basins
- Trends

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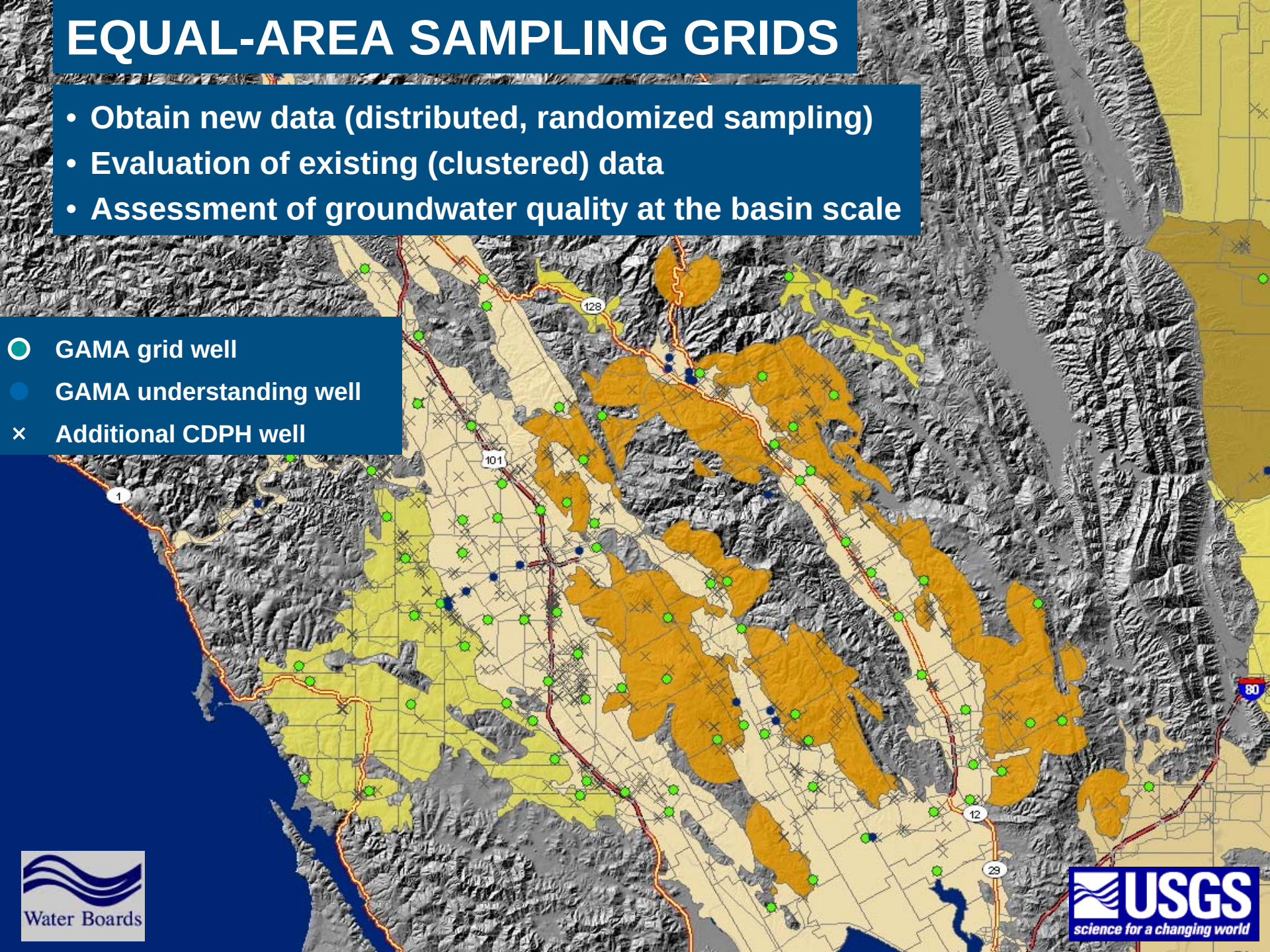
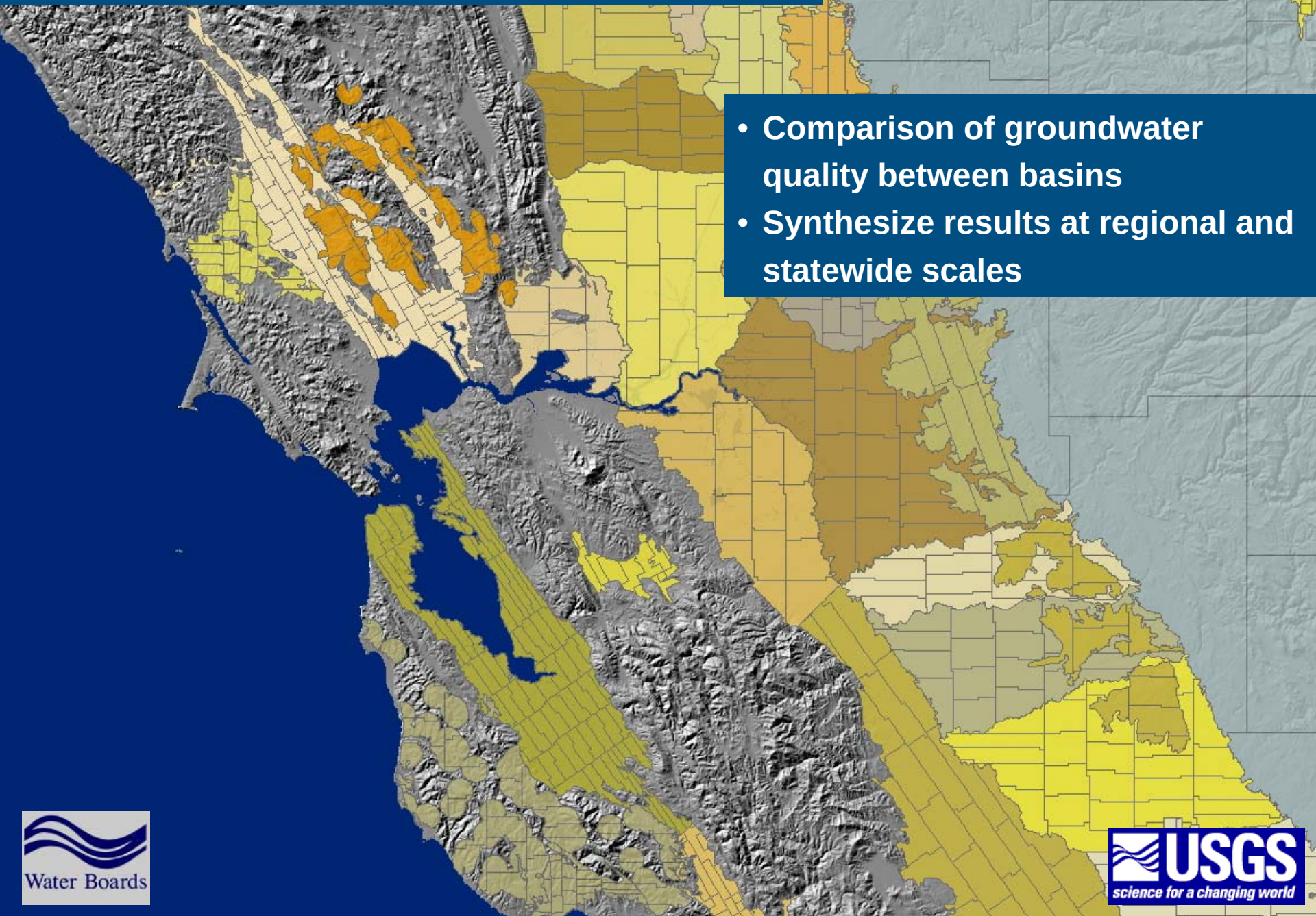
EQUAL-AREA SAMPLING GRIDS

- Obtain new data (distributed, randomized sampling)
- Evaluation of existing (clustered) data
- Assessment of groundwater quality at the basin scale



EQUAL-AREA SAMPLING GRIDS



- Comparison of groundwater quality between basins
- Synthesize results at regional and statewide scales

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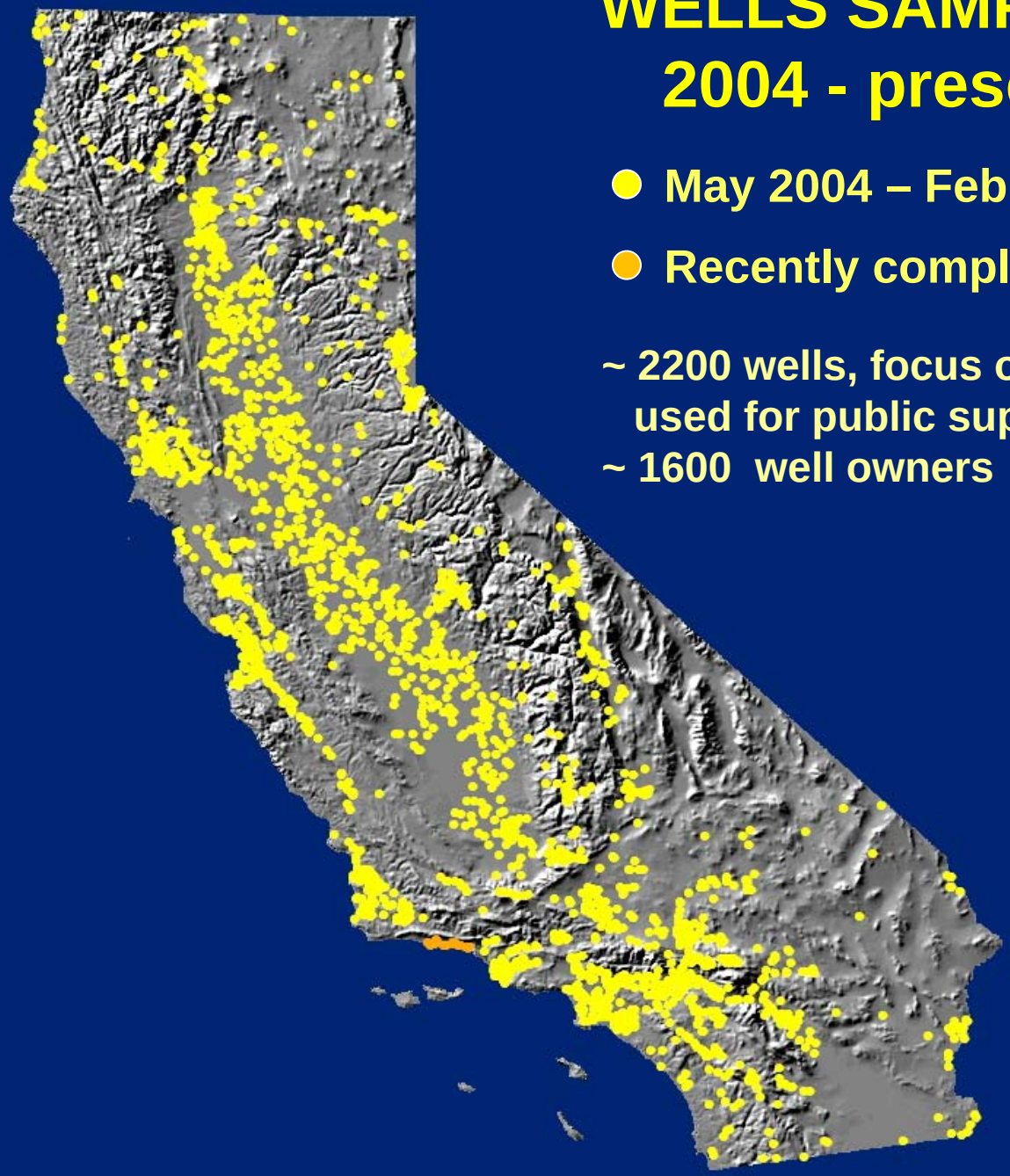
WELLS SAMPLED 2004 - present



- May 2004 – February 2010
- Recently completed

~ 2200 wells, focus on depth zone used for public supply
~ 1600 well owners

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Comparison of GAMA and CDPH Title 22

Constituent Class	CDPH – Title 22		GAMA-PBP	
	Number of compounds	Median reporting limit (µg/L)	Number of compounds	Median reporting limit (µg/L)
Volatile organic compounds (VOC)	**32**	**0.5**	**85**	**0.06**
Pesticides	**34**	**1**	**83**	**0.01**
Perchlorate	**1**	**4**	**1**	**0.1**
Hydrologic tracers & indicators	**1**	**--**	**~ 20**	**--**

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ASSESSMENT REQUIRES CONTEXT

- **Regulatory and non-regulatory health-based benchmarks**

  (1) Maximum Contaminant Levels, Action Levels, Treatment Technique Levels (3) Notification Levels, (4) Health Advisory Levels, (5) Risk Specific Dose

- **Aesthetic benchmarks**

  (2) Secondary Maximum Contaminant levels

- **Relative concentrations**

  environmental concentration divided by benchmark

  similar to Health-Based Screening Level Quotients

  (Toccalino and Norman, 2006)

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AQUIFER-SCALE PROPORTION

Belitz and others, 2010

HIGH relative concentration > 1

MODERATE

0.5 < rel. conc. < 1 for inorganic
0.1 < rel. conc. < 1 for organic

LOW rel. conc. < 0.5 for inorganic
rel. conc. < 0.1 for organic

Organic constituents are generally introduced by people

Inorganic constituents occur naturally or can be introduced by people

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AQUIFER-SCALE PROPORTION

Belitz and others, 2010

HIGH

MODERATE

LOW

- Primary focus is on depth zone used for public supply
- Concentrations in shallower and deeper groundwater can differ from concentrations in the zone tapped by public supply wells
- GAMA evaluates untreated water, not water delivered to consumers

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AQUIFER-SCALE PROPORTION

Belitz and others, 2010

Constituent

Vanadium

Class

Trace elements

Group of classes

Inorganics

- Primary focus is on depth zone used for public supply
- Concentrations in shallower and deeper groundwater can differ from concentrations in the zone tapped by public supply wells
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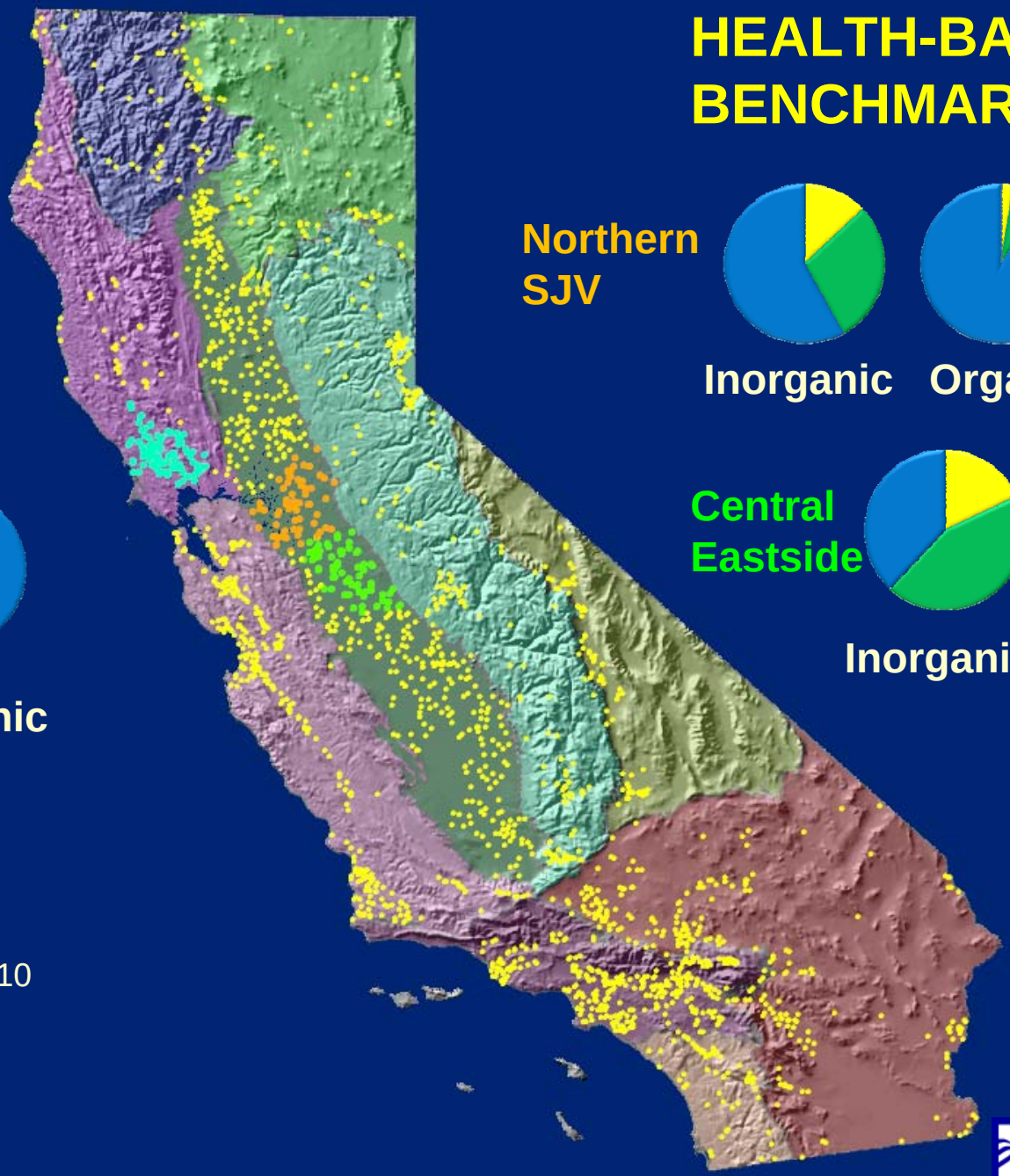
HEALTH-BASED BENCHMARKS

Relative Conc.

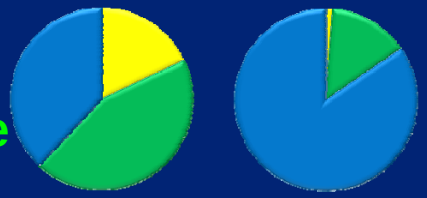
- High
- Moderate
- Low



Northern SJV

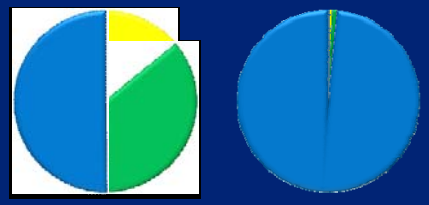
Inorganic Organic

Central Eastside



Inorganic Organic

North SF Bay



Inorganic Organic

Bennett and others, 2010
Kulongoski and others, 2010
Landon and others, 2010

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GAMA evaluates untreated water from the aquifer system

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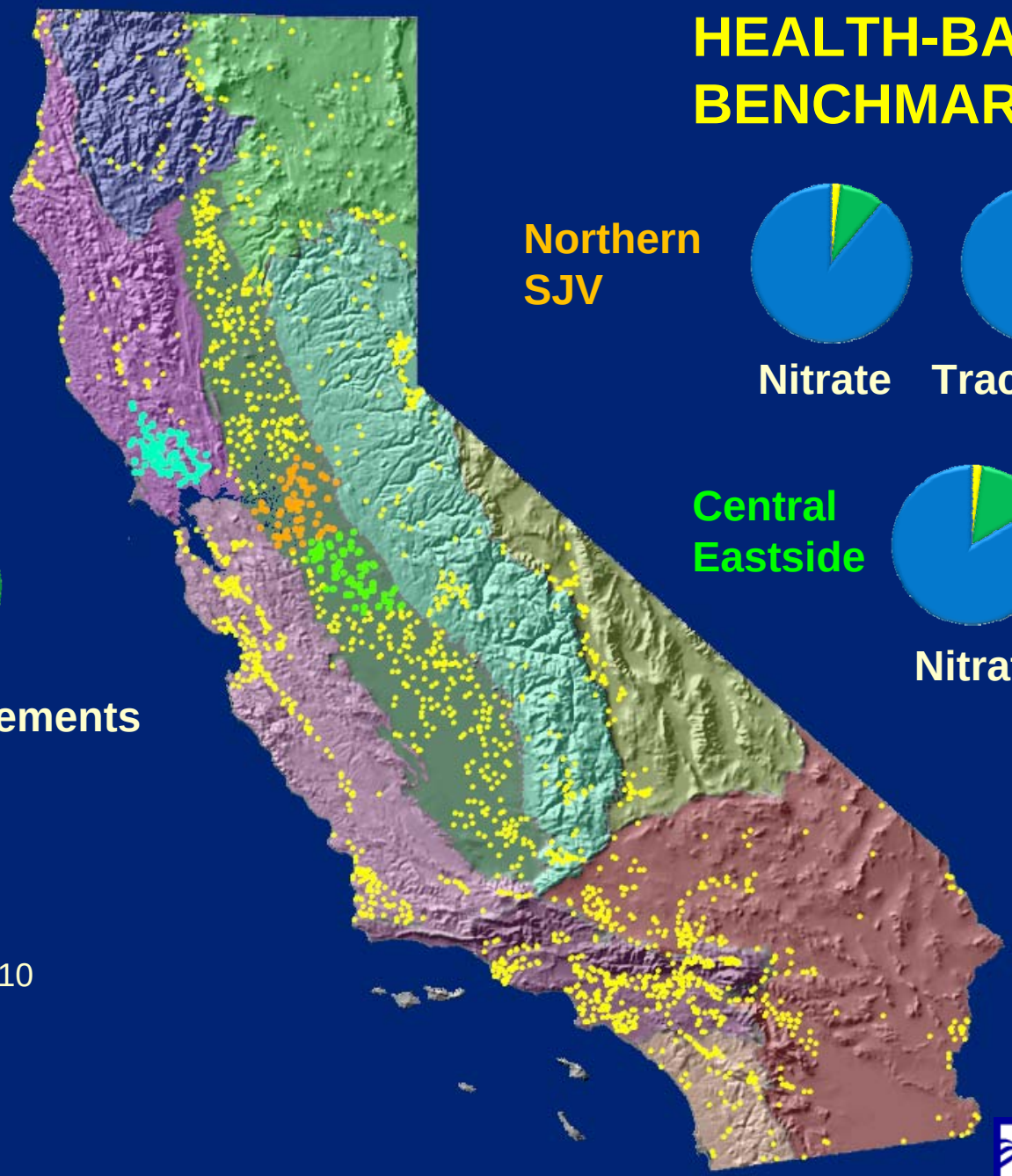
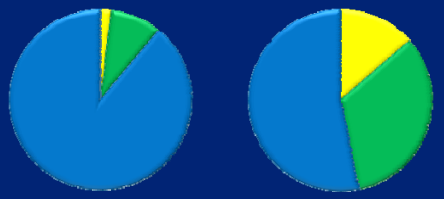
HEALTH-BASED BENCHMARKS

Relative Conc.

- High
- Moderate
- Low

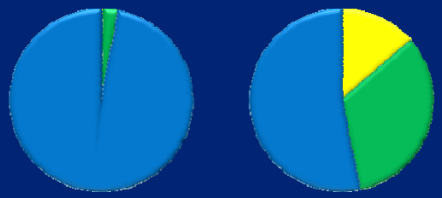


Northern SJV



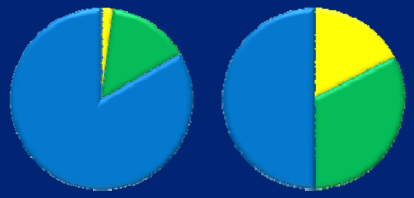
Nitrate Trace elements

North SF Bay



Nitrate Trace elements

Central Eastside



Nitrate Trace elements

Bennett and others, 2010
Kulongoski and others, 2010
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TRACE ELEMENTS ABOVE HEALTH-BASED BENCHMARKS

- Arsenic
- Boron, Uranium, Vanadium, Molybdenum, Fluoride
- Strontium, Lead

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GAMA evaluates untreated water from the aquifer system

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SCIENTIFIC FINDINGS

- **High concentrations of uranium in the Central Valley are due to the mobilization of naturally-occurring uranium by downward-moving, bicarbonate-rich irrigation return flows. Elevated bicarbonate is a result of plant productivity. In the future, an increasing number of public supply wells are expected to be affected by high concentrations of uranium.** [Jurgens and others, 2010]

- **High concentrations of vanadium are associated with sediment derived from mafic, igneous source rock and alkaline conditions.** [Wright and Belitz, 2010]

- **Perchlorate can occur naturally in deep groundwater at low concentrations (0.1 to 0.5 μg/L) under a range of climatic conditions (arid to humid). Concentrations above 4.0 μg/L are unlikely to be natural.** [Fram and Belitz, 2011]

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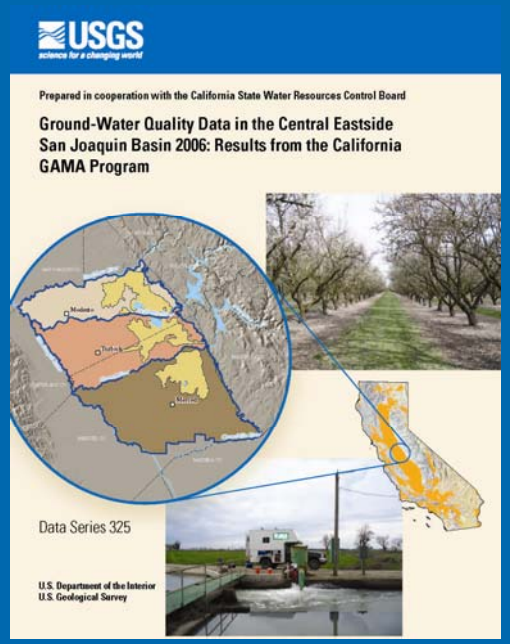
STUDY UNIT PUBLICATIONS

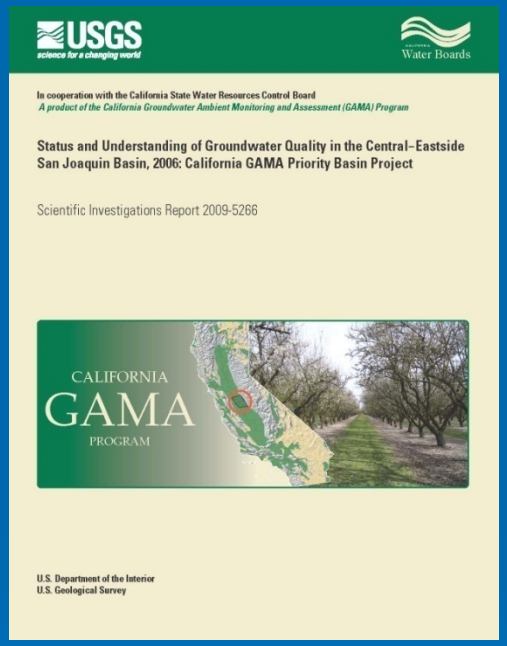
Data Series Report



Data collected by USGS

28 published, to date

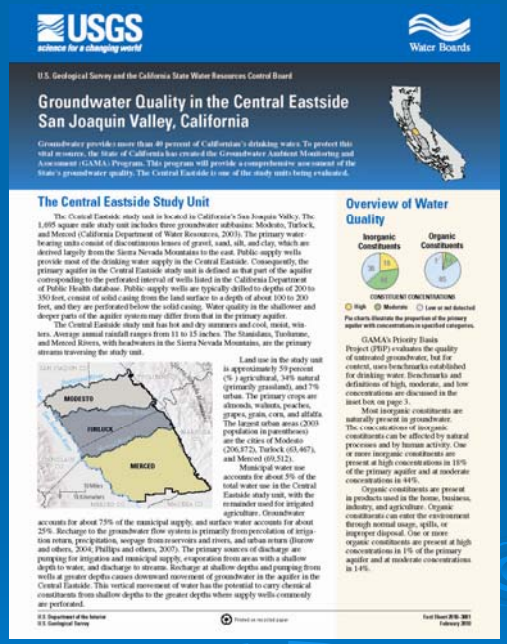
Scientific Investigations Report



Assessment based on USGS + CDPH data

3 published, to date

Fact Sheet



Communicate results

3 published, to date

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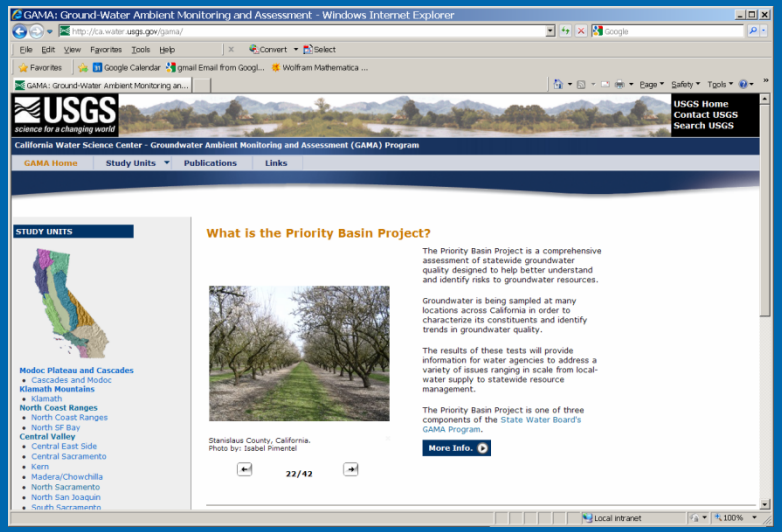
GAMA PRIORITY BASIN PROJECT COMMUNICATION

Kick-off and Wrap-up Meetings

San Diego, May 2005

http://ca.water.usgs.gov/gama



with link to Waterboard GAMA website

Customized Well Owner Reports

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Well Owner Report

Detected constituents on the Intermediate *schedule*

Gama ID MADCHOW-01 *Sample Date* 4/14/2008 @ 920

Parameter Code	*Parameter Name*	*Value*	*Units*	*Threshold Value*	*Threshold Type*
00010	Water Temperature	20.5	deg Celsius		
00095	Specific Conductance, field	485	µS/cm	900 (1600)	SMCL-CA
00400	pH, field	6.8	standard units	6.5 - 8.5	SMCL-US

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PRELIMINARY CONCLUSIONS

- Health-based benchmarks, relative concentrations, and "aquifer-scale proportions" provide a context for comparing different constituents and different study units
- From the perspective of public supply aquifers (statewide), inorganic constituents are more prevalent at high concentrations than human-introduced organic constituents
- From the perspective of public supply aquifers (statewide), naturally occurring trace elements and radioactivity are more prevalent at high concentrations than human-introduced nitrate
- The prevalence of high concentrations of uranium, nitrate, and other human-introduced constituents may increase in public supply aquifers in the future
- Results in some basins may vary from statewide patterns. For example, nitrate, perchlorate and solvents are prevalent at high concentrations (in the depth zone used for public supply) in some basins

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Selected references

with the exception of Toccalino and Norman (2006), all publications are products of the GAMA-PBP project

- Belitz, K., Dubrovsky, N.M.; Burow, K.; Jurgens, B.; and Johnson, T, 2003, "Framework for a ground-water quality monitoring and assessment program for California," USGS Water-Resources Investigation Report 03-4166, 78 p.
- Toccalino, P., Norman, J.F. 2006. Health-based screening levels to evaluate U.S. Geological Survey ground water quality data, Risk Analysis, 25(5), 1339-1348.
- Belitz, K, Bryant Jurgens, Matt Landon, Miranda Fram, and Tyler Johnson, 2010, "Aquifer-Scale Proportion in Regional Assessment of Ground-Water Quality," Water Resources Research, 46, W11550, doi:10.1029/2010WR009321.
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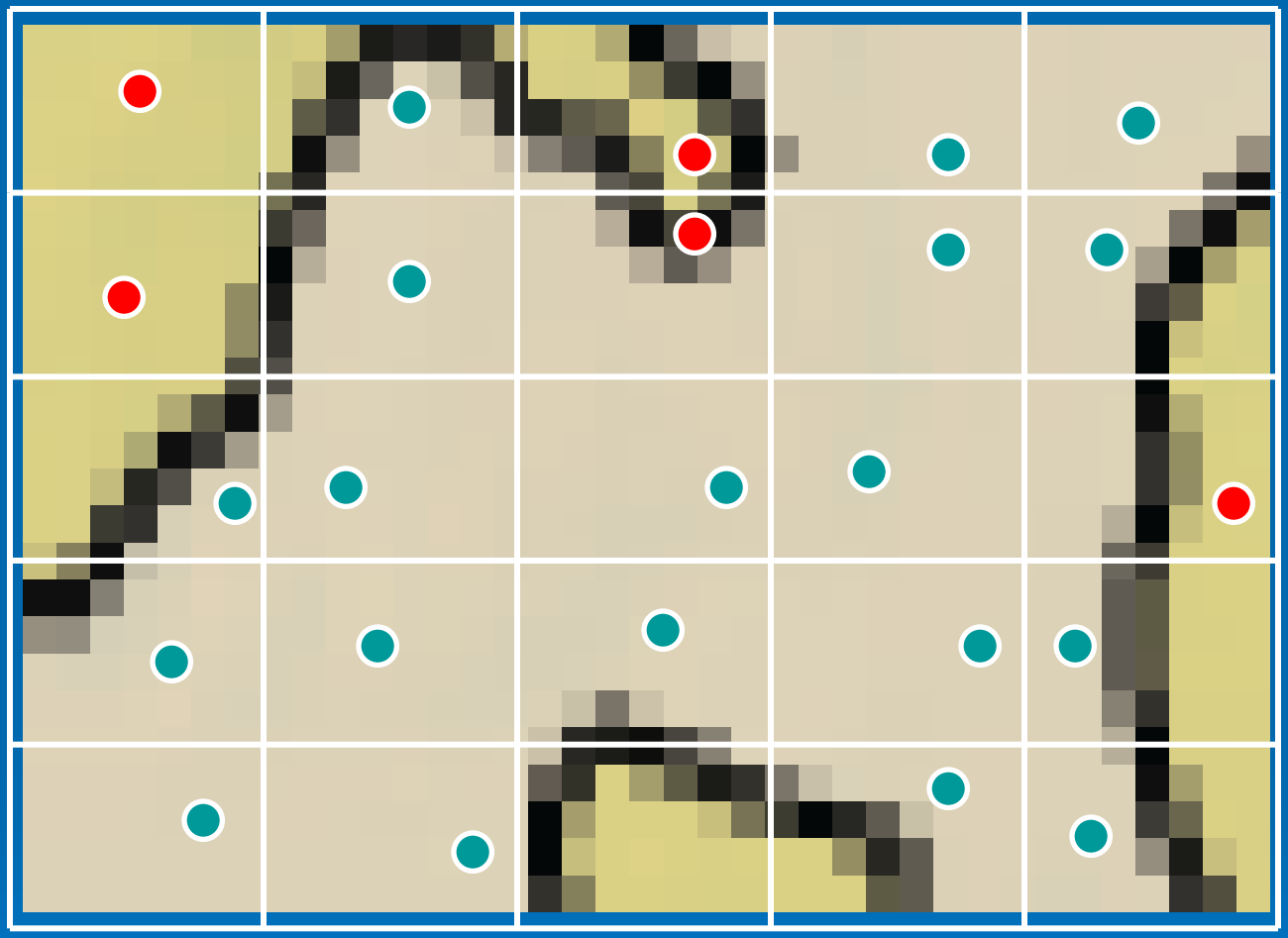
- Wright, Michael T. and Belitz, Kenneth 2010, "Factors Controlling the Regional Distribution of Vanadium in Groundwater," Groundwater, 48(4), p.515-525.
- Landon, Matthew K., Kenneth Belitz, Bryant R. Jurgens, Justin T. Kulongoski, and Tyler Johnson, 2010, Status and Understanding of Ground-Water Quality in the Central-Eastside San Joaquin Basin, 2006: California GAMA Program's Priority Basin Project, U.S. Geological Survey Scientific Investigations Report 2009-5266, 97 p.
- Kulongoski, Justin T., Belitz, Kenneth, Landon, M.K, Farrar, Christopher, 2010, Status and Understanding of Groundwater Quality in the North San Francisco Bay Groundwater Basins, 2004: California GAMA Priority Basin Project: U.S. Geological Survey Scientific Investigations Report 2010-5089, 88p.
- Bennett, G.L., V, Fram, M.S., Belitz, Kenneth, and Jurgens, B.C., 2010, Status and understanding of groundwater quality in the Northern San Joaquin Basin, 2005: California GAMA Priority Basin Project: U.S. Geological Survey Scientific Investigations Report 2010-5175, 82 p.
- Fram, Miranda and Kenneth Belitz, 2011, Probability of detecting naturally-occurring perchlorate in groundwater in California and the southwestern USA, Environmental Science and Technology 45 (4), p 1271–1277, DOI: 10.1021/es103103p.

GRID-BASED PROPORTION

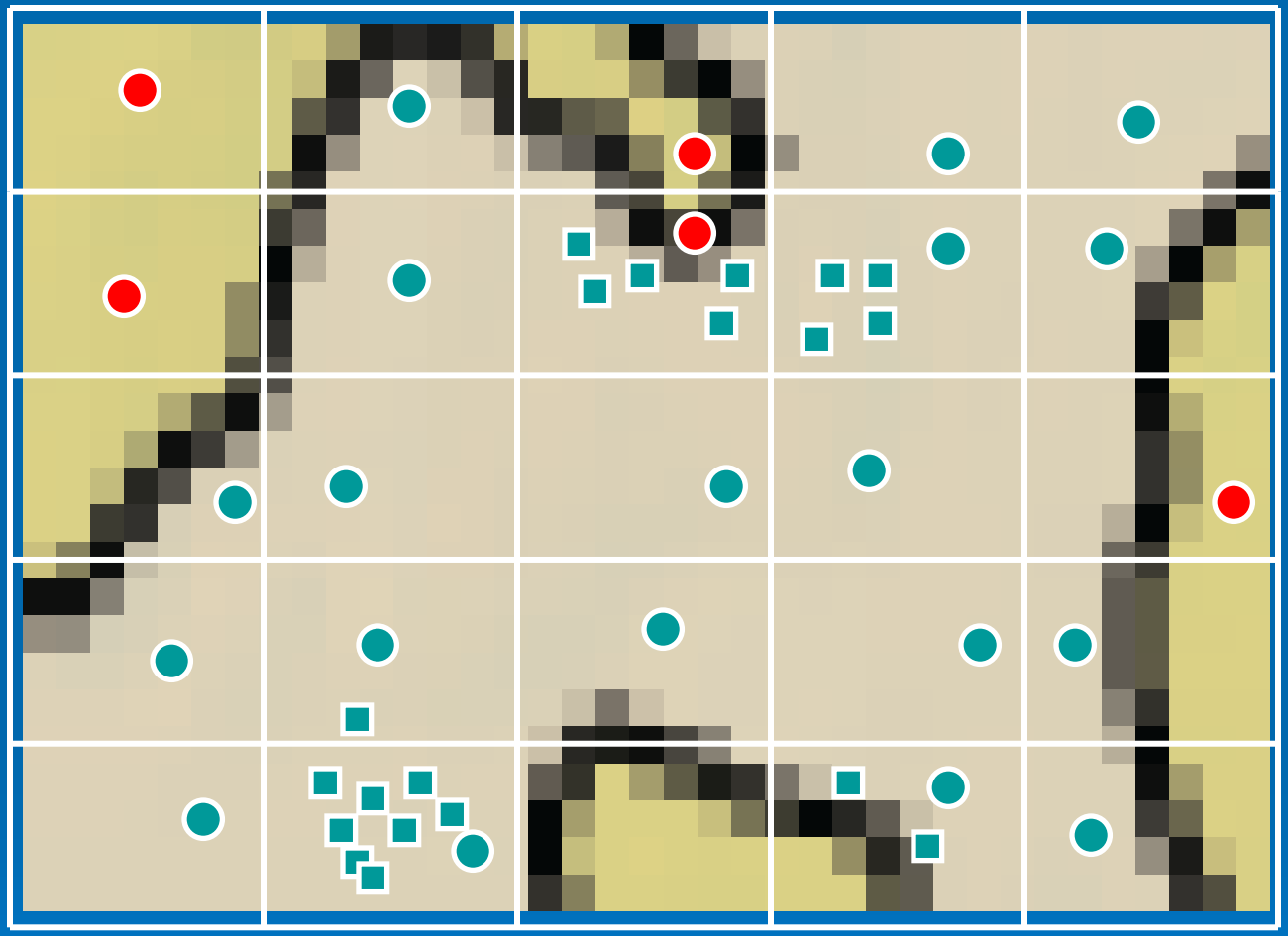


PROPORTION = NUMBER HIGH / TOTAL NUMBER

Organic data ➔ USGS
Inorganic dagta ➔ USGS + CDPH

Belitz and others, 2010

SPATIALLY-WEIGHTED PROPORTION



- Compute proportion in each cell
- Then, compute proportion for entire area
- USGS + CDPH data

Belitz and others, 2010

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