

# ***SB4 Model Criteria for Groundwater Monitoring***

**State Water Resources Control Board  
(April 8th; CalEPA, Sacramento, CA)**

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National Laboratory**



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# SB4 requires groundwater monitoring

## Section 7. Groundwater Monitor Plan

- (c) Development of model groundwater monitoring criteria

*The State Board **shall develop model groundwater monitoring criteria***

- (d) Requirement for expert advice

— *The state board ... **shall seek the advice of experts** on the design of the model groundwater monitoring criteria..*



**LLNL is responsible for providing expert advice on “model criteria” for groundwater quality monitoring**

# LLNL is using both internal and external expertise

## Lawrence Livermore National Laboratory

Dr. Bradley K. Esser, Lead

Dr. Joseph Morris

Dr. Susan Carroll

Vic Madrid, PG, CHG

## Lawrence Berkeley National Laboratory

Dr. William T. Stringfellow

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Dr. Harry Beller

Dr. Charu Varadharajan

## CSU Bakersfield

Dr. Jan Gillespie

## Stanford University

Dr. Rob Jackson

## Duke University

Dr. Avner Vengosh

## University of Guelph

Dr. Beth Parker

Dr. John Cherry

Short bios are on the SWRCB SB4 website

**LLNL is the scientific expert chosen by the State**

# More than one plan required

- **(7c) Development of model groundwater monitoring criteria**
  - *The model criteria shall address a **range of spatial sampling scales** from methods for conducting appropriate monitoring on individual oil and gas wells subject to a well stimulation treatment, to methods for conducting a regional groundwater monitoring program.*

Scale	Responsibility	What
<b>Well by well, Neighbor</b>	Well Operator (Permit)	An individual or small set of oil & gas wells
		A nearby water well
<b>Regional</b>	Water Board	Groundwater basin
		Oil & gas field

**For “well by well”, the DOGGR final rule requires approval of a groundwater monitoring plan by the Water Board**

# We have submitted draft recommendations for area-specific monitoring criteria to Water Board staff

## **Groundwater Sampling, Testing, and Monitoring for hydraulic fracture or acid well stimulations where protected groundwater is present.**

- (a) The purpose of this section is to provide **groundwater monitoring model criteria** for groundwater sampling, testing, and monitoring related to well stimulation (WS) in areas where protected groundwater exists. Protected groundwater is defined as groundwater with Total Dissolved Solids (TDS) of less than 10,000 ppm in an aquifer of sufficient volume for beneficial use and for which the Water Board has not concurred on a request for exclusion from groundwater monitoring. These area-specific groundwater monitoring criteria do not apply to regional groundwater monitoring programs developed by the State Water Resources Control Board or the Regional Water Board.

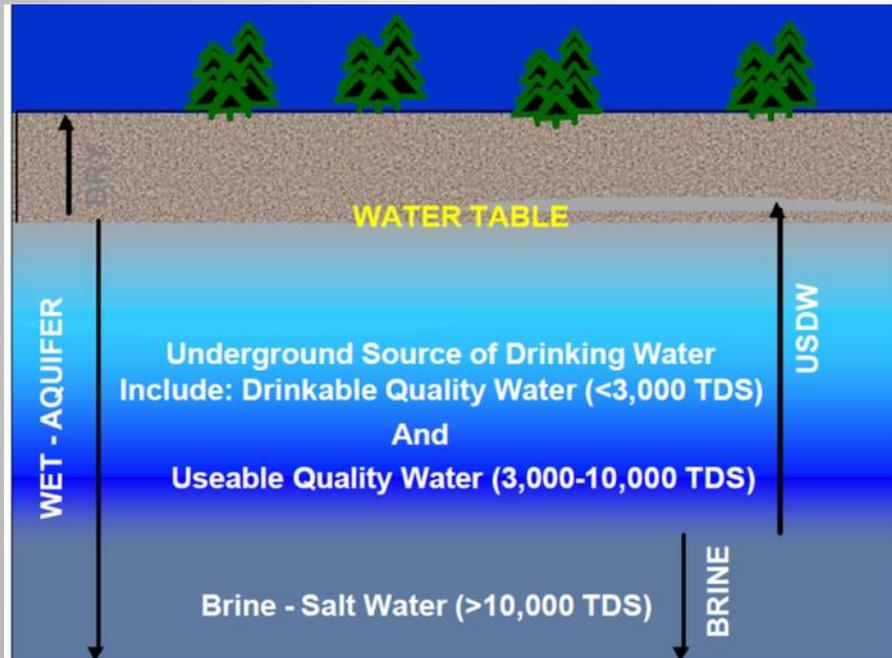
- **We use “area-specific” and not “well-by-well”**
  - In densely drilled oil fields, one monitor well may serve to monitor more than one stimulated well

# What groundwater should be monitored?

- **We recommend monitoring groundwater up to 10,000 ppm TDS**
  - Contains fewer than 10,000 mg/l total dissolved solids
  - Sufficient quantity of ground water for beneficial use
  - Not excluded from a requirement to submit a groundwater monitoring plan
- **Rationale**
  - California is in the midst of an historic drought
    - *Any water with the potential for beneficial use should be protected*
  - Desalination of brackish groundwater is technically feasible
    - *More than a dozen plants desalinate brackish groundwater*

**USDW groundwater should be monitored for impact**

# “Useable” groundwater needs to mapped



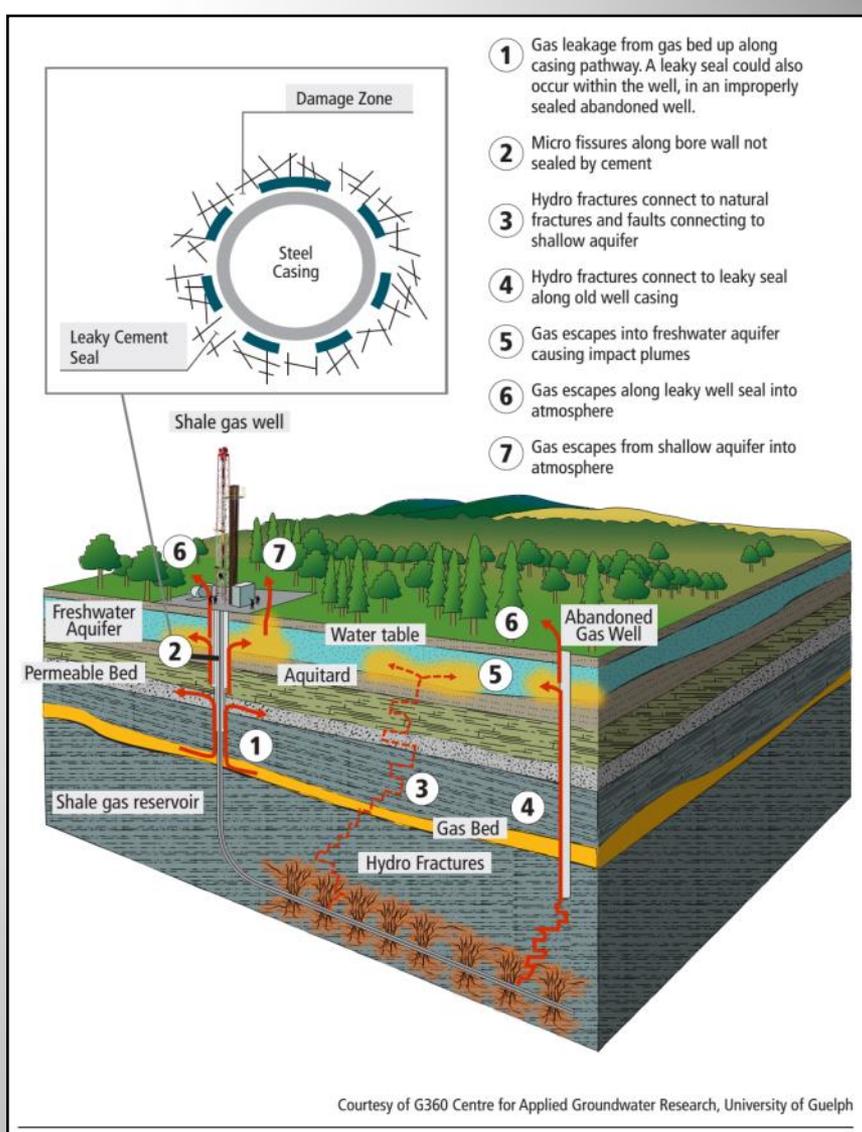
The distribution of “useable” groundwater (TDS = 3,000 to 10,000 ppm) is poorly known

## ■ Recommendations

- Groundwater monitor plans should include data relevant to determining aquifer salinity
- The State should systematically determine the spatial and vertical distribution of useable (3,000 - 10,000 mg/L) groundwater in all basins containing oil & gas fields

# Contaminant pathways

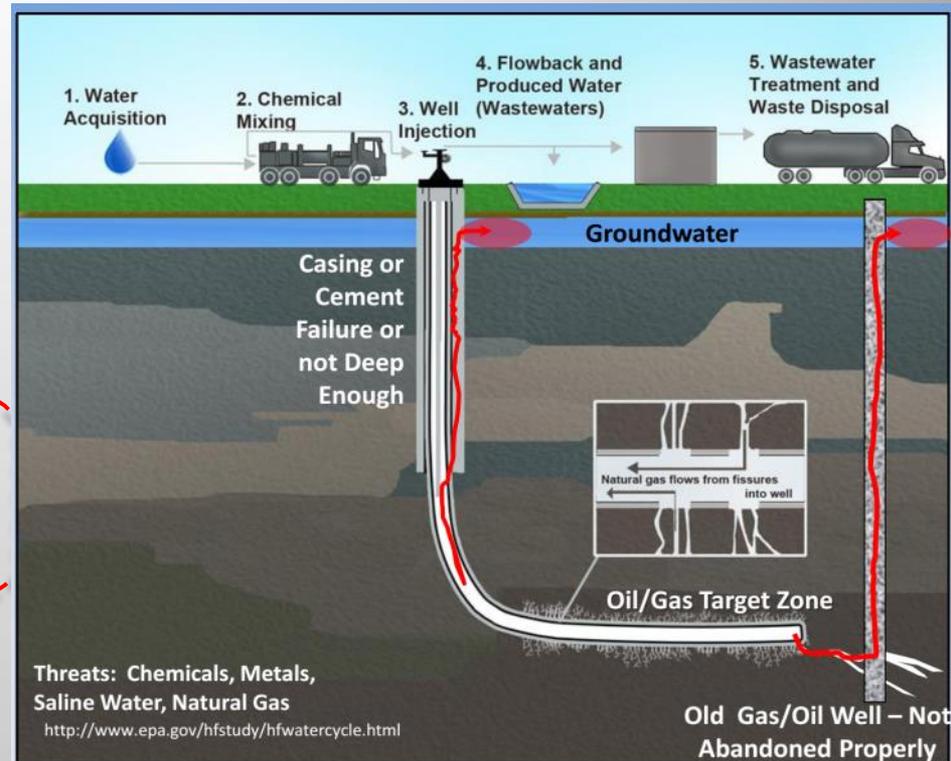
Contamination Source/Pathway	Shallow	Intermediate, Deep
Wastewater: sumps	X	
Wastewater: injection	X	X
Oil & gas wells	X	X
Inactive and abandoned wells	X	X
Natural fractures & faults	X	X
Hydrofracturing	X	X



Contaminant sources & pathways were considered in developing monitor plan criteria

# Contaminant pathways

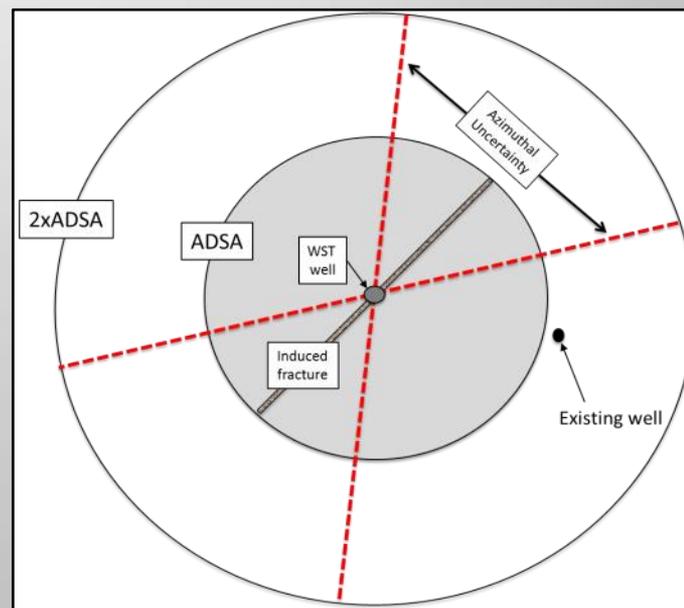
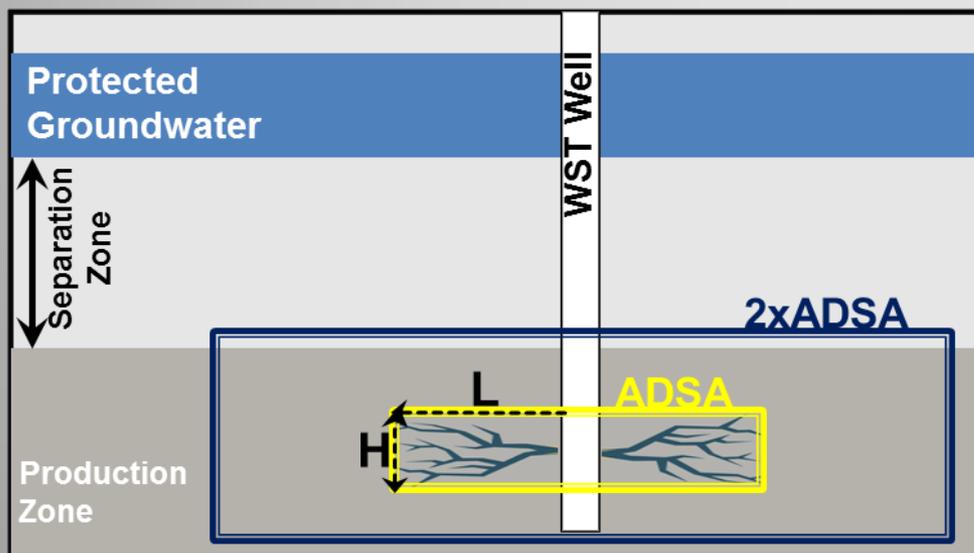
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Wells are a potential pathway of concern

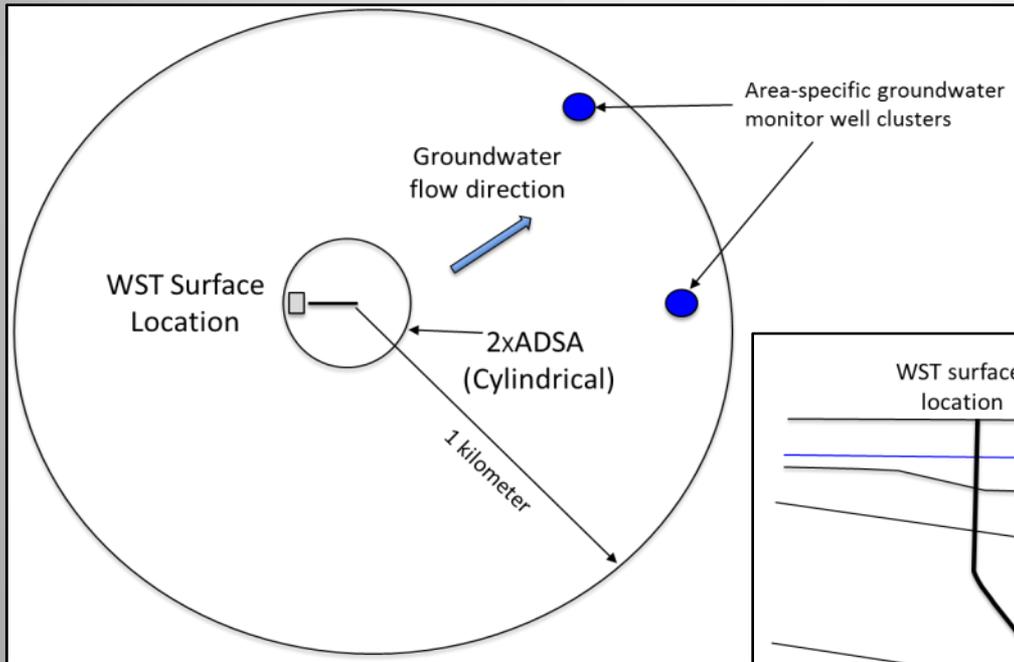
# DOGGR regulation requires identification of wells and geologic features in close proximity to stimulated wells

- The “axial dimensional stimulation area” (ADSA) is the volume of subsurface stimulated during WST.
  - We recommend a conservative “groundwater-protective” cylindrical ADSA with provision for operator to provide data for a smaller azimuth angle



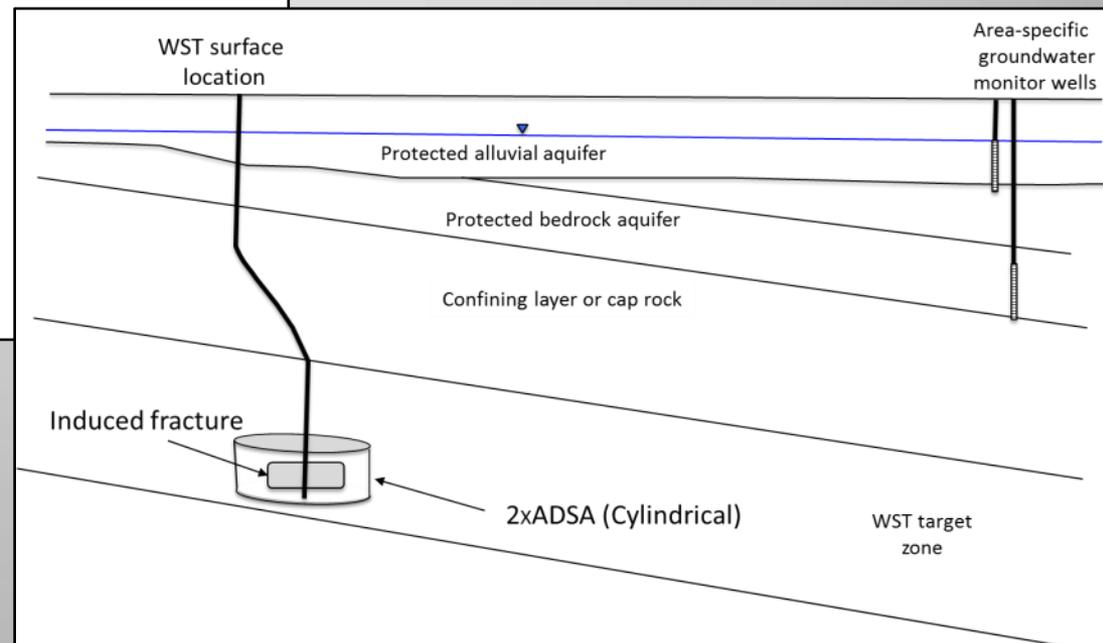
**We recommend that groundwater monitoring always be required when wellbores are present within 2xADSA**

# We recommend monitoring of all protected groundwaters within one kilometer of the stimulated well

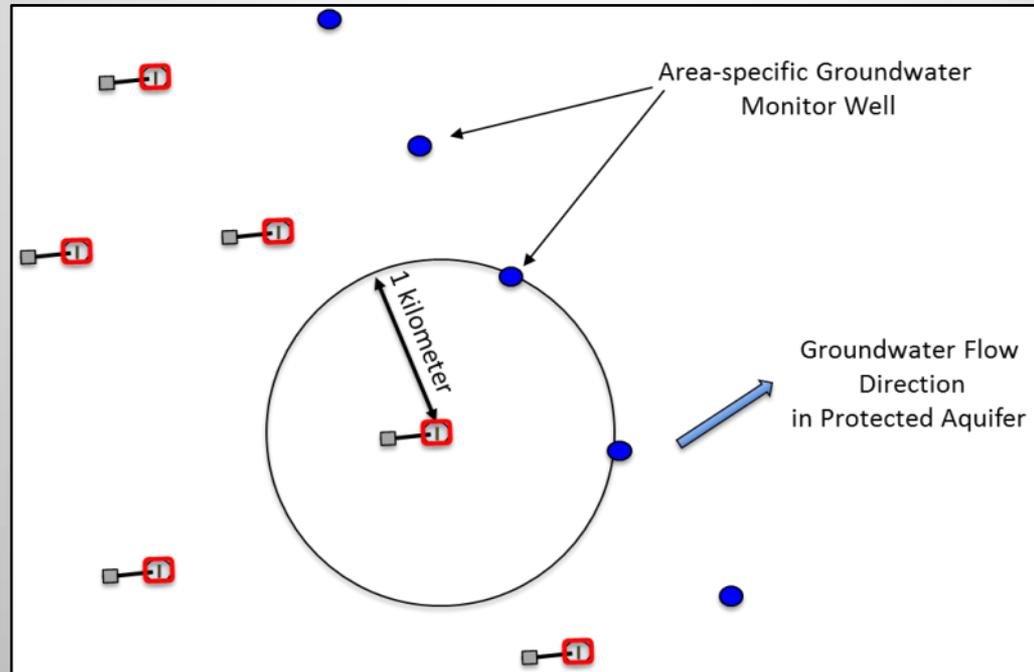


**Multiple aquifers will require multiple monitor wells or a multi-level monitoring system.**

**We also recommend the use of “guard” wells between stimulated wells and water supply wells.**



# Projects of more than one stimulated well can share monitoring wells



- **In one scenario, area monitoring may not be required**
  - No groundwater with TDS < 3,000 ppm is present; AND
  - No vertical conduits within 2xADSA of the stimulated well are present; AND
  - A regional monitoring well is present within 1 mile of the stimulated well

# We recommend semi-annual monitoring of a tiered list of water quality analytes

- **A core set of analytes analyzed for every sample**
  - Analytes in the interim regulation
  - Methane and methane isotopic composition
  - Guar gum sugars
  - Two chemical additives chosen based on mass used and persistence
- **A secondary set of analytes only if evidence for a change in water quality is observed**
  - Toxic well stimulation chemical additives (e.g. biocides, surfactants)
- **We recommend establishing a baseline and using a RCRA approach to detecting significant changes in water quality**
  - Operator can also propose a method
  - USEPA (2009) Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance, EPA 530/R-09-007.

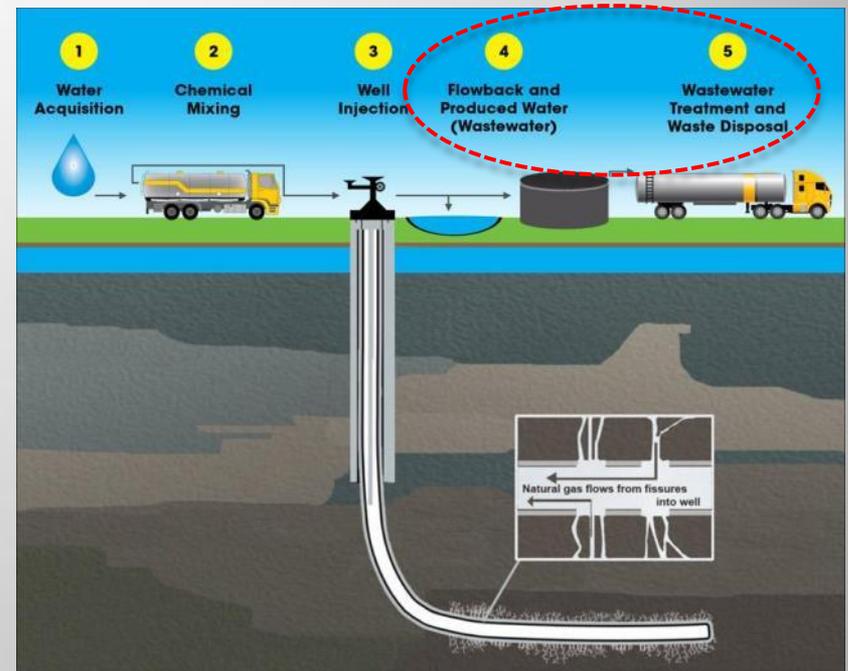
# Regional monitoring goals

- **Detect migration of oil & gas fluids out of “isolated” zones into protected groundwater**
  - Does not distinguish between WST, EOR, and UIC
  - Requires mapping of protected groundwater resources
  - Requires development of new hydrogeologic conceptual models
- **Monitor impact of sumps on shallow groundwater**
  - Use GAMA Shallow Groundwater approach over more focused area
- **Investigate impact of well bore integrity on water quality**
  - Will require study design

**We endorse these goals for the regional monitor plan**

# The regional program should monitor the impact of all oil & gas development on protected groundwater quality

- **The contaminant pathways of most concern to regional groundwater quality are not unique to well stimulation**
  - Wastewater disposal through discharge to unlined sumps
  - Wastewater disposal through underground injection into non-exempt aquifers
  - Well integrity failure
- **A primary concern is salinity and natural constituents in formation fluids and produced fluids**



- **Many of the chemicals used in well stimulation are not unique to well stimulation**
  - Biocides, surfactants

# Regional water quality monitoring

- **Water quality monitoring should be coordinated with other SB4 water quality monitoring efforts**
  - Monitor all samples for analytes monitored in area wide program
  - Monitor select samples for intrinsic tracers of source and transport
  - Monitor select samples for toxic and indicator compounds
- **The regional monitoring program should have access to samples collected in other SB4 or UIC monitoring programs**
  - Samples of injected fluid, produced water and groundwater
  - Will allow analysis of non-routine analytes, e.g. intrinsic tracers such as noble gases and the isotopic composition of Li, B, S, and Sr

**SB4 monitoring programs should be coordinated**

# The monitoring programs should be adaptive

- **California is leading the nation in regulation of well stimulation**
  - Full disclosure of chemical additives
  - Systematic groundwater monitoring of new well stimulation projects
  - Regional groundwater monitoring of oil & gas fields
- **Monitoring a deep subsurface source is fundamentally different than monitoring a surface source**
  - The hydrogeology and permeability of strata between currently used groundwater aquifers and oil and gas production zones is poorly known
  - The distribution of brackish groundwater is poorly known,
  - Available data needs to be compiled and digitized;
  - Monitoring strategies need to be vetted

**Time will be required to implement a long-term regional groundwater monitoring plan**

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