Comments on Draft Model Criteria for Groundwater Monitoring in Areas of Oil and Gas Well Stimulation. April 29, 2015 Draft document by SWRCB

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General Comments

2.0 AREA-SPECIFIC MONITORING:

The purpose of the Area-Specific Monitoring stated in the Draft Model Criteria document is “early detection” of potential impacts to protected water from well stimulation. Implementation of the work described in the draft Model Criteria, unfortunately, won’t likely meet that stated objective. Groundwater monitoring at the scale proposed in the document hardly assures detection (early or otherwise) of impacts from WSTs.

Equivocal Results Almost Guaranteed

Experience in characterizing and monitoring shallow contaminated sites under RCRA and CERCLA regulatory programs shows that it is often difficult to characterize and, in many cases, even detect contamination at many sites under “ideal conditions” as compared to the scale of oil field WST monitoring. Groundwater moves relatively slowly and contaminant plumes are often narrow due to limited hydrodynamic dispersion of the contaminants in most groundwater flow systems (MacFarlane, Cherry et al. 1983, Mackay, Cherry et al. 1986, Cherry 1993, van der Kamp, Luba et al. 1994). Conventional networks of monitoring wells (often comprised of dozens of monitoring wells) sometimes fail to detect contamination even when the plumes are shallow and monitoring is performed within a few hundred feet of the contaminant source zone.

Then consider the enormous variability and uncertainty associated with the scale of monitoring of potential releases from WST activities, which typically occur thousands of feet below the ground surface. Little is known about the hydraulic connection between the WST zones and shallow groundwater or the flow field in the vicinity of the WST. Hydraulic gradients are unknown and are almost certainly complex, and will be temporally variable depending on the operational status of oil and gas wells, injection wells, and water supply wells in the vicinity of the well undergoing the WST. Installing and monitoring one well 0.5 miles from the WST well with a screen length up to 50 feet (which is an order of magnitude greater than screen lengths currently recommended at contaminated sites) in a presumed downgradient location is almost guaranteed to yield equivocal results. If there was a hydraulic pathway from the WST zone to the monitoring well, the travel time could be decades to centuries before the contaminant could reach the well. So, how long should groundwater monitoring be conducted before it is terminated? 10 years? 100 years? 500 years? At what point would one conclude that there has been no impact to groundwater? No responsible hydrogeologist would be able to conclude that based on the uncertainties in the flow field, time of travel, biases in a monitoring well with 50 feet of well screens, etc. And what if elevated concentrations of a target chemical compound were detected in the monitoring well? WST activities are typically performed in California in mature oil and gas fields where there has been nearly 100 years of oil and gas development. There is an enormous potential for false positives in the monitoring data due to prior surface and subsurface releases of oil and gas and brines from natural and anthropogenic sources. Such false positives -- or false negatives -- would undermine the public's confidence in the State's SB4 groundwater monitoring program, and more generally, the reliability of groundwater monitoring in California. Such a regulatory miscue cannot be afforded at a time when there is a need to build support for more extensive groundwater monitoring in California to ensure that the State's groundwater basins are managed in a more sustainable way.

Pilot monitoring projects needed

As was the case at industrial sites in the 1970s, fundamental field research and pilot-scale monitoring projects are needed at California WST sites to provide insight and guidance on the following three key factors:

> Where: Where should groundwater samples be collected? How far from the WST zone should samples be collected, both laterally and vertically? From how many depths should samples be collected?
>
> When: When should groundwater samples be collected? How frequently? For how long?
>
> What: What type of monitoring instrumentation is most appropriate (e.g., engineered multilevel monitoring systems vs. long-screened wells)? What chemicals and other parameters should be analyzed for? Is there a "short list" of indicator parameters that could be routinely monitored with less frequent monitoring for the full suite of analytes?

Such pilot projects should be undertaken as soon as possible to guide and inform California's nascent program of monitoring WSTs in oil-producing regions. In the interim, while field research is being performed at select sites in California, focused monitoring should be performed in and around oil fields where WSTs are currently being performed. Such monitoring should be referred to, however, as "Baseline" or "Sentry" monitoring, and not "Detection Monitoring" to avoid false expectations. Such sentry monitoring programs should include depth-discrete samples collected from clusters of monitoring wells or engineered multi-level monitoring systems. Chemical analyses could include those constituents listed in the Draft Model Criteria document.

Focus should be on In-Well Monitoring of Possible Releases from WST Zone

The Draft Model Criteria has neglected to reference proven technologies that could actually detect early releases of WST fluids to protected groundwater. Documenting the integrity of the annular seals during and/or immediately after the WST is the most meaningful and cost-effective form of monitoring possible. For example, standard well Mechanical Integrity Tests (MITs) using temperature and/or short-lived radioactive tracers are routinely performed to document the integrity of annular seals in oil and gas wells. These tests are performed routinely on Class II injection wells throughout the U.S. Such tests were performed on a Class I injection well in Fresno County in 2013 immediately after a fracture stimulation to assess the integrity of the annular seals in the well. The MIT results assured all parties that there was no leakage of fracking fluids upward through or around the annular seal in the stimulated well. Logging services for such MITs are inexpensive (e.g., <$10,000 per well) and are readily available throughout California.

I recognize that in-well monitoring of annular seal integrity in the context of SB4 falls under regulations enforced by DOGGR and not the SWRCB. However, such monitoring can provide early detection of impacts to protected groundwater, which could then assessed further, in a more focused and cost-effective manner, under the oversight of the SWRCB. Consequently, there should be some mention of this and reference to in-well monitoring of WSTs in the SWRCB's SB4 Model Criteria document.

Comments on Specific Sections of the Draft Model Criteria for Groundwater Monitoring

Section 2.0 Area-Specific Monitoring Program

2.1.1 Groundwater Monitoring Design

The purpose of the area-specific groundwater monitoring stated in this section is "early detection" of potential impacts to protected water from WSTs. The program misses this goal by not focusing first on direct detection of releases from the well undergoing the WST, e.g., via MITs that can be performed in the WST well (see discussion above).

Number and Locations of Monitoring Wells

General comments on this topic are presented below. The draft Model Criteria states that water supply wells may be used as monitoring wells. This is inadvisable because of the strong biases in long-screened wells of any type (monitoring and water supply). At best, samples from long screened wells yield blended samples, which could dilute many of the trace compounds that are the target of SB4 monitoring to concentrations below available detection limits. Further, ambient vertical flow in the wells when they are not pumped (i.e., due to natural vertical gradients in the aquifer) also create a significant bias that is difficult to avoid, even with extended purging (e.g., see Elci, Molz et al. (2001)). For this reason, SB4 groundwater monitoring should utilize clusters of single-interval wells or engineered multi-depth monitoring systems that avoid these biases. See Einarson (2006) for a further discussion of sampling biases and options for reliable multi-depth groundwater monitoring instrumentation.

Also in this section, the SWRCB states that well screen lengths should be "less than 50 feet." That is a very long screen interval compared to well screen lengths typically required at contaminated sites (5 to 10 feet). Such long screens will yield blended samples and samples that are biased by ambient vertical flow in the wells. Further, vertical gradients are typically temporally variable in California (due to seasonal precipitation and groundwater pumping). Consequently, the bias caused by ambient vertical flow in long-screened wells also varies seasonally. This contributes to the variability and "noise" in monitoring data that often obscures real trends. Clusters of short-screened wells or engineered multi-depth monitoring systems eliminate the biases caused by sample blending and ambient vertical flow within the wellbore.

2.1.2 Groundwater Monitoring Plan Requirements

2.1.2.1. Map of the oil field and 0.5 mile buffer.

- Include <u>former</u> produced water ponds also in e)
- Specify <u>active, idle, and abandoned</u> water wells in f).

2.1.2.2. Map extending 1 mile from stimulation

- Include <u>former</u> produced water ponds also in c)
- Specify <u>active, idle, and abandoned</u> water wells in d).

2.1.2.3. Map of groundwater monitoring network extending 1 mile from stimulation

- Include <u>former</u> produced water ponds also in c)
- Specify <u>active, idle, and abandoned</u> water wells in d).

2.1.2.4. Cross sections

- Include former produced water ponds also in b)
- Logs and completion diagrams for active, inactive, and abandoned water wells and oil and gas wells should also be included in these cross sections where intersected.

2.1.2.5. Cross sections

- Include former produced water ponds also in e)
- Logs and completion diagrams for active, inactive, and abandoned water wells and oil and gas wells should also be included in these cross sections where intersected.

2.1.2.9. Detailed description of the well to be stimulated, and any wells within two times the ADSA .

Add cement bond logs and any other logs or tests that can provide information about the integrity of annular seals (including past MIT tests) to list of geophysical logs; and any other analyses of well integrity.

Addendum to an Approved Groundwater Monitoring Plan

See comments under Section 2.1.2 (Groundwater Monitoring Plan Requirements) above.

2.1.3 Sampling and Testing Requirements

See comments above on frequency of monitoring. The cost for chemical analyses for the proposed list of analytes will be very high. Is it worth considering a streamlined list of compounds (e.g., EC, TDS, select organics) for routine monitoring, with less frequent analysis of the complete list of compounds? Or, perhaps analysis of the complete list could also be triggered by an exceedance in one or more of the routinely monitored parameters.

4.0 REGIONAL GROUNDWATER MONITORING PROGRAM

4.2 Components of Regional Monitoring Program

Well Integrity

Existing information about the integrity of seals in existing wells in the area should also be compiled and reviewed. This includes cement bond logs and any other logs that may exist that provide information about the integrity of annular seals. Further, as discussed above, the results of any existing internal or external Mechanical Integrity Tests (MITs) should be compiled and reviewed to assess specific testing that may have been performed to assess the integrity of annular seals. In some cases, new external MITs can be performed in select (or all) wells in the study area. External MITs can include temperature surveys, temperature decay surveys and radioactive tracer surveys. External MITs were performed before and after fracture stimulating a 9,000-foot-deep Class 1 (nonhazardous) injection well in Fresno County in 2013. Those tests provided conclusive evidence that the fracture stimulation did not create a conduit in the cement seal in the well above the zone of treatment. Additionally, External MITs are performed in all four of the injection wells at the Fresno County site annually, in compliance with an EPA operating permit, to demonstrate the ongoing integrity of the annular seals in the injection wells. Guidance on performing MITs can be found at:
http://www.epa.gov/r5water/uic/r5guid/r5_05_2008.htm .

External MITs aren't very expensive, all things considered. Well Analysis Corporation (http://www.waclog.com/welaco2_014.htm), located in Bakersfield, performs MITs in wells throughout California. The cost for a thorough MIT testing program is typically under $10,000 per well.

4.3 Regional Monitoring Program Approach

The document states that "Initially, well types to be used will rely on existing wells using depth dependent sampling techniques." Care should be taken when collecting depth-discrete samples from long-screened wells. For example, collection of water samples from multiple depths in a well using depth-discrete samplers such as pressurized bailers, pumping from multiple depths in a wells, or collection of samples from multiple passive samplers positioned at multiple depths typically yields biased results and should be avoided. This is most often due to ambient vertical flow in the unpumped wellbore. This topic and the biases in the sampling results are described in detail by Einarson (2006).

Methods have been developed to measure depth-discrete vertical wellbore flow and collect depth-dependent groundwater samples in wells that are actively being pumped (e.g., (Izbicki 1999, Izbicki 2004)). These methods have been shown to be very effective in developing vertical profiles of groundwater flow and solute concentrations (Gossell, Nishikawa et al. 1999, Landon, Jurgens et al. 2010, O'Leary, Izbicki et al. 2012). However, there are two important points that should be considered when using this type of method to sample long-screened wells in the context of SB4 monitoring. First, the pre-testing operational status of the well should be known and, if possible, manipulated to ensure steady-state conditions prior to performing the testing. Depth-discrete groundwater sampling using the USGS (Izbicki) method should only be performed when the well is being pumped and has been pumped for an extended period of time. Turning off the well prior to or while performing the depth-discrete sampling can redistribute the groundwater within the wellbore and adjacent aquifers (e.g., see Elci, Molz et al. 2001).

Second, samples collected inside the well are of blended water that is flowing into the well from multiple depths. Thus, there is significant dilution of water flowing into the well from discrete zones. Consequently, low concentrations of some solutes targeted for SB4 monitoring may be diluted to below the detection limit using the USGS (Izbicki) sampling method.

The alternative method for collecting depth-discrete groundwater samples, as stated in the Draft Model Criteria document, are clusters of singles wells, nested wells (several wells placed in a single borehole) or a depth-discrete engineered multilevel monitoring system. Nested wells should be avoided because of the difficulty in installing reliable annular seals in those types of wells (DTSC 2014). Engineered multilevel systems (MLS) provide more reliable seals because only one pipe or tube is installed in a single borehole. Further information on options for multilevel groundwater monitoring is provided by Einarson (2006). Some engineered monitoring systems now facilitate field tests that can be performed to document the integrity of the annular seals prior to sample collection (see draft appendix on multilevel monitoring technologies being prepared by Cherry et al. for inclusion in LLNL's *Recommendations on Model Criteria for Groundwater Sampling, Testing, and Monitoring of Oil and Gas Development in California* (Esser, Beller et al. 2015). Engineered multilevel monitoring systems are commercially available and have been installed at more than a thousand locations in California to depths greater than 2,000 feet.

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