(5/19/15) Public Workshop- Item 6
Model Criteria for Groundwater Monitoring
Deadline: 5/29/15 by 12:00 noon



Groundwater Resources Association of California
grac.org



May 29, 2015

Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, CA 95814

Sent via email to commentletters@waterboards.ca.gov

**Re: Comment Letter – Model Criteria for Groundwater Monitoring**

Dear Ms. Townsend:

The Groundwater Resources Association of California (GRA) appreciates the opportunity to comment on the Proposed Draft Model Criteria for Groundwater Monitoring in areas of oil and gas well stimulation, prepared by the Water Board, as required by California Water Code section 10783 (Senate Bill 4, Pavley, Statues of 2013). GRA welcomes and applauds the Water Board's continued efforts to protect California's precious groundwater resources from potential degradation through various human activities, including operations at oil and gas fields.

GRA is a nonprofit, statewide, volunteer organization formed in 1992 with over 1,400 practicing scientists, engineers and other professionals with groundwater expertise dedicated to resource management that protects and improves groundwater supply and quality through education and technical leadership. GRA has helped formulate statewide policy on the development, management, and protection of the state's groundwater resources, soil and groundwater remediation, and environmental assessments.

With the strong state, national, and international interest that has developed over the last decade related to increased oil and gas activities due to improved well drilling and stimulation techniques, including hydraulic fracturing, and their potential impacts on the environment, GRA has formed a Well Stimulation Working Group under our Legislative Committee to review and provide input on emerging well stimulation and groundwater monitoring regulations and legislation. Our goal is to ensure the protection of California's groundwater resources through the development of wise groundwater monitoring regulations that not only comply with the requirements of SB4, but are also practical to implement, provide meaningful and timely data, and withstand scientific scrutiny regarding the results.

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To that end, the GRA Well Stimulation Working Group members have carefully reviewed the April 29, 2015 "Draft Model Criteria for Groundwater Monitoring In Areas of Oil and Gas Well Stimulation" document made available on the Water Board's web site at the following address: www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/docs/model_criteria_draft_report.pdf. We offer the attached Table of General and Specific Comments to the draft criteria for your consideration to improve the overall effectiveness of the groundwater monitoring program.

GRA members are very experienced and familiar with planning and performing groundwater investigations at contaminated sites throughout the State. We know the extreme difficulties that can occur in defining accurate monitoring and protection programs even after scores of monitoring wells have been installed and detailed analyses performed often due to the complex nature of geological conditions in the subsurface such as heterogeneous soils and aquifer materials, preferential flow pathways, varying vertical gradients, variation in groundwater and contaminant movement, and unknown source locations. Multiply this complexity of shallow systems by the inherently more complicated significantly deeper systems in petroleum fields, with multiple intervening geologic layers between the fresh groundwater and hydrocarbon reservoirs with unknown geologic and hydrogeologic properties, along with the multiple potential source areas for leaks of well stimulation fluids to occur from surface fluid containment storage areas, leaking pipelines, annular spaces of the vertical pipe, and the slanted/horizontal pipe and perforations, and you can easily see the challenges faced designing an appropriate groundwater monitoring system.

In addition, there is the potential for legacy contamination from the petroleum fields unrelated to well stimulation activities to complicate source identification. A simple "cookie cutter" approach to groundwater monitoring for well stimulation activities of one up-gradient monitoring well and two down-gradient wells in an oil/gas field spaced over a half mile apart would likely not meet the monitoring objectives, and would be fortuitous at best to detect any contamination releases from a specific well stimulation treatment. All the resulting "Non-Detects" may give false impressions that leaks have not occurred. Additionally, there are risks to installing monitoring wells through multiple aquifers to theses great depths and pressures, including seal and casing failure, so the requirements for deep monitoring should be weighed accordingly and only installed by qualified contractors.

We believe a more appropriate method would be to closely monitor the well stimulation activities themselves. If an accident or release occurs, either at the land surface, or in the annular seal or vertical pipe, or in the stimulation zone itself, or through a nearby conduit such as abandoned well or fault zone, then a proper groundwater monitoring program could be designed and implemented around that release point to track the movement of the release and obtain the necessary data to design the most effective remediation or containment system in consultation with the Water Boards.

But GRA recognizes the tight timeframe and pressure that the Water Board is under to adopt a regulation by July 1, 2015. Acknowledging the shortness of time to meet SB4 requirements, we recommend having a reopener in the regulation a year after they take effect to incorporate lessons learned and any new or improved methods for practical and useful groundwater monitoring in the oil and gas environment. We would also recommend including in the regulations an "Alternatives Section" to allow for an operator to propose an alternative groundwater monitoring plan based on site specific conditions, new technologies, unique hydrogeology, or for other reasons. Such an "Alternatives Section" has been presented in other regulations by the State, such as the recently adopted "Groundwater Replenishment Using Recycled Water" regulations (i.e. see Title 22, California Code of Regulations, Section 60320.130 or Section 60320.230). Any proposed alternatives would need review of the applicable Regional Water Boards or State Water Board for approval, denial, or modification thereto.

Finally, GRA believes that pilot studies should be completed to improve upon the knowledge base for groundwater monitoring requirements at Well Stimulation Treatment (WST) sites. 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 developing program of monitoring WSTs in oil and gas 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 and gas 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.

GRA trusts that the information in this letter and attached Table are useful to help meet the State meet the goal of developing meaningful groundwater monitoring regulations for well stimulation activities in oil and gas field operations. We look forward to the successful implementation of the new regulations, and are glad to offer any technical assistance or reviews from our experienced and professional GRA membership.

If you have any questions on this submittal, please feel free to contact me at (562) 275-4240

Sincerely,

Ted Johnson, PG, CHG
President
Groundwater Resources Association of California

Attached: Table of General and Specific Comments to the SWRCB's April 29, 2015 "Draft Model Criteria for Groundwater Monitoring In Areas of Oil and Gas Well Stimulation" document

Cc: GRA Board of Directors

**Table 1. GRA Comments to Draft Model Criteria for Groundwater Monitoring is Areas of Oil and Gas Well Stimulation**

| Document Section | Page Number/ Paragraph | Statement from the Draft Model Criteria | Comment |
|---|---|---|---|
| **General comments** | | | |
| NA | NA | NA | Successfully monitoring groundwater for any negative impacts associated with any WST activities will be a very difficult task. This is due to the depth of WST in deep hydrocarbon zones compared to the shallower freshwater aquifers, and the intervening low permeability "caps" that have trapped the hydrocarbons. Any leaks from those deep zones could take a very circuitous route and years to reach fresh groundwater, if ever, and having a monitoring well in the right place to intercept any contamination will be fortuitous. Therefore, the resulting "Non-Detects" may give a false impression that leaks have not occurred.<br><br>Because releases from WST activities to fresh groundwater can occur potentially through numerous avenues, including surface containments and pipelines, cement seals in the casing, the fractured zone itself, through nearby wells, or through faults or other breaks in formations, a series of methods should be employed to have confidence in a comprehensive monitoring program. Methods including detailed conceptual geologic modeling to identify the areas of greatest risk on which to focus monitoring, pressure monitoring of the wells and formations to identify if/when leaks occur, geophysical monitoring of the formations, and groundwater monitoring as necessary including vertical and horizontal gradient analysis to identify expected pathways of any contaminant releases. |
| NA | NA | NA | The model criteria are vague, which may result in inconsistent interpretation by both regulatory oversight agencies and parties performing the work. It is recommended that a higher level of detail and guidance be provided for work scopes to be developed and completed. This should result in a more consistent application of the model. |
| NA | NA | NA | Oil and gas well stimulation is sometimes conducted over large areas (square miles) and at great depths (miles); in rock with multiple aquifer zones, variable stratigraphy and structure; and in oil and gas deposits where well stimulation has been conducted for many years. Therefore, designing an early detection monitoring system for pollution from current well stimulation is a major undertaking. Consider the amount of resources needed for detection ground water monitoring at surface point sources, such as waste impoundments or landfills, where tens of monitoring wells might be necessary, and monitoring costs can be tens or hundreds of thousands of dollars annually. Detection groundwater monitoring of a WST is far more complex that monitoring surface point sources. |
| NA | NA | NA | Because a reliable detection monitoring program at well stimulation sites is such an extensive and expensive undertaking, groundwater monitoring might not be the most effective and efficient means of detecting water pollution from well stimulation. Nevertheless, as stated repeatedly by the Draft Criteria, the legislature has mandated groundwater monitoring at well stimulation sites; e.g., Draft Criteria, page 4, bottom, states “Area-specific groundwater monitoring shall be designed for early detection of potential impacts to protected water from well stimulation treatments.” Thus, the question of whether groundwater monitoring at well stimulation sites is an efficient and effective means of detecting pollution is not discussed further herein, and it is given that the Draft Criteria is intended to provide reliable early detection of groundwater pollution from well stimulation. |
| NA | NA | NA | It should be recognized that the fluids used to inject and hydraulically fracture a formation for oil and gas recovery will likely be pulled back into the well when the pump is turned on to extract the oil or gas. The risk is low for any fluids to escape the capture zone of the stimulated and pumping well, unless the well sits idle for a long period of time, which is not likely since the purpose of the stimulation is to turn the pump on and produce petroleum, produced water, flowback water, and any injected chemicals. This is another reason why more detailed analysis and planning should be done to design a specific monitoring program for each site. |
| **Specific Comments** | | | |
| Section 1 | 3/1 | “These Model Criteria are intended to evaluate whether groundwater contamination can be attributable to a particular event…” | This is a clear statement of the purpose of the model criteria. The event is implied to be the injection of well stimulation fluids. As limited volumes of injected fluids will be released, and as the potentially harmful chemicals are likely to be relatively dilute, it becomes apparent that detection may be difficult. Therefore groundwater monitoring will require a dense proximal network and the use of very low detection limits. |
| Section 2 | 4/3 | Protected water …is defined as…" | This definition is not consistent with some beneficial use designations made by the State Water Resources Control Board and Regional Water Quality Control Boards, the entities mandated to make such designations in California. For example, the Central Coast RWQCB designated all groundwater throughout the Central Coastal Basin, except the Soda Lake Sub-basin, as suitable for agricultural water supply, municipal and domestic water supply, and industrial use. This includes water with greater than 10,000 milligrams per liter (mg/L) Total Dissolved Solids (TDS), which the Draft Criteria excludes as protected water for current and future beneficial use, contrary to the Water Board designation. Also, as a practical matter, water with greater than 10,000 mg/L TDS can be, and in places is, desalinated to produce drinking water, so it warrants protection from well stimulation pollution. |

**Table 1. GRA Comments to Draft Model Criteria for Groundwater Monitoring is Areas of Oil and Gas Well Stimulation**

| Document Section | Page Number/ Paragraph | Statement from the Draft Model Criteria | Comment |
|---|---|---|---|
| Section 2 | 4/3 | "Protected water for current and future beneficial use is defined as…" | The publicly available information or testing procedures that will be used to determine the TDS should be described or referenced. |
| Section 2 | 4/3 | "…within an aquifer of sufficient volume…" | The publicly available information or testing procedures that will be used to determine the aquifer yield should be described or referenced. |
| Section 2.1 | 4/5 | "Many parameters of the Model Criteria refer to the Axial Dimensional Stimulation Area…" | The methodology to be used for determining the Axial Dimensional Stimulation Area should be described or referenced. |
| Section 2.1 | 4/5 | "The ASDA…of the subsurface area" | This statement refers to a volume, not an area. We suggest stating "volume" rather than "area". |
| Section 2.1.1 | 5/1 | "Groundwater monitoring data will be used to initially establish baseline conditions..." | Definition of "baseline" is unclear. Does "baseline" include constituents associated with natural and legacy anthropogenic sources? |
| Section 2.1.1 | 5/1 | "Data from wells up gradient of the stimulation may be used to help establish a baseline of water quality impacts" | Since gradient is important, there should be an explanation of how it will be defined. A gradient requires at least three wells installed at non-obtuse angles screened in the same aquifer, but may not be reliably calculated unless there are more wells. There should be a limit on the degree of extrapolation between measured heads used for to calculate gradient as wells become distant. |
| Section 2.1.1 | 5/3 | "Water Board staff will evaluate data and statistical test results" | It is unclear how Water Board staff will get involved, since well stimulation permits are issued by DOGGR. |
| Section 2.1.1 | 5/4 | "Water supply wells may be used as monitoring wells". | Water supply wells are generally unsuitable as monitoring wells due to their large well screens and high-yield water production. Long screened wells will tend to dilute any low level contaminants, so that a "Non-Detect" may be reported when in fact contamination is present. Short screened wells (ideally no more than 20 feet) should be used. |
| Section 2.1.1 | 5/5 | "…one upgradient and two downgradient monitoring wells will be required for each protected aquifer that is penetrated by the stimulated well" | It is unlikely that three wells will be capable of reliable, early detection of pollutants because of the variability and complexity of all relevant factors, including great horizontal, and more importantly, vertical, extent of many protected aquifers. The three well minimum was adopted decades ago because at least three points are necessary to grossly define a flow direction. However, in a producing oil field, with significant variability of flow directions, a more extensive monitoring network would be required to evaluate flow directions that are capable of providing reliable, early detection of pollutants. |
| Section 2.1.1 | 5/5 | "Upgradient and downgradient groundwater monitoring shall be located within 0.5 mile of the surface projection of the zones(s) of stimulation" | Monitoring wells should be within the travel distance of the well stimulation fluids emanating from the production well, such that the chemicals can be detected based on selected analytical tests; wells may need to be installed much closer than 0.5 miles. |
| Section 2.1.1 | 5/6 | "When multiple protected aquifers are present…" | For multi-aquifer zones, it recommended that no more than 3 vertical zones be monitored: the upper, middle and lower aquifer systems. In-well systems should be utilized to monitor the oil well casing and annulus seal integrity and will provide earlier detection and location of leaks than the proposed groundwater monitoring system. |
| Section 2.1.1 | 5/7 | All groundwater monitoring wells shall be completed with limited screen lengths, preferably less than 50 feet. | A CA licensed PE or PG should recommend the appropriate screen lengths based on the hydrostratigraphy. Fifty feet may be too long to detect trace constituents. In most modern day environmental investigations, short screened wells are considered more reliable. Long screened wells may tend to dilute any low level contaminants, so that a "Non-Detect" may be reported when in fact contamination is present. Short screened wells (ideally no more than 20 feet) should be used, with 5 to 10 feet preferred. |
| Section 2.1.1 | 5/8 | "Monitoring wells shall be completed so the screened interval is located in a portion of the aquifer(s) that will best detect any impacts from well stimulation" | This statement should be removed. It is not possible to forecast where a release might occur vertically (well head, penetrating well casing, stimulation zone, etc.) and install a monitoring point at the "best" location. |
| Section 2.1.1 | 5/9 | "For any water-supply well located within one mile and downgradient of the surface projection…" | What publicly available records should be reviewed to collect information on water supply wells? Is information on private wells required also? Does field reconnaissance need to be conducted to verify well locations and conditions? |
| Section 2.1.1 | 5/9 | "A water supply well must be accompanied by a sentry monitoring well." | That section's introductory paragraph states a supply well might serve as a monitoring well. Item 5 states that a sentry well is needed between the stimulated well and the water supply well. Clarity is required to define what constituents a monitoring well. |

**Table 1. GRA Comments to Draft Model Criteria for Groundwater Monitoring is Areas of Oil and Gas Well Stimulation**

| Document Section | Page Number/ Paragraph | Statement from the Draft Model Criteria | Comment |
|---|---|---|---|
| Section 2.1.2 | 6 | Entire Section | Further detail should be provided on the minimum scope of work required to document information on oil wells, injection wells and water supply wells. What publicly available records should be reviewed (Munger Oil field maps, DOGGR records, water well permit records, etc.)? Does field reconnaissance need to be conducted to verify well locations and conditions? It should be noted that most supply well information (construction details, pumping records) cannot be obtained without Regulatory Agency support and submittal of a Freedom of Information Request. |
| Section 2.1.2 | 7/1 | "Water supply wells (public, private domestic, irrigation, and industrial) | Further detail should be provided on the minimum scope of work that will need to be completed to collect, review and interpret geologic and hydrogeologic information necessary to construct the requested cross-sections. This would include published geologic reports, specific types of geologic maps, boring logs, publicly available records, etc. Does field reconnaissance need to be conducted to verify surface features and geologic conditions? |
| Section 2.1.2 | 8/Item 5C | "The distribution of groundwater salinity, and gas presence and composition…: | The type of gas or gasses to be monitored should be specified. |
| Section 2.1.2 | 9/Item 6 | "Information,…used for the determination of salinity distribution…" | The purpose and interpretation of salinity monitoring in the aquifers should be described. Is this to monitor the potential upward intrusion of high salinity water at depth into overlying aquifers or leakage of produced high salinity water during well pumping? |
| Section 2.1.2 | 9/Item 9 | "A detailed description of the well(s) to be stimulated…" | It should be noted that some of this information may be proprietary |
| Section 2.1.2 | Maps | Entire section | Suggest modifying all statements that stipulate depiction on one or more maps of specific wells to simply state "all wells" . This way all potential conduits, sources of introduced chemicals from well stimulation, monitoring points and sources of supply are included. |
| Section 2.1.2 | Maps | "Contours showing the potentiometric surface for each protected aquifer, showing arrows indicating groundwater flow direction. The operator shall document whether the water levels were measured during pumping or non - pumping conditions" | The request to have pumping or non pumping conditions for water levels used to create contour maps is not appropriate, as water levels measured when water levels are not in equilibrium (due to pumping or recovery after pumping) will likely lower/alter the contour lines and hence the depicted flow lines. If data pumping wells are combined with data from non-pumping wells, the resulting contour maps will not be representative of flow conditions. We suggest that all water levels used as the basis for contour maps be collected from non-pumping wells when the water levels have reached equilibrium. Preferably, potentiometric measurements are collected from monitoring wells screened in the same aquifer to avoid this problem (as long as the monitoring wells are out of the influence of any production wells). |
| Section 2.1.2 | 7/1 | "Contours showing the potentiometric surface for each protected aquifer, showing arrows indicating groundwater flow direction… measured during pumping or non-pumping conditions" | The basis for those contours should be described. Contours based on three wells can be misleading, and operation of nearby pumps may be unknown. |
| Section 2.1.2 | 7/ Item 4 | At least two cross-sections shall be submitted | At these large and variable sites, two cross sections will often be insufficient, and the number and extent of cross sections submitted should be based primarily on the size and heterogeneity of volumes and features depicted. |
| Section 2.1.2 | 7 / Item 4j | "Any known geologic features…" | Geologic features should include folds. |
| Section 2.1.2 | 8/ Item 4m | "Depths of low-permeability zones and the strata that contain them **that will function** to hydraulically isolate…" | We suggest restating this to "that will or might function". |
| Section 2.1.2 | 7/ Item 4 | NA | Suggest adding additional criteria for cross-sections that include: high permeability zones that could allow pollutant migration, screen intervals of all wells, stratigraphy of all zones present, and extents and configuration of all actual and potential oil and gas deposits and production zones. |
| Section 2.1.2 | 6 | NA | Suggest adding additional criteria: proppants and all other stimulation fluid constituents not required elsewhere in the Draft Criteria, source and chemistry of water to be used in stimulation fluid, and all planned injection parameters such as pressures, volumes, durations, effects, etc. |

**Table 1. GRA Comments to Draft Model Criteria for Groundwater Monitoring is Areas of Oil and Gas Well Stimulation**

| Document Section | Page Number/ Paragraph | Statement from the Draft Model Criteria | Comment |
|---|---|---|---|
| Section 2.1.3 | 11,12/Item 5 | "Groundwater samples shall be analyzed using current applicable …methods… | The extensive list of analytes appears overly broad for the intended monitoring purposes. In addition, some of the requested analyses are unique, costly and performed at specialty laboratories. It is suggested that the list of analytes be reduced to key compounds that are persistent, mobile, and associated with the well stimulation program that will indicate if the stimulation fluids have impacted overlying groundwater aquifers. |
| Section 2.1.3 | 11,13/Item 6 | "If concentrations of the analytes… change between sampling events... | Same comment as above |
| Section 2.1.3 | 11,13/Item 6 | "If concentrations of the analytes… change between sampling events... | Changes in naturally occurring constituents should be expected. The emphasis should be on changes in constituents associated with the specific WST treatment. |
| Section 2.1.3 | 13 | NA | Aquifer properties should be included in the analysis program for installed wells. It is recommended that hydraulic conductivity be analyzed for each monitored zone through slug or pump tests. This information should be used to evaluate linear transport velocities from the stimulated well to downgradient monitoring points. |
| Section 2.1.4 | 13,14 | Entire Section | This section should be expanded to include data analysis requirements to assess whether the monitoring program is adequate and whether any leaks have been detected. The proposed reporting requirements at this time are merely data transmittal. At a minimum groundwater flow patterns, gradients and velocities should be evaluated for each monitored aquifer zone and detected analytes discussed with respect to potential releases from the stimulated well. |
| Section 3.1 | 16/1 | "All water sampling…shall be performed by a third-party contractor… | All sampling work should be conducted under the oversight of a CA licensed PE or PG with hydrogeologic experience. |