



2021 Annual Performance Report:
**Model Criteria for Groundwater Monitoring in Areas of Oil
and Gas Well Stimulation**

Reporting Period: January 1, 2021 through December 31, 2021

STATE WATER RESOURCES CONTROL BOARD

March 30, 2022

Table of Contents

1.0	INTRODUCTION	7
1.1	BACKGROUND	7
2.0	AREA-SPECIFIC GROUNDWATER MONITORING.....	8
2.1	GROUNDWATER MONITORING PLANS	9
2.2	REQUESTS FOR EXCLUSION AND ADDED WELLS.....	9
3.0	PROPERTY-OWNER NOTIFICATIONS AND REQUESTED WATER SAMPLING.....	10
4.0	ASSESS IMPLEMENTATION COSTS	11
5.0	REGIONAL MONITORING PROGRAM.....	11
5.1	PUBLISHED REGIONAL MONITORING PROGRAM RESULTS AND FINDINGS- 2021.....	12
6.0	LESSONS LEARNED FROM IMPLEMENTATION OF THE MODEL CRITERIA	13
APPENDIX A - WEB LINK GLOSSARY		18
APPENDIX B - PERFORMANCE MEASURES		21
APPENDIX C - TABLES.....		23
APPENDIX D - REGIONAL MONITORING PROGRAM WORK CONDUCTED.....		30

GLOSSARY

Area-specific Groundwater Monitoring Plan (GMP) – A groundwater monitoring plan submitted by the oil and gas field operator to characterize baseline water quality conditions and detect potential impacts to protected water from well stimulation treatments. A GMP may be developed for a stimulated well or group of stimulated wells. The GMP should describe the groundwater monitoring design, as well as proposed groundwater sampling and analytical testing.

Addendum: An operator may propose an addendum to a GMP in which additional wells to stimulate in an area would be added to a GMP approved previously by State Water Resources Control Board (State Water Board) and Regional Water Quality Control Board staff (collectively, Water Boards).

Axial Dimensional Stimulation Area (ADSA) – The estimated maximum length, width, height, and azimuth of the area(s) stimulated by a well stimulation treatment (WST) (California Geologic Energy Management Division [CalGEM] Well Stimulation Treatment Regulations, July 1, 2015). CalGEM approves or denies the ADSA as part of the well stimulation permitting process. After approval of the ADSA, a well stimulation permit may be issued to an operator; however, stimulation cannot occur until State Water Board staff has approved either a groundwater monitoring plan or request for exclusion from groundwater monitoring associated with the permitted well(s).

Designated Contractors – State Water Board is required to designate one or more qualified independent third-party contractors to perform property owner requested water quality sampling and testing (Pub. Resources Code, §3160, subdivision (d)(7)(B)). The designated contractor must not work for or be affiliated with an oil and gas operator. A list of approved designated contractors is maintained by the State Water Board.

Exempted aquifer – As defined in 40 Code of Federal Regulations (CFR) part 146.4, an aquifer or a portion thereof which meets the criteria for an underground source of drinking water may be determined to be an “exempted aquifer” if:

- 1) It does not currently serve as a source of drinking water, and
- 2) it cannot now and will not in the future serve as a source of drinking water.

In addition it must meet the requirements of California Public Resources Code (PRC) 3131(a):

- 1) Criteria set forth in Section 146.4 of Title 40 of the Code of Federal Regulations.
- 2) The injection of fluids will not affect the quality of water that is, or may reasonably be, used for any beneficial use.
- 3) The injected fluid will remain in the aquifer or portion of the aquifer that would be exempted.

Refer to 40 CFR part 146.4 and PRC 3131(a) for regulation specifics.

Groundwater Monitoring – Monitoring of protected water in a specific area to characterize baseline water quality conditions and to assess potential effects to beneficial use waters from well stimulation treatment activities (i.e., monitoring well sampling and gauging of water levels).

Interim Groundwater Monitoring Plan (interim GMP) – GMP approved during the interim period (January 1, 2014 – July 6, 2015) prior to the State Water Board adoption of the Model Criteria for Groundwater Monitoring in Areas of Oil and Gas Well Stimulation.

Model Criteria for Groundwater Monitoring in Areas of Oil and Gas Well Stimulation (Model Criteria) – Outlines the methods to be used for assessment, sampling, analytical testing, and reporting of water quality associated with oil and gas well stimulation treatments. Adopted by the State Water Board July 7, 2015.

Performance Measures – Performance measures are a means to evaluate the effectiveness and efficiency of the Model Criteria. Five (5) goals were developed through a process of meetings with stakeholder groups. Performance measures are included in the *Model Criteria for Groundwater Monitoring in Areas of Well Stimulation: Summary of Goals, Strategies, Proposed Performance Measures, and Plans for Implementation* (March 1, 2016).

Protected Water – Water with less than 10,000 milligrams per liter of total dissolved solids and located outside an exempt aquifer

Regional Groundwater Monitoring Program (RMP) – As required by Senate Bill 4 (Statutes of 2013), and detailed in the Model Criteria, the State Water Board is to implement an oil and gas regional groundwater monitoring program in order to protect all waters designated for any beneficial use, while prioritizing the monitoring of groundwater that is or has the potential to be a source of drinking water. Factors considered for the RMP include well stimulation treatments, among other events or activities that have the potential to contaminate groundwater. The U.S. Geological Survey is the technical lead on the RMP.

Request for Exclusion from Area-Specific Groundwater Monitoring– A document submitted by the oil and gas field operator to request exclusion from groundwater monitoring before proceeding with well stimulation activities. State Water Board staff must provide a written concurrence to the operator for the exclusion from groundwater monitoring.

Request to Add Wells to an Existing Exclusion (Added Wells): An operator may submit requests to add wells to stimulate in an existing exclusion area approved previously by Water Boards staff.

Well stimulation treatment (WST) – A treatment procedure for a well to enhance production by increasing the permeability of the formation. WSTs include, but are not limited to, hydraulic fracturing treatments and acid well stimulation treatments.

Submittal Status:

Approved - Submittal was reviewed and has met the requirements of the Model Criteria.

Denied - Submittal did not meet the minimum requirements of the Model Criteria.

Cancelled - Submittal was retracted by the operator or review discontinued by State Water Board.

Review in Progress - Submittal is being reviewed by Water Boards staff.

On Hold - Water Boards staff are not currently reviewing the submittal. Submittals may be put "On Hold" for the following reasons:

- Comments have been forwarded to the operator and the operator is working on a revised submittal.
- Water Boards staff are awaiting approval of the Axial Dimensional Stimulation Area (ADSA) from CalGEM.
- The submittal is on hold at the request of the operator.

ABBREVIATIONS AND ACRONYMS

ADSA	Axial Dimensional Stimulation Area
Annual Model Criteria Performance Report	2021 Annual Performance Report: Model Criteria for Groundwater Monitoring in Areas of Oil and Gas Well Stimulation
bbbl	barrel(s) of oil
CalGEM	California Geologic Energy Management Division
CIPA	California Independent Petroleum Association
COGG	United States Geological Survey California Oil, Gas, and Groundwater Program (see RMP)
GeoTracker	GeoTracker Information System
GMP	Area-specific groundwater monitoring plan
GMR	Area-specific groundwater monitoring report associated with GMPs
MCL	maximum contaminant level
Model Criteria	Model Criteria for Groundwater Monitoring in Areas of Oil and Gas Well Stimulation
neighbor notification	CalGEM Well Stimulation Treatment Neighbor Notification Form
operator	oil and gas field operator
RMP	Regional Monitoring Program (see COGG)
Regional Water Board	Regional Water Quality Control Board
reporting period	January 1, 2021 - December 31, 2021
State Water Board	State Water Resources Control Board
USGS	United States Geological Survey
Water Boards	State Water Resources Control Board and Regional Water Quality Control Boards
WellSTAR	Well Statewide Tracking and Reporting System
WSPA	Western States Petroleum Association
WST	Well Stimulation Treatment

1.0 INTRODUCTION

This Annual Performance Report summarizes work performed from January 1, 2021 through December 31, 2021 (reporting period) by staff from the State Water Resources Control Board (State Water Board) and associated agencies to implement the *Model Criteria for Groundwater Monitoring in Areas of Oil and Gas Well Stimulation* (Model Criteria).

State Water Board staff developed the Model Criteria to guide the process for assessing potential effects of well stimulation treatments (WSTs) on California's groundwater resources. It outlines groundwater monitoring requirements for area-specific groundwater monitoring conducted by oil and gas operators (operators), as well as the approach State Water Board staff will take to conduct a Regional Monitoring Program (RMP).

A WST cannot be performed until staff from the California Department of Conservation, California Geologic Energy Management Division (CalGEM) issues a WST permit and the State Water Board and the appropriate Regional Water Quality Control Board (collectively, Water Boards) staff have:

- approved an operator-submitted groundwater monitoring plan (GMP), or
- approved an operator-submitted request for exclusion from groundwater monitoring.

If the operator proposes WST for additional wells in an area where a GMP or exclusion was previously approved, an addendum to the GMP (addendum) or a request to add wells to an existing exclusion is required.

The requirement for a GMP is limited to areas where protected water is present. Protected water is defined as:

- Water with less than 10,000 milligrams per liter (mg/L) of total dissolved solids
- Located outside of an exempt aquifer

Efforts performed by State Water Board staff for implementation of the Model Criteria during the reporting period are presented in six sections of this report. Please note that URLs for hyperlinks can be found in the Web Link Glossary (Appendix A).

1.1 Background

Senate Bill 4 (Pavley, Statutes of 2013) required the State Water Board to establish and implement a comprehensive regulatory groundwater monitoring and oversight program for WSTs (including hydraulic fracturing) in areas of oil and gas operations (California Water Code section 10783). The State Water Board was also required to develop a "model criteria" for groundwater monitoring to assess potential effects of WSTs on California's groundwater resources. The Model Criteria was adopted by the State Water Board on July 7, 2015 (*Resolution No. 2015-0047*). It outlines requirements for groundwater monitoring conducted by operators, as well as the approach the State Water Board will take to conduct the RMP.

Prior to the Model Criteria, CalGEM developed *Emergency Interim Regulations* which included groundwater monitoring requirements. The interim regulations were effective from January 1, 2014 to June 30, 2015, operators were required to submit either an approved groundwater

monitoring plan (interim GMP) or a letter from State Water Board staff concurring that the well(s) planned for WST does not penetrate protected water. If no additional WSTs were planned in an area with an approved interim GMP, the operator continued monitoring under the interim GMP. Several interim and Model Criteria GMPs were active during this reporting period. Data from both are uploaded to the State Water Board's GeoTracker information system ([GeoTracker](#)).

The original performance measures (Appendix B) were presented to the State Water Board on March 1, 2016 and included goals, strategies, and plans for implementing the Model Criteria. The State Water Board [Model Criteria for Groundwater Monitoring in Areas of Well Stimulation: Summary of Goals, Strategies, Proposed Performance Measures, and Plans for Implementation](#) (Performance Measures) specifies that the State Water Board prepare and make publicly available an "Annual Model Criteria Performance Report" with the following five performance measures:

1. Provide transparent and availability of online information and documentation
2. Provide clear milestones and timely deliverables
3. Understand and mitigate impacts of well stimulation on water quality and public health
4. Provide region-specific or localized flexibility, where possible
5. Assess implementation costs

2.0 AREA-SPECIFIC GROUNDWATER MONITORING

Well stimulation permits are required prior to performing WSTs. The number and status of well stimulation permits can be found on the CalGEM Well Statewide Tracking and Reporting System ([WellSTAR](#)). Effective December 17, 2019, the public can use WellSTAR to find information about WST permits and disclosures.

A GMP is required where protected water is present. If the operator proposes WST for additional wells in an area where a GMP is approved, then an addendum to the GMP is required. A GMP is required unless an operator can make a technical demonstration that the wells to be stimulated do not penetrate protected water. Operators must obtain approval for additional WST wells to be stimulated in an existing exclusion from groundwater monitoring. Process flowcharts for Water Boards staff review of Area Specific Monitoring Program submittals can be found on the [Additional Resources](#) webpage. A summary table of the 2021 groundwater monitoring information is provided below.

Operators are required to submit data from groundwater monitoring wells sampled as part of GMPs to GeoTracker as Groundwater Monitoring Reports (GMRs). Water Boards staff review GMRs and provide comments to operators via comment letters that are also archived in GeoTracker.

2021 Summary Table: Submittals and Review Timeline Milestones

Type of Submittal	Approved	Denied	Review in Progress / On Hold	Cancelled	Total	Average Review Time (days)	Total No. of Approved WST Wells
GMPs	0	0	1	0	1	--	--
Addenda	0	0	3	0	3	--	--
Requests for Exclusions	0	0	2	0	2	--	--
Requests to Add Wells to an Existing Exclusion	9	0	0	0	9	31	32

Note – Approved requests for exclusion do not include specific WST wells

2.1 Groundwater Monitoring Plans

Water Boards staff reviewed one GMP and three addenda during the reporting period. The status and review timeline milestones for GMP and addenda are summarized in Appendix C - Tables 1 and 2. The locations of GMP and addenda submitted, and wells stimulated in 2021 are shown in Figure 1.

Process and Timeline for Reviewing Groundwater Monitoring Plans

Water Boards staff conduct a completeness check to verify all required information once a GMP or addendum has been uploaded to GeoTracker, and then initiates the review. Water Boards staff develop comments to obtain additional information from the operator. If Water Boards staff provide comments or deny a GMP and the operator chooses to pursue WST, the operator is required to submit a revised GMP or addendum. The Axial Dimensional Stimulation Area (ADSA) must be approved by CalGEM before a GMP or addendum can be approved. When submittals are placed "On Hold", that time is not included in the calculation of total review time.

Groundwater Monitoring Plans Submitted that Propose Alternative Methods

The Model Criteria allows Water Boards staff to consider proposed alternatives and modifications to the methods for GMPs based on factors such as site-specific conditions (e.g., terrain, geology, access), number and depth of aquifers containing protected water, potential pathways, and risk to receptors (e.g., groundwater resources). Water Boards staff shall provide at least 15 days' notice and an opportunity for public comment on the proposal prior to approving a proposed alternative or modification. State Water Board staff did not receive an alternative proposal for groundwater monitoring in 2021.

2.2 Requests for Exclusion and Added Wells

Water Boards staff may grant an exclusion from groundwater monitoring requirements if staff concur with the absence of protected water. During this reporting period, Water Boards staff reviewed two requests for exclusion and nine requests to add wells to an existing exclusion (added wells). The status and review timeline milestones for exclusions and added wells are

summarized in Appendix C - Tables 3 and 4. The locations of these submittals and wells stimulated in 2021 are shown in Figure 2. All requests for exclusion and added wells reviewed were in the following county and oil fields:

- Kern County – North Belridge, South Belridge, and McKittrick

Process and Timeline for Reviewing Requests for Exclusion

Water Boards staff conduct a completeness check to verify all required information once a request for exclusion or added wells has been uploaded to GeoTracker and then initiates the review. If necessary, comments are developed to obtain additional information from the operator. After staff have completed their review, the request for exclusion is either approved or denied. When submittals are placed “On Hold”, that time is not included in the calculation of total review time. Request for exclusion approval does not depend on CalGEM approving an ADSA but is based solely on whether sufficient technical information was submitted to clearly demonstrate the absence of protected water. The time for Water Boards staff to review requests for exclusion and added wells submittals during the reporting period is summarized in Appendix C - Tables 3 and 4.

3.0 PROPERTY-OWNER NOTIFICATIONS AND REQUESTED WATER SAMPLING

Operators are required to hire an independent third-party to notify property owners, or tenants of a property, located within 1,500 feet of the well to be stimulated or within 500 feet of the surface representation of the horizontal path of the area of stimulation. CalGEM is responsible for maintaining records regarding the third-party notification process. The third party sends the property owners or tenants a Well Stimulation Treatment Neighbor Notification Form (neighbor notification), which includes information such as the earliest date the well may be stimulated and how the property owner may request water quality testing on an existing water well or surface water suitable for drinking. Additional information regarding this process can be found on the [CalGEM Well Stimulation Treatment Neighbor Notification and Water Sampling](#) webpage. As of October 29, 2019, neighbor notification forms must be submitted through the WellSTAR electronic database. CalGEM staff provided to Water Boards staff the count of neighbor notifications sent to property owners. Historical notification counts are found in Appendix C - Table 5. The 2021 notification counts are summarized below:

- Aera Energy, LLC – 5
- Chevron USA, Inc – 17

State Water Board staff maintain a [List of Designated Contractors for Water Sampling](#) (designated contractor) to perform property owner requested water quality sampling. Once a property owner receives a notification regarding WST from an operator, the property owner may choose a designated contractor to perform water quality sampling. Designated contractors are required to notify State Water Board staff prior to sampling and upload the results to GeoTracker after analysis. During 2021, State Water Board staff did not receive any notifications of water sampling requests.

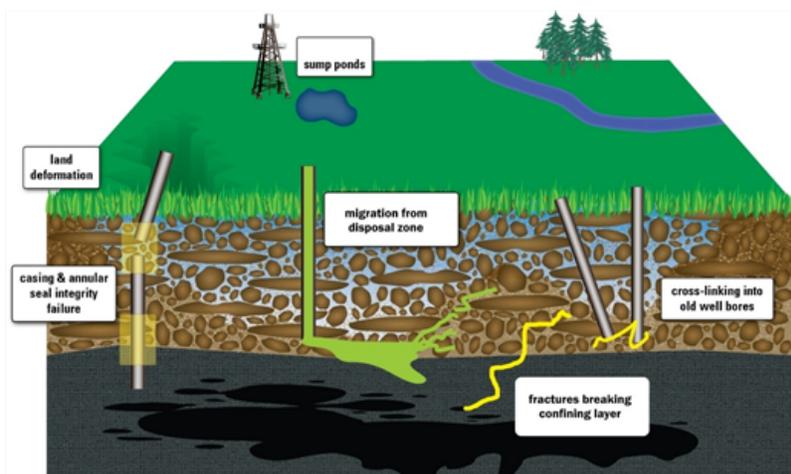
4.0 ASSESS IMPLEMENTATION COSTS

State Water Board staff, in cooperation with operators and representatives from California Independent Petroleum Association (CIPA) and Western States Petroleum Association (WSPA), developed a list of information needed to assess operator costs. CIPA, in collaboration with WSPA, used a third-party aggregator to collect and report estimated operator costs associated with the implementation of the Model Criteria. In 2021, the reported estimated cost for operators to perform tasks associated area-specific monitoring and the RMP was \$638,680 and \$95,296, respectively. These costs are described in detail in Appendix C - Table 6.

Water Boards have a total of 14 staff positions dedicated to WST activities budgeted at \$2.45 million per year and the RMP has a budget of \$7.4 million per year. Both are funded through the Oil, Gas, and Geothermal Administrative Fund.

5.0 REGIONAL MONITORING PROGRAM

The goal of the RMP is to evaluate potential impacts from WST and oil field operations, and to characterize the risk to water designated for any beneficial use (e.g., drinking water). The RMP evaluates pathways (see illustration below) by determining which WSTs and other oil and gas operations have the potential to contaminate groundwater. Potential pathways include the injection of water and/or steam during enhanced oil recovery practices, underground oilfield water injection, leakage along improperly constructed and/or compromised wells, surface disposal ponds, or natural geologic sources.



Potential Pathways between Oil & Gas Activities and Protected Groundwater
(Source: USGS, <https://ca.water.usgs.gov/projects/oil-gas-groundwater/science/pathways/>)

The United States Geological Survey (USGS) is the technical lead of the RMP, which the USGS refers to as the California Oil, Gas, and Groundwater (COGG) Program. The approach used by the USGS includes mapping groundwater salinity, characterizing and monitoring groundwater in wells near oil fields, and characterizing oilfield fluids. Together, with site-specific information about the local geology, hydrology, and historic disposal areas, this approach helps to

systematically and comprehensively collect and interpret information that will help support the protection of beneficial use water in California.

USGS and State Water Board staff selected study areas using results from the prioritization analysis (*Davis and others, 2018*). Well depth, water chemistry, geophysical, geologic, and oilfield operational data were compiled by USGS into numerical databases for use in the regional analyses. Appendix D presents a summary of work conducted as of 2021 for each of these major tasks:

1. Salinity mapping
2. Groundwater sampling
3. Oilfield fluid sampling
4. Interpretative analysis of the collected data from tasks 1 through 3 in each of these selected fields.

During the reporting period, the USGS identified suitable locations of groundwater wells, as well as oil production wells and injection well sites that met water and fluid sample criteria for the RMP. Once the well locations were determined, the USGS worked with operators to obtain access to collect samples. Samples collected include 95 water supply and monitoring wells in eight study areas and 40 oilfield fluid sample sites in six study areas. State Water Board staff hosted a public meeting on December 8, 2021, where USGS presented an update on RMP activities and findings.

5.1 Published Regional Monitoring Program Results and Findings-2021

In 2021, the RMP focused on USGS publication of results describing new methodologies for investigating hydrocarbons and salts in groundwater near areas of oil and gas operations. Complete references to USGS publications are available on the [State Water Board RMP webpage](#). The observations below summarize results from publications in 2021.

- Rosecrans et al., 2021 “[Groundwater Quality of Aquifers Overlying the Oxnard Oil Field, Ventura County, California](#)”
 - Please see the [Rosecrans, 2021 article summary](#) for key findings.
- McMahon et al., 2021 “[Relative risk of groundwater-quality degradation near California \(USA\) oil fields estimated from ³H, ¹⁴C, and ⁴He](#)”
 - Isotopes of hydrogen, carbon, and helium were used to estimate the age of groundwater near select oil fields and compared to groundwater chemistry data. Results show higher risks of potential impacts from different sources depending on groundwater age. Premodern groundwater (recharged prior to 1953) has a relatively higher risk of impacts from upward migration than modern water which has a relatively higher risk from land-surface sources.
- Karolyte et al., 2021 “[Noble gas signatures constrain oil-field water as the carrier phase of hydrocarbons occurring in shallow aquifers in the San Joaquin Basin, USA](#)”

- Noble gas data were used to examine groundwater source and interactions near various oil field areas in California. These novel methods demonstrate that noble gases can be useful for determining the source of hydrocarbon gases found in water.
- Stephens et al., 2021 “*Stratigraphic and structural controls on groundwater salinity variations in the Poso Creek Oil Field, Kern County, California, USA*”
 - Please see the *Stephens et al., 2021 article summary* for key findings.
- Tyne et al., 2021 “*Investigating the effect of enhanced oil recovery on the noble gas signature of casing gases and produced waters from selected California oil fields*”
 - Noble gas data, from various oil field areas in California, were analyzed to compare how casing gas and produced fluids evolve as a result of oil field development. Results show that noble gas concentrations in a reservoir are controlled by the volume and composition of water that is injected into it.
- Terry et al., 2021 “*Geostatistical Mapping of Salinity Conditioned on Borehole Logs, Montebello Oil Field, California*”
 - Salinity concentrations were modeled using groundwater sample data and resistivity from geophysical logs. The aquifer in the Montebello study area is mostly fresh water. An area of higher salinity groundwater was estimated by the model and confirmed by a consistent groundwater sample and resistivity data in the area.

6.0 LESSONS LEARNED FROM IMPLEMENTATION OF THE MODEL CRITERIA

A summary of opportunities identified by ongoing program evaluation based on performance measures is provided below with highlights of actions completed in 2021 and actions planned for 2022:

- Provide transparent and available information online:
 - New groundwater monitoring data was uploaded to GeoTracker and updates were made to the State Water Board Oil and Gas program webpage to include recent USGS publications. State Water Board staff developed a GIS layer in GeoTracker to display U.S. Environmental Protection Agency approved aquifer exemption boundaries and coordinated with CalGEM staff to convert data sets to a format that can be shown on GeoTracker.
 - In 2022, State Water Board staff will continue to evaluate opportunities to improve data visualizations and data sharing strategies within GeoTracker.
- Provide clear milestones and timely deliverables:
 - Water Boards staff met with operators to discuss new projects and provide feedback on submittal criteria and process to expedite review.
 - In 2022, State Water Board staff will continue evaluating tracking tools to monitor the status of operator submittals to increase review efficiency. State Water Board staff will review and cancel projects that have remained inactive for extended periods of time, the WST permit cancelled or denied by CalGEM, and/or the operator elected not to pursue WST within the GMP or exclusion area.

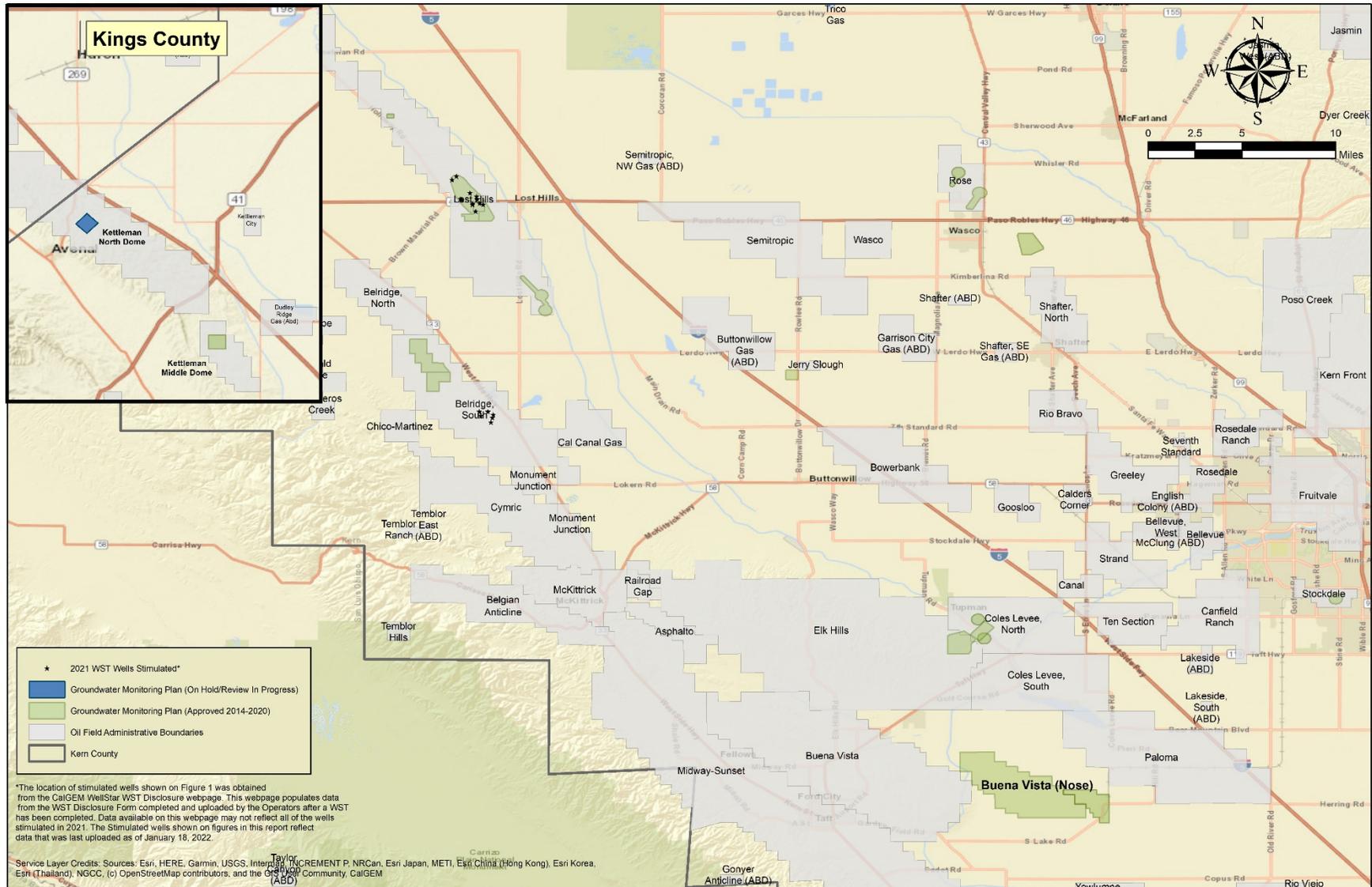
2021 Annual Model Criteria Performance Report

- Understand and mitigate impacts of well stimulation on water quality and public health:
 - State Water Board staff hosted public briefings on RMP activities and facilitated kick off meetings with the USGS and operators prior to sampling. Additionally, State Water Board staff sent GMR review comments to operators to ensure Model Criteria compliance.
 - In 2022, State Water Board staff will continue its evaluation of the Model Criteria. Finally, public meeting(s) will be held to present technical findings following RMP publications.
- Provide region-specific or localized flexibility:
 - State Water Board staff received no alternative proposals for groundwater monitoring during the reporting period.
- Assess implementation costs:
 - State Water Board staff will continue to identify and assess implementation costs.

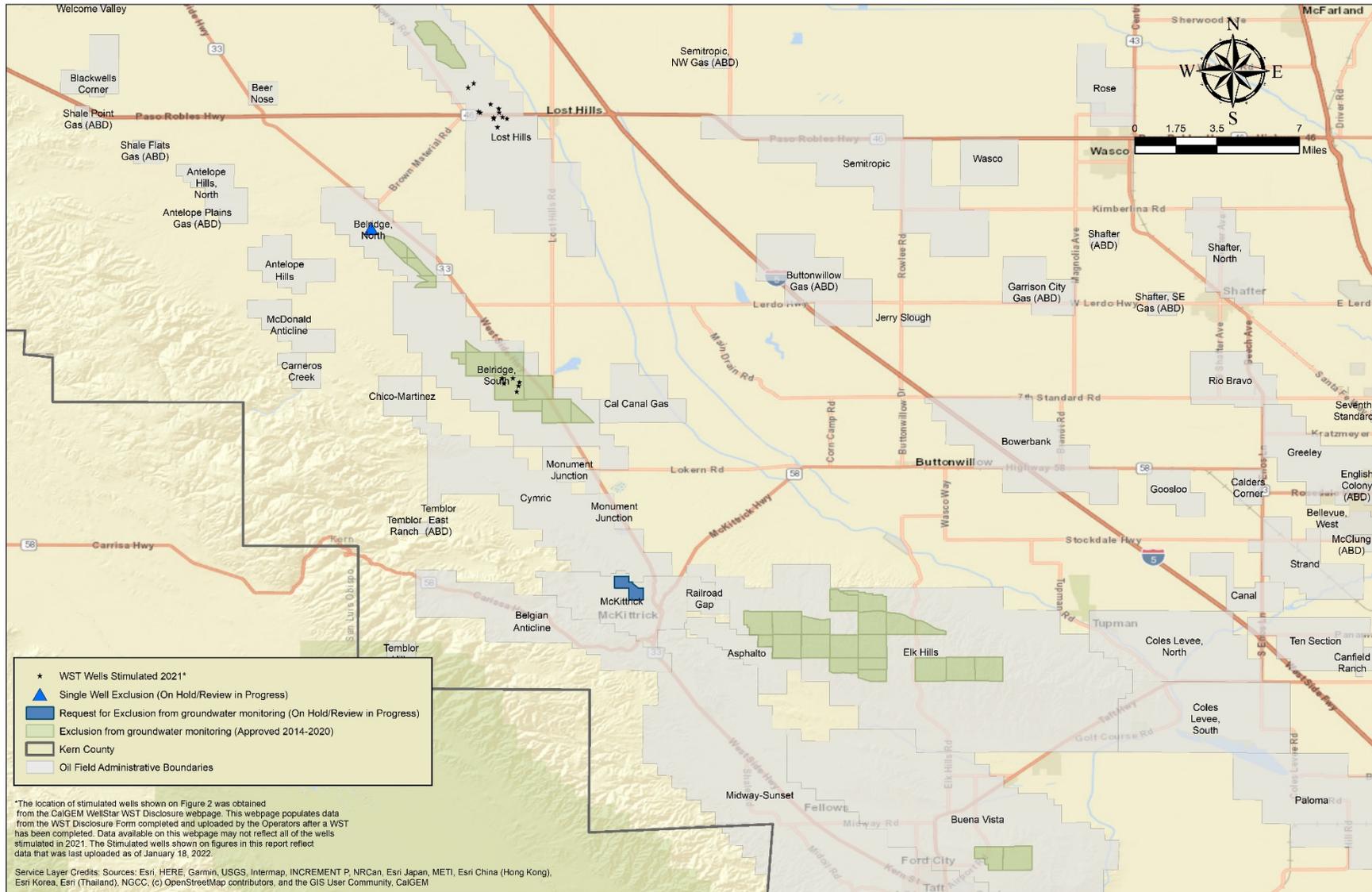
FIGURES

FIGURE 1 GROUNDWATER MONITORING PLANS AND WELLS STIMULATED
(JANUARY 1, 2021 - DECEMBER 31, 2021)

FIGURE 2 REQUESTS FOR EXCLUSION FROM GROUNDWATER MONITORING
AND WELLS STIMULATED (JANUARY 1, 2021 - DECEMBER 31, 2021)



**Figure 1. Groundwater Monitoring Plans and Wells Stimulated
(January 1, 2021- December 31, 2021)**



**Figure 2. Requests for Exclusion from Groundwater Monitoring and Wells Stimulated
(January 1, 2021- December 31, 2021)**

Appendix A - WEB LINK GLOSSARY

LINK TEXT	URL ADDRESS	SECTION
MODEL CRITERIA FOR GROUNDWATER MONITORING IN AREAS OF OIL AND GAS WELL STIMULATION	https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/well_stimulation/index.shtml	1
40 CODE OF FEDERAL REGULATIONS (CFR) PART 146.4	https://www.waterboards.ca.gov/rwqcb3/board_info/agendas/2017/january/item9/item9_att1.pdf	1
RESOLUTION NO. 2015-0047	https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2015/rs2015_0047.pdf	1
EMERGENCY INTERIM REGULATIONS	https://www.conservation.ca.gov/index/Pages/preregulations.aspx	1
GEOTRACKER	https://geotracker.waterboards.ca.gov/	1
MODEL CRITERIA FOR GROUNDWATER MONITORING IN AREAS OF WELL STIMULATION: SUMMARY OF GOALS, STRATEGIES, PROPOSED PERFORMANCE MEASURES, AND PLANS FOR IMPLEMENTATION	https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/performance_measures/index.shtml	1
WELLSTAR	https://wellstar-public.conservation.ca.gov/	2
ADDITIONAL RESOURCES	https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/additional_resources/	2
CALGEM WELL STIMULATION TREATMENT NEIGHBOR NOTIFICATION AND WATER SAMPLING MCLS FOR DRINKING WATER	https://www.conservation.ca.gov/calgem/Pages/WSTNeighborNotificationAndWaterSampling.aspx https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MCLsandPHGs.shtml	3
STATE WATER BOARD LIST OF DESIGNATED CONTRACTORS FOR WATER SAMPLING CALGEM WELL STIMULATION TREATMENT NEIGHBOR NOTIFICATION AND WATER SAMPLING	https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/docs/list_of_designated_contractors_sept_2019.pdf https://www.conservation.ca.gov/calgem/Pages/WSTNeighborNotificationAndWaterSampling.aspx	3
STATE WATER BOARD RMP WEBPAGE	https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/regional_monitoring/docs/poso-creek-article-summary.pdf	5
DAVIS AND OTHERS, 2018 GROUNDWATER QUALITY OF AQUIFERS OVERLYING THE OXNARD OIL FIELD,	https://doi.org/10.3133/sir20185065	5
	https://www.sciencedirect.com/science/article/pii/S0048969720383558?via%3Dihub	5

2021 Annual Model Criteria Performance Report

VENTURA COUNTY, CALIFORNIA		
ROSECRANS, 2021 ARTICLE SUMMARY	https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/article_summary_oxnard_study.pdf	5
RELATIVE RISK OF GROUNDWATER-QUALITY DEGRADATION NEAR CALIFORNIA (USA) OIL FIELDS ESTIMATED FROM 3H, 14C, AND 4HE	https://doi.org/10.1016/j.apgeochem.2021.105024	5
NOBLE GAS SIGNATURES CONSTRAIN OIL-FIELD WATER AS THE CARRIER PHASE OF HYDROCARBONS OCCURRING IN SHALLOW AQUIFERS IN THE SAN JOAQUIN BASIN, USA	https://www.sciencedirect.com/science/article/pii/S0009254121004344?via%3Dihub	5
STRATIGRAPHIC AND STRUCTURAL CONTROLS ON GROUNDWATER SALINITY VARIATIONS IN THE POSO CREEK OIL FIELD, KERN COUNTY, CALIFORNIA, USA	https://link.springer.com/article/10.1007/s10040-021-02381-5	5
STEPHENS ET AL., 2021 ARTICLE SUMMARY	https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/regional_monitoring/docs/poso-creek-article-summary.pdf	5
INVESTIGATING THE EFFECT OF ENHANCED OIL RECOVERY ON THE NOBLE GAS SIGNATURE OF CASING GASES AND PRODUCED WATERS FROM SELECTED CALIFORNIA OIL FIELDS	https://www.sciencedirect.com/science/article/pii/S0009254121004836?via%3Dihub	5
GEOSTATISTICAL MAPPING OF SALINITY CONDITIONED ON BOREHOLE LOGS, MONTEBELLO OIL FIELD, CALIFORNIA	https://ngwa.onlinelibrary.wiley.com/doi/10.1111/gwat.13155	5

Appendix B - PERFORMANCE MEASURES

Goals	Strategy
<p>Goal #1: Transparency and availability of online information and documentation.</p>	<p>1.1 Improve and expand upon available datasets and the ability to analyze and manipulate that data.</p>
	<p>1.2 Improve online user experience with simplified and clear messaging to make data easier to access.</p>
	<p>1.3 Create data communication/sharing strategy to optimize data and information sharing between the State Water Board, Regional Water Boards, CalGEM, and other agencies, as appropriate.</p>
<p>Goal #2: Provide clear milestones and timely deliverables.</p>	<p>2.1 Make milestones and deliverables outlined in the Model Criteria and Senate Bill 4 (Chapter 313, Statutes of 2013, including Water Code section 10783), publicly available.</p>
	<p>2.2 Prepare review processes, flowcharts, and timelines for reviewing GMPs and requests for exclusion from groundwater monitoring, including interagency collaboration and program efficiencies.</p>
<p>Goal #3: Understand and mitigate impacts of well stimulation on water quality and public health.</p>	<p>3.1 Provide regular assessments of monitoring data, including pilot study results and identification of any chemicals of concern.</p>
	<p>3.2 Mitigate problems as they occur and share mitigation efforts with stakeholders.</p>
	<p>3.3 Develop a plan to re-evaluate the effectiveness of monitoring. Modify the scope of work and approach based on evaluation of the data collected and evaluated.</p>
	<p>3.4 Coordinate with other agencies to identify risk.</p>
<p>Goal #4: Provide region-specific or localized flexibility where possible.</p>	<p>4.1 Consider local conditions when reviewing groundwater plans.</p>
	<p>4.2 Clearly communicate why region-specific activities are occurring.</p>
	<p>4.3 Use consistent flexibility criteria for monitoring.</p>
<p>Goal #5: Assess implementation costs.</p>	<p>5.1 Assess implementation cost for the State Water Board and stakeholders.</p>

Appendix C - TABLES

LIST OF TABLES

Table 1	Groundwater Monitoring Plans Reviewed (January 1, 2021 – December 31, 2021)
Table 2	Groundwater Monitoring Plans (addenda) Reviewed (January 1, 2021 - December 31, 2021)
Table 3	Requests for Exclusion Reviewed (January 1, 2021 - December 31, 2021)
Table 4	Requests for Exclusion (added wells) Reviewed (January 1, 2021 - December 31, 2021)
Table 5	Number of Neighbor Notifications sent by Operators
Table 6	Estimated Operator Costs Provided by CIPA and WSPA

Notes and Acronyms for all tables:

-- = not applicable

ADSA = Axial Dimension Stimulation Area

CalGEM = California Geologic Energy Management Division – Department of Conservation

GMP = Groundwater Monitoring Plan

WST = Well Stimulation Treatment

Bbl = Barrel(s) of oil

1. Located in Kern County, unless otherwise noted.
2. Date of Revised Plan submission to GeoTracker or other action by Operator.
3. On Hold indicates that Water Boards staff are waiting on additional information from the operator, waiting for the approved ADSA from CalGEM, or the submittal has been placed On Hold at the request of the operator.
4. Days to complete the process equates to the elapsed time between the "GMP Date Accepted" to "Status/Determination Date". For GMPs (new and addenda) with multiple revisions, days to complete the process equates to the sum of days to review the original submittal and the days to review each of the revisions. This time includes communications with the operator, Regional Water Board staff, and CalGEM, review of data and the submittal, and preparation and review of agency correspondence. Refer to the Process Flowchart for Uploading and Reviewing GMPs (new or addenda) on the Additional Resources webpage for the detailed flowchart of the GMP review process.
5. Days to complete the process equates to the elapsed time between the "Request for Exclusion Accepted Date" to "Status/Determination Date". For Requests for Exclusions with multiple revisions, days to complete the process equates to the sum of days to review the original submittal and the days to review each of the revisions. This time includes communications with the operator, Regional Water Board staff, and CalGEM, review of data and the submittal, and preparation and review of agency correspondence. Refer to the Process Flowchart for Reviewing Requests for Exclusion from Groundwater Monitoring on the Additional Resources webpage for the detailed flowchart of the Exclusions from Groundwater Monitoring review process.
6. Days to complete the process equates to the elapsed time between the "Date Accepted Request for Exclusion (added wells)" to "Status/Determination Date". For Request for Exclusion (added wells) with multiple revisions, days to complete the process equates to the sum of days to review the original submittal and the days to review each of the revisions. This time includes communications with the operator, Regional Water Board staff, and CalGEM, review of data and the submittal, and preparation and review of agency correspondence. Refer to the Process Flowchart for Reviewing Well Stimulation Permit Applications on the Additional Resources webpage for the detailed flowchart of the Exclusions from Groundwater Monitoring review process.

Table 1: Groundwater Monitoring Plans Reviewed (January 1, 2021 – December 31, 2021)

GeoTracker Global Identification	Oil Field or (Area)	Township (T), Range (R), Section (S) ¹	Operator	GMP Date Accepted	New or Addendum GMP	Days for Initial Response	Interim Review Actions (GeoTracker Submittal Date(s))	Status/ Determination ²	Number of WST Wells Approved	Status/ Determination Date	Days to Complete Process ³	Comments
GAOG10011823	Kettleman North Dome	T22S, R17E, S11	California Resources Corporation	2/11/2019	New	85	Operator submitted a revised GMP (2/11/2019) Operator placed the project on hold (4/9/2019)	On Hold	-	-	-	Water Board staff sent comment letter on 10/16/2018. Water Board staff accepted revised GMP on 2/11/2019. Water Board review complete on 2/22/2019, but issuance of approval on hold without receipt of ADSA narrative. Operator placed the project on hold on 4/9/2019. CalGEM denied the associated WST well permits on 8/3/2021.

Table 2: Groundwater Monitoring Plans (addenda) Reviewed (January 1, 2021 - December 31, 2021)

GeoTracker Global Identification	Oil Field or (Area)	Township (T), Range (R), Section (S) ¹	Operator	GMP Date Accepted	New or Addendum GMP	Days for Initial Response	Interim Review Actions (GeoTracker Submittal Date(s))	Status/ Determination ²	Number of WST Wells Approved	Status/ Determination Date	Days to Complete Process ³	Comments
GAOG10010391	Lost Hills	T26S, R21E, S29, S32, S33 T27S, R21E, S4, S5	Chevron USA, Inc	6/18/2019	Addendum	71	-	On Hold	36	-	-	Water Board staff informed the operator of the completion of addendum review but could not issue approval without receipt of the CalGEM ADSA on 8/20/2019.
GAOG10010391	Lost Hills	T26S, R21E, S29, S32, S33, and T27S, R21E, S4, S5	Chevron USA, Inc	6/8/2020	Addendum	67	Operator submitted a revised Addendum (2/26/2021)	Review in Progress	13	-	-	Water Board staff provided comments to operator by email on 8/14/2020. Revised addendum uploaded to Geotracker on 2/26/2021 . Water Board staff contacted CalGEM regarding the status of the associated WST package on 4/16/2021, and CalGEM response indicated the WST Package requires operator to submit CEQA documentation.
GAOG10009277	Belridge, South	T28S, R20E, S12, S13, T28S, R21E, S18	Aera Energy LLC	7/8/2019	Addendum	-	-	Review in Progress	2	-	-	Addendum is under Water Board staff review, but cannot be completed without receipt of ADSA narrative.

Table 3 Requests for Exclusion Reviewed (January 1, 2021 - December 31, 2021)

GeoTracker Global Identification	Oil Field or (Area)	Township (T), Range (R), Section (S) ¹	Operator	Request for Exclusion Accepted Date	Days for Initial Response	Interim Review Actions (GeoTracker Submittal Date(s))	Status/ Determination ²	Number of WST Wells Approved	Status/ Determination Date	Days to Complete Process ³	Comments
GAOG10012394	Belridge, North	T27S,R20E,SE 1/4 of S27	Aera Energy LLC	12/12/2018	51	-	On Hold	1	-	-	Water Board staff and CalGEM reviewed the exempt status of the Mclure Shale unit, and sent comment letter on 2/1/2019. Water Board staff review is on hold due to information deficiencies in operator provided documentation.
GAOG10011060	McKittrick	T30S,R22E,S7,8,9,16,17,18	Chevron USA, Inc	10/31/2017	9	-	On Hold	3	-	-	Water Board staff conducted a conference call with the Operator on 11/9/2017. Water Board staff review continues to be on hold due to information deficiencies in operator provided documentation.

Table 4 Requests for Exclusion (added wells) Reviewed (January 1, 2021 - December 31, 2021)

GeoTracker Global Identification	Oil Field or (Area)	Township (T), Range (R), Section (S) ¹	Operator	Date Accepted Request of Additional WST Wells	Days for Initial Response	Status/ Determination ²	Number of WST Wells added to Approved Exclusion	Status/ Determination Date	Days to Complete Process ³
GAOG10009503	Belridge, South	SECTION 29 - T28S,R21E	Aera Energy LLC	12/14/2020	37	Approved	3	1/20/2021	37
GAOG10009503	Belridge, South	SECTION 29 - T28S,R21E	Aera Energy LLC	3/17/2021	43	Approved	2	4/29/2021	43
GAOG10008913	Belridge, South	SECTION 28 - T28S,R21E	Aera Energy LLC	3/17/2021	7	Approved	2	4/29/2021	10
GAOG10009914	Belridge, South	SECTION 20 -T28S, R21E	Aera Energy LLC	12/14/2020	7	Approved	1	1/20/2021	16
GAOG10009914	Belridge, South	SECTION 20 - T28S,R21E	Aera Energy LLC	3/17/2021	7	Approved	1	4/29/2021	10
GAOG10008892	Belridge, South	SECTION 33 -T28S, R21E,	Aera Energy LLC	12/14/2020	37	Approved	9	1/20/2021	37
GAOG10008915	Belridge, South	SECTION 34 -T28S, R21E,	Aera Energy LLC	12/14/2020	37	Approved	1	1/20/2021	37
GAOG10008915	Belridge, South	SECTION 34 - T28S,R21E	Aera Energy LLC	3/17/2021	43	Approved	2	4/29/2021	43
GAOG10011107	Belridge, North	SECTION 1 - T28S,R20E	Aera Energy LLC	3/17/2021	47	Approved	11	5/3/2021	47

Table 5 Number of Neighbor Notifications sent by Operators

Operator	2014	2015	2016	2017	2018	2019	2020	2021
Aera Energy, LLC	818	960	29	138	250	233	73	5
Berry Petroleum Company, LLC	-	-	-	-	160	219	-	-
Breitburn Energy Co., LLC	18	-	-	-	1	-	-	-
Central Resources, Inc	19	-	-	-	42	-	-	-
Chevron USA, Inc	35	6	-	-	-	-	27	17
Crimson Resource Management	194	-	-	-	-	-	-	-
DCOR, LLC	11	-	-	-	-	-	-	-
Occidental of Elk Hills, Inc	57	36	-	-	-	-	-	-
Seneca Resources Corporation	19	4	-	-	-	-	-	-
Vintage Production California, LLC	108	-	-	-	-	-	-	-
California Resources Elk Hills, LLC	-	5	42	2	93	57	-	-
Linn Operating, Inc	-	273	-	-	-	-	-	-
Salt Creek Oil, LLC	-	-	2	-	-	-	-	-
Total	1,279	1,284	73	140	546	509	100	22

Table 6 Estimated Operator Costs Provided by CIPA and WSPA

Operator Cost Category	2014 -2016 (1)	2017	2018	2019	2020	2021
Number of GMPs Developed	19	7	16	20	1	0
GMP Cost	\$517,250	\$207,843	\$131,719	\$864,872	\$17,645	\$0
Wells Installed	19	12	8	5	2	1
Well Installation Cost	\$5,806,232	\$2,000,673	\$351,744	\$1,450,014	\$514,860	\$117,000
Samples Collected	105	85	106	95	103	79
Reports Submitted	28	12	12	20	24	15
Sampling and Reporting Cost	\$990,000	\$418,702	\$273,423	\$293,253	\$310,615	\$267,126
Samples Analyzed	86	80	106	95	101	77
Sample Analysis Cost	\$172,500	\$188,490	\$288,345	\$243,469	\$226,620	\$249,183
Other Subcontractor and Consultant Fees	\$111,969	\$150,000	\$98,601	\$20,000	\$17,000	\$2,371
Total Cost (Capital + Operating Expenses)	\$7,597,951	\$2,965,708	\$1,143,831	\$2,871,608	\$1,086,740	\$635,680

Requests for Exclusion	2014 - 2016 (1)	2017	2018	2019	2020	2021
Requests for Exclusion	11	7	29	32	10	5
Requests for Exclusion Cost	\$73,710	\$76,075	\$46,400	\$525,600	\$5,400	\$3,000

Total Area-Specific Costs	2014 - 2016 (1)	2017	2018	2019	2020	2021
GMP + Exclusion Costs	\$7,671,661	\$3,041,783	\$1,190,231	\$3,397,208	\$1,092,140	\$638,680

Regional Monitoring Program	2014 - 2016 (1)	2017	2018	2019	2020	2021
RMP Estimated Total Operators Cost	\$15,000	\$18,000	\$265,525	\$0	\$135,700	\$95,296

Well Stimulation Treatments and Production	2014 - 2016 (1)	2017	2018	2019	2020	2021
WSTs Performed - GMP	176	34	129	96	26	12
Oil Production from WSTs - GMP (bbl)	1,362,969	451,478	312,501	362,810	18,728	68,774
WSTs Performed - Exclusions	1,089	122	115	70	34	6
Oil Production from WSTs - Exclusions (bbl)	9,438,976	296,336	523,299	166,875	25,903	28,140

Summary	2014 - 2016 (1)	2017	2018	2019	2020	2021
Oil Produced subject to Model Criteria Requirements (bbl)	10,801,945	747,814	835,800	529,685	44,631	96,914
Estimated Groundwater Monitoring Cost per Sample	\$72,361	\$34,891	\$10,791	\$30,227	\$5,381	\$6,566
Groundwater Monitoring Cost per bbl of oil	\$5.57	\$6.57	\$3.66	\$7.91	\$58.03	\$9.24
Average Cost of Compliance per Monitoring Well	\$43,170	\$87,227	\$8,867	\$29,913	\$41,798	\$52,973

Note: (1) Reporting period equal to 2.5 years.

Appendix D - REGIONAL MONITORING PROGRAM
WORK CONDUCTED

Appendix D Summary of USGS Work Conducted to date through December 31, 2021

Oil Field	County	Salinity Mapping	Groundwater Sampling	Oilfield Fluid Sampling	Interpretive Analysis Published
Various	Kern, Los Angeles	X	X	X	X
Buena Vista	Kern	X	X	X	X
Bellevue	Kern	X	X	X	
Bellevue West	Kern	X	X		
Cal Canal Gas	Kern	X			X
Canfield Ranch	Kern	X	X	X	
Cat Canyon	Santa Barbara	X	X	X	
Cat Canyon	Santa Barbara	X	X	X	
Edison	Kern		X	X	
Elk Hills	Kern	X	X		X
Fruitvale	Kern	X	X	X	X
Greeley	Kern	X	X		
Kern River	Kern		X	X	
Lost Hills	Kern	X	X	X	X
Midway-Sunset	Kern	X	X	X	X
Montebello	Los Angeles	X	X		X
Mountain View	Kern		X	X	
North Belridge	Kern	X	X	X	X
North Coles Levee	Kern	X	X		X
Orcutt	Santa Barbara		X	X	X
Oxnard	Ventura		X		X
Placerita	Los Angeles		X	X	
Poso Creek	Kern	X	X	X	X
Rio Bravo	Kern	X	X		
Rosedale	Kern	X	X		
Rosedale Ranch	Kern	X	X	X	X
San Ardo	Monterey	X	X	X	X

2021 Annual Model Criteria Performance Report

Oil Field	County	Salinity Mapping	Groundwater Sampling	Oilfield Fluid Sampling	Interpretive Analysis Published
Santa Fe Springs	Los Angeles		X	X	
Santa Maria Valley	Santa Barbara		X		
South Belridge	Kern	X	X	X	X
South Coles Levee	Kern	X			X
South Cuyama	Santa Barbara	X			X
Strand	Kern	X	X	X	
Ten Section	Kern	X	X	X	
Wilmington-Torrance	Los Angeles		X	X	X
Yowlumne	Kern	X			