December 31, 2015

Well Stimulation Treatment
First Annual Report

California Department of Conservation

Division of Oil, Gas, and Geothermal Resources

STATE OF CALIFORNIA	NATURAL RESOURCES AGENCY	DEPARTMENT OF CONSERVATION
EDMUND G. BROWN, JR. *Governor*	*JOHN LAIRD* *Secretary*	*DAVID BUNN* *Director*

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Well Stimulation Treatment
First Annual Report

Reporting Period: January 1, 2014 – September 30, 2015

DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

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December 31, 2015

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Acronyms and Abbreviations

Term	Description
3-D	Three-dimensional
ABD	Abandoned
BBLS	Barrels. This is the standard unit of measure for liquid volume in the oil and gas industry. For conversion to gallons or acre-feet: • 1 barrel = 42 U.S. gallons • 325851 U.S. gallons = 1 acre-foot • 7,758 barrels = 1 acre-foot
CA	California
CalRecycle	State of California Department of Resources Recycling and Recovery
CARB	State of California Air Resources Board
CCR	California Code of Regulations
CCST	California Council on Science and Technology
CH_3COOH	Acetic acid
District	Administrative region within the Division.
Division	State of California Division of Oil, Gas & Geothermal Resources
DOC	State of California Department of Conservation
DTSC	State of California Department of Toxic Substances Control
GWMP	Groundwater Monitoring Plan
EIA	United States Energy Information Agency
EIR	Environmental Impact Report
ft	feet
FY	Fiscal Year
h	Formation Thickness or Depth (units: feet)
H^+	Hydrogen Ion
HCl	Hydrochloric acid
HF	Hydrofluoric acid
Interim Period	January 1, 2014 to June 30, 2015
IWSTN	Interim Well Stimulation Treatment Notice
k	Formation Permeability (units: millidarcies)
KCl	Potassium chloride

Term	Description
KDG	Khristianovic-Geertsma-de.Klerk (fracture propagation model)
LLC	Limited Liability Corporation
SON	Statement of Non-Applicability
MD	Measured Depth (units: feet)
MOU	Memoranda of Understanding
MOA	Memoranda of Agreement
No.	number
NOP	Notice of Preparation
NOV	Notice of Violation
NTO	Notice to Operators
OAL	State of California Office of Administrative Law
OOIP	Original Oil in Place
P3D	Pseudo-three-dimensional (fracture propagation model)
PKN	Perkins-Kern-Nordgren (fracture propagation model)
psia	pounds per square inch
Regional Water Boards	Regional Water Quality Control Boards
SB 4	CA Senate Bill 4 (2013)
SDWA	Safe Drinking Water Act of 1974 (Federal)
State Water Board	California State Water Resources Control Board
TVD	Total Vertical Depth (units: feet)
UIC	Underground Injection Control
USGS	United States Geological Survey
Water Boards	State Water Board and Regional Water Boards
WST	Well Stimulation Treatment

Executive Summary

In September 2013, Governor Brown signed into law Senate Bill 4 (SB 4), establishing the most comprehensive Well Stimulation Treatment (WST) regulatory program in the United States. SB 4 required the development and implementation of detailed regulations, preparation of an independent scientific study (ISS), preparation of a statewide, programmatic environmental impact report (EIR), increased interagency collaboration, increased data transparency and public disclosure, and preparation of an annual report to the state legislature.

Prior to the enactment of SB 4, the California Department of Conservation (Department), Division of Oil, Gas, and Geothermal Resources (Division) had begun engaging with stakeholders in spring 2012 to develop a "discussion draft" for WST regulations. Once SB 4 was signed, the Division continued its rulemaking efforts to produce emergency regulations for the interim period (January 1, 2014–June 30, 2015) under SB 4. These emergency regulations were required under SB 4 to provide oversight of WST while the Division developed permanent regulations that took effect July 1, 2015. The result of the Division's rulemaking process is a comprehensive set of regulations that help ensure well stimulation in California is performed safely and transparently.

This first annual report is intended to satisfy the legislative requirements of SB 4, but also provides context and background on the development of the WST regulations. Part 1 of the report summarizes the WST environmental impact report, the independent scientific study, the growth of Division staff, and the increased collaboration between the Division and State Water Board and other agencies. Part 2 provides a summary response to each legislative reporting requirement. The appendices include a timeline of SB 4 implementation, lists the public input opportunities provided during the regulatory process, and includes a background primer on the science of well stimulation.

The following are some key facts from this report:

- During the interim period, 2,127 WST permits (Interim WST Notices) were approved as complete for 15 operators. When approved as complete, these permits are valid for 365 days from the approval date. Approximately 95% of the approved Interim WSTN Notices were for hydraulic fracturing.
- With few exceptions, WST were limited geographically to Kern, Kings, and Ventura counties in relatively mature oil fields.
- 99% of WSTs occurred in Kern County, 89% of WST was performed on diatomite.
- The average fracture length of WST performed in diatomite formations was 83 feet.
- The average fracture length of WST performed in non-diatomite formations ranged from 150 to 308 feet.
- 98% of recovered WST fluids were reinjected into Class II underground injection wells, which are regulated separately under the Division's Underground Injection Control (UIC) program.
- 78% of the water used as base fluids in WST treatments came from domestic water systems, and 84% was reported as suitable for domestic or irrigation purposes.
- The Division issued 58 Notices of Violation for minor infractions of WST regulatory requirements.

- There were no well failures associated with WST, no emergency responses or spills, and no requests for confidential well status or trade secret protection.
- Out of more than 1,000 neighbors receiving notice of WST, only one requested water sampling.
- All WST operations except one were performed within existing oilfield boundaries, and the one performed outside an existing boundary occurred after a groundwater monitoring plan was developed.

Part I: Introduction

On September 20, 2013, Governor Edmund G. Brown, Jr. signed into law Senate Bill 4 (Pavley, Ch. 313, Stats of 2013). On November 15, 2013, the California Department of Conservation (Department), Division of Oil, Gas and Geothermal Resources (Division) began the rulemaking for the emergency regulations that governed well stimulation treatment (WST) activities during the interim period. The emergency regulations were in effect from January 1, 2014 through June 30, 2015. The permanent WST regulations became effective on July 1, 2015.

Objective and Scope of This Report

The objective of this report is to provide aggregated information to the California Legislature and public regarding WST in California.

The report covers well stimulation and related activities performed in California from January 1, 2014 through September 30, 2015. These dates cover WST activities performed during the interim period and three months after the effective date of the permanent regulations. Information about actual and specific WSTs performed during this period is derived from operator disclosures (post-WST job reports) submitted to the Division. A detailed timeline of the implementation of SB 4 can be found in *Table 1: Detailed Timeline of Key Events*.

Public Resources Code section 3215, subdivision (c)(1)-(8), requires that this report address the following items:

1. Aggregated data detailing the disposition of any produced water from wells that have undergone well stimulation treatments.
    - [See *Disposition of Post-WST Produced Fluids* in Part II of this document.]
2. Aggregated data describing the formations where wells have received well stimulation treatments including the range of safety factors used and fracture zone lengths.
    - [See *California Geology and Well Stimulation* in Part II of this document.]
3. The number of emergency responses to a spill or release associated with a well stimulation treatment.
    - [See *Emergency Responses* in Part II of this document.]
4. Aggregated data detailing the number of times trade secret information was not provided to the public, by county and by each company, in the preceding year.
    - [See *Trade Secret Information* in Part II of this document.]
5. Data detailing the loss of well and well casing integrity in the preceding year for wells that have undergone well stimulation treatment. For comparative purposes, data detailing the loss of well and well casing integrity in the preceding year for all wells shall also be provided. The cause of each well and well casing failure, if known, shall also be provided.
    - [See *Loss of Well and/or Well Casing Integrity* in Part II of this document.]
6. The number of spot check inspections conducted pursuant to subdivision (l) of Section 3160, including the number of inspections where the composition of well stimulation fluids were verified and the results of those inspections.

- [See *WST Witnessing and Spot-Checking* in Part II of this document.]

7. The number of well stimulation treatments witnessed by the Division.
   - [See *WST Witnessing and Spot-Checking* in Part II of this document.]
8. The number of enforcement actions associated with well stimulation treatments, including, but not limited to, notices of deficiency, notices of violation, civil or criminal enforcement actions, and any penalties assessed.
   - [See *Division Enforcement* in Part II of this document.]

Public Resources Code 3215, subdivision (c) also stipulates inclusion of aggregated reporting information from Public Resources Code 3160.

As indicated in the Executive Summary, the first report includes more history and background than will be included in subsequent annual reports.

Development and Implementation of Senate Bill 4

Overview of Implementation of Senate Bill 4

SB 4 provides a comprehensive regulatory framework for WST in California. Most of SB 4 is implemented through regulations developed by the Division in consultation with the public and stakeholders and approved by the California Office of Administrative Law (OAL). The principal objective of these regulations is to ensure that well stimulation is done safely and transparently with technical standards, required testing and monitoring, and public disclosures.

Major components of SB 4 require:

- The development and implementation of emergency regulations to govern WST during the interim period pending the Division's development of permanent regulations. Emergency regulations were formally submitted to the OAL on December 19, 2013 and took effect January 1, 2014. The emergency regulations require operators to provide written notice and certificate of compliance, interim model groundwater monitoring criteria, and public disclosure including notifying neighboring surface property owners and tenants
- The development and implementation of permanent regulations for WST. Although SB 4 called for permanent regulations by January 1, 2015, the statute was amended in mid-2014 by SB 861 to change the effective date of those regulations to July 1, 2015. The permanent regulations require operators to apply for and obtain a WST permit, comply with well construction and equipment integrity evaluation and testing, monitor during and after stimulation (including for seismic events) and publicly disclose information about their WST operations
- Consultation with the public and other stakeholders for input in the development of both the emergency and permanent regulations. Information about hearings and workshops is provided in *Appendix C – Public Outreach and Stakeholder Workshop*. Further information about the administrative rulemaking process is available at: http://www.oal.ca.gov/Regular_Rulemaking_Process.htm
- Preparation and publication of an Independent Scientific Study regarding WST in California, prepared by independent experts outside the Division.
- Preparation of a statewide, programmatic Environmental Impact Report (EIR) to evaluate WST.

- Increased collaboration between the Division, the Water Boards, the California Department of Toxic Substances Control (DTSC), the California Air Resources Board (CARB), the Department of Resources Recycling and Recovery (CalRecycle) and other agencies to develop coordinated regulatory programs for various aspects of WST.
- The development of information technology systems for enhanced reporting and access to WST-related data.
- Preparation of a comprehensive annual report on well stimulation (Public Resources Code § 3215, subd. (c)) to be provided to the Legislature January 1, 2016.

Actions by the State Water Board during the Interim Period

This section addresses the State Water Board's fulfillment of statutory and regulatory duties assigned to it in the interim period for implementing SB 4. SB 4 placed duties on the Division and the State Water Board during the interim period and required the agencies to cooperate in fulfilling those duties. During the interim period the State Water Board developed its web page *Water Quality in Areas of Oil and Gas Production* to act as a nexus for the programs and activities implemented under SB 4:

- http://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/

The State Water Board performed the following activities during the Interim Period:

- Designed and launched its web page Water Quality in Areas of Oil and Gas Production.
- Designated and provided guidelines to Third-Party Water Samplers.
- Reviewed water sampling information collected as part of the third-party water sampling that was performed.
- Modified existing GeoTracker groundwater information system (GeoTracker) to accept groundwater monitoring plans (GWMPs), reports or groundwater monitoring data uploaded by operators, and third-party contractors.
- Developed Model Criteria for Groundwater Monitoring in Areas of Oil and Gas Well Stimulation (Model Criteria) with experts, and stakeholders including the regulated community and the Division. This process included hearings, provision of draft Model Criteria public and stakeholder comments, review of comments, and modification of the Model Criteria.
- Received and reviewed operator's technical documents that request exclusion from groundwater monitoring requirements in certain areas; deny or approve requests; issued Statements of Non-applicability (SONs) where request for exclusion approved. The State Water Board approved and issued SONs for 21 requests for exclusion during the interim period.
- Provided expert advice, consultation and co-review to the Division for its review of operator's GWMPs for proposed WSTs, including coordination of review and comments from various Regional Water Quality Control Boards (Regional Water Boards) and providing Regional Water Board comments to the Division. The Water Boards assisted the Division in determining that 43 proposed GWMPs were accurate and complete and approvable during the Interim Period.

The Division continues to work closely with the Water Boards on WST as well as the Underground Injection Control Program.

Environmental Impact Report

SB 4 required the preparation of an Environmental Impact Report (EIR) to analyze the statewide impacts of WST. Input regarding the content and scope of the EIR was received at several public scoping meetings around the state, and the draft EIR was made available for public review and comment.

On July 1st, 2015, the Division certified the Final EIR, the "Analysis of Oil and Gas Well Stimulation Treatments in California." The Department led the preparation of the EIR, which included:

- Contracting with Aspen Environmental Group for its expertise in preparation of EIRs;
- Conducting extensive public and stakeholder comment and involvement.

Tables listing public hearings and workshops are found in *Appendix C – Public Outreach and Stakeholder Workshop*. More than 200,000 written or electronic public comments were received and reviewed by the Department during the public comment periods.

The Final EIR analyzed the impacts of WSTs, including hydraulic fracturing, performed in a manner consistent with the Division's permanent regulations. The EIR evaluated the possible impacts of all activities associated with all possible WST at existing or new wells located within or outside of currently identified oil fields.

The EIR can be found here:

- http://www.conservation.ca.gov/dog/Pages/SB4_Final_EIR.aspx

Independent Scientific Study (ISS)

Pursuant to SB 4, the California Natural Resources Agency commissioned the California Council on Science and Technology (CCST) and Lawrence Berkeley National Laboratory to conduct an independent scientific assessment of WST, including hydraulic fracturing, in California. The CCST published Volume I on January 14, 2015. On July 9, 2015, CCST publicly released Volume II and III to complete the assessment. The assessment covered the fundamentals of WST, as well as potential environmental impacts to water quality, air quality (including greenhouse gas emissions), induced seismicity, ecology, traffic, and noise. Volume III of the assessment presented case studies to assess environmental issues and qualitative hazards for specific regions of the state.

The CCST's assessment can be found here:

- https://ccst.us/projects/hydraulic_fracturing_public/SB 4.php

Chronologic Listing of Key Events

Here is a timeline of the implementation of SB 4.

Table 1: Detailed Timeline of Key Events

Date	Description
Prior to Well Stimulation Regulations (Before Jan 1, 2014)	
May 16, 2012	First workshop on Listening Tour regarding future hydraulic fracturing regulations, 7 events hosted through July 25, 2012
Dec. 18, 2012	Discussion draft of hydraulic fracturing regulations released
Feb. 19, 2013	First workshop on the draft hydraulic fracturing regulations, 5 workshops held through April 19, 2013
Sept. 20, 2013	Governor signed SB 4 into law
Nov. 15, 2013	Formal rulemaking for the permanent regulations commenced Start of 60 day public comment
Nov. 15, 2013	Division issued Notice of Preparation for the EIR on WST in California
Nov. 20, 2013	Notice to operators issued by the Division addressing certification of compliance requirements to address mandates of SB 4 effective January 1, 2014
Dec 10, 2013	First EIR scoping meeting, 5 meetings held December 2013 through January 9, 2014
Dec. 11, 2013	Notice of proposed emergency regulations is published
Dec. 19, 2013	Emergency regulations submitted to OAL
Dec. 30, 2013	OAL approved SB 4 emergency regulations for the interim period
Interim Period of WST Regulations (Jan 1, 2014 - June 30, 2015)	
Jan. 1, 2014	Emergency SB 4 interim WST regulations go into effect
Jan. 6, 2014	First hearing for round one SB 4 WST regulations Public comment 60-day 5 hearings were held through January 13, 2014
Jan. 14, 2014	CCST publishes scientific review of oil and gas development technologies in California (Vol. 1)
June 13, 2014	First revised text of proposed permanent regulations released for 45-day public comment
June 20, 2014	SB 861 signed into law, extending the interim regulations through June 30, 2015
June 20, 2014	The Division filed request with OAL to readopt interim regulations
June 27, 2014	OAL approved re-adoption of interim regulations
July 1, 2014	Readopted interim regulations took effect
July 15, 2014	First hearing for round two SB 4 WST regulations Public comment 60-day 5 hearings were held through July 23, 2014

Date	Description
Oct 9, 2014	Second revised text of proposed regulations released for 15-day public comment
Dec. 30, 2014	OAL approved final text of permanent SB 4 WST regulations
Dec. 30-31, 2014	Memoranda of Agreement between agencies are finalized
Jan. 14, 2015	Division published a Draft EIR and began a 62-day public review period
Feb 10, 2015	First Draft EIR public meetings: 6 meetings held during the month of February
Permanent WST Regulations (July 1, 2015 - present)	
July 1, 2015	Permanent SB 4 WST regulations took effect
July 1, 2015	State Oil and Gas Supervisor certified final EIR on analysis of WST in California
July 1, 2015	CCST delivered scientific review of oil and gas development technologies in California - (Volumes 2 and 3 to CA NRA)
July 9, 2015	CCST published scientific review of oil and gas development technologies in California (Vols. 2 and 3)

Transition from Interim to Permanent WST Regulations

The interim period for WST regulation ended June 30, 2015, and the permanent regulations for WST took effect July 1, 2015. During the six months leading to the effective date of the permanent regulations, the Division and the Water Boards took the following actions to help ensure operator compliance for the permanent regulation requirements:

- Division staff discussed the changes with all operators whose Interim WST Notices were approved as complete during the interim period.
- Both the Division and the Water Boards held workshops to discuss the permanent regulations:
    - Division workshops focused on the enhanced and additional requirements of the permanent regulations.
    - State Water Board workshops sought input for finalizing the State Water Board's Model Criteria for Groundwater Monitoring in Areas of Oil and Gas Well Stimulation.
- The Division substantially changed pages of its website to provide information about the permanent regulation requirements, and to note that the interim period had ended.

Interim WST Notices approved as complete during the interim period allowed an operator to begin a WST operation within 365 days of the date of the Division's signature on the Notice. However, any WST operations performed after July 1, 2015 (including WST performed under unexpired Notices approved as complete during the interim period) must adhere to all applicable requirements of the permanent regulations, including compliance with public disclosure and post-stimulation reporting requirements.

Contact Information

Questions regarding the content of this report may be emailed to the following:

- WST@conservation.ca.gov

Visit the Division of Oil, Gas & Geothermal Resources website:

- http://www.conservation.ca.gov/dog/

Part II: Well Stimulation in California

Public Resources Code section 3215, subdivision (c) and Related Information

The information in this section has been organized by subject and, as a result, does not follow the sequence as provided in Public Resources Code section 3215, subdivision (c).

Disposition of Post-WST Produced Fluids

> *Public Resources Code section 3215, subdivision (c)(1): "Aggregated data detailing the disposition of any produced water from wells that have undergone well stimulation treatments."*

All WSTs performed in California since January 1, 2014 have used water as the base fluid. Fluids that are produced from the wells subject to WST include produced water, base fluid, and remaining chemical additives. Once production begins, the portion of fluids coming up from the well that consist of base fluids and chemicals associated with WST diminishes, and produced fluids are predominately composed of oil and produced water. This data describes recovered fluid and its disposition.

Most produced water is injected back into the subsurface via individually-permitted Class II injection wells. For the period covered by this report, the primary method of disposal (97.74%) of WST-related produced fluid was by disposal back into the ground via non-commercial Class II injection. The majority of Class II injection wells are owned by the individual oil and gas well operators, however, the Division also regulates commercial Class II disposal wells, which are typically operated by entities focused on providing disposal services rather than oil production. The remainder of produced fluids were disposed of via commercial Class II injection wells, while a small fraction was recycled.

Some caveats to consider when looking at this data are that some wells did not have sufficient pressure to generate flow back of fluids used. Such situations frequently required additional fluid to flush the well of treatment materials. This additional fluid contributes to the volume of recovered fluids, but is not reflected in base fluid volume calculations for the reporting period. As such, the below information cannot be compared to base fluid volume to establish an accurate ratio. Development of reporting processes under the permanent regulations has resulted in collection of more detailed information.

Tables 2 through 4 provide information regarding the average volume of fluids recovered from well stimulation treatment operations. Tables 5 through 8 provide data on the disposition of recovered fluids. Units for volumes shown are rounded to the nearest barrel (BBLS). As required by SB 4, this information is reported by district, county, and operator.

Table 2: Average Recovered Fluid per Well by Well Operator, County and District

Well Operator	Kern County District 4 (BBLS)	Kings County District 5 (BBLS)	Ventura County District 2 (BBLS)	Averages by Operator (BBLS)
Aera Energy, LLC	73		245	**74**
Breitburn Energy Co., LLC	6,222			**6,222**
Central Resources	5,026			**5,026**
Chevron USA, Inc.	141			**141**
Crimson Resource Management	22			**22**
KMD Operating Company, LLC		7,855		**7,855**
Occidental of Elk Hills, Inc.	2,705			**2,705**
Seneca Resources Corporation	4,081			**4,081**
Vintage Production California, LLC	778			**778**
Averages by County/District	**551**	**7,855**	**245**	**565**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.
Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 3: Average Recovered Fluid per Well by Stimulation Type, County and District

Stimulation Type	Kern County District 4 (BBLS)	Kings County District 5 (BBLS)	Ventura County District 2 (BBLS)	Averages by Stimulation Type (BBLS)
Acid Fracture	6,801			**6,801**
Acid Matrix	1,111	7,855		**1,786**
Hydraulic Fracture	535		245	**534**
Averages by County	**551**	**7,855**	**245**	**565**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.
Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 4: Average Recovered Fluid per Well by Stimulation Type and Oil Field

Oil Field	Acid Fracture (BBLS)	Acid Matrix (BBLS)	Hydraulic Fracture (BBLS)	Averages by Oil Field (BBLS)
Belridge, North			1,210	**1,210**
Belridge, South	6,801		240	**250**
Elk Hills		1,111	3,357	**2,705**
Kettleman Middle Dome		7,855		**7,855**
Lost Hills			207	**207**
North Coles Levee			5,026	**5,026**
Rose			760	**760**
Stockdale			22	**22**
Ventura			245	**245**
No Associated Field			1,000	**1,000**
Averages by Stimulation Type	**6,801**	**1,786**	**534**	**565**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Disposition of Recovered Fluid (Water)

Table 5: Disposition of Recovered Fluid by Well Operator

Well Operator	Class II Injection Well (BBLS)	Recycled (BBLS)	Commercial Disposal (BBLS)	Totals by Operator (BBLS)
Aera Energy, LLC	63,258			**63,258**
Breitburn Energy Co., LLC	298,662			**298,662**
Central Resources	10,052			**10,052**
Chevron USA, Inc.	4,278	940		**5,218**
Crimson Resource Management	22			**22**
KMD Operating Company, LLC	15,709			**15,709**
Occidental of Elk Hills, Inc.	167,699			**167,699**
Seneca Resources Corporation	8,161			**8,161**
Vintage Production California, LLC			10,120	**10,120**
Totals by Disposition	**567,841**	**940**	**10,120**	**578,901**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 6: Disposition of Recovered Fluid by County and District

County/District	Class II Injection Well (BBLS)	Recycled (BBLS)	Commercial Disposal (BBLS)	Totals by County/District (BBLS)
Kern County - District 4	551,398	940	10,120	**562,458**
Kings County - District 5	15,709			**15,709**
Ventura County - District 2	734			**734**
Totals by Disposition	**567,841**	**940**	**10,120**	**578,901**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 7: Disposition of Recovered Fluid by Oil Field

Oil Field	Class II Inj. Well (BBLS)	Recycled (BBLS)	Commercial Disposal (BBLS)	Totals by Oil Field (BBLS)
Belridge, North	180,330			**180,330**
Belridge, South	176,014			**176,014**
Elk Hills	167,699			**167,699**
Kettleman Middle Dome	15,709			**15,709**
Lost Hills	17,281	940		**18,221**
North Coles Levee	10,052			**10,052**
Rose			9,120	**9,120**
Stockdale	22			**22**
Ventura	734			**734**
No Associated Field			1,000	**1,000**
Totals by Disposition	**567,841**	**940**	**10,120**	**578,901**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 8: Disposition of Recovered Fluid by Volume and Percent

	Class II Injection Well	Recycled	Commercial Disposal	Total
Volumes (BBLS)	**567,841**	**940**	**10,120**	**578,901**
Percentages	**98.09%**	**0.16%**	**1.75%**	**100%**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

California Geology and Well Stimulation

> *Public Resources Code section 3215, subdivision (c)(2) "Aggregated data describing the formations where wells have received well stimulation treatments including the range of safety factors used and fracture zone lengths."*

This section will first cover information about zones and formations, discuss safety factors, and then provide data on fracture zone lengths and heights. In addition to the requirement in section 3125 (c)(2) above, Public Resources Code Section 3160 requires inclusion of other information disclosed by operators about the length and height of the fractures.

Stimulated Zones and Formations

The names of stimulated zones were reported by operators in both Notices and Disclosures. Oil and gas "zones" refer to the areas within a geologic formation where oil, gas, and water are trapped due to some geologic structure such as a fault, variable stratigraphy, or other feature that traps a resource in a particular area of the subsurface. The names reported by operator are grouped as follows for the purposes of this report:

- Diatomite:
  - Belridge
  - Belridge Diatomite
  - Opal Diatomite
- Etchegoin
- Kreyenhagen
- Monterey:
  - Devilwater-Gould
  - Lower Nozu
  - Lower Reef Ridge
  - McClure Shale
  - McDonald Shale
  - Stevens Sand
  - Undifferentiated Stevens
- Pico
  - A Block, Zone Q,S,U Sand
  - Pico / Repetto

The following are the identified zones which received stimulation during the reporting period for the counties/districts in which stimulation treatment occurred.

Table 9: Number of Stimulations in Each Zone by County and District

Stimulated Zone	Kern County District 4	Kings County District 5	Ventura County District 2	Totals by Formation
Diatomite	921			**921**
Etchegoin	54			**54**
Kreyenhagen		2		**2**
Monterey	45			**45**
Pico			3	**3**
Totals by County/District	**1020**	**2**	**3**	**1025**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.
Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 10: Number of Stimulations in Each Zones by Oil Field

Stimulated Zone	Belridge, North	Belridge, South	Elk Hills	Kettleman Middle Dome	Lost Hills	North Coles Levee	Rose	Stockdale	Ventura	No Associated Field	Totals by Formation
Diatomite	149	704			68						**921**
Etchegoin			36		18						**54**
Kreyenhagen				2							**2**
Monterey		1	26		2	2	12	1		1	**45**
Pico									3		**3**
Totals by Oil Field	**149**	**705**	**62**	**2**	**88**	**2**	**12**	**1**	**3**	**1**	**1025**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Maps showing the location of stimulation can be found in *Appendix A – Geographic Information*.

Safety Factors and Fracture Zone Lengths

Safety factors for hydraulic fracture zones are based upon establishing a protective area around the proposed fracture zone, and are used in making risk management and mitigation determinations. During the interim period, WST approval was a ministerial process that focused on operator compliance with reporting, disclosure, and notification requirements. Although the Division will obtain fracture dimension information under the permanent regulations, it was not required during the interim period. As of the date of this report, the Division has not issued a WST permit under the permanent regulations. Implementation of safety factors occurs once fracture dimension information is gathered and analyzed.

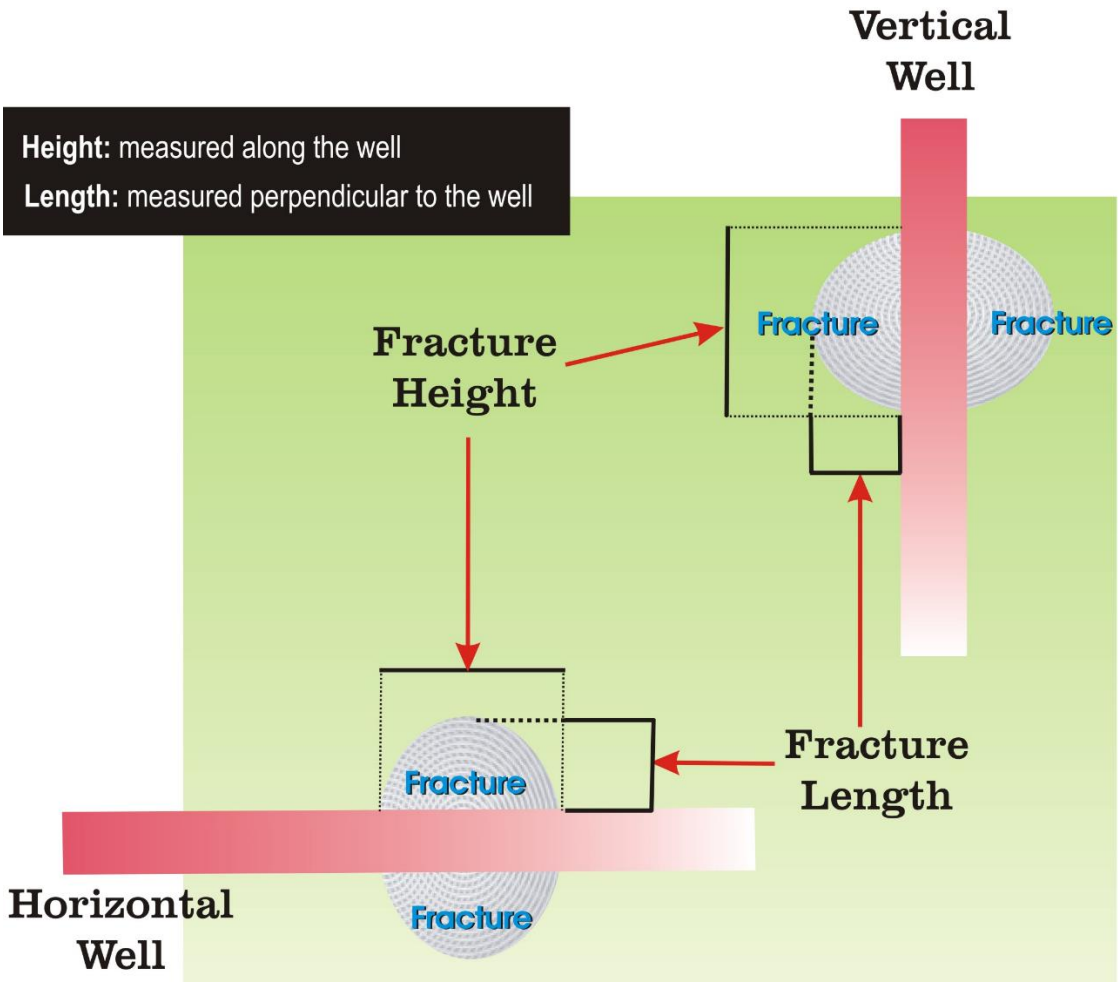
The primary safety factor in the permanent regulations is that the review area for geological features surrounding a proposed WST must be as at least five times the fracture zone dimensions. The Division adds to this safety factor in the permanent regulations by evaluating wellbores or other possible migration pathways within two times the fracture zone dimensions.

Fracture zone lengths and heights are estimated by well operators according to sophisticated reservoir models (as discussed in "Hydraulic Fracturing" in *Appendix B - Background of Well Stimulation in California*). These estimations provide the basis for the minimum safety factor calculations for determining risk factors for a WST. One of the key factors in estimating the fracture zone is the type of formation involved at the point of stimulation.

The figures below categorize the average fracture length and height for WSTs performed by formation. These are key data points in determining safety factors. In this report and in California's WST statutes and regulations, the terms "length" and "height" of stimulation mean the following:

- Length. The length of stimulation is the estimated distance that stimulation extends away from the well. Length is *measured at right angle (i.e., 90 degrees) to the well:*
    - For a vertical well, length is a horizontal distance.
    - For a well that is directionally drilled and the stimulated portion of the well is horizontal, length is measured as the vertical distance that stimulation extends above (or possibly below) the stimulated portion of the well.
- Height. The height of stimulation is the estimated extent (or footage) of stimulation as measured along the well of the zone receiving stimulation. Height is *measured along (i.e., parallel to) the well:*
    - For a vertical well, height is a vertical distance (i.e., a range of depth).
    - For a well that is directionally drilled and the stimulated portion of the well is horizontal, height is measured as the lateral (i.e., horizontal) distance that stimulation was performed along of the well.

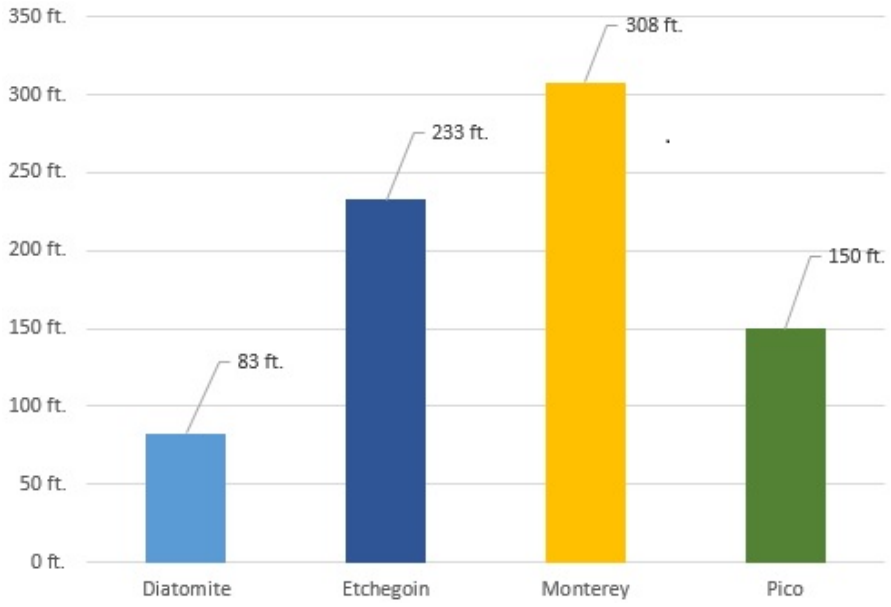
Figure 1: Use of "Height" and "Length" in Describing WST Fractures in Californian



When looking at the figures and tables below it is important to consider that during the interim period, height of stimulation was not reported by individual stages but by providing a gross total for all stimulated zones in the wellbore. Height of stimulation is determined by the top and bottom of the stimulated stage. Reported information for the interim period only provides the highest level of the top stage and the lowest level of the bottom stage. Providing an aggregation of these gross totals would substantially misrepresent stimulation heights and is therefore not represented in the following figure.

As shown below, the average fracture lengths vary in different formations. The type of geology is one of the key pieces of information used to establish safety factors.

Figure 2: Average Length of Fracture by Formation



These tables show fracture length and height (length of stimulation/height of stimulation). These dimensions apply only to stimulation by fracture and are represented in feet. As required, they show the information by district, county, district and operator. Oil field was added to show that fracture lengths and heights vary by field.

Table 11: Average Length of Stimulation by Well Operator, County and District

Well Operator	**Kern County District 4 (ft.)**	**Ventura County District 2 (ft.)**
Aera Energy, LLC	79	150
Breitburn Energy Co., LLC	150	
Central Resources	250	
Chevron USA, Inc.	75	
Crimson Resource Management	170	
Occidental of Elk Hills, Inc.	312	
Seneca Resources Corporation	530	
Vintage Production California, LLC	280	
Averages by County/District	**97**	**150**

Counties/Districts not listed did not contain occurrences of stimulation treatment by fracturing.
Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 12: Average Length of Stimulation by Oil Field, County and District

Oil Field	Kern County District 4 (ft.)	Ventura County District 2 (ft.)
Belridge, North	109	
Belridge, South	78	
Elk Hills	312	
Lost Hills	92	
North Coles Levee	250	
Rose	270	
Stockdale	170	
Ventura		150
No Associated Field	400	
Averages by County/District	**97**	**150**

Counties/Districts not listed did not contain occurrences of stimulation treatment by fracturing.
Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 13: Average Height of Stimulation by Well Operator, County and District

Well Operator	Kern County District 4 (ft.)	Ventura County District 2 (ft.)
Aera Energy, LLC	640	214
Breitburn Energy Co., LLC	970	
Central Resources	203	
Chevron USA, Inc.	200	
Crimson Resource Management	130	
Occidental of Elk Hills, Inc.	616	
Seneca Resources Corporation	400	
Vintage Production California, LLC	199	
Averages by County/District	**631**	**214**

Counties/Districts not listed did not contain occurrences of stimulation treatment by fracturing.
Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 14: Average Height of Stimulation by Oil Field, County and District

Oil Field	Kern County District 4 (ft.)	Ventura County District 2 (ft.)
Belridge, North	708	
Belridge, South	649	
Elk Hills	616	
Lost Hills	407	
North Coles Levee	203	
Rose	182	
Stockdale	130	
Ventura		214
No Associated Field	400	
Averages by County/District	**631**	**214**

Counties/Districts not listed did not contain occurrences of stimulation treatment by fracturing.
Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

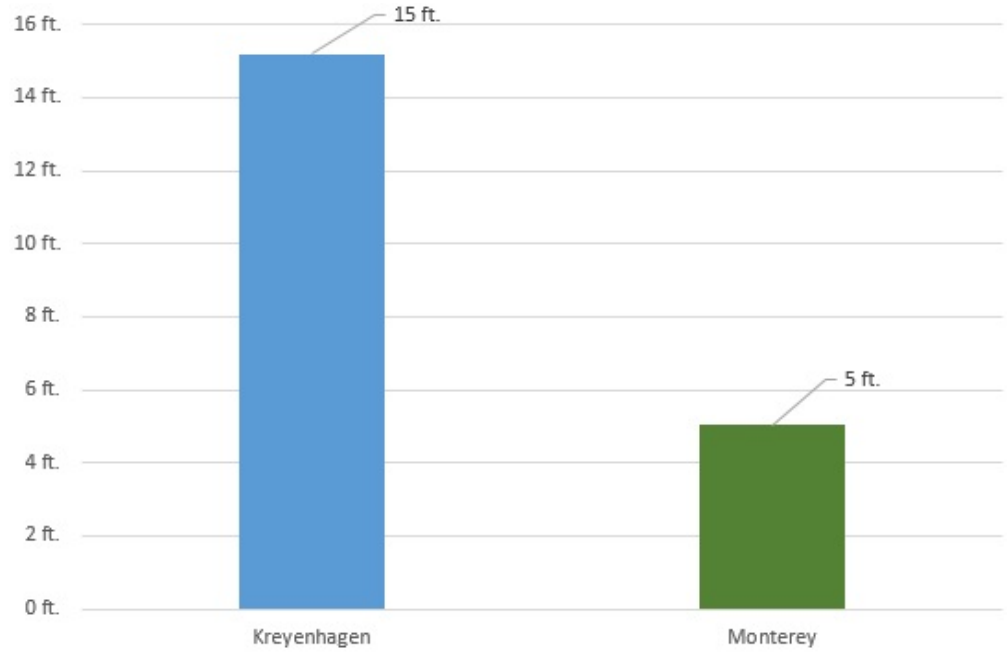
Acid Matrix Stimulation

Acid matrix WST does not fracture the target formation. It utilizes lower pressures than hydraulic fracturing WST, and the distance of stimulation into the formation is less than that of hydraulic fracturing. Because acid matrix stimulation does not fracture the formation this section will focus on depth of acid penetration rather than fracture zone length.

Depth of Acid Penetration

Depth of Penetration is a vertical distance only when the stimulated portion of a well is horizontal. For a vertical well, the Depth of Penetration is a horizontal distance. Just as with the data of fracture zone length, it is important to note that during the interim period information used to calculate depth of penetration was not differentiated by stimulation stage. As well stimulation treatments typically consist of several stages of stimulation, the information below cannot accurately depict the average for the entirety of all penetration depths for the reporting period. Subsequent reports will include more accurate information.

Figure 3: Average Depth of Penetration by Formation



Trade Secret Information

> *Public Resources Code section 3215, subdivision (c)(4) "Aggregated data detailing the number of times trade secret information was not provided to the public, by county and by each company, in the preceding year."*

Operators are required to report information regarding all additives and chemical constituents of fluids used in wells for well stimulation. SB 4 imposes substantial limitations on operators' ability to avoid public disclosure of treatment fluid constituents on the bases of trade secret protection. No trade secret claims were made by any operator for wells stimulated during this reporting period, so withholding of public disclosure on the basis of a trade secret did not occur.

WST Witnessing and Spot-Checking

> *Public Resources Code section 3215, subdivision (c)(7) "The number of well stimulation treatments witnessed by the division."*

SB 4 requires Division personnel to visit WST operations and observe or verify a variety of tasks, quantities and dimensions. During the interim period, the Division visited some WST operations and verified that aspects of those operations conformed to the Interim WST Notices and operator disclosures.

Witnessing and spot-checking involve different levels of oversight by the Division:

- Witnessing is a visit made to evaluate many aspects of an operation including, but not limited to:
    - Casing and tubing pressure testing to ensure well integrity prior to WST
    - WST surface equipment pressure testing prior to WST

- Observation of WST stages

- Spot-checking is a visit made specifically to evaluate how closely the WST fluid actually used conforms to the composition that was approved by the Division.

Field Tests/Witnessing

The Division used the interim period to observe WST field practices and develop processes and procedures for thorough and effective witnessing of WSTs. As a result of this effort, Division staff have witnessed 100% of the 118 WST operations that have occurred since the permanent regulations came into effect on July 1, 2015 through the end of the reporting period.

Spot Checks Conducted

> *Public Resources Code section 3215, subdivision (c)(6) "The number of spot check inspections conducted pursuant to subdivision (l) of Section 3160, including the number of inspections where the composition of well stimulation fluids were verified and the results of those inspections."*

As noted above, the Division used the interim period to develop witnessing and spot check protocols to ensure thorough and effective spot checks of WST fluids. The Division conducted 13 spot checks, representing 11% of the WST operations performed during the period covered by this report. All spot checks performed found the WST fluid actually used met regulatory requirements for consistency with the composition that was approved by the Division on the WST Notice or application.

Division Enforcement

> *Public Resources Code section 3215, subdivision (c)(8) "The number of enforcement actions associated with well stimulation treatments, including, but not limited to, notices of deficiency, notices of violation, civil or criminal enforcement actions, and any penalties assessed."*

Enforcement actions taken during the period included:

- **Notices of Deficiency/Notices of Violation (NOVs):** The Division issued fifty-eight NOVs to operators for violations of disclosure requirements under the interim regulations. Specifically, ten NOVs were issued for late submission of disclosures, and forty-eight NOVs were issued for disclosures lacking evidence of collection and testing samples of recovered fluid.

- **Civil or Criminal Enforcement Actions:** The Division may issue civil enforcement orders to operators who violate legal requirements, or for the purposes of ordering necessary tests or remedial work. (*See, e.g.,* Public Resources Code, §§ 3106, 3224, 3225, 3226, 3236.5.) The Division issued one order to an operator in September 2015 requiring additional sampling and testing of water produced from wells subject to WST. The Division did not initiate any criminal enforcement actions during the reporting period.

- **Penalties Assessed:** No monetary penalties were initiated by the Division prior to the end of September, 2015. Violations during the reporting period did not warrant monetary penalties.

Data on compliance issues with regard to stimulations performed after July 1, 2015 are in the process of being evaluated.

Table 15: Notices of Violation

Oil Field	South Belridge	North Belridge	Total
Disclosure submission over 60 days	10		**10**
No recovered fluid analysis report	20	28	**48**
Totals by Oil Field	**30**	**28**	**58**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Reports of Incidents/Events

Loss of Well and/or Well Casing Integrity

> *Public Resources Code section 3215, subdivision (c)(5) "Data detailing the loss of well and well casing integrity in the preceding year for wells that have undergone well stimulation treatment. For comparative purposes, data detailing the loss of well and well casing integrity in the preceding year for all wells shall also be provided. The cause of each well and well casing failure, if known, shall also be provided."*

There was no reported loss of well or well casing integrity associated with any WST activity during the reporting period.

The permanent regulations implemented July 1, 2015 include several important new requirements for pre-WST assessment of well integrity. Such requirements include:

- Requiring operators to perform specialized pressure-testing shortly before a WST.
- Division evaluation of evidence that the cement-casing bond of a well is sufficient to prevent significant migration of fluids, particularly under the increased pressures that occur during WST operations.

Emergency Responses

> *Public Resources Code section 3215, subdivision (c)(3) "The number of emergency responses to a spill or release associated with a well stimulation treatment."*

There were no emergency responses, spills, or releases of any liquids or regulated substances associated with WSTs performed during the reporting period.

Seismic Data

There was no seismic activity of a magnitude 2.7 or greater reported as associated with any WST activity during the reporting period. The formal requirement for operators to monitor for and report such events became mandatory July 1, 2015 under the permanent regulations.

Public Resources Code section 3160 and Related Information

> *Public Resources Code section 3215, subdivision (c): "…The report shall include aggregated data of all of the information required to be reported pursuant to Section 3160 reported by the district, county, and operator."*

This section includes those provisions of Public Resources Code 3160 that require reporting and other notification and can be aggregated. To fulfill this requirement, all aggregable information from the section 3160 reporting and notification processes is summarized below unless already provided in response to *Public Resources Code section 3215, subdivision (c)* . The statute requires items meeting these criteria must be "reported by the district, county, and operator," therefore reportable items include a table for each of those.

Well Stimulation Treatment Applications and Notices

The interim regulations for implementing SB 4 were effective January 1, 2014 through June 30, 2015. During the interim period, Interim WST Notices were reviewed for completeness under a ministerial process to ensure that notices contained all required information. Not all requested notices were approved; unapproved notices were usually revised by operators and resubmitted to the Division for re-review and potential approval.

Well Stimulation Notices Received

The following tables provide information regarding the number of Interim WST Notices and WST applications received during the reporting period, listed by well operator, county, district, oil field, and proposed stimulation type.

A searchable listing of Interim WST Notices can be found here:

- http://maps.conservation.ca.gov/doggr/iwst_index.html

It is important to note that with some Interim WST Notice and WST applications there was an iterative process with the well operators wherein the notice was returned to the operator for correction and the notice/application was later resubmitted. This may have occurred more than once with the same notice/application. While each resubmittal had to be administratively processed in the same manner as an original submittal, these were not tracked separately. Therefore, the quantities listed below for notices/applications received do not fully recognize the quantity processed.

Approximately 50 wells were the subject of more than one Interim WST Notice. These situations occurred for several reasons which are listed here:

1. Most commonly – the initially-submitted notice was for a well that had not yet been drilled. During the pre-drill planning process the operator's planned surface or bottom location changed sufficiently to warrant amending the requested notice.
2. Commonly – the operator wished to renew an approved Interim WST Notice, which when approved as complete, allowed an operator 365 days to begin a stimulation from the date of Division signature. Some operators who had received Interim WST Notices and did not quickly stimulate their wells chose to submit a second notice in order to maximize planning and schedule flexibility.

3. Less Commonly – the operator's plans called for some minor change in the stimulation program. Common minor changes included a change in the planned stimulation target or depth, or a change in the planned additives/chemistry program.
4. Least Commonly – several operators sought flexibility to perform different stimulation programs on the same well. Reasons for this included operator interest in testing common stimulation techniques in targets or locations for which an optimal strategy for enhancing formation permeability had not yet been identified.

The following tables include the information on notices according to SB 4 reporting requirements.

Table 16: Number of WST Applications and Notices Received by Well Operator and County

Well Operator	Fresno County	Kern County	Kings County	Los Angeles Offshore	Orange County	Ventura County	Totals by Operator
Aera Energy, LLC		1758				3	**1761**
Breitburn Energy Co., LLC		54					**54**
Central Resources, Inc.		4					**4**
Chevron USA, Inc.		53					**53**
Crimson Resource Management		1					**1**
DCOR, LLC						2	**2**
KMD Operating Company, LLC			3				**3**
LINN Operating, Inc.		30			2		**32**
Longview Energy Company	3						**3**
Macpherson Oil Company		2					**2**
MK Operating, LLC		1					**1**
Occidental of Elk Hills, Inc.		174					**174**
Salt Creek Oil, LLC		6					**6**
Seneca Resources Corporation	3	3					**6**
The Termo Company						2	**2**
Thums Long Beach Company				13			**13**
Vintage Production California, LLC	4	89					**93**
Totals by County	**10**	**2175**	**3**	**13**	**2**	**7**	**2210**

Counties not listed had no well stimulation treatment notices for the period.

Source: WST Tracker, operator disclosures

Table 17: Number of WST Applications and Notices Received by County and Stimulation Type

County	Acid Fracture	Acid Matrix	Hydraulic Fracture	Totals by County
Fresno County	4		6	**10**
Kern County	8	94	2073	**2175**
Kings County		2	1	**3**
Los Angeles Offshore			13	**13**
Orange County			2	**2**
Ventura County			7	**7**
Totals by Type	**12**	**96**	**2102**	**2210**

Counties not listed had no well stimulation treatment notices for the period.

Source: WST Tracker, operator disclosures

Table 18: Number of WST Applications and Notices Received by District and Stimulation Type

District	Acid Fracture	Acid Matrix	Hydraulic Fracture	Totals by District
District 1			14	**14**
District 2			8	**8**
District 4	8	94	2073	**2175**
District 5	4	2	7	**13**
Totals by Type	**12**	**96**	**2102**	**2210**

Districts not listed had no well stimulation treatment notices.

Source: WST Tracker, operator disclosures

Table 19: Number of WST Applications and Notices Received by Oil Field and Stimulation Type

Oil Field	Acid Fracture	Acid Matrix	Hydraulic Fracture	Totals by Oil Field
Asphalto		8		**8**
Belridge, North			305	**305**
Belridge, South	2	1	1446	**1449**
Brea-Olinda			2	**2**
Buena Vista		1		**1**
Cantua Creek			1	**1**
Coalinga			3	**3**
Elk Hills		83	81	**164**
Hopper Canyon			2	**2**
Jerry Slough (ABD)			1	**1**

Oil Field	Acid Fracture	Acid Matrix	Hydraulic Fracture	Totals by Oil Field
Kettleman Middle Dome		2	1	**3**
Kettleman North Dome	10		2	**12**
Lost Hills		1	142	**143**
McKittrick			4	**4**
North Coles Levee			4	**4**
North Shafter			18	**18**
Northwest Lost Hills			6	**6**
Paloma			6	**6**
Riverdale			3	**3**
Rose			36	**36**
Round Mountain			2	**2**
San Emidio Nose			3	**3**
South Mountain			2	**2**
Stockdale			1	**1**
Tejon			1	**1**
Ventura			3	**3**
Wilmington			13	**13**
No Associated Field			14	**14**
Totals by Type	**12**	**96**	**2102**	**2210**

Source: WST Tracker, operator disclosures, WellStat

Approved Well Stimulation Applications and Notices

The following tables provide information regarding the number of Interim WST Notices and WST applications that were approved and permitted during the reporting period. No WST applications have been approved after June 30, 2015.

Table 20: Number of WST Applications and Notices Approved/Permitted by Well Operator and County

Well Operator	Fresno County	Kern County	Kings County	Los Angeles County	Orange County	Ventura County	Totals by Operator
Aera Energy, LLC		1730				3	**1733**
Breitburn Energy Co., LLC		50					**50**
Central Resources		4					**4**

Well Operator	Fresno County	Kern County	Kings County	Los Angeles County	Orange County	Ventura County	Totals by Operator
Chevron USA, Inc.		56					**56**
Crimson Resource Management		1					**1**
DCOR, LLC						3	**3**
Linn Operating, Inc.		29			2		**31**
KMD Operating Company, LLC			3				**3**
MK Operating, LLC	1						**1**
Occidental of Elk Hills, Inc.		160					**160**
Salt Creek Oil, LLC		6					**6**
Seneca Resources Corporation	2	3					**5**
THUMS Long Beach Co.				13			**13**
Vintage Production California, LLC	1	48	9				**58**
White Knight Productions, LLC	3						**3**
Totals by County	**7**	**2087**	**12**	**13**	**2**	**6**	**2127**

Counties not listed had no well stimulation treatment notices.

Source: Interim Well Stimulation Treatment Notices Index

Table 21: Number of WST Applications and Notices Approved/Permitted by County and Stimulation Type

County	Acid Fracture	Acid Matrix	Hydraulic Fracture	Totals by County
Fresno County	1		6	**7**
Kern County	2	86	1999	**2087**
Kings County	5	4	3	**12**
Los Angeles County			13	**13**
Orange County			2	**2**
Ventura County			6	**6**
Totals by Stimulation Type	**8**	**90**	**2029**	**2127**

Counties not listed had no well stimulation treatment notices.

Source: Interim Well Stimulation Treatment Notices Index

Table 22: Number of WST Applications and Notices Approved/Permitted by District and Stimulation Type

District	Acid Fracture	Acid Matrix	Hydraulic Fracture	Totals by District
District 1			15	**15**
District 2			6	**6**
District 4	2	86	1999	**2087**
District 5	6	4	9	**19**
Totals by Stimulation Type	**8**	**90**	**2029**	**2127**

Districts not listed had no well stimulation treatment notices.

Source: Interim Well Stimulation Treatment Notices Index

Table 23: Number of WST Applications and Notices Approved/Permitted by Oil Field and Stimulation Type

Oil Field	Acid Fracture	Acid Matrix	Hydraulic Fracture	Totals by Oil Field
Belridge, North			304	**304**
Belridge, South	2	1	1433	**1436**
Brea-Olinda			2	**2**
Buena Vista		1		**1**
Cantua Creek (ABD)			1	**1**
Coalinga			2	**2**
Coles Levee, North			4	**4**
Elk Hills		83	77	**160**
Hopper Canyon			3	**3**
Kettleman Middle Dome		2	1	**3**
Kettleman North Dome	6	2	2	**10**
Lost Hills		1	124	**125**
Lost Hills, Northwest			6	**6**
McKittrick			4	**4**
Paloma			6	**6**
Riverdale			3	**3**
Rose			28	**28**
San Emidio Nose			3	**3**
Shafter, North			7	**7**
Stockdale			1	**1**

Oil Field	Acid Fracture	Acid Matrix	Hydraulic Fracture	Totals by Oil Field
Ventura			3	**3**
Wilmington			13	**13**
No Associated Field			2	**2**
Totals by Type	**8**	**90**	**2029**	**2127**

Source: Interim Well Stimulation Treatment Notices Index, WellStat

Stimulated Wells

Stimulations Performed

The majority of well stimulation treatments in the reporting period were hydraulic fractures performed in Kern County and were performed primarily by Aera Energy, LLC.

Summary statistics for the entire reporting period are:

- **Number of Stimulation Treatments Performed:** 1,025
- **Primary Stimulation Type:** Hydraulic fracture (97.95%)

Searchable indexes of post-stimulation reports for every stimulation performed in California after December 31, 2013. The indexes are available here:

- (Interim Period) http://www.conservation.ca.gov/dog/Pages/IWSTDisclosureDisclaimer.aspx.
- http://www.conservation.ca.gov/dog/Pages/WSTDisclosureSearchDisclaimer.aspx

Operators are required to report stimulation information to the Division via the disclosure process (Cal. Code Regs., title 14, section 1788, as amended) and reports of stimulations are referred to as "disclosures" in statute, regulation and the Division website. Stimulations performed during the reporting period are described in the following tables.

The following tables provide aggregated data detailing the number of WSTs, shown by operator and stimulation type for each county/district.

Table 24: Number of Well Stimulation Treatments by Well Operator, Stimulation Type, County and District

Well Operator	Acid Fracture	Acid Matrix	Hydraulic Fracture	Kern County District 4	Kings County District 5	Ventura County District 2	Total by Operator
Aera Energy, LLC	1		857	855		3	**858**
Breitburn Energy Co., LLC			48	48			**48**
Central Resources			2	2			**2**
Chevron USA, Inc.			37	37			**37**

Well Operator	Acid Fracture	Acid Matrix	Hydraulic Fracture	Kern County District 4	Kings County District 5	Ventura County District 2	Total by Operator
Crimson Resource Management			1	1			**1**
KMD Operating Company, LLC		2			2		**2**
Occidental of Elk Hills, Inc.		18	44	62			**62**
Seneca Resources Corporation			2	2			**2**
Vintage Production California, LLC			13	13			**13**
Totals	**1**	**20**	**1004**	**1020**	**2**	**3**	**1025**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 25: Number of Well Stimulation Treatments by Stimulation Type and Oil Field

Oil Field	Acid Fracture	Acid Matrix	Hydraulic Fracture	Totals by Oil Field
Belridge, North			149	**149**
Belridge, South	1		704	**705**
Elk Hills		18	44	**62**
Kettleman Middle Dome		2		**2**
Lost Hills			88	**88**
North Coles Levee			2	**2**
Rose			12	**12**
Stockdale			1	**1**
Ventura			3	**3**
No Associated Field			1	**1**
Totals by Stimulation Type	**1**	**20**	**1004**	**1025**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Wells Stimulated Outside Field Boundaries

All WST activities during the reporting period occurred within oil field boundaries except one. This WST was performed by Vintage Production, LLC on well 238-8H, approximately 1.4 miles east and outside the bounds of the Buena Vista oil field within west-central Kern County. The stimulation was by hydraulic

fracture and performed after a groundwater monitoring plan had been completed as part of the Interim WST Notice.

Well Depths – True Vertical and Measured Depths

This section provides information regarding the average depth of well, by both measured depth and true vertical depth, for wells receiving stimulation during the reporting period, aggregated by well operator, county, district, oil field, and stimulation type. Depths are measured in feet (ft.) and are designated as either measured depth (MD) or true vertical depth (TVD).

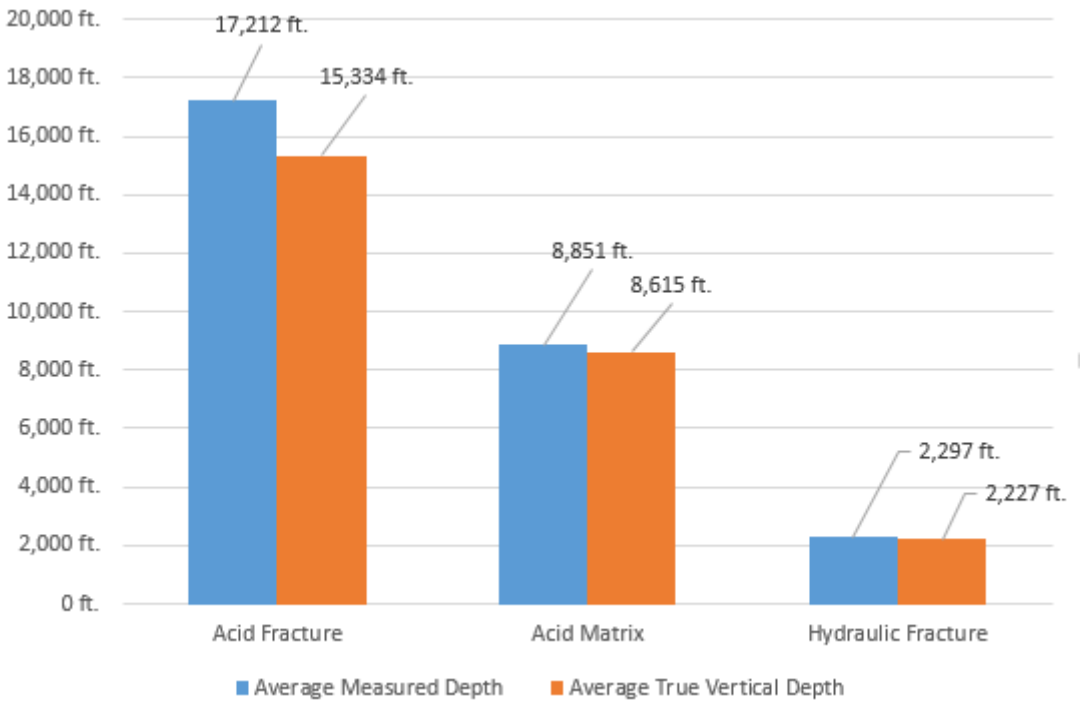
MD represents the actual length of the borehole. An MD is best thought of as the total length of drill pipe, etc, that must be placed into a well to reach the bottom.

TVD represents the vertical distance from a point in the well (usually the current or final depth) to a point at the surface, usually the elevation of the rotary Kelly bushing.

The difference between TVD and MD can be minor to very large. For a well that is drilled straight downward, the MD could potentially be the same as the TVD, though in reality even vertical wells are not straight.

Many stimulations are performed on wells that are drilled vertically down to a certain depth and then curved upward toward horizontal, and drilled horizontally for a distance – much like the shape of the letter L. For such wells the MD will be much greater than the TVD.

Figure 4: Average Measured Depth and True Vertical Depth of Stimulated Wells by Stimulation Type



The following are tables measured by average depth of well, by both measured depth and true vertical depth, for wells receiving stimulation during the reporting period. As required, they are aggregated by

well operator, county, district, oil field, and stimulation type. Depths are measured in feet (ft.) and are designated as either measured depth (MD) or true vertical depth (TVD).

Table 26: Average Measured Depth of Well by Well Operator, County and District

Well Operator	Kern County District 4 (ft.)	Kings County District 5 (ft.)	Ventura County District 2 (ft.)
Aera Energy, LLC	1,898		6,216
Breitburn Energy Co., LLC	2,756		
Central Resources	9,953		
Chevron USA, Inc.	2,665		
Crimson Resource Management	11,752		
KMD Operating Company, LLC		13,039	
Occidental of Elk Hills, Inc.	6,208		
Seneca Resources Corporation	12,753		
Vintage Production California, LLC	12,330		
Averages by County/District	**2,408**	**13,039**	**6,216**

Counties/Districts not listed did not contain occurrences of stimulation.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 27: Average True Vertical Depth of Well by Well Operator, County and District

Well Operator	Kern County District 4 (ft.)	Kings County District 5 (ft.)	Ventura County District 2 (ft.)
Aera Energy, LLC	1,891		6,166
Breitburn Energy Co., LLC	2,753		
Central Resources	9,922		
Chevron USA, Inc.	2,660		
Crimson Resource Management	11,731		
KMD Operating Company, LLC		12,249	
Occidental of Elk Hills, Inc.	6,084		
Seneca Resources Corporation	7,515		
Vintage Production California, LLC	8,388		
Averages by County/District	**2,334**	**12,249**	**6,166**

Counties/Districts not listed did not contain occurrences of stimulation.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 28: Average True Vertical Depth and Measured Depth of Well by County, District and Stimulation Type

County/District	Average Measured Depth (ft.)			Average True Vertical Depth (ft.)		
	Acid Fracture	Acid Matrix	Hydraulic Fracture	Acid Fracture	Acid Matrix	Hydraulic Fracture
Kern County – District 4	17,212	8,386	2,285	15,334	8,211	2,215
Kings County – District 5		13,039			12,249	
Ventura County – District 2			6,216			6,166

Counties/Districts not listed did not contain occurrences of stimulation.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 29: Average True Vertical Depth and Measured Depth of Well by Oil Field and Stimulation Type

Oil Field	Average Measured Depth (ft.)			Average True Vertical Depth (ft.)		
	Acid Fracture	Acid Matrix	Hydraulic Fracture	Acid Fracture	Acid Matrix	Hydraulic Fracture
Belridge, North			1,986			1,982
Belridge, South	17,212		1,876	15,334		1,872
Elk Hills		8,386	5,317		8,211	5,213
Kettleman Middle Dome		13,039			12,249	
Lost Hills			2,790			2,665
North Coles Levee			9,953			9,922
Rose			12,312			8,231
Stockdale			11,752			11,731
Ventura			6,216			6,166
No Associated Field			12,545			10,267
Averages by Stimulation Type	**17,212**	**8,851**	**2,297**	**15,334**	**8,615**	**2,227**

Oil fields not listed did not contain occurrences of stimulation.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Horizon Depths

This section reports the average depths of stimulated horizons (in feet) by well operator and County/District for well stimulation treatments. In this context, the term *horizon* is used synonymously with *zone* or *formation*. It is important to note that during the interim period information used to calculate horizon depths was not differentiated by stimulation stage. As well stimulation treatments

typically consist of several stages of stimulation, the information below cannot accurately depict the average for the entirety of all stimulation horizon depths for the reporting period.

Table 30: Average Measured Depth of Top of Horizon by Operator, County and District

Well Operator	Kern County District 4 (ft.)	Kings County District 5 (ft.)	Ventura County District 2 (ft.)
Aera Energy, LLC	863		4,790
Breitburn Energy Co., LLC	1,427		
Central Resources	9,570		
Chevron USA, Inc.	1,525		
Crimson Resource Management	11,417		
KMD Operating Company, LLC		11,492	
Occidental of Elk Hills, Inc.	4,115		
Seneca Resources Corporation	7,276		
Vintage Production California, LLC	8,603		
Averages by County/District	**1,250**	**11,492**	**4,790**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 31: Average Measured Depth of Top of Horizon by Oil Field and Stimulation Type

Oil Field	Acid Fracture (ft.)	Acid Matrix (ft.)	Hydraulic Fracture (ft.)
Belridge, North			851
Belridge, South	11,255		845
Elk Hills		6,146	3,284
Kettleman Middle Dome		11,492	
Lost Hills			1,641
North Coles Levee			9,570
Rose			8,328
Stockdale			11,417
Ventura			4,790
No Associated Field			11,910
Averages by Stimulation Type	**11,255**	**6,680**	**1,163**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 32: Average True Vertical Depth of Top of Horizon by Operator, County and District

Well Operator	Kern County District 4 (ft.)	Kings County District 5 (ft.)	Ventura County District 2 (ft.)
Aera Energy, LLC	860		4,779
Breitburn Energy Co., LLC	1,425		
Central Resources	9,570		
Chevron USA, Inc.	1,522		
Crimson Resource Management	11,409		
KMD Operating Company, LLC		11,125	
Occidental of Elk Hills, Inc.	4,103		
Seneca Resources Corporation	7,276		
Vintage Production California, LLC	8,103		
Averages by County/District	**1,240**	**11,125**	**4,779**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.
Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 33: Average True Vertical Depth of Top of Horizon by Oil Field and Stimulation Type

Oil Field	Acid Fracture (ft.)	Acid Matrix (ft.)	Hydraulic Fracture (ft.)
Belridge, North			849
Belridge, South	11,215		842
Elk Hills		6,129	3,275
Kettleman Middle Dome		11,125	
Lost Hills			1,636
North Coles Levee			9,570
Rose			7,960
Stockdale			11,409
Ventura			4,779
No Associated Field			9,811
Averages by Stimulation Type	**11,215**	**6,629**	**1,153**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Stage Depths – Average Stimulation Depth

This section shows the aggregated information for average stimulation depths based upon start and ending stage depths (in feet) as reported by well operators.

For the purposes of this report, disclosure form fields which were labeled as "start" and "end" for measured depth and true vertical depth for the stage during the reporting period had been corrected to indicate "top" and "bottom", respectively. "Start" and "end" resulted in ambiguity as to intention and reporting processes have been put in place to facilitate clear collection and reporting of this information as of July 1, 2015. The ambiguity resulted in some of the values reported for these data points to be inverted; this inversion has been corrected below.

It is also important to note that during the interim period information used to calculate these depths was not differentiated by stimulation stage. As well stimulation treatments typically consist of several stages of stimulation, the information below cannot accurately depict the average for the entirety of all penetration depths for the reporting period. Top and bottom depths below indicate top of topmost stage to bottom of bottom stage.

Table 34: Average Measured Depth of Top of Stimulation by Operator, County and District

Well Operator	Kern County District 4 (ft.)	Kings County District 5 (ft.)	Ventura County District 2 (ft.)
Aera Energy, LLC	1,098		4,857
Breitburn Energy Co., LLC	2,292		
Central Resources	9,537		
Chevron USA, Inc.	1,663		
Crimson Resource Management	11,430		
KMD Operating Company, LLC		11,318	
Occidental of Elk Hills, Inc.	4,355		
Seneca Resources Corporation	10,030		
Vintage Production California, LLC	9,145		
Averages by County/District	**1,519**	**11,318**	**4,857**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 35: Average Measured Depth of Top of Stimulation by Oil Field and Stimulation Type

Oil Field	Acid Fracture (ft.)	Acid Matrix (ft.)	Hydraulic Fracture (ft.)
Belridge, North			1,273
Belridge, South	11,770		1,083
Elk Hills		6,531	3,465
Kettleman Middle Dome		11,318	
Lost Hills			1,886
North Coles Levee			9,537
Rose			8,912
Stockdale			11,430
Ventura			4,857
No Associated Field			11,934
Averages by Stimulation Type	**11,770**	**7,010**	**1,429**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 36: Average Measured Depth of Bottom of Stimulation by Operator, County and District

Well Operator	Kern County District 4 (ft.)	Kings County District 5 (ft.)	Ventura County District 2 (ft.)
Aera Energy, LLC	1,756		5,238
Breitburn Energy Co., LLC	2,033		
Central Resources	9,756		
Chevron USA, Inc.	2,164		
Crimson Resource Management	11,600		
KMD Operating Company, LLC		12,648	
Occidental of Elk Hills, Inc.	5,775		
Seneca Resources Corporation	12,615		
Vintage Production California, LLC	12,076		
Averages by County/District	**2,206**	**12,648**	**5,238**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 37: Average Measured Depth of Bottom of Stimulation by Oil Field and Stimulation Type

Oil Field	Acid Fracture (ft.)	Acid Matrix (ft.)	Hydraulic Fracture (ft.)
Belridge, North			1,744
Belridge, South	13,360		1,720
Elk Hills		8,221	4,774
Kettleman Middle Dome		12,648	
Lost Hills			2,500
North Coles Levee			9,756
Rose			12,060
Stockdale			11,600
Ventura			5,238
No Associated Field			12,265
Averages by Stimulation Type	**13,360**	**8,663**	**2,096**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 38: Average True Vertical Depth of Top of Stimulation by Operator, County and District

Well Operator	Kern County District 4 (ft.)	Kings County District 5 (ft.)	Ventura County District 2 (ft.)
Aera Energy, LLC	1,094		4,847
Breitburn Energy Co., LLC	2,285		
Central Resources	9,537		
Chevron USA, Inc.	1,659		
Crimson Resource Management	11,422		
KMD Operating Company, LLC		10,978	
Occidental of Elk Hills, Inc.	4,339		
Seneca Resources Corporation	7,513		
Vintage Production California, LLC	8,184		
Averages by County/District	**1,497**	**10,978**	**4,847**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 39: Average True Vertical Depth of Top of Stimulation by Oil Field and Stimulation Type

Oil Field	Acid Fracture (ft.)	Acid Matrix (ft.)	Hydraulic Fracture (ft.)
Belridge, North			1,269
Belridge, South	11,720		1,079
Elk Hills		6,511	3,451
Kettleman Middle Dome		10,978	
Lost Hills			1,824
North Coles Levee			9,537
Rose			8,047
Stockdale			11,422
Ventura			4,847
No Associated Field			9,831
Averages by Stimulation Type	**11,720**	**6,957**	**1,407**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 40: Average True Vertical Depth of Bottom of Stimulation by Operator, County and District

Well Operator	Kern County District 4 (ft.)	Kings County District 5 (ft.)	Ventura County District 2 (ft.)
Aera Energy, LLC	1,751		5,219
Breitburn Energy Co., LLC	2,031		
Central Resources	9,756		
Chevron USA, Inc.	2,159		
Crimson Resource Management	11,592		
KMD Operating Company, LLC		12,126	
Occidental of Elk Hills, Inc.	5,701		
Seneca Resources Corporation	7,153		
Vintage Production California, LLC	8,348		
Averages by County/District	**2,139**	**12,126**	**5,219**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 41: Average True Vertical Depth of Bottom of Stimulation by Oil Field and Stimulation Type

Oil Field	Acid Fracture (ft.)	Acid Matrix (ft.)	Hydraulic Fracture (ft.)
Belridge, North			1,741
Belridge, South	12,795		1,716
Elk Hills		8,055	4,739
Kettleman Middle Dome		12,126	
Lost Hills			2,370
North Coles Levee			9,756
Rose			8,204
Stockdale			11,592
Ventura			5,219
No Associated Field			10,065
Averages by Stimulation Type	**12,795**	**8,462**	**2,032**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Confidential Wells

Division records of nearly all hydrocarbon well records in California are available for public review and may be found on the Division's online Well Finder page (http://www.conservation.ca.gov/dog/Pages/Wellfinder.aspx).

A small number of wells have confidential status that lasts for a limited period of time. (Public Resources Code section 3234.) Confidential status allows an operator to keep certain information secret in order to protect well investment capital and is granted by many jurisdictions besides the State of California. Onshore wells are granted confidentiality for a two-year period, and offshore wells are granted confidentiality for a five-year period. By statute, the Division may extend the period of confidentiality up to two years if justified by extenuating circumstances.

No wells stimulated during the reporting period had confidential status.

Types of Wells Receiving Well Stimulation Treatment

This section provides information regarding the well type (specific uses of wells) for wells which were stimulated during the reporting period.

- Hydrocarbon production wells are used to extract fluid hydrocarbons from the subsurface.
- Steamflood and waterflood wells are used to inject steam or water into the ground in order to raise pressure and/or temperature in order to promote movement of hydrocarbons.

Table 42: Number of Wells by Type by Operator

Well Operator	Hydrocarbon Production	Steamflood	Waterflood	Totals by Operator
Aera Energy, LLC	680	151	27	**858**
Breitburn Energy Co., LLC	48			**48**
Central Resources	2			**2**
Chevron USA, Inc.	37			**37**
Crimson Resource Management	1			**1**
KMD Operating Company, LLC	2			**2**
Occidental of Elk Hills, Inc.	62			**62**
Seneca Resources Corporation	2			**2**
Vintage Production California, LLC	13			**13**
Totals by Well Type	**847**	**151**	**27**	**1025**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 43: Number of Wells by Type by County and District

County/District	Hydrocarbon Production	Steamflood	Waterflood	Totals by County/District
Kern County - District 4	842	151	27	**1020**
Kings County - District 5	2			**2**
Ventura County - District 2	3			**3**
Totals by Well Type	**847**	**151**	**27**	**1025**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 44: Number of Wells by Type by Stimulation Type

Stimulation Type	Hydrocarbon Production	Steamflood	Waterflood	Totals by Stimulation Type
Acid Fracture	1			**1**
Acid Matrix	20			**20**
Hydraulic Fracture	826	151	27	**1004**
Totals by Well Type	**847**	**151**	**27**	**1025**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 45: Number of Wells by Type by Stimulation Type and Oil Field

Oil Field	Hydrocarbon Production			Steamflood			Waterflood			Totals by Oil Field
	Acid Fracture	Acid Matrix	Hydraulic Fracture	Acid Fracture	Acid Matrix	Hydraulic Fracture	Acid Fracture	Acid Matrix	Hydraulic Fracture	
Belridge, North			149							**149**
Belridge, South	1		526			151			27	**705**
Elk Hills		18	44							**62**
Kettleman Middle Dome		2								**2**
Lost Hills			88							**88**
North Coles Levee			2							**2**
Rose			12							**12**
Stockdale			1							**1**
Ventura			3							**3**
No Associated Field			1							**1**
Totals by Type	**1**	**20**	**826**		**0**	**151**		**0**	**27**	**1025**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

72-Hour WST Notices Received from Well Operators

Operators are required to provide the Division a 72-hour notification prior to initiating a WST. 72-hour notices were properly provided for 99% of WSTs performed during the reporting period.

Table 46: Number of 72-Hour WST Notices Received by Well Operator, County and District

Well Operator	Kern County District 4	Kings County District 5	Ventura County District 2	Totals by Operator
Aera Energy LLC	851		2	**853**
BreitBurn Operating LP	44			**44**
Central Resources	2			**2**
Chevron USA, Inc.	44			**44**
Crimson Resource Management	1			**1**
KMD Operating Company, LLC		1		**1**
Occidental of Elk Hills, Inc.	58			**58**
Vintage Production California	12			**12**
Total by County	**1012**	**1**	**2**	**1015**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 47: Number of 72-Hour WST Notices Received by County, District, and Stimulation Type

Well Operator	Hydraulic Fracture	Acid Matrix	Acid Fracture	Totals by County/District
Kern County - District 4	996	15	1	**1012**
Kings County - District 5	1			**1**
Ventura County - District 2	2			**2**
Total by County	**999**	**15**	**1**	**1015**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Notification of Availability for Water Testing and Sampling

Prior to performing WST on an oil or gas well, operators are required to hire an independent third-party to identify surface owners and tenants of property that is either located within a 1,500-foot radius of the wellhead receiving WST, or within 500 feet of the surface representation of the horizontal path of the subsurface parts of the well. The third-party sends the identified owners and tenants a Well Stimulation Treatment Neighbor Notification Form, which indicates, among other things, the earliest date upon which the well stimulation treatment may be performed. Well stimulation treatment cannot commence until at least 30 days after all required notices have been provided.

WST Requiring Neighbor Notification

The purpose of this section of the report is to demonstrate the number of planned WSTs requiring neighbor notifications in comparison to wells which did not necessitate neighbor notifications. However, during the interim period, well operators were not reporting instances where no neighbor notifications were required and there is no consistent data for the interim period covered by this report. The only relevant data available is for notifications actually sent. Processes have been put in place to facilitate collection of this information as of July 1, 2015.

Table 48: Number of Planned Well Stimulation for which Neighbor Notifications were sent by Well Operator, County and District

Well Operator	Kern County District 4	Orange County District 1	Ventura County District 2	Totals by Operator
Aera Energy, LLC	611			**611**
Breitburn Energy Co., LLC	18			**18**
California Resources of Elk Hills	6			**6**
Central Resources, Inc.	4			**4**
Chevron USA, Inc.	40			**40**
Crimson Resource Management	1			**1**
DCOR			1	**1**
Linn Operating Co.	26	1		**27**
Occidental of Elk Hills, Inc.	42			**42**
Seneca Resources Corporation	5			**5**
Vintage Production California, LLC	22			**22**
Total by County/District	**775**	**1**	**1**	**777**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Neighbor Notification reporting from Well Operators

Number of Neighbors Notified

Neighbor notifications are sent to landowners and/or tenants by independent third-party agencies on behalf of well operators. The following information is based upon reports submitted by third-party agencies for neighbor notifications sent. The figures represent distinct recipients/individuals for a particular planned stimulation for a particular well. Third-party agencies send neighbor notifications for a planned stimulation based upon individual addresses or parcels. As such, a single surface owner may have received several notifications regarding a single planned stimulation, one for each of their related properties. The number of neighbor notifications per stimulation is not fixed and could vary from none (e.g., exemption from self-notifying, for a well centered within a single, very large parcel of land

owned/occupied by the well operator) to dozens (e.g., where a well stimulation might be planned close to an area of small residential or other parcels).

During the interim period, neighbor notification reporting did not specify the type of planned stimulation. As such, the data cannot be aggregated by planned stimulation type. Processes have been put in place to facilitate collection of this information as of July 1, 2015.

Table 49: Number of Neighbor Notifications Recipients by Well Operator, County and District

Well Operator	Kern County District 4	Orange County District 1	Ventura County District 2	Totals by Operator
Aera Energy, LLC	963			**963**
Breitburn Energy Co., LLC	18			**18**
California Resources Elk Hills, LLC	6			**6**
Central Resources, Inc.	19			**19**
Chevron USA, Inc.	42			**42**
Crimson Resource Management	194			**194**
DCOR			11	**11**
Linn Operating, Inc.	26	1		**27**
Occidental of Elk Hills, Inc.	57			**57**
Seneca Resources Corporation	20			**20**
Vintage Production California, LLC	108			**108**
Totals by County/District	**1453**	**1**	**11**	**1465**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.
Source: Neighbor Notification reporting from Well Operators

Water Sampling Requests

Upon receipt of a neighbor notification, a surface property owner or tenant can request water sampling and testing for certain water sources on the parcel. Multiple water sources on a single parcel (e.g., groundwater well and surface water) can result in multiple requests from a single owner or tenant. The Division and the State Water Board co-administer the program of tracking, identifying participating parties, receiving results for and potential enforcements for the Neighbor Notification sampling and testing program. Tracking and monitoring of water sources is not under the purview of the Division as this falls under the authority of State and Regional Water Boards. The sampling and testing program is subject to audit and review by the State Water Board. Information regarding requested water sampling and testing was provided to the Division by the State Water Board.

The State Water Board informed the Division that during the reporting period only one sampling was requested in response to more than one thousand notifications sent. The sampling was performed on

behalf of DCOR, LLC for the prospective stimulation of its Hopper 31 well within Ventura County's Hopper Canyon oil field. Despite performing the Neighbor Notification including collection of a baseline water sample, DCOR did not stimulate the well. As such, no follow-up testing to compare to the baseline sample was required or performed.

Neighbor Notification Audits Performed

Neighbor notifications are sent by independent third-party agencies. During the reporting period, eight such third-party agencies were engaged in providing neighbor notifications on behalf of well operators. An audit of notifications for planned well stimulations for 2014 was performed on two of these agencies. The audit consisted of a random spot-check of notifications sent for planned well stimulations representing three of the 10 well operators planning to perform well stimulations during the reporting period.

- Third Party Agencies Audited:
  - Maverick Petroleum, Inc.
  - Stoel Rives, LLP
- Affected Well Operators:
  - Aera Energy, LLC
  - Occidental of Elk Hills, Inc.
  - Vintage Production California, LLC

The audit verified that notifications had been performed as represented by third-party agencies. Verifications included review of certified mail delivery receipts and contacting reported notification recipients. No inaccuracy in reported information was found during the audits.

Any audits or reviews of the sampling and testing program which may have been performed by the State Water Board or any other agency are not within the scope of this report.

Groundwater Protection Compliance Status

This section addresses the protection of water resources. Effective January 1, 2014, all well stimulation treatment notices in California were required to include either a Groundwater Monitoring Plan (GWMP) or a Statement of Non-Applicability (SON). WSTs performed in 2014 under the authority of Notices received by the Division during the late 2013 Certification of Compliance period were exempted from this requirement (indicated as "N/A" in the figures below), though nearly all of the Certification of Compliance period notices contain material intended to fulfill the intent of SB 4 for protection of water resources.

GWMPs and SONs can be for either a single well or an area encompassing a specified set of wells. As such, a straight count of GWMPs and SONs would in no way relate to the figures for numbers of wells stimulated or the number of wells covered by either a GWMP or an SON.

Table 50: Number of Stimulated Wells with either GWMP/SON/Not Applicable by Operator, County and District

Well Operator	Kern County District 4			Kings County District 5			Ventura County District 2			Totals by Operator
	GWMP	SON	N/A	GWMP	SON	N/A	GWMP	SON	N/A	
Aera Energy, LLC	51	660	144						3	**858**
Breitburn Energy Co., LLC		48								**48**
Central Resources	2									**2**
Chevron USA, Inc.	29	7	1							**37**
Crimson Resource Management	1									**1**
KMD Operating Company, LLC				1	1					**2**
Occidental of Elk Hills, Inc.	23	26	13							**62**
Seneca Resources Corporation	2									**2**
Vintage Production California, LLC		1	12							**13**
Totals by Stimulation Type	**108**	**742**	**170**	**1**	**1**	**0**	**0**	**0**	**3**	**1025**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 51: Number of Stimulated Wells with either GWMP/SON/Not Applicable by Oil Field, County and District

Oil Field	Kern County District 4			Kings County District 5			Ventura County District 2			Totals by Oil Field
	GWMP	SON	N/A	GWMP	SON	N/A	GWMP	SON	N/A	
Belridge, North		121	28							**149**
Belridge, South	2	587	116							**705**
Elk Hills	23	26	13							**62**
Kettleman Middle Dome				1	1					**2**
Lost Hills	80	7	1							**88**
North Coles Levee	2									**2**
Rose		1	11							**12**
Stockdale	1									**1**
Ventura									3	**3**

Oil Field	Kern County District 4			Kings County District 5			Ventura County District 2			Totals by Oil Field
	GWMP	SON	N/A	GWMP	SON	N/A	GWMP	SON	N/A	
No Associated Field			1							**1**
Totals by County/District	**108**	**742**	**170**	**1**	**1**	**0**	**0**	**0**	**3**	**1025**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 52: Number of Stimulated Wells with GWMP, SON, or Not Applicable by Stimulation Type

Compliance Type	Acid Fracture	Acid Matrix	Hydraulic Fracture	Totals
GWMP		9	100	**109**
SON	1	6	736	**743**
Not Applicable		5	168	**173**
Totals by Stimulation Type	**1**	**20**	**1004**	**1025**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Water Usage (Base Fluid)

This section discusses the sources, volumes, and suitability for domestic or irrigation purposes of water used to make up WST fluids. All WSTs permitted by the Division and performed by operators under SB 4 statute and regulation have used water as a base fluid. No stimulations were performed during the interim period using nitrogen or hydrocarbon base fluids; these fluids have been used in California and elsewhere in the past. Units for volumes shown are rounded to the nearest barrel (BBLS).

Base Fluid Water Source

The sources of water used to comprise WST base fluid were reported by operators. The sources, as they were reported by operators, are listed below under three categories:

- Domestic Water System:
  - Bakersfield Domestic Water Supply
  - Belridge Water District from California Aqueduct
  - Casitas Municipal Water District
  - West Kern Water District
- Produced Water:
  - Field Produced Water
  - Lease Produced Water

- Produced Fluid
- Produced Tulare Water
- Produced Water
- Tulare Water

- Private Water Production Well:
  - Aera-owned Industrial water source wells completed in the Tulare Aquifer
  - Kern Front
  - Private Landowner in Rose Field
  - Private well in Rose Field - Potable-unappropriated groundwater
  - Private well in Rose Field – Shafter Wasco Irrigation District
  - Private well in Shafter-Wasco Irrigation District
  - South Coles Levee Water Well #1

These categories provide a clear breakdown of WST base fluid by the original source. The following tables show total volumes by source as well aggregated the data, as required, by district, county, and operator.

Table 53: WST Base Fluid Sources by Volume and Percent

	Domestic Water System	Private Water Production Well	Produced Fluid	Total
Volumes (BBLS)	**2,027,858**	**188,077**	**392,794**	**2,608,729**
Percentages	**78%**	**7%**	**15%**	**100%**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 54: WST Base Fluid Source by Well Operator

Well Operator	Domestic Water System (BBLS)	Private Water Production Well (BBLS)	Produced Fluid (BBLS)	Totals by Operator (BBLS)
Aera Energy, LLC	1,496,520	33,039		**1,529,559**
Breitburn Energy Co., LLC	357,418		89,354	**446,772**
Central Resources		9,895		**9,895**
Chevron USA, Inc.			159,705	**159,705**
Crimson Resource Management	2,559		452	**3,010**
KMD Operating Company, LLC		15,709		**15,709**
Occidental of Elk Hills, Inc.	70,305		118,019	**188,324**
Seneca Resources Corporation	101,057		25,264	**126,321**

Well Operator	Domestic Water System (BBLS)	Private Water Production Well (BBLS)	Produced Fluid (BBLS)	Totals by Operator (BBLS)
Vintage Production California, LLC		129,434		**129,434**
Totals by Source	**2,027,858**	**188,077**	**392,794**	**2,608,729**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 55: WST Base Fluid Source by County and District

County/District	Domestic Water System (BBLS)	Private Water Production Well (BBLS)	Produced Fluid (BBLS)	Totals by County/District (BBLS)
Kern County - District 4	2,020,165	172,368	392,794	**2,585,327**
Kings County - District 5		15,709		**15,709**
Ventura County - District 2	7,693			**7,693**
Totals by Source	**2,027,858**	**188,077**	**392,794**	**2,608,729**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures
Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Table 56: WST Base Fluid Source by Oil Field

Oil Field	Domestic Water System (BBLS)	Private Water Production Well (BBLS)	Produced Fluid (BBLS)	Totals by Oil Field (BBLS)
Belridge, North	491,627		57,201	**548,828**
Belridge, South	1,285,601		32,154	**1,317,755**
Elk Hills	70,305		118,019	**188,324**
Kettleman Middle Dome		15,709		**15,709**
Lost Hills	170,073	33,039	184,969	**388,081**
North Coles Levee		9,895		**9,895**
Rose		123,521		**123,521**
Stockdale	2,559		452	**3,010**
Ventura	7,693			**7,693**
No Associated Field		5,913		**5,913**
Totals by Source	**2,027,858**	**188,077**	**392,794**	**2,608,729**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Total Base Fluid Used for WST

The following tables demonstrate the aggregated data for the total amount of base fluid used by operator, per county and district, and the overall totals. Units for volumes shown are rounded to the nearest barrel (BBLS). As required, they are aggregated by district, county, and operator.

Table 57: Total WST Base Fluid Volume by Well Operator, County and District

Well Operator	Kern County District 4 (BBLS)	Kings County District 5 (BBLS)	Ventura County District 2 (BBLS)	Totals by Operator (BBLS)
Aera Energy, LLC	1,521,866		7,693	**1,529,559**
Breitburn Energy Co., LLC	446,772			**446,772**
Central Resources	9,895			**9,895**
Chevron USA, Inc.	159,705			**159,705**
Crimson Resource Management	3,010			**3,010**
KMD Operating Company, LLC		15,709		**15,709**
Occidental of Elk Hills, Inc.	188,324			**188,324**
Seneca Resources Corporation	126,321			**126,321**
Vintage Production California, LLC	129,434			**129,434**
Totals by County/District	**2,585,327**	**15,709**	**7,693**	**2,608,729**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.
Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 58: Total WST Base Fluid Volume by Stimulation Type, County and District

Stimulation Type	Kern County District 4 (BBLS)	Kings County District 5 (BBLS)	Ventura County District 2 (BBLS)	Totals by Stimulation Type (BBLS)
Acid Fracture	3,332			**3,332**
Acid Matrix	20,006	15,709		**35,715**
Hydraulic Fracture	2,561,989		7,693	**2,569,682**
Totals by County/District	**2,585,327**	**15,709**	**7,693**	**2,608,729**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.
Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 59: Total WST Base Fluid Volume by Stimulation Type and Oil Field

Oil Field	Acid Fracture (BBLS)	Acid Matrix (BBLS)	Hydraulic Fracture (BBLS)	Totals by Field (BBLS)
Belridge, North			548,828	**548,828**
Belridge, South	3,332		1,314,423	**1,317,755**
Elk Hills		20,006	168,318	**188,324**
Kettleman Middle Dome		15,709		**15,709**
Lost Hills			388,081	**388,081**
North Coles Levee			9,895	**9,895**
Rose			123,521	**123,521**
Stockdale			3,010	**3,010**
Ventura			7,693	**7,693**
No Associated Field			5,913	**5,913**
Totals by Stimulation Type	**3,332**	**35,715**	**2,569,682**	**2,608,729**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Average WST Base Fluid Volume

The following tables demonstrate the aggregated data for the per-job-average amount of base fluid used by operator, shown by county and district. Units for volumes shown are rounded to the nearest barrel (BBLS). As required, they are aggregated by district, county, and operator.

Table 60: Average WST Base Fluid Volume by Well Operator, County and District

Operator	Kern County District 4 (BBLS)	Kings County District 5 (BBLS)	Ventura County District 2 (BBLS)	Averages by Operator (BBLS)
Aera Energy, LLC	1,780		2,564	**1,783**
Breitburn Energy Co., LLC	9,308			**9,308**
Central Resources	4,948			**4,948**
Chevron USA, Inc.	4,316			**4,316**
Crimson Resource Management	3,010			**3,010**
KMD Operating Company, LLC		7,855		**7,855**
Occidental of Elk Hills, Inc.	3,037			**3,037**
Seneca Resources Corporation	63,161			**63,161**
Vintage Production California, LLC	9,956			**9,956**
Averages by County/District	**2,535**	**7,855**	**2,564**	**2,545**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 61: Average WST Base Fluid Volume by Stimulation Type, County and District

Stimulation Type	Kern County District 4 (BBLS)	Kings County District 5 (BBLS)	Ventura County District 2 (BBLS)	Averages by Type (BBLS)
Acid Fracture	3,332			**3,332**
Acid Matrix	1,111	7,855		**1,786**
Hydraulic Fracture	2,559		2,564	**2,559**
Averages by County/District	**2,535**	**7,855**	**2,564**	**2,545**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 62: Average WST Base Fluid Volume by Stimulation Type and Oil Field

Oil Field	Acid Fracture (BBLS)	Acid Matrix (BBLS)	Hydraulic Fracture (BBLS)
Belridge, North			3,683
Belridge, South	3,332		1,867
Elk Hills		1,111	3,825
Kettleman Middle Dome		7,855	
Lost Hills			4,410
North Coles Levee			4,948
Rose			10,293
Stockdale			3,010
Ventura			2,564
No Associated Field			5,913
Averages by Stimulation Type	**3,332**	**1,786**	**2,559**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

WST Base Fluid Suitability for Domestic or Irrigation Purposes

This section provides information as to the suitability or unsuitability of water used in base fluids for other purposes, such as irrigation or domestic purposes. The suitability of base fluid for irrigation or domestic purposes was a data point reported by operators. However, where the water source was listed as domestic water system, the suitability status has been corrected in this report to indicate that such base fluid is suitable for irrigation or domestic purposes.

In future annual reports, this section will provide information regarding instances where fluid other than water was used in the base fluid. Collection of information regarding fluids other than water was not part of the reporting process during the interim period. Processes have been put in place to facilitate collection of this information as of July 1, 2015.

Table 63: WST Base Fluid Suitability by Well Operator

Well Operator	Suitable (BBLS)	Not Suitable (BBLS)	Totals by Operator (BBLS)
Aera Energy, LLC	1,525,816	3,743	**1,529,559**
Breitburn Energy Co., LLC	357,418	89,354	**446,772**
Central Resources	9,895		**9,895**
Chevron USA, Inc.		159,705	**159,705**
Crimson Resource Management	2,559	452	**3,010**
KMD Operating Company, LLC	15,709		**15,709**

Occidental of Elk Hills, Inc.	70,305	118,019	**188,324**
Seneca Resources Corporation	101,057	25,264	**126,321**
Vintage Production California, LLC	123,521	5,913	**129,434**
Totals by Source	**2,206,279**	**402,450**	**2,608,729**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 64: WST Base Fluid Suitability by County and District

County/District	Suitable (BBLS)	Not Suitable (BBLS)	Totals by County/District (BBLS)
Kern County - District 4	2,184,539	400,788	**2,585,327**
Kings County - District 5	15,709		**15,709**
Ventura County - District 2	6,031	1,662	**7,693**
Totals by Source	**2,206,279**	**402,450**	**2,608,729**

Counties/Districts not listed did not contain occurrences of well stimulation treatment.

Table 65: WST Base Fluid Suitability by Oil Field

Oil Field	Suitable (BBLS)	Not Suitable (BBLS)	Totals by Oil Field (BBLS)
Belridge, North	491,627	57,201	**548,828**
Belridge, South	1,283,520	34,235	**1,317,755**
Elk Hills	70,305	118,019	**188,324**
Kettleman Middle Dome	15,709		**15,709**
Lost Hills	203,112	184,969	**388,081**
North Coles Levee	9,895		**9,895**
Rose	123,521		**123,521**
Stockdale	2,559	452	**3,010**
Ventura	6,031	1,662	**7,693**
No Associated Field		5,913	**5,913**
Totals by Source	**2,206,279**	**402,450**	**2,608,729**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 66: WST Base Fluid Suitability by Volume and Percent

	Suitable	Not Suitable	Totals
Volumes (BBLS)	**2,206,279**	**402,450**	**2,608,729**
Percentages	**84.57%**	**15%**	**100%**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Base Fluids other than Water

There was no base fluid other than water reported as used for the reporting period.

Recovered Fluids

Radioactivity of Recovered Fluids

Radioactivity of fluids recovered from WST activities was not consistently reported during the interim period. Reporting processes put in place effective July 1, 2015 provides the following information for disclosures received from that date through the end of the reporting period. Analysis is performed for gross alpha particles which are emitted during the decay of certain radioactive isotopes (such as radium, uranium and thorium) which are found naturally in the earth's crust.

- **Gross Alpha Particle analysis values range:** -539 to 2,483 pCi/L.
- **Gross Alpha Particle analysis value average:** 193.16 pCi/L.

Radiological Components or Tracers

Use of radiological components or tracers for WST fluids was not correctly reported on a small percentage of disclosures during the interim period. Research into the issue revealed that no radiological components or tracers were used at any time during the reporting period for any WST.

Waste Fluids other than Water

Recovery of waste fluids other than water was not correctly reported during the reporting period. Research into the issue revealed that there were no waste fluids other than water recovered during the reporting period.

Chemical Constituents Used in Well Stimulation Treatment

Not counting water, a total of 253 different chemical constituents were reported as used in WST during the reporting period. These ranged from being used 1071 times for stimulations to being used only once. While this information cannot be aggregated in any meaningful way, a complete list, sorted by the name of the chemical constituent, is provided below.

Table 67: Top 20 Chemical Constituents used in WST by Frequency of Use

Constituent Name	CAS Number	Times Used for WST
Crystalline silica: Quartz (SiO2)	14808-60-7	1071
Diatomaceous Earth, Calcined	91053-39-3	850
Guar Gum	9000-30-0	712
2-Methyl-4-Isothiazolin-3-One	2682-20-4	664
Crystalline Silica: Cristobalite	14464-46-1	664
Magnesium Chloride	7786-30-3	664
Magnesium Nitrate	10377-60-3	664
5-Chloro-2-Methyl-4-Isothiazolin-3-One	26172-55-4	663
Ammonium Persulfate	7727-54-0	661
Hemicellulase Enzyme Concentrate	9025-56-3	657
Ethylene Glycol	107-21-1	655
2-Butoxy-1-Propanol	15821-83-7	648
Isotridecanol, ethoxylated	9043-30-5	648
Paraffinic Petroleum Distillate	64742-55-8	648
Petroleum Distillates	64742-47-8	648
1-Butoxy-2-Propanol	5131-66-8	647
Sodium Hydroxide	1310-73-2	645
Sodium Tetraborate Decahydrate	1303-96-4	608
Phosphonic Acid	13598-36-2	528
Nitrilotris (Methylene Phosphonic Acid)	6419-19-8	527

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 68: Chemical Constituents used in WST by Constituent Name

Constituent Name	CAS Number	Times Used for WST
1, 2, 3 - Propanetriol	56-81-5	7
1,2,3-Trimethylbenzene	526-73-8	12
1,2,4,5-Tetrabromobenzene	636-28-2	1
1,2,4-Trimethylbenzene	95-63-6	6
1,2-benzisothiazolin-3-one	2634-33-5	7
1,2-Diiodobenzene	615-42-9	1
1,3,5-Tribromobenzene	626-39-1	1

Constituent Name	CAS Number	Times Used for WST
1,3,5-Trimethylbenzene	108-67-8	6
1,4-Dibromobenzene	106-37-6	1
1-bromo-3,5-dichlorobenzene	19752-55-7	1
1-Bromo-4-iodobenzene	589-87-7	1
1-Butoxy-2-Propanol	5131-66-8	647
1-Chloro-4-Iodobenzene	637-87-6	1
1-Eicosene	3452-07-1	13
1-Hexadecene	629-73-2	19
1-Iodonaphthalene	90-14-2	1
1-Methoxy-2-Propanol	107-98-2	2
1-Octadecene	112-88-9	19
1-Tetradecene	1120-36-1	20
2,2 Dibromo-3-nitrilopropionamide	10222-01-2	9
2,2`,2"-nitrilotriethanol	102-71-6	29
2,2'-oxydiethanol	111-46-6	28
2,4,5-Tribromotoluene	3278-88-4	1
2,4,6-Tribromotoluene	6320-40-7	1
2,4-Dibromomesitylene	6942-99-0	1
2,5-Dibromothiophene	3141-27-3	1
2,7-Naphthalenedisulfonic acid, 3-hydroxy-4-[(4-sulfor-1-naphthalenyl) azo] -, trisodium salt	915-67-3	1
2,7-Naphthalenedisulfonic acid, 5-(acetylamino) -4-hydroxy-3-[(2-methoxyphenyl) azo] -, disodium salt	6625-46-3	1
2-Bromonaphthalene	580-13-2	1
2-Butoxy-1-Propanol	15821-83-7	648
2-butoxyethanol	111-76-2	1
2-ethylhexan-1-ol	104-76-7	30
2-hydroxy-N,N,N-trimethylethanaminium chloride	67-48-1	7
2-hydroxytrimethylene,bis(trimethylammonium) dichloride	55636-09-4	382
2-Iodobiphenyl	2113-51-1	1
2-Methyl-4-Isothiazolin-3-One	2682-20-4	664
2-Monobromo-3-nitrilopropionamide	1113-55-9	10
2-Propenoic acid, polymer with sodium phosphinate	129898-01-7	29

Constituent Name	CAS Number	Times Used for WST
3,5-Dibromotoluene	1611-92-3	1
3-aminopropyl (sileanetriol)	58160-99-9	11
4-Chlorobenzophenone	134-85-0	1
4-Iodo-o-Xylene	31599-61-8	1
4-Iodotoluene	624-31-7	1
5-Chloro-2-Methyl-4-Isothiazolin-3-One	26172-55-4	663
5-Iodo-m-Xylene	22445-41-6	1
9-Bromophenanthrene	573-17-1	1
Acetic acid	64-19-7	56
Acetic acid, potassium salt	127-08-2	29
Acetyl Triethyl Citrate	77-89-4	12
Acid Phosphate Ester	9046-01-9	1
Acrylamide acrylate copolymer	9003-06-9	1
Acrylonitrile	107-31-1	1
Alcohol, C11-14, ethoxylated	78330-21-9	29
Alcohol, C7-9-iso, C8, ethoxylated	78330-19-5	26
Alcohol; C9-11-iso; C10; ethoxylated	78330-20-8	1
Alcohol; C9-C11; Ethoxylated	68439-46-3	1
Alcohols, C12-16, ethoxylated	68551-12-2	6
Alcohols, C14-C15, ethoxylated	68951-67-7	19
Aldehyde	104-55-2	2
Aldol	107-89-1	2
Alkyl (c10-c14) alcohols, ethoxylated	66455-15-0	29
Alkylaryl sulfonate	68584-27-0	6
Alkylbenzene sulfonate compd. with 2-propanamine	68584-25-8	9
Alkylbenzene sulfonate compd. with triethanolamine	68584-24-7	9
Aluminum chloride, hexahydrate	7784-13-6	1
Aluminum Needles	7429-90-5	1
Aluminum Oxide	1344-28-1	5
Aluminum Silicate	1302-76-7	1
Amine Salts	54300-24-2	2
Amines, hydrogenated tallow alkyl, acetates	61790-59-8	16

Constituent Name	CAS Number	Times Used for WST
Ammonium acetate	631-61-8	3
Ammonium bifluoride	1341-49-7	2
Ammonium chloride	12125-02-9	68
Ammonium fluoride	12125-01-8	18
Ammonium Persulfate	7727-54-0	661
Ammonium; diallyldimethyl-; chloride; polymers	26062-79-3	1
Ampicillin	69-53-4	11
Bentonite, benzyl(hydrogenated tallow alkyl) dimethylammonium stearate complex	121888-68-4	1
Benzoic acid	65-85-0	3
Benzyldimethylammonium chloride	122-18-9	1
Benzyllauryldimethylammonium chloride	139-07-1	1
Boric Acid (H3BO3)	10043-35-3	63
Calcium chloride	10043-52-4	30
Calcium magnesium sodium phosphate frit	65997-18-4	7
Caprylamidopropyl betaine	73772-46-0	9
Cationic polymethacrylamide	86706-87-8	2
Chlorous acid, sodium salt	7758-19-2	3
Choline Chloride	67-48-1	4
Citric Acid	77-92-9	85
Citrus terpenes	94266-47-4	21
Cocamidopropyl betaine	61789-40-0	9
Cocamidopropylamide oxide	68155-09-9	9
Copper dichloride	7447-39-4	18
Corundum	1302-74-5	3
Crosslinked PO/EO-block polymer	68123-18-2	30
Crystalline Silica: Cristobalite	14464-46-1	664
Crystalline silica: Quartz (SiO2)	14808-60-7	1071
Cumene	98-82-8	6
D-Glucitol	50-70-4	2
Diammonium peroxidisulphate	7727-54-0	7
Diatomaceous Earth, Calcined	91053-39-3	850

Constituent Name	CAS Number	Times Used for WST
Dicoco dimethyl quaternary ammonium chloride	61789-77-3	30
Diethanolamine	111-42-2	4
Dimethylbenzylmyristylammonium chloride	139-08-2	1
Dioctyl sulfosuccinate sodium salt	577-11-7	30
Disodium Ethylene Diamine Tetra Acetate (impurity)	139-33-3	1
Disodium octaborate tetrahydrate	12008-41-2	6
D-limonene	5989-27-5	20
Dodecylbenzene sulfonic acid	27176-87-0	4
Enzyme	37288-54-3	11
Erythorbic Acid	89-65-6	7
Ethanol	64-17-5	11
Ethoxylated Alcohol	68131-39-5	1
Ethoxylated alcohol	68439-45-2	1
Ethoxylated alcohol	68603-25-8	1
Ethoxylated Alcohol C12-15	68131-39-5	21
Ethoxylated C11 Alcohol	34398-01-1	1
Ethoxylated Castor Oil	61791-12-6	21
Ethoxylated hexanol	68439-45-2	7
Ethoxylated nonylphenol	68412-53-3	1
Ethoxylated propoxylated 4-nonylphenol-formaldehyde resin	30846-35-6	1
Ethylene Glycol	107-21-1	655
Ethylene glycol monobutyl ether	111-76-2	23
Ethylene Glycol Monobutyl Ether (2-Butoxyethanol)	111-76-2	1
Ethylene oxide	75-21-8	20
Etidronic acid	2809-21-4	1
Food red 10	3734-67-6	1
Formaldehyde	50-00-0	9
Formic Acid	64-18-6	5
Glassy calcium magnesium phosphate	65997-17-3	1
Glutaraldehyde	111-30-8	7
Glycerol	56-81-5	50
Glyoxal	107-22-2	2

Constituent Name	CAS Number	Times Used for WST
Guar Gum	9000-30-0	712
Heavy aromatic naphtha	64742-94-5	1
Hemicellulase enzyme	9012-54-8	8
Hemicellulase Enzyme Concentrate	9025-56-3	657
Hexamethylenetetramine	100-97-0	17
Hydrated magnesium silicate	14807-96-6	30
Hydrochloric acid	7647-01-0	29
Hydrofluoric acid	7664-39-3	1
Hydrogen fluoride (Hydrofluoric acid)	7664-39-3	1
Hydroxylamine hydrochloride	5470-11-1	18
Ingredient Data is listed below as Other	N/A	33
Iron Oxide	1309-37-1	5
Isopropanol	67-63-0	35
Isotridecanol, ethoxylated	9043-30-5	648
Lactose	63-42-3	45
Lactose	9004-34-6	11
Laryl hydrosultaine	13197-76-7	8
Light aromatic naphtha	64742-95-6	6
Magnesium Chloride	7786-30-3	664
Magnesium Nitrate	10377-60-3	664
Methanol	67-56-1	140
Methyl Borate	121-43-7	62
Methyl Isobutyl Ketone	108-10-1	2
Methyl oxirane polymer with oxirane	9003-11-6	31
Mixture of dimer and trimer fatty acids of indefinite compostion derived from tall oil	61790-12-3	19
Mixture of dimer and trimer fatty acids of indefinite compostion derived from tall oil	61788-89-4	2
Modified Polymeric Alkoxylate	52501-07-2	2
Monoethanolamine	141-43-5	4
Monoethanolamine borate	26038-87-9	45
Mullite	1327-36-2	3
Mullite	1302-93-8	1

Constituent Name	CAS Number	Times Used for WST
Naphthalene	91-20-3	6
Nitrilotriacetic acid	139-13-9	1
Nitrilotris (Methylene Phosphonic Acid)	6419-19-8	527
Nitrogen	7727-37-9	1
Non-crystalline silica (impurity)	7631-86-9	38
Nonionic Alkoxylate	70559-25-0	21
Olefin	64743-02-8	6
Oleic acid	112-80-1	30
Orange Terpene	68647-72-3	2
Organic Phosphonate	2809-21-4	1
Organic polyol	112-27-6	21
Organic phosphonate	15827-60-8	2
Organic phosphonate	70714-66-8	2
Oxyalkylated alkylphenolic resin	63428-92-2	6
Oxyalkylated Amine Quat	138879-94-4	277
Oxyalkylated Fatty Acid	61791-00-2	2
Oxyalkylated polyamine	68130-99-4	2
Paraffinic Petroleum Distillate	64742-55-8	648
Petroleum Distillate Blend (3)	8042-47-5	22
Petroleum Distillates	64742-47-8	648
Phenolic resin	9003-35-4	27
Phosphonic Acid	13598-36-2	528
Poly(dimethylaminoethylmethylacrylate) dimethyl sulphate quat.	27103-90-8	23
Poly(oxy-1,2-ethandiyl), a-(nonylphenyl)-w-hydroxy-	9016-45-9	18
Poly(oxy-1;2-ethanediyl);a-hydro-hydroxy- Ethane-1;2-diol; ethoxylated	25322-68-3	1
poly(tetrafluoroethylene)	9002-84-0	61
Polyalkylene	7756-94-7	2
Polyamine Polyethers	68815-69-6	1
Polyamine Polyethers	68815-65-1	1
Polydimethyl diallyl ammonium chloride	26062-79-3	45
Polyethers	68815-65-6	21
Polyethylene glycol monohexyl ether	31726-34-8	30

Constituent Name	CAS Number	Times Used for WST
Polyethylene Glycol Trimethyl Nonyl Ether	84133-50-6	2
Polyethylene oxide	25322-68-3	1
Polylactide resin	9051-89-2	1
Polymer	9003-11-6	1
Polypropylene glycol	25322-69-4	5
Potassium Acetate	127-08-2	1
Potassium Bicarbonate	298-14-6	63
Potassium borate	1332-77-0	30
Potassium Carbonate	584-08-7	64
Potassium Chloride	7447-40-7	16
Potassium hydroxide	1310-58-3	36
Potassium iodide	7681-11-0	4
Potassium oleate	143-18-0	31
Propanol	71-23-8	1
Propargyl Alcohol	107-19-7	28
Propylene glycol	57-55-6	50
Quaternary Ammonium Chloride	61789-71-7	1
Quaternary Ammonium Compound	100765-57-9	2
Quaternary ammonium compounds chlorides derivatives	68989-00-4	1
Reaction product of acetophenone, formaldehyde, thiourea and oleic acid in dimethyl formamide	68527-49-1	19
Silanetrio; (3-aminopropyl, homopolymer	68400-07-7	11
Silica gel	112926-00-8	2
Sodium bisulfite	7631-90-5	46
Sodium bromate	7789-38-0	1
Sodium carbonate	497-19-8	1
Sodium chloride	7647-14-5	392
Sodium citrate	68-04-2	7
Sodium erythorbate	6381-77-7	1
Sodium Glycolate (impurity)	2836-32-0	1
Sodium Hydroxide	1310-73-2	645
Sodium persulfate	7775-27-1	50

Constituent Name	CAS Number	Times Used for WST
Sodium polyacrylate	9003-04-7	51
Sodium sulfate	7757-82-6	50
Sodium sulfite	7757-83-7	1
Sodium Tetraborate	1330-43-4	2
Sodium Tetraborate Decahydrate	1303-96-4	608
Sulferized Polyolefin	68037-13-8	2
Sulfuric acid	7664-93-9	5
Tar bases, quinoline derivs., benzyl chloride quaternized	72480-70-7	2
Tetrakis(hydroxymethyl)phosphonium sulfate	55566-30-8	30
Tetrasodium ethylenediaminetetraacetate	64-02-8	1
Titanium Oxide	13463-67-7	5
Toluene	108-88-3	3
Tricalcium phosphate	7758-87-4	18
Triethanolamine	102-71-6	1
Triethanolamine zirconate	10133-44-7	1
Trisodium Ethylenediaminetetraacetate (impurity)	150-38-9	1
Trisodium nitrilotriacetate (impurity)	5064-31-3	1
Tryptone	73049-73-7	13
Ulexite	1319-33-1	7
Vinylidene Chloride-methylacrylate polymer	25038-72-6	30
Walnut Shells	84012-43-1	3
Xanthan Gum	11138-66-2	7
Xylene	1330-20-7	9
Xylenesulfonic acid	25321-41-9	3
Yeast Extract	8013-01-2	13
Zirconium dichloride oxide	7699-43-6	30

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Additives Used in Well Stimulation Treatment

Additive Suppliers

The following suppliers were utilized for WST additives in California for the reporting period:

- Baker Hughes
- Halliburton
- North American Chemical Services
- Schlumberger
- Tracero

As shown in the following tables, Baker Hughes was, by a large margin, the primary supplier for WST additives in California.

Table 69: Frequency of Supplier Use for Additives in WST

Stimulation Type	Baker Hughes	Halliburton	Schlumberger	North American Chemical Services	Tracerco
Acid Matrix		19	1		
Acid Fracture	1				
Hydraulic Fracture	916	41	51	1	8
Grand Total	**917**	**60**	**52**	**1**	**8**

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Table 70: 10 Most Frequently Used Additives in WST

Additive Trade Name	Supplier	Purpose	Times Used for WST
X-Cide 207 [SB-4]	Baker Hughes	Biocide	700
Enzyme G-I [SB-4]	Baker Hughes	Breaker	693
GW-3LDF [SB-4]	Baker Hughes	Gelling Agent	684
GBW-5 [SB-4]	Baker Hughes	Breaker	675
XLW-10A [SB-4]	Baker Hughes	Crosslinker	615
Sand, Brown [SB-4]	Baker Hughes	Proppant	563
ScaleSorb 3 [SB-4]	Baker Hughes	Scale Inhibitor	556
Clay Master 10 [SB-4]	Baker Hughes	Clay Control	395
Clay Master 5C [SB-4]	Baker Hughes	Clay Control	277
Sand, White [SB-4]	Baker Hughes	Proppant	164

Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Additive Usage and Purpose

There are over 180 different additives identified for use in WST. This information cannot be aggregated in any meaningful way. The following tables provide a listing of all additives used during the reporting period, including the number of times each was used, as well as the supplier for the additive and the purpose for which the additive was used. In addition to the below, water (CAS number 7732-18-5) was used in every well stimulation treatment.

Table 71: Additives used in WST by Supplier and Purpose

Supplier	Purpose	Additive Trade Name	Times Used for WST
Baker Hughes	Acidizing	HCl, 10.1 - 15% [SB-4]	6
Baker Hughes	Acidizing	Acetic Acid, Glacial [SB-4]	1
Baker Hughes	Acidizing	BJ SandStone Acid 30-LT (ABF30) [SB-4]	1
Baker Hughes	Acidizing	HCl, 5.1 - 7.5% [SB-4]	1
Baker Hughes	Acidizing	HV Acid[SB-4]	1
Baker Hughes	Activator	Activator, Superset W [SB-4]	9
Baker Hughes	Anti-sludging Agent	AS-10 [SB-4]	1
Baker Hughes	Biocide	X-Cide 207 [SB-4]	700
Baker Hughes	Breaker	Enzyme G-I [SB-4]	693
Baker Hughes	Breaker	GBW-5 [SB-4]	675
Baker Hughes	Breaker	High Perm CRB-LT [SB-4]	31
Baker Hughes	Breaker	EnZyme G HpH-II [SB-4]	11
Baker Hughes	Breaker	Enzyme G HT-II	2
Baker Hughes	Breaker Catalyst	BC-3 [SB-4]	34
Baker Hughes	Buffer	BF-7L [SB-4]	64
Baker Hughes	Buffer	BF-8L [SB-4]	26
Baker Hughes	Clay Control	Clay Master 10 [SB-4]	395
Baker Hughes	Clay Control	Clay Master 5C [SB-4]	277
Baker Hughes	Clay Control	Potassium Chloride [SB-4]	12
Baker Hughes	Clay Control	FSA-1 [SB-4]	10
Baker Hughes	Clay Control	ClayCare, ClayTreat-2C [SB-4]	4
Baker Hughes	Corrosion Inhibitor	CI-27 [SB-4]	6
Baker Hughes	Corrosion Inhibitor	CorrSorb 3600	1
Baker Hughes	Corrosion Inhibitor	CI-39 [SB-4]	1
Baker Hughes	Crosslinker	XLW-10A [SB-4]	615

Supplier	Purpose	Additive Trade Name	Times Used for WST
Baker Hughes	Crosslinker	XLW-32 [SB-4]	62
Baker Hughes	Crosslinker	XLW-4 [SB-4]	26
Baker Hughes	Crosslinker	XLW-56 [SB-4]	2
Baker Hughes	Crosslinker	Boric Acid [SB-4]	1
Baker Hughes	Diverting Agents	Benzoic Acid [SB-4]	1
Baker Hughes	Gelling Agent	GW-3LDF [SB-4]	684
Baker Hughes	Gelling Agent	GW-4LDF [SB-4]	22
Baker Hughes	Iron Control	Ferrotrol 300L [SB-4]	75
Baker Hughes	Iron Control	Ferrotrol 210 [SB-4]	6
Baker Hughes	Non-emulsifier	NE-118 [SB-4]	6
Baker Hughes	Non-emulsifier	NE-530	1
Baker Hughes	Paraffin inhibitor	Paravan 35	1
Baker Hughes	Proppant	Sand, Brown [SB-4]	563
Baker Hughes	Proppant	Sand, White [SB-4]	164
Baker Hughes	Proppant	FlexSand LS [SB-4]	20
Baker Hughes	Proppant	Super LC [SB-4]	16
Baker Hughes	Proppant	TerraProp Plus [SB-4]	5
Baker Hughes	Proppant	FlexSand HS [SB-4]	5
Baker Hughes	Salts	Ammonium Chloride [SB-4]	1
Baker Hughes	Scale Inhibitor	ScaleSorb 3 [SB-4]	556
Baker Hughes	Solvent	US-40 [SB-4]	1
Baker Hughes	Surface Tension Reducer	InFlo 72 [SB-4]	24
Baker Hughes	Surfactant	GasFlo G2 [SB-4]	9
Halliburton	Additive	DCA-14005	37
Halliburton	Additive	Ammonium Fluoride - 35%	18
Halliburton	Additive	CITRIC ACID	15
Halliburton	Additive	Potassium Chloride [SB-4]	12
Halliburton	Additive	DCA-13005	3
Halliburton	Additive	ABF	3
Halliburton	Additive	KCL (POTASSIUM CHLORIDE)	2
Halliburton	Additive	DCA-11001	2

Supplier	Purpose	Additive Trade Name	Times Used for WST
Halliburton	Additive	DCA-15002	1
Halliburton	Anti-sludging Agent	DCA-31002	1
Halliburton	Biocide	BE-3S BACTERICIDE	6
Halliburton	Biocide	BE-3S	5
Halliburton	Biocide additive	2-Monobromo-3-nitrilopropionamide	1
Halliburton	Breaker	DCA-13002	34
Halliburton	Breaker	GBW-30 BREAKER	30
Halliburton	Breaker	DCA-13005	3
Halliburton	Breaker	DCA-13003	3
Halliburton	Breaker	Sodium chloride	2
Halliburton	Buffer	DCA-14001	3
Halliburton	Buffer	DCA-14002	1
Halliburton	Buffer additive	Ammonium acetate	1
Halliburton	Clay Stabilization Agent	DCA-16002	31
Halliburton	Clay Stabilizer	DCA-16004	21
Halliburton	Cleaner	DCA-32008	20
Halliburton	Cleaner	DCA-22001	2
Halliburton	Cleaner additve	Ethylene glycol	1
Halliburton	Cleaner additve	Poly(oxy-1,2-ethandiyl), a-(nonylphenyl)-w-hydroxy-	1
Halliburton	Corrosion Inhibitor	DCA-14005	37
Halliburton	Corrosion Inhibitor	DCA-17002	23
Halliburton	Corrosion Inhibitor additive	Propargyl alcohol	1
Halliburton	Crosslinker	BC-140C	30
Halliburton	Crosslinker	DCA-19002	6
Halliburton	Crosslinker	DCA-19001	5
Halliburton	Crosslinker	DCA-19003	1
Halliburton	Crosslinker Additive	DCA-11001	2
Halliburton	Crosslinker Additive	Crystalline silica, quartz	2
Halliburton	Crosslinker Additive	Triethanolamine	1
Halliburton	Crosslinker Additive	Ulexite	1
Halliburton	Fluid Loss Additive	DCA-21003	2

Supplier	Purpose	Additive Trade Name	Times Used for WST
Halliburton	Fluid Loss Additive	NITROGEN LIQUEFIED	1
Halliburton	Friction Reducer	DCA-23001	1
Halliburton	Gelling Agent	DCA-25005	36
Halliburton	Gelling Agent	DCA-25009	1
Halliburton	Intensifier	DCA-18001	2
Halliburton	Intensifier	DCA-18002	2
Halliburton	Iron Reducing Agent	DCA-26001	18
Halliburton	Iron Reducing Agent	CITRIC ACID	15
Halliburton	Other Ingredient(s)	Crystalline Silica, Quartz	2
Halliburton	Other Ingredient(s)	Sodium chloride	2
Halliburton	Other Ingredient(s)	1-Eicosene	1
Halliburton	Other Ingredient(s)	1-Hexadecene	1
Halliburton	Other Ingredient(s)	1-Octadecene	1
Halliburton	Other Ingredient(s)	1-Tetradecene	1
Halliburton	Other Ingredient(s)	2-Ethyl hexanol	1
Halliburton	Other Ingredient(s)	Alcohols, C14-C15, ethoxylated	1
Halliburton	Other Ingredient(s)	Amines, hydrogenated tallow alkyl, acetates	1
Halliburton	Other Ingredient(s)	Bentonite, benzyl(hydrogenated tallow alkyl) dimethylammonium stearate complex	1
Halliburton	Other Ingredient(s)	Ethylene oxide	1
Halliburton	Other Ingredient(s)	Mixture of dimer and trimer fatty acids of indefinite compostion derived from tall oil	1
Halliburton	Other Ingredient(s)	Methanol	1
Halliburton	Other Ingredient(s)	Poly(oxy-1,2-ethanediyl), alpha-hexyl-omega-hydroxy(C2H4O)N(C6H14O)	1
Halliburton	Other Ingredient(s)	Reaction product of acetophenone, formaldehyde, thiourea and oleic acid in dimethyl formamide	1
Halliburton	Other Ingredient(s)	Silica gel	1
Halliburton	Other Ingredient(s)	Sodium hydroxide	1
Halliburton	Other Ingredient(s)	Sodium polyacrylate	1
Halliburton	Other Ingredient(s)	Tricalcium phosphate	1
Halliburton	Other Ingredient(s)	Xanthan gum	1

Supplier	Purpose	Additive Trade Name	Times Used for WST
Halliburton	pH Control Additive	DCA-14005	37
Halliburton	Proppant	SAND - PREMIUM WHITE	32
Halliburton	Proppant	VERSAPROP	2
Halliburton	Proppant	SAND - COMMON WHITE - SSA-2	2
Halliburton	Proppant	CERAMIC PROP	1
Halliburton	Proppant	DSC-01	1
Halliburton	Scale Inhibitor	DCA-30001	31
Halliburton	Scale Inhibitor	Citric Acid - 50%	2
Halliburton	Scale Inhibitor	DCA-30005	1
Halliburton	Scale Inhibitor additive	Sodium bisulfite	1
Halliburton	Solvent	HYDROCHLORIC ACID 10-30%	21
Halliburton	Solvent	ACETIC ACID	19
Halliburton	Solvent	CITRIC ACID	15
Halliburton	Solvent	DCA-31003	7
Halliburton	Solvent	ACETIC ACID 80%	2
Halliburton	Solvent	15% HYDROCHLORIC ACID	2
Halliburton	Solvent	13.5% HCl / 1.5% HF	1
Halliburton	Solvent	12/3 HCL/HF Acid	1
Halliburton	Solvent additive	Ethoxylated hexanol	1
Halliburton	Speciality Surfactant	DCA-32005	6
Halliburton	Speciality Surfactant	RockOn MX 5-3521	6
Halliburton	Speciality Surfactant	MX 5-3521	3
Halliburton	Speciality Surfactant	MC MX 5-3521	2
Halliburton	Surfactant	MX 5-3521	3
Halliburton	Surfactant	MC MX 5-3521	2
Halliburton	Wetting Agent	DCA-32003	9
Halliburton	Wetting Agent additive	Alkylbenzene sulfonate compd. with 2-propanamine	1
Halliburton	Wetting Agent additive	Alkylbenzene sulfonate compd. with triethanolamine	1
North American Chemical Services	Scale Inhibitor	245 FS	10
Schlumberger	Acidizing	15% HYDROCHLORIC ACID	2

Supplier	Purpose	Additive Trade Name	Times Used for WST
Schlumberger	Acidizing	12/3 - Mud Acid	1
Schlumberger	Flush	Ammonium Chloride 5%	1
Schlumberger	Proppant	S012-1630	35
Schlumberger	Proppant	S333-1630	32
Schlumberger	Proppant	B361-1630	6
Schlumberger	Proppant	S022-Premium	4
Schlumberger	Proppant	S333-2040	4
Schlumberger	Proppant	S333-3050	3
Schlumberger	Proppant	S020-PREMIUM	2
Schlumberger	Proppant	S012-2040	1
Schlumberger	Proppant	50/120 Sinterblast	1
Schlumberger	Proppant	40/70 Ceramic	1
Schlumberger	Proppant	S020-Standard	1
Schlumberger	Proppant Transport	YF125-Flex	36
Schlumberger	Proppant Transport	SOZ	34
Schlumberger	Proppant Transport	YF120ST	7
Schlumberger	Proppant Transport	YF130-Flex	3
Schlumberger	Proppant Transport	YF135-Flex	3
Schlumberger	Proppant Transport	WF130	3
Schlumberger	Proppant Transport	HCl 15	1
Schlumberger	Proppant Transport	Mud Acid 12:3	1
Schlumberger	Proppant Transport	TMAC	1
Schlumberger	Proppant Transport	YF125-FLEX-L065	1
Schlumberger	Proppant Transport	YF125-FLEX + RC	1
Schlumberger	Proppant Transport	WF135	1
Schlumberger	Proppant Transport	YF130-Flex + RC	1
Schlumberger	Proppant Transport	YF135-Flex + RC	1
Schlumberger	Proppant Transport	WF120	1
Tracerco	Diagnostics	Chemical Tracer	4
Tracerco	Organic Carrier	D-limonene	4

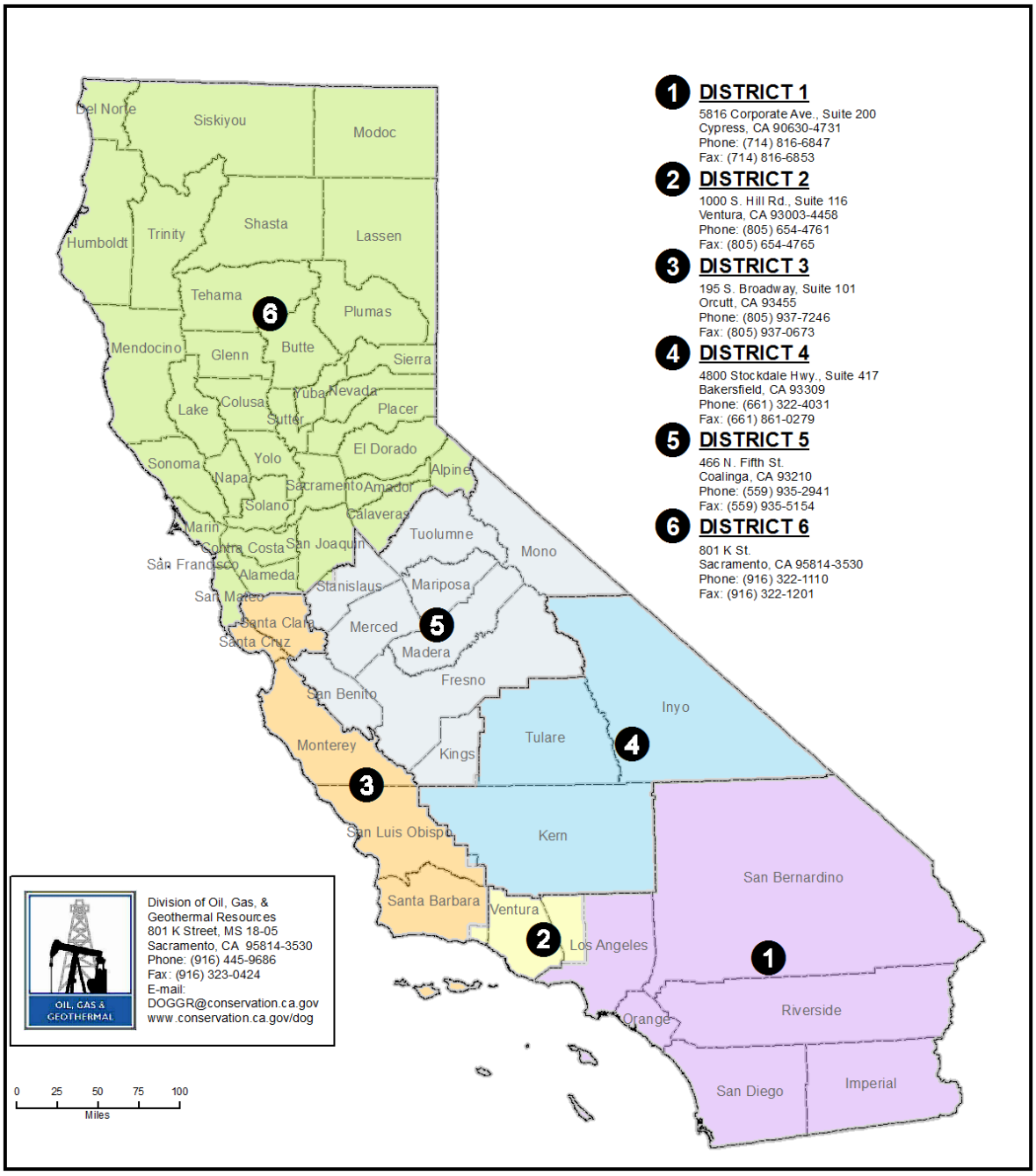
Source: Interim Well Stimulation Database, WST Disclosures Index, operator disclosures

Appendix A – Geographic Information

Oil and Gas District Map

The following image displays the six districts for oil, gas, and geothermal resources in California.

Figure 5: Oil and Gas District Boundaries



Area Maps: Oil Fields with Stimulations

The following are maps of the oil fields in which stimulation treatment was performed during the reporting period. The figures below represent Kern, Kings, and Ventura Counties, respectively.

Figure 6: Location of Oil Fields with WST

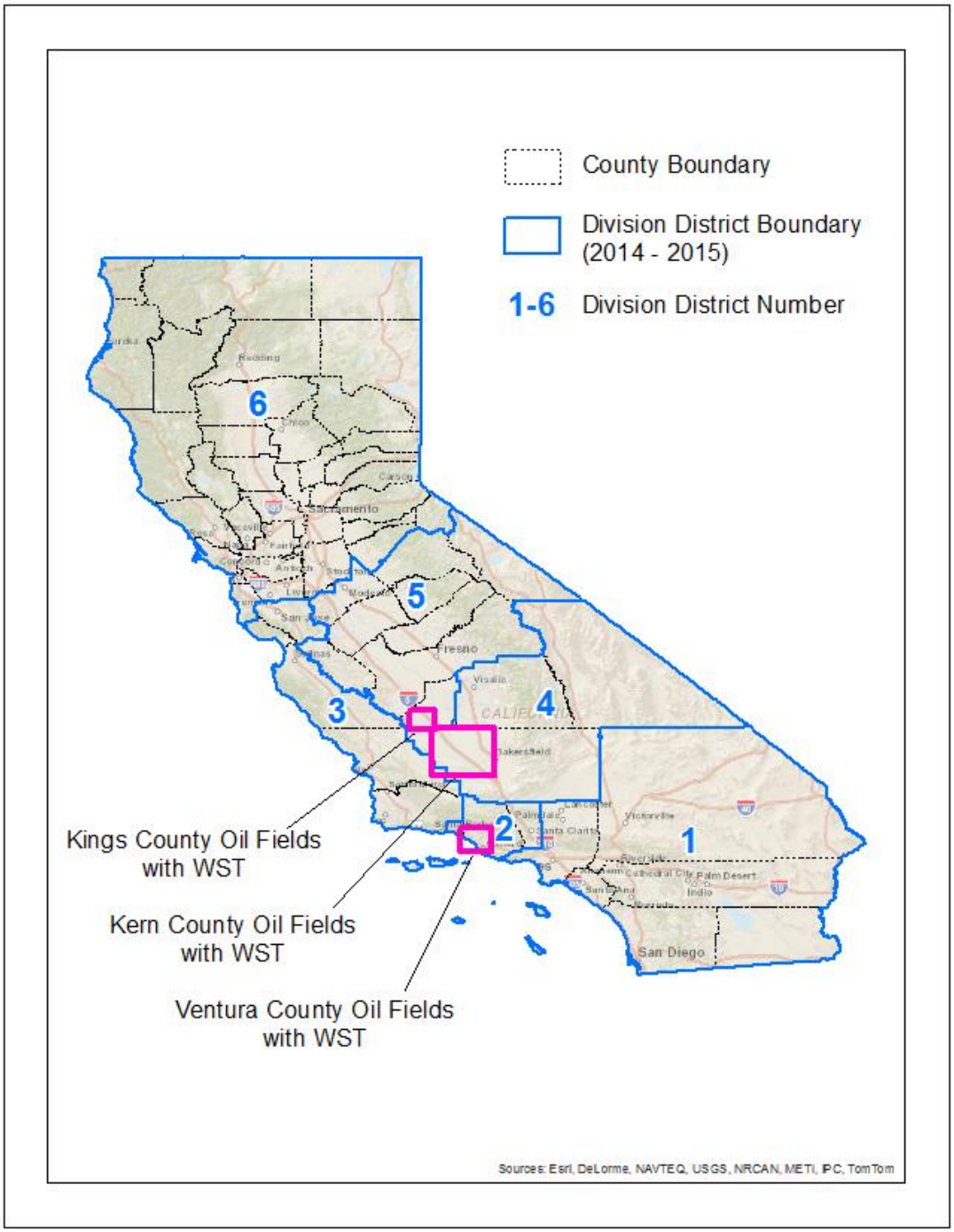


Figure 7: Kern County Oil Fields with WST

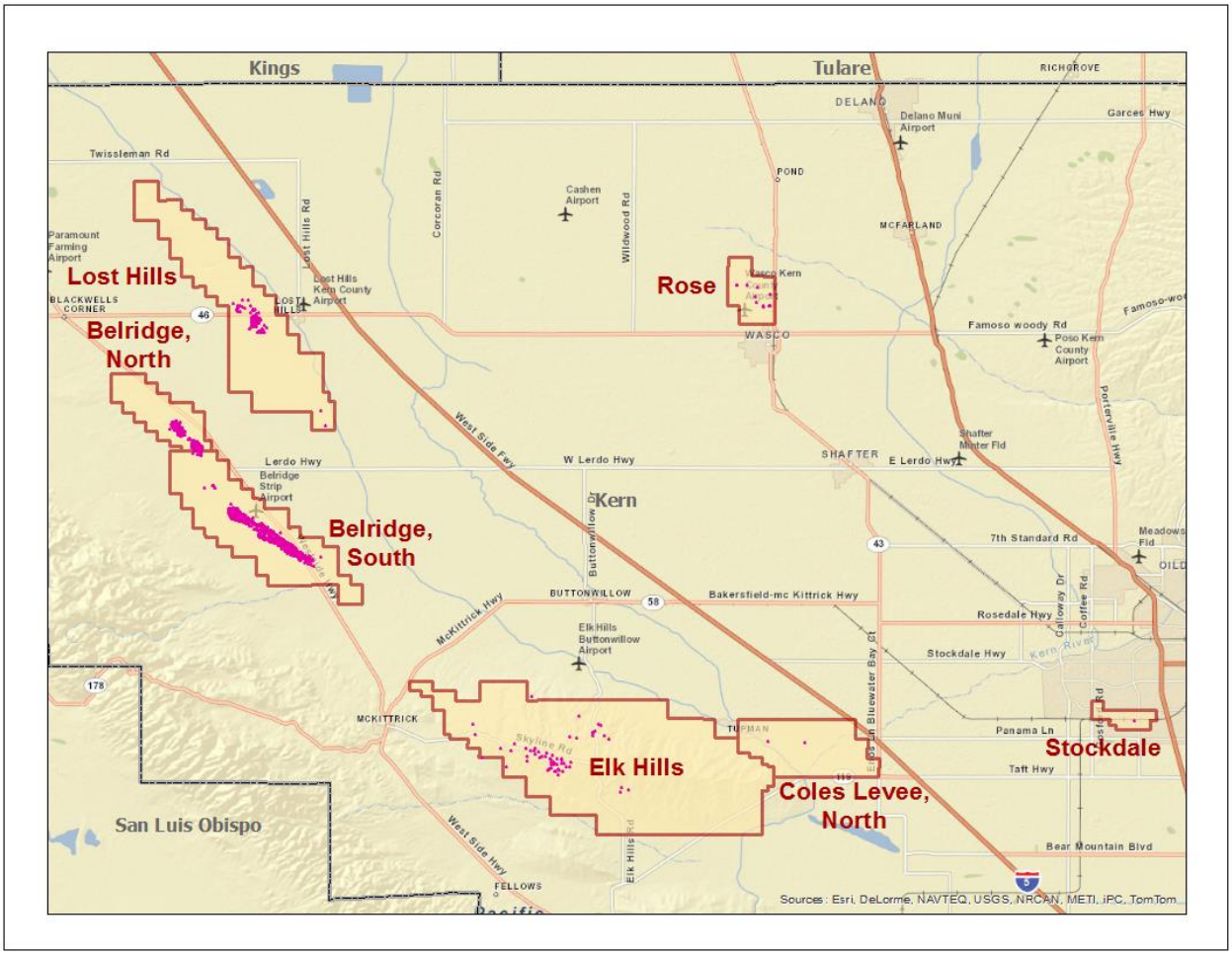


Figure 8: Kings County Oil Fields with WST

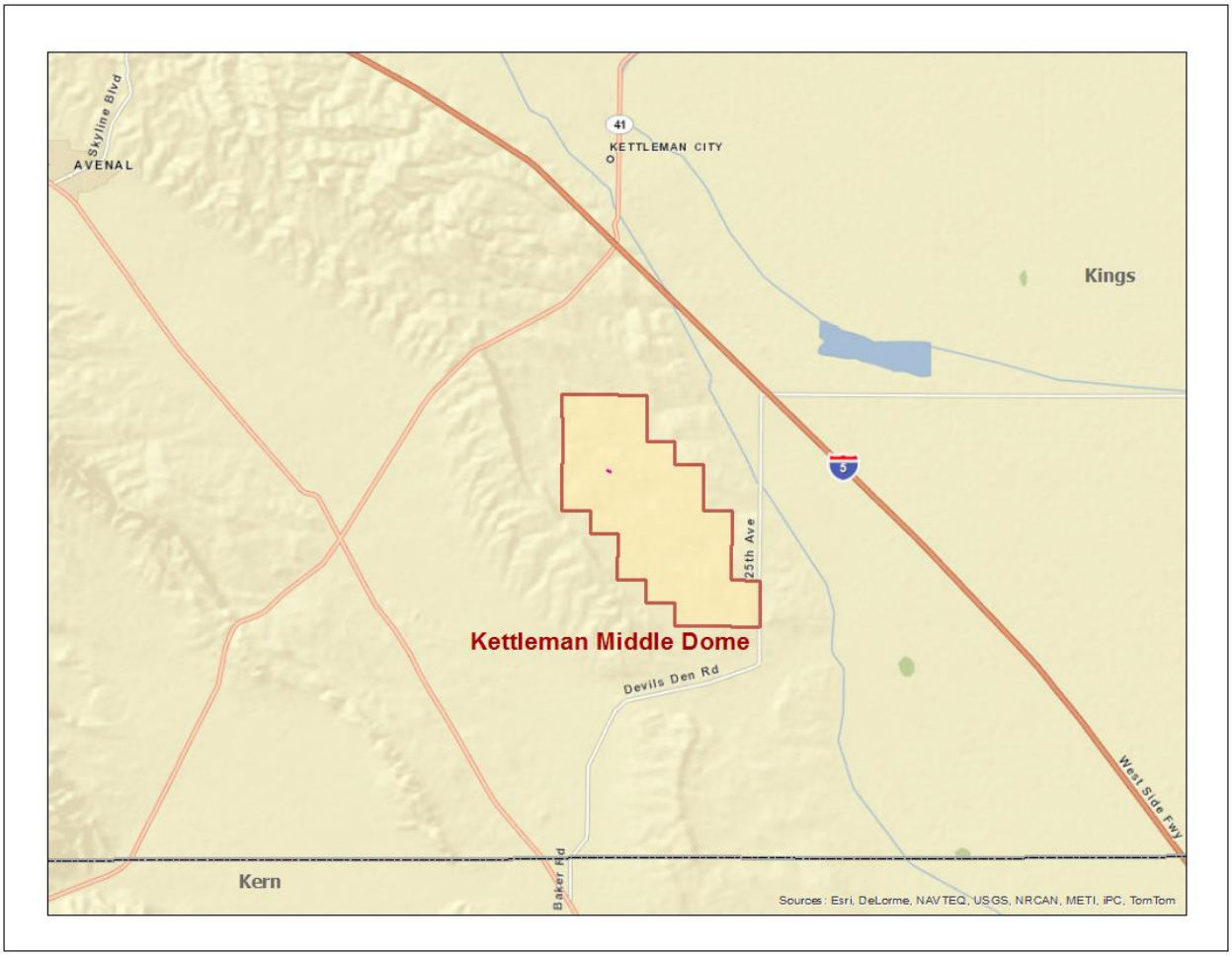
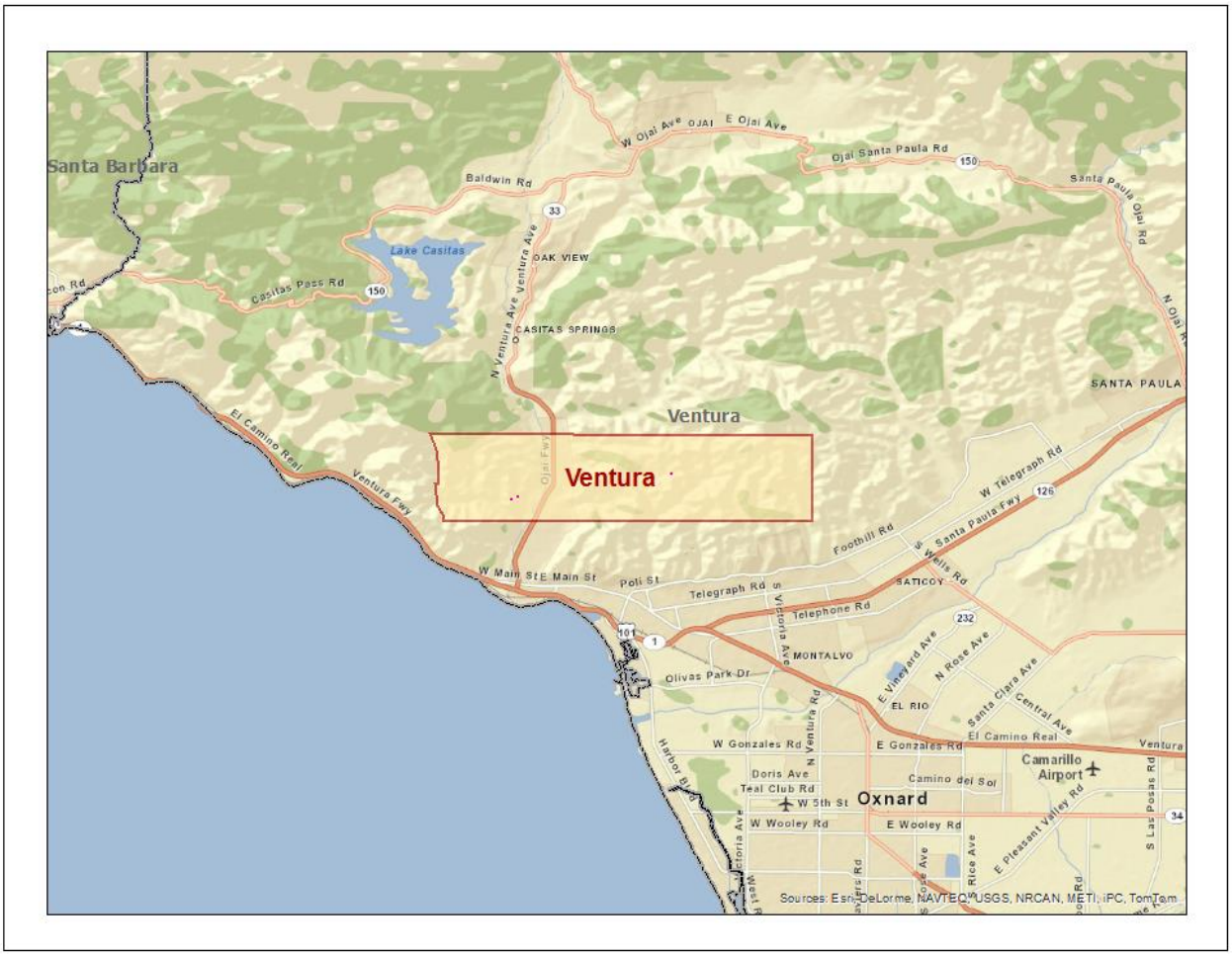


Figure 9: Ventura County Oil Fields with WST



Area Maps: WST with Groundwater Monitoring Plans or Statement of Non-applicability

The following are maps of the WSTs which were performed is association with a GWMPs or had a statement of non-applicability to indicate that there was no groundwater in the area which required monitoring. The figures below represent Kern County East, Kern County North, Kern County South, and Kings County, respectively.

Figure 10: Kern County East – WST Wells under a GWMP or Statement of Non-applicability

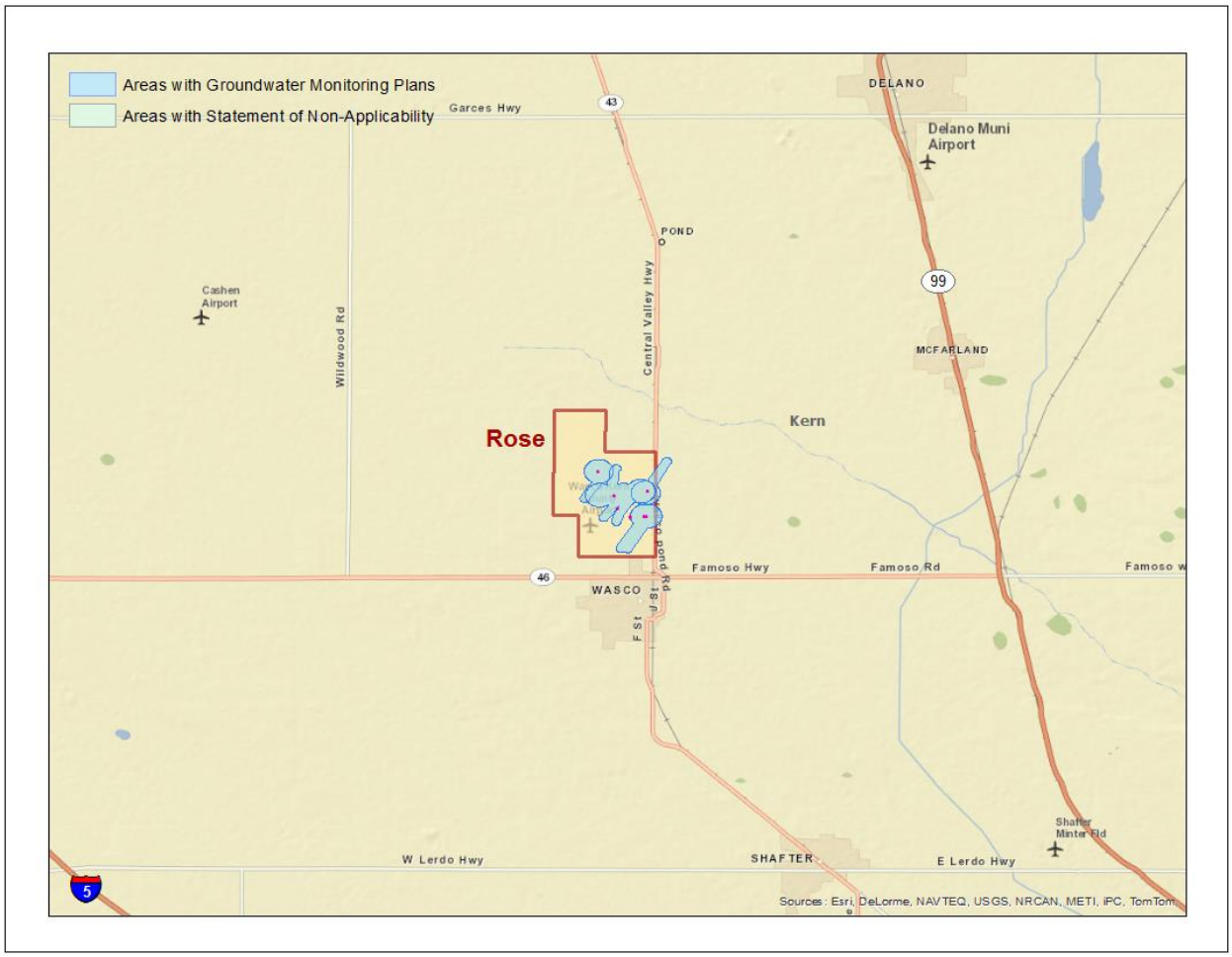


Figure 11: Kern County North – WST Wells under a GWMP or Statement of Non-applicability

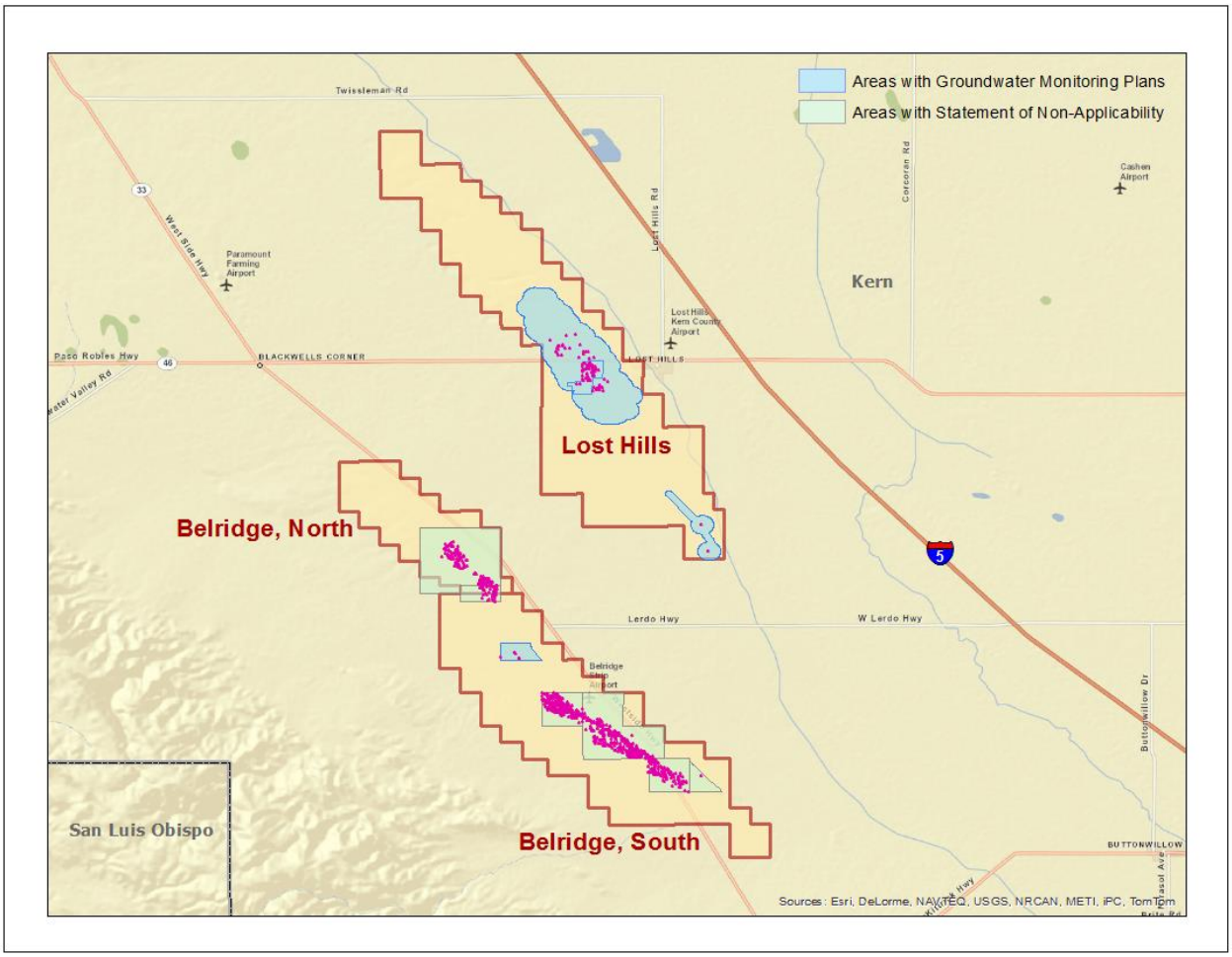


Figure 12: Kern County South – WST Wells under a GWMP or Statement of Non-applicability

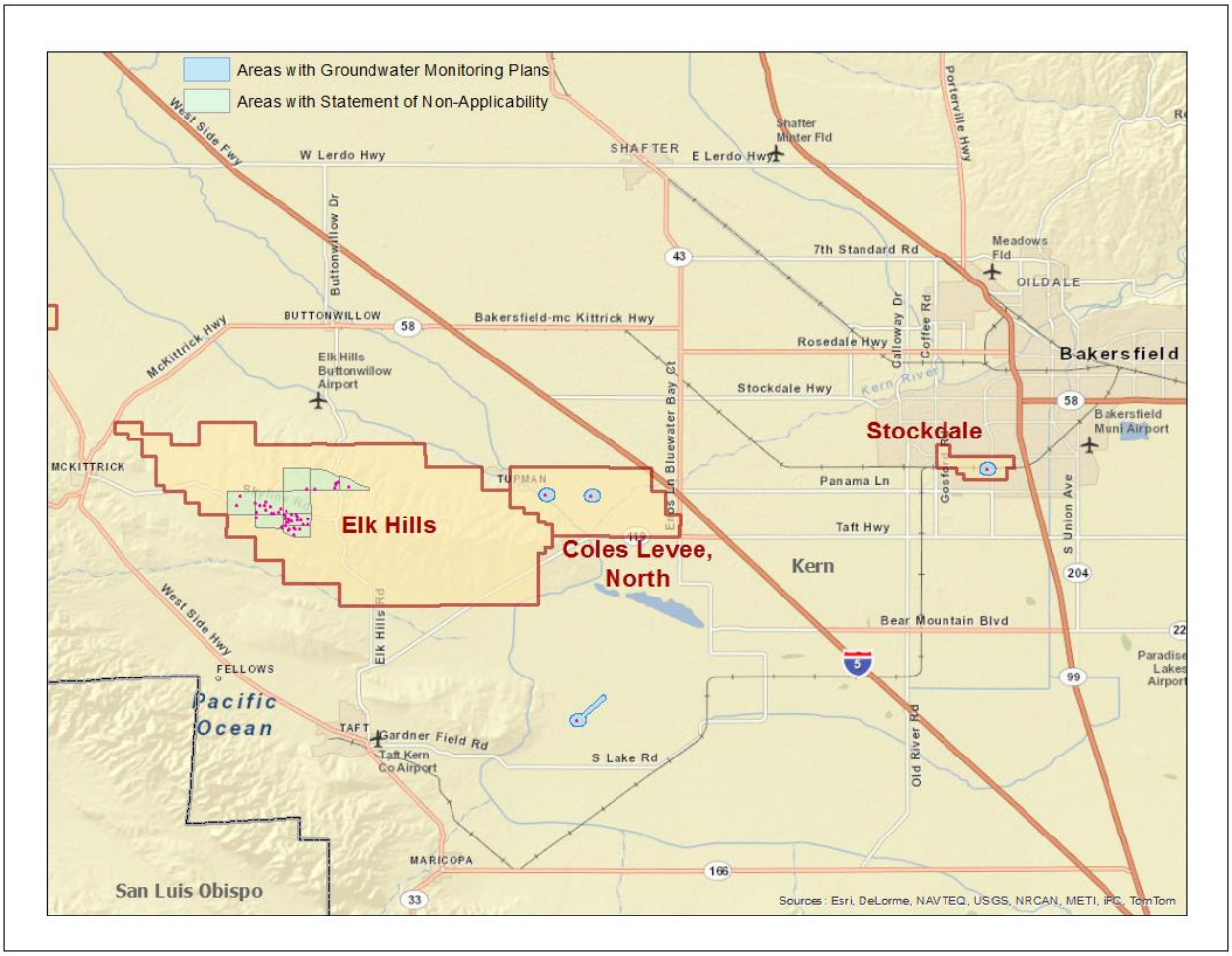
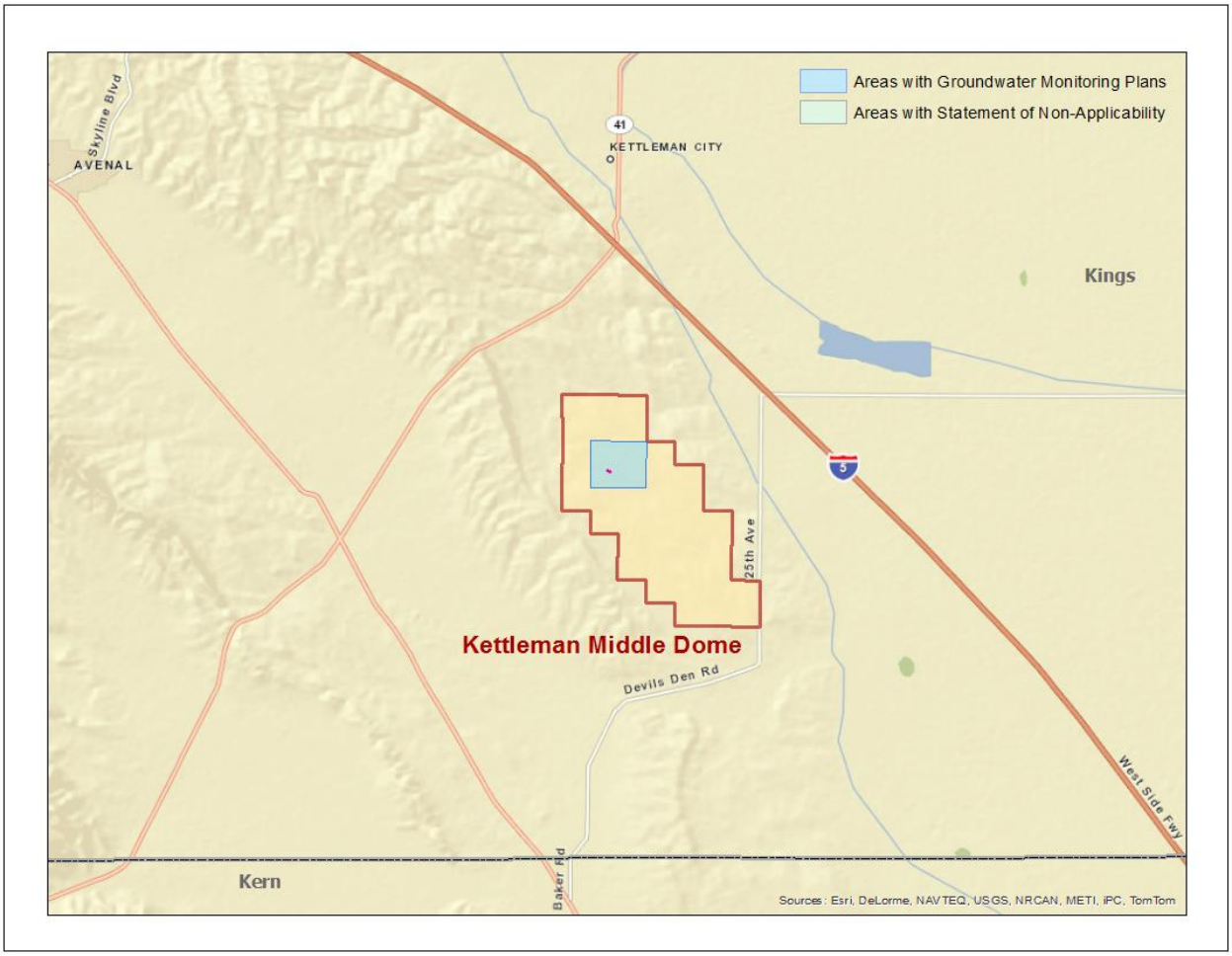


Figure 13: Kings County – WST Wells under a GWMP or Statement of Non-applicability



Appendix B – Background of Well Stimulation in California

History in California

Hydraulic fracturing is the most commonly used technique for increasing formation permeability in California and worldwide. Acid matrix and acid fracture stimulations are far less commonly used.

Hydraulic fracturing of rock was first used in 1947 in Kansas, and was licensed to the Halliburton Company for use in oilfield applications in 1949. In California, hydraulic fracturing was used as early as March 8, 1950 when Naval Petroleum Reserve No. 1 stimulated a well (Well Finder, well 338, property section 32S, API# 02927547) to increase the permeability of hydrocarbon-bearing horizons or formations near production wells.

Acid matrix stimulation was invented in the very late 1800s, though it was not commonly used until the 1930s (http://www.api.org/~/media/files/oil-and-natural-gas/hydraulic-fracturing/acidizing-oil-natural-gas-briefing-paper-v2.pdf). The oldest use of acid matrix or acid fracture stimulation in California is not known.

Concepts and Terminology of Hydrocarbon Flow in Rock

Both hydraulic fracturing and acid matrix stimulation are used to increase the permeability of rock. Permeability is the ease at which a fluid can flow through rock or any other solid material. A rock needs to have both permeability and porosity for a fluid to flow through it:

- **Porosity** is the percent of pore space between grains of a rock (formation). The non-solid space (or volume) is called "void space" or "pore space". In nearly all rocks that contain oil, natural gas ("gas") or groundwater, pore space is most commonly the tiny spaces between the grains of sand or smaller particles that make up those rocks. Rocks made of sand or smaller particles of similar origin are sedimentary rocks. Sedimentary rocks make up more than 99% of the rock systems that contain oil or gas. Sedimentary rocks have porosities that most commonly vary from roughly 15-45%.

Figure 14: Example of Porosity

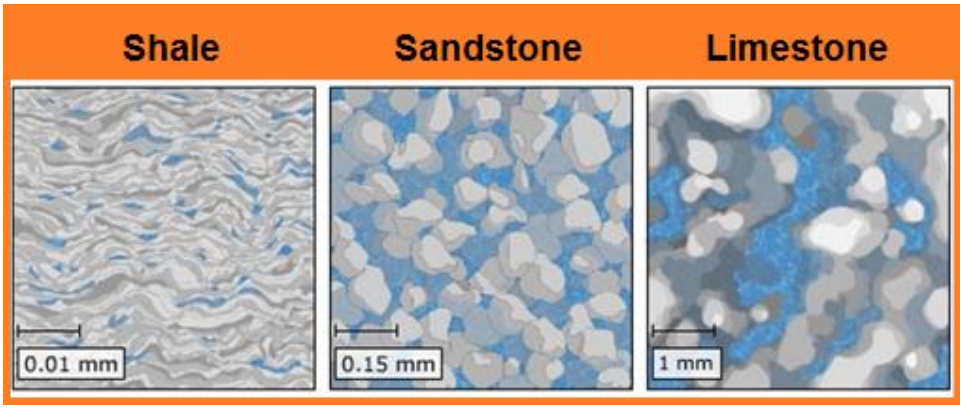


Image Source: USEPA

- **Permeability** is the ability of rock (or any other solid material) to transmit fluid. If a solid has no pore space it is effectively impossible for fluid to flow through it. The permeability of a rock that has porosity depends on several factors:
    - Connectivity of the pore spaces. Fluid cannot flow from one pore to another if the pores are not connected.
    - How wide or how narrow the best "flow paths" are within the permeable rock. This is similar to thinking of the ease of driving quickly on a twisty and narrow two-lane road, vs. driving quickly on a straight, wide, freeway.
    - The fluid itself. Oil flows (migrates) much more slowly than gas or water in rock systems. This is because oil molecules are much larger than gas or water molecules, and because oil is a much thicker (more viscous) fluid than gas or water. This is similar to thinking of the ease of driving a convoy of small cars, vs. a convoy of trucks with semi-trailers, along a twisty and narrow road.

Figure 15: Example of Permeability

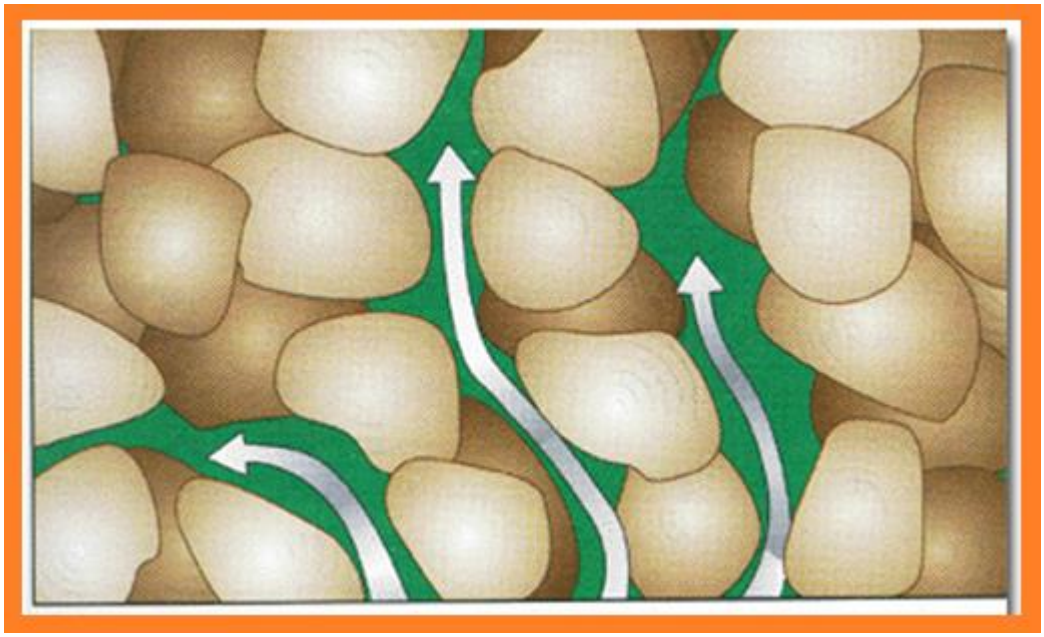


Image Source: USEPA

Increasing the permeability of a rock formation in order to get more fluid (or fluid more quickly) into or out of the rock is called Well Stimulation Treatment (WST). The permeability is most commonly increased by breaking the rock using hydraulic fracturing, and less commonly by dissolving some of the minerals in the rock to increase the porosity and permeability (acid matrix stimulation). Nearly all methods of increasing rock permeability are performed by briefly injecting water into a well that has been constructed into a region of rock within the ground.

Petroleum Formation Systems and Reservoirs

Petroleum formation systems include:

1. Source rock, where organic material (kerogen) accumulates before being converted to hydrocarbons.
2. Overburden pressure to bury the source rock sufficiently so that temperatures within it would rise into the 'thermal window' in which oil and then gas form.
3. Reservoir rock to contain hydrocarbons.
4. Seal rock to prevent escape (e.g., surface seeps) of hydrocarbon fluids from the reservoir rock.

The key processes of petroleum formation are:

- Maturation of source organics into potential fuel hydrocarbons
- Migration and trapping of those hydrocarbons in reservoir rock

Geologic folds and faults form traps for hydrocarbon accumulation, and faults and fractures form pathways for fluid flow. *Figure 16: Example of Typical Well Casing Characteristics* shows the different subsurface zones, the sealing cap rock, the casing and the tubular production set-ups in a typical hydrocarbon production well. It also illustrates the principles of California hydrocarbon production well construction standards and the basic principles of geologic and hydrologic isolation, called *zonal isolation* (discussed in section *Preventing the Migration of Fluids* later in this appendix).

Figure 16: Example of Typical Well Casing Characteristics

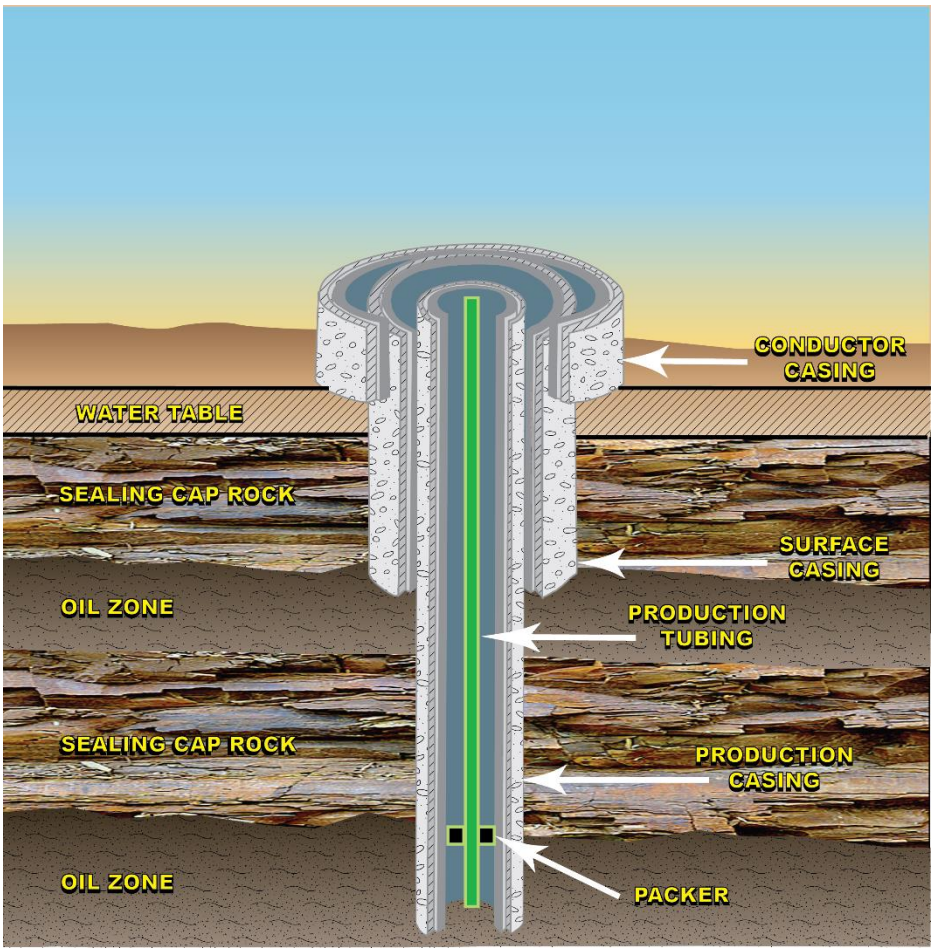


Image Source: USEPA

Oil Reserves and Locations of Well Stimulation Treatment in California

Oil has been produced from many portions of California. Many of the most easily extracted and large pools of oil and gas have probably been discovered and produced. The use of WST techniques have allowed well operators in California and around the world to extract hydrocarbons from the containing rock systems with lower permeability.

In 2011 the U.S. Energy Information Agency (EIA) estimated that the original oil in place (OOIP) in California's Monterey Formation was between 13 and 15.4 billion barrels (BBLS). This estimate exceeded the combined OOIP estimates for three oil-rich shales located elsewhere in three different regions of the U.S. that were being extensively developed for hydrocarbon production by hydraulic fracturing (the Eagle Ford, the Bakken and the Marcellus shales.) Publication of this estimate aroused interest from various stakeholders who had a variety of positive and negative reactions to the prospective huge growth in hydraulic fracturing and other oil field activity that might occur in California because of this vast OOIP estimate.

In 2014 the EIA greatly decreased its estimate of Monterey Formation OOIP. The estimate was decreased by 96% to an estimate of 20 to 620 million BBLS. The primary reason for the decreased estimate was EIA's identification that the majority of Monterey Formation rocks had not reached the temperature required to form oil from the kerogen (thermal maturity). Kerogen molecules are nonflowing, large molecules more directly related to the original organic matter from which hydrocarbons form. Kerogen begins to convert naturally into oil when the containing rock heats up to a temperature of approximately 140 degrees Fahrenheit. As the temperature increases over time, the kerogen converts to natural gas. Because most of the Monterey Formation in California had never been buried deeply enough to reach this temperature, the majority of Monterey Formation rock that could contain oil was far less than had been published by the EIA in 2011.

On October 6, 2015 the Unites States Geological Survey (USSG) released additional estimates of hydrocarbons that might be present as components of the Monterey Formation within the San Joaquin Basin, e.g., only a portion of the state. The estimates did not significantly contradict the 2014 estimate from the EIA.

The Monterey Formation (also referred to as Monterey Shale) is sometimes incorrectly portrayed as a rock system of all or nearly all low permeability. This is incorrect because there are many rock types within the Monterey Formation. Oil has been produced for many decades from the Monterey Formation without the use of WST, from sandstone and even naturally-fractured shale.

Diatomite

Diatomite is a sedimentary rock composed of the opal or silica skeletons of tiny plankton. Diatomite has a very high porosity – sometimes more than 40%. Because the plankton skeletons are very small, the pore spaces between and inside them are also very small and fluid cannot easily flow through diatomite. California well operators have pioneered the stimulation of diatomite by hydraulic fracture WST in order to increase the rock's permeability and recover the oil within it.

Neither oil production from diatomite, the nature of California oil reserves, nor California WST techniques are unique to California. Petroleum systems similar to the Monterey Shale are found in other countries. For example, diatomite is being evaluated for oil production in Japan.

Types of Well Stimulation Treatments

Three types of WSTs have been used in California since the implementation of SB 4. The methods are listed below and ranked from most-used to least-used:

1. Hydraulic fracturing treatment
2. Acid matrix treatment
3. Acid fracturing treatment

Hydraulic Fracturing Well Stimulation Treatment

Hydraulic fracturing involves the temporary injection of fluid at high pressures into the rock formation that contains oil or gas.

Injection of fluid into a specific zone of rock at a high enough pressure breaks the rock by creating new cracks or fissures through which oil or gas can easily flow to a well. Without the increase of permeability because of the new cracks or fissures, fluid would flow more slowly through the rock system into a well.

Base Fluid

A “base fluid” is the fluid into which other substances are dissolved or added in order to make a fluid for WST or other use. This can be thought of as adding flour to broth to create a gravy.

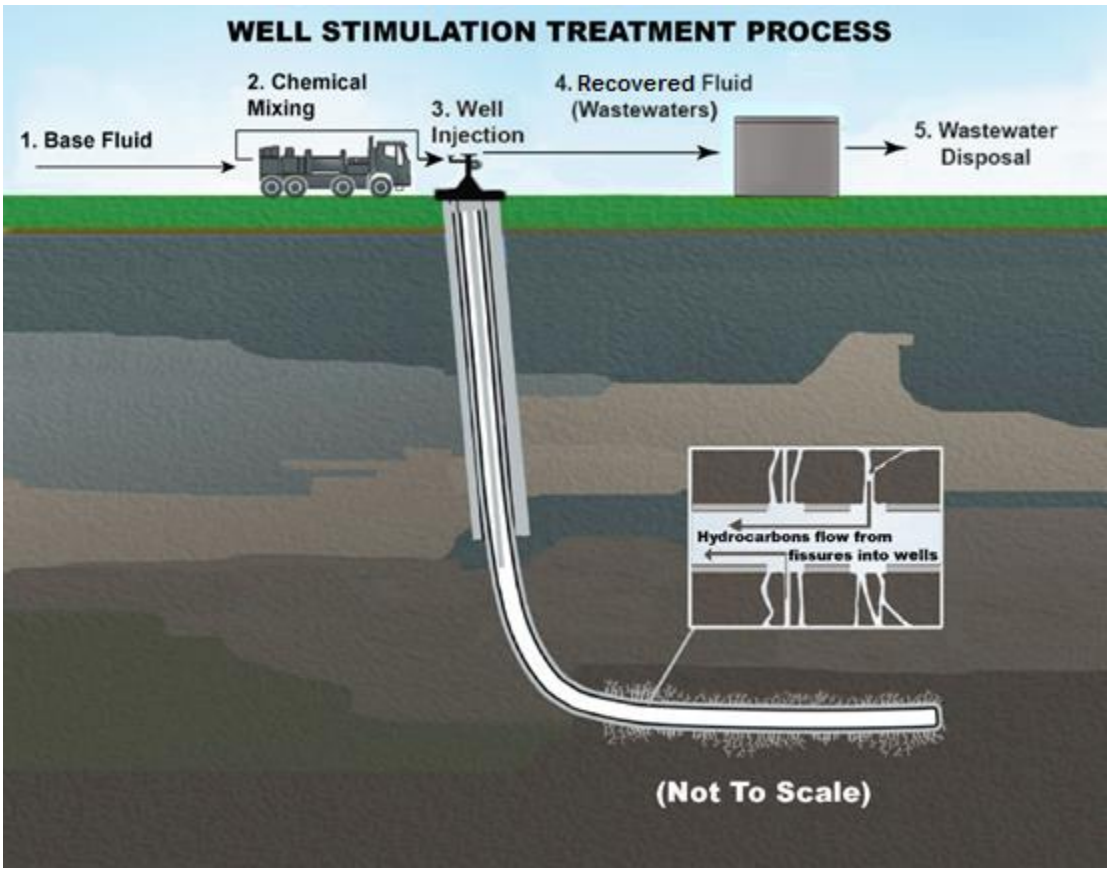
Well Stimulation Fluids – Sources and Disposal

The stages of fluid usage in WST is described broadly below in 5 stages:

1. **Water Acquisition:** Large volumes of water are used in the hydraulic fracturing process.
2. **Chemical Mixing:** Once delivered to the well site, the acquired water is combined with chemical additives and proppant to make the hydraulic fracturing fluid.
3. **Well Injection**: Pressurized hydraulic fracturing fluid is injected into the well, creating cracks in the geological formation that provide highly conductive flow paths for hydrocarbons to reach the wellbore and be produced to the surface.
4. **Recovered and Produced Water (Hydraulic Fracturing Wastewaters):** When pressure in the well is released, hydraulic fracturing fluid, formation water, and natural gas begin to flow back up the well. This combination of fluids, containing hydraulic fracturing chemical additives and naturally occurring substances, must be stored on-site—in tanks or other containers —before treatment, recycling, or disposal.
5. **Wastewater Treatment and Waste Disposal:** Wastewater can be dealt with in any of several ways, including but not limited to:
    - Disposal by underground injection
    - Treatment followed by disposal to surface water bodies
    - Recycling (with or without treatment) for use in future hydraulic fracturing operations

See the following illustration:

Figure 17: Stages of Base Fluid Usage



Disposal of Recovered Fluids (Produced Water)

Recovered Fluid and Produced Water are both waste fluids that come from a hydrocarbon production well. Both are primarily water and usually unsuitable for drinking, irrigation or other use.

Oil typically coexists with water in the ground. That groundwater is generally unsuitable for consumption, other domestic uses or irrigation without being treated due to its high salinity. The routine flow of water along with oil from a well is referred to as *Produced Water*. In California and areas of the world where better water is available for domestic, irrigation or industrial use, produced water is generally injected back deep into the ground instead of treated for use. In California produced water is usually reinjected in accordance with both the Division's Underground Injection Control (UIC) program and the federal Safe Drinking Water Act (SDWA) of 1974. Wells that the Division has authorized to be used to reinject produced water are called Class II (UIC) wells in accordance with U.S. Environmental Protection Agency, SDWA and Division programs and requirements.

Recovered Fluid comes back into a well and may reach the ground surface facilities after a WST is performed. It flows back into and possibly up a well for minutes to a few months after a WST is performed. Recovered fluid is composed of the naturally-present oil, gas and formation water that coexist with the reservoir in the region where the well is completed, and a portion of the WST fluid that was used to stimulate the formation.

The chemical composition and other characteristics of recovered fluids gradually evolve to those of the produced water-oil mixture of a stable, producing well after a WST is performed. Because of this the fluid requirements enacted by SB 4 were written to mesh with and supplement various Division UIC regulations, as well as statutes and regulations of other agencies.

Proppants

Rock systems can move because they are slightly elastic. Because of this elasticity, a rock system that has been broken or fractured from the injection of fluid at high pressure, will "close back up" when the pressure of the injected fluid is allowed to decrease. If the newly-formed fractures close back up the rocks' permeability will decrease and oil, gas and other fluids will be less able to flow through the rock.

The cracks created by hydraulic fracturing are kept from closing back up by partially filling them with quartz sand grains or other durable particles. The sand quartz grains or other particles are called "proppants." The proppants hold the two surfaces of rock away from each other to keep the crack open, so that most of the permeability created by the new crack is retained. In most WST operations in California the proppants are grains of quartz sand that have been mined, washed, and sorted for use as proppant.

Figure 18: Proppants

Rock systems that are deep enough in the ground can be under enough weight (pressure) to break a quartz sand grain if it is holding two walls or surfaces of rock apart. This depth is approximately 8,000 to 10,000 feet, depending on properties of both the rock and the particular quartz sand grain proppant itself. In California some WSTs have been performed at great enough depths that coated quartz grains or artificial materials like ceramic beads were used as proppants.

Hydraulic fracturing is performed using fluids (usually water) because fluids can move through narrow spaces (such as steel pipe ("well casing") or steel tubing within a well, as well as be easily pumped to high pressures. Worldwide, hydraulic fracturing has been performed using other fluids than water (CCST, 2015). Hydraulic fracturing of rock for purposes of oil or gas production in California has been conducted using only water as the "base fluid" since the implementation of SB 4 began in December 2013.

Additives

Both liquid and solid additives are mixed into a base fluid in order to make it more effective for hydraulic fracturing (or acid matrix stimulation). Proppant is only one type of additive used in WST that is designed to increase oil or gas production.

Additives to base fluids serve many purposes in WSTs including:

- **Gelling agents:** Gelling agents make WST fluid thick enough that proppant in the fluid will move with it into the new fractures rather than settle prematurely to the bottom of the fluid in piping, the well, or just outside of the well.
- **Friction-reducers:** Friction occurs when fluid flows at increased flow rates. Pumping WST fluid through several miles of narrow steel (as in a deep WST operation) can be difficult because pressure is lost between the pumps at the ground surface and the WST area within the rock itself.
- **Corrosion preventers:** Some WST fluid additives – particularly in acid matrix WSTs – can corrode well steel and other equipment. Corrosion inhibitors prevent or slow the corrosion of steel to minimize any chemical degradation of steel well casing, tubing, or pipe.
- **Biocides:** Some additives are used to kill or inhibit bacteria that might damage WST fluid. Because guar gum – a naturally-occurring food starch – is often used as a gelling additive, the gelling property could be easily lost if bacteria were allowed to grow and consume the guar gum. Biocides inhibit bacterial consumption of guar gum to help ensure that when the WST fluid is pumped into the ground the proppant is carried with it into the newly-created fractures.
- **Flushes:** Some additives are used to stabilize fluids existing in a well as WST is begun. The most common flushes are acid and/or salt solutions.
- **Acids:** In acid matrix stimulations the presence, types, and amounts of acid are critical to dissolving limestone minerals (usually dolomite or calcite) to create new pore space and thereby increase permeability. Hydrochloric acid and hydrofluoric acid are used in nearly every acid matrix stimulation and react with the rock (rock matrix) as they remain in or migrate within rock. The acid reaction with molecules in the rock neutralize or use up the acid.

Acid Matrix WST

Acid matrix stimulation uses acid to dissolve specific minerals within the treated formation and thereby create pore space and increase porosity. Most acid matric stimulation uses hydrochloric acid (HCl) to dissolve carbonate minerals (usually calcite and dolomite, which are the key components of limestone and marble). Other acids are usually blended into an acid matrix fluid to increase its effectiveness. One acid that is very commonly mixed into HCl is hydrofluoric acid (HF). This is used to dissolve non-carbonate minerals and/or to control the effects of clay particles that become freed up when carbonate mineral rock is dissolved by HCl. Acetic acid and (CH_3COOH) and formic acid (HCOOH) are also commonly used.

One of the processes by which acids are used to dissolve carbonate minerals are shown in the chemical equation below, which shows the dissolution of calcite, which is the primary component in carbonate rocks such as limestone or dolomite. In the formula below, the target mineral is shown first, the acid is shown second, and the resulting chemical (reaction products) are shown to the right of the arrow.

$$2H^{+} + CaCO_3 \rightarrow Ca^{++} + H_2O + CO_2$$

In California, most acid matrix stimulation targets thin layers of the mineral dolomite that is present within shale or other fine-grained sedimentary rocks. These sedimentary rocks have high porosity but low permeability. By dissolving the thin layers of dolomite, a pore space similar to a crack or fracture is created to increase the rock's permeability.

Acid matrix stimulation is rarely performed at pressure great enough to fracture rock because it is intended to make new pore space by chemically dissolving rather than breaking rocks.

Because acid matrix stimulation does not create or need to hold fractures open, proppants are not used. Since proppants are not used, gelling agents are not needed to thicken a WST fluid so that proppant could be carried. Biocides are generally not necessary because guar gum is not present as a gelling agent. The use of other additives such as friction reducers, various stabilizers, and de-gelling agents is generally less in acid matrix stimulations.

Acid Fracturing Well Stimulation Treatment

Acid fracturing is a third common WST that relies upon both sufficient fluid pressure to break a rock and create new fractures, and acid to dissolve minerals, to create new pore space and increase permeability. A proppant may or may not be used in acid fracturing WSTs. When a proppant is not used there is no need for gelling agents.

Dimensions and Extent of Hydraulic/Acid Fracturing and Acid Matrix Treatments

The growth, final dimensions and volumes of fractures created during either hydraulic or acid fracture stimulations, or the extents of areas expected to be partially dissolved during acid matrix stimulations, are estimated by well operators during their planning processes. Operators supplied estimated dimensions of WSTs to the Division as part of both the Interim and Permanent regulations for its review in determining whether permission could be granted to perform a WST.

Hydraulic Fracturing

Hydraulic fracturing is an important method used to enhance the recovery of hydrocarbons from reservoirs, especially for formations with low permeability. The majority of WST operations are hydraulic fracture.

Designing a hydraulic fracture job requires an understanding of fracture growth as a function of treatment parameters. Fracture zone dimensions are estimated with specialized computer software. There are various models used to estimate the development of fracture geometries and dimensions. These engineering models are created using complex calculations and can be broadly classified into two-dimensional (2-D) and three-dimensional (3-D) categories:

- 2-D models include:
    - PKN (Perkins-Kern-Nordgren) fracture model
    - KDG (Khristianovic-Geertsma-de.Klerk) fracture model

- Radial model
- Three-D models include:
  - Fully 3-D models
  - P-3D (Pseudo-3-dimensional) model

The P-D3 model is commonly used by well operators where the reservoir properties are familiar and hydraulic fracturing has already been conducted. The P-D3 model is popularly used in the industry due to its simplification of height growth at the wellbore and along the fracture length in a multi-layered formation.

Acid Matrix Stimulation

Acid Matrix stimulation treatments are conducted below fracture pressure and do not crack rock or create fractures. These WSTs rely upon acid to flow through pore space and directly contact minerals and dissolve them. Because of this, the dimensions expected for acid matrix WSTs are approximately $1/10^{th}$ to $1/20^{th}$ of the dimensions expected for hydraulic fracture WSTs.

Acid Fracturing

Acid Fracture stimulations may be expected to have similar dimensions as hydraulic fracture WSTs. This is because the acid reaction of the formation in the WST does not typically penetrate further than the fracture dimensions. Some differences in fracture dimensions will exist depending on whether a proppant is used.

California Well Construction Standards

Preventing the Migration of Fluids

The Division has had requirements for the construction, testing, repair and reporting information of wells for many decades. The Division's most important principal for reviewing well construction or current or actual status of any well is called *zonal isolation*. Zonal isolation is the concept in well construction standards that will ensure formations that contain fresh water, saline water, oil, or natural gas are kept isolated from one another.

Hydrocarbon production wells in California are constructed to meet zonal isolation requirements. Zonal isolation requirements provide for durability and prevention of unintended movement of any fluid in a wellbore. Zonal isolation prevents the potential contamination of stratum filled with fresh water, briny water, oil, or gas, with any other fluid.

To achieve zonal isolation, current rules require that a cement barrier be placed between the well and the surrounding geologic strata or stratum. The cement bonds to the surrounding rock and forms a barrier against fluid migration between the well and the surrounding rock. Cement barriers must meet certain standards for strength and integrity. If they do not meet the standards, they must be modified or replaced. Steel well casings – sometimes composed of several layers of metal and cement, depending upon the well depth – also prevent interaction of fluids going in a wellbore with the surrounding geologic formations and pore fluids. If the integrity of a well casing is compromised by ground

movement, corrosion, or other mechanisms, the operator must notify the Division and repair or properly abandon the well in order to prevent improper migration of fluids in the wellbore.

The specific requirements for well construction – and testing to verify that a well is providing zonal isolation – depend upon the allowed use(s) of the well and various aspects of its location. More information about requirements for well construction in California may be found on the Division website.

Appendix C – Public Outreach and Stakeholder Workshops

SB 4 Regulations Outreach and Workshop Schedules

The following tables show the public outreach efforts conducted prior to the on-set and during the implementation of SB 4 regulations. The outreach activities included pre-regulation environmental impact report (EIR) meetings in 2013, a listening tour in 2012, workshops conducted around the state to discuss preliminary draft regulations, public comment hearings conducted around the state as part of the adoption of the permanent regulations, and adoption and re-adoption of the emergency interim regulations.

Fundamental to any program development and regulatory process is public outreach and stakeholder involvement. This was followed during the implementation process of SB 4.

The process that allowed any party to participate in the rule-making process (i.e., the writing of regulations) can be found at:

- http://www.oal.ca.gov/res/docs/pdf/HowToParticipate.pdf

The statutorily mandated environmental impact report (EIR) process resulted in an initial five public outreach meetings during the fall of 2013, and the winter of 2014. The EIR public outreach meetings took place in Oakland, Sacramento, Ventura, Bakersfield and Long Beach. Due to public demand, subsequent EIR meetings were held in six locations as shown in table 79. The final version of the approved EIR report can be found at:

- http://www.conservation.ca.gov/dog/Pages/SB 4_Final_EIR.aspx

Consistent with the State's regulatory process guidelines, public workshops were also held at these locations. The objective was to solicit and receive the public and stakeholders' input to the regulations. ASPEN consultants were contracted to handle the EIR process while the California Council on Science and Technology (CCST) consultants performed the independent scientific study for the program. The link to the final CCST scientific study report is shown below:

- http://ccst.us/projects/hydraulic_fracturing_public/SB 4.php

Table 72: Listening Tour

Location	Date	Time
1115 Truxton Ave., Bakersfield, CA 93301 Kern County Board of Supervisors Chambers , First Floor	May 15, 2012	7:00-9:00 PM
800 S. Victoria Ave, Ventura, CA 93009 Ventura County Board of Supervisors' Chambers	May 30, 2012	7:00-9:00 PM
9770 Culver Boulevard, Culver City CA, 90232 City County Chambers	June 12, 2012	7:00-9:00 PM
1212 N. Bellflower Blvd. Long Beach, CA 90815 Calif. State University-Long Beach Student Union	June 13, 2012	7:00-9:00 PM

Location	Date	Time
940 N. Main Street Salinas, CA 93906 Santa Lucia Room, Steinbeck Institute	June 27, 2012	7:00-9:00 PM
511 East Lakeside Parkway Santa Maria CA, 93455 Santa Barbara County Board of Supervisors Meeting Room	July 11, 2012	7:00-9:00 PM
1001 I Street Sacramento, CA 95814 Byron Sher Auditorium in CA Environment Protection Agency Headquarters	July 25, 2012	7:00-9:00 PM

Table 73: Round One SB 4 Public Comment Hearings 60-Day

Location	Date	Time
1001 I Street, 2nd Floor Sacramento, CA Sierra Hearing Room in the Cal/EPA Building	**January 6, 2014**	**3:00-7:00 PM**
1212 Bellflower Blvd., Long Beach CA CA State University Auditorium	**January 6, 2014**	**3:00-7:00 PM**
One Main Street, Salinas, CA National Steinbeck Center	**January 8, 2014**	**3:00-7:00 PM**
1115 Truxton Ave. Bakersfield, CA Kern County Administrative Center, First Floor Board Chambers	**January 8, 2014**	**3:00-7:00 PM**
511 East Lakeside Pkwy. Santa Maria, CA Santa Barbara County Supervisors' Hearing Room	**January 13, 2014**	**3:00-7:00 PM**

Table 74: SB 4 Emergency/Interim Regulations

Location of Submission	Effective Date
Submitted to the Office of Administrative Law	**12/19/2013**

Table 75: EIR Scoping Meetings

Location	Date	Time
550 10th Street Oakland, CA Oakland Convention Center	**December 10, 2013**	**4:00-8:00 PM**
828 I Street Sacramento, CA Sacramento Tsakopoulos Library Galleria	**December 11, 2013**	**4:00-8:00 PM**

Location	Date	Time
701 Truxton Ave., Bakersfield, CA Kern County Library Beale Memorial Auditorium	**December 12, 2013**	**4:00-8:00 PM**
4700 Loma Vista Road Ventura, CA Ventura College Performing Arts Center	**January 8, 2014**	**4:00-8:00 PM**
300 E. Ocean Blvd., Long Beach, CA Long Beach Convention Center	**January 9, 2014**	**4:00-8:00 PM**

Table 76: Discussion Draft

Workshop Name:	Date
Los Angeles Draft Hydraulic Fracturing Regulations Workshop	**2/19/2013**
Bakersfield Draft Hydraulic Fracturing Regulations Workshop	**3/13/2013**
Sacramento Draft Hydraulic Fracturing Regulations Workshop	**3/21/2013**
Monterey Draft Hydraulic Fracturing Regulations Workshop	**4/30/2013**
Santa Barbara Draft Hydraulic Fracturing Regulations Workshop	**4/19/2013**

Table 77: Round 2 SB 4 Public Comment Hearings 45-Day

Location	Date	Time
511 East Lakeside Pkwy Santa Maria, CA Santa Barbara Supervisors' Hearing Room	July 15, 2013	4:00-7:00PM
300 E. Ocean Blvd. Long Beach, CA Long Beach Convention & Entertainment Center	July 17, 2013	4:00-7:00PM
1416 Ninth Street Sacramento, CA Natural Resources Agency Auditorium	July 21, 2013	4:00-7:00PM
One Main Street Salinas, CA National Steinbeck Center, Salinas Room	July 23, 2013	4:00-7:00PM
1115 Truxton Ave. Bakersfield, CA Kern County Board of Supervisors' Chambers	July 23, 2013	4:00-7:00PM

Table 78: SB 4 Emergency/Interim Regulations Re-adoption

Description	Date
The request for re-adoption of the emergency regulations was made on:	June 20, 2014
The effective date was on:	July 1, 2014

Table 79: Draft EIR Public Meetings

Location	Date	Time
4700 Loma Vista Road, Ventura, CA 93003 Ventura College Performing Arts Center	February 10, 2015	5:00-8:00 PM
100 S. Main Street Los Angeles, CA 90012, CA Dept. Of Transportation (Cal Trans) Building, Conference RM. 01.040 A,B, & C	February 11 2015	5:00-8:00 PM
1515 Clay Street Oakland, CA 94612 Elihu Harris State Building, Auditorium	February 18, 2015	5:00-8:00 PM
1416 9th Street Sacramento, CA 95814 California Natural Resources Agency Building, Auditorium	February 19, 2015	5:00-8:00 PM
1115 Truxton Avenue Bakersfield, CA 93301 Kern County Administrative Center, First Floor Board Chambers	February 23, 2015	5:00-8:00 PM
One Main Street Salinas, CA 93901 National Steinback Center, Salinas Room	February 25, 2015	5:00-8:00 PM

Table 80: Public Comments Period

Description	Date
Opening Date - 15-day (No Hearings)	October 9, 2014
Closing Date	October 24, 2015

Appendix D – References and Data Sources

The following were used as data sources for this report:

- American Petroleum Institute: http://www.api.org/~/media/files/oil-and-natural-gas/hydraulic-fracturing/acidizing-oil-natural-gas-briefing-paper-v2.pdf
- The California Council on Science and Techonology's website its reports on WST: http://ccst.us/projects/hydraulic_fracturing_public/SB 4.php
- The California Public Resources Code and California Code of Regulations (CCR) for Conservation of Oil, Gas and Geothermal Resources (Department of Conservation publication no. Public Resources Code10, October 2015): ftp://ftp.consrv.ca.gov/pub/oil/laws/PRC10.pdf
- The State Water Board's webpage *Water Quality in Areas of Oil and Gas Production*: http://www.waterboards.ca.gov/water_issues/programs/groundwater/SB 4/index.shtml
- Chi U. Ikoku: Natural Gas Engineering, A systems Approach, PennWell Books, Division of PennWell Publishing Company.
- The Division of Oil, Gas, and Geothermal Resources WST unit's internal Interim Well Stimulation Access database. This is an internal Access database developed by staff specifically process data for use in this report.
- The Division of Oil, Gas, and Geothermal Resources WST unit's *WST Tracker.xlsx.* This is an internal Excel workbook developed by Interim WST unit staff specifically to track the progress of requests to perform WSTs, through Notices, actual stimulations, and Disclosing of stimulations.
- The Division of Oil, Gas, and Geothermal Resources' website for the Environmental Impact Report on hydraulic fracturing and other WST: http://www.conservation.ca.gov/dog/Pages/SB 4_Final_EIR.aspx
- The Division of Oil, Gas, and Geothermal Resources' Interim WST Disclosures Index: http://www.conservation.ca.gov/dog/Pages/IWSTDisclosureDisclaimer.aspx
- The Division of Oil, Gas, and Geothermal Resources' WST Disclosures Index: http://www.conservation.ca.gov/dog/Pages/WSTDisclosureSearchDisclaimer.aspx
- The Division of Oil, Gas, and Geothermal Resources' Interim WST Notice Index: http://www.conservation.ca.gov/dog/Pages/IWST_disclaimer.aspx
- Neighbor Notification reporting by third-party agencies.
- Operator disclosures.
- The U.S. Geological Survey's 2015 report on the nationwide use of water in hydraulic fracturing WSTs: http://www.usgs.gov/newsroom/article.asp?ID=4262
- Well Finder: A publicly available resource on the Division of Oil, Gas, and Geothermal Resources' website: http://www.conservation.ca.gov/dog/Pages/Well Finder.aspx
- WellStat: This is an internal Access database that is focused on monthly reporting of oil, water and other fluids produced from or injected via wells.

Appendix E - Glossary

Acid Fracture Stimulation	The combined use of acid and fracturing to increase the permeability of (stimulate) a portion of rock or sediment formation intercepted by a well.
Acid Matrix Stimulation	The use of acid to dissolve mineral material in order to increase the permeability of (stimulate) a portion of rock or sediment formation intercepted by a well.
Additive	One or more substances added to a base fluid to make up a well stimulation treatment (WST) fluid.
Base Fluid	A liquid (or potentially a gas) into which additives are mixed, to make up a WST fluid.
Base Fluid Source	The source or origin of a base fluid.
Base Fluid Suitability	The suitability of water base fluid for domestic use (e.g., human or livestock consumption) or irrigation (e.g., agricultural use).
California Code of Regulations	California Code of Regulations. Well stimulation treatment (WST) is regulated within Title 14, Sections 1751 through 1789 of the California Code of Regulations.
California Council on Science and Technology	A non-government organization that was commissioned pursuant to SB 4 to prepare the expert Independent Scientific Assessment of WST.
Cement Evaluation	The requirement implemented 7/1/2015 (Permanent regulations) that an operator evaluate the cement presence and cement-casing bond by radial log or potentially other method and provide the log to the Division at least 72 hours before beginning a WST. See “Zonal Isolation” and “Well Integrity”.
Certification of Compliance	A Division approval of documents submitted in December 2013 by a well operator for the intended WST of a specific well. A Certificate of Compliance approved by the Division resulted in issuance of an Interim (Period) WST Notice.
Class II (Injection) Well	Class II wells in California are approved and regulated by the Division for the injection of fluids produced as byproducts of the recovery or production of oil or gas, or for storage of hydrocarbons pursuant to the Division’s UIC program. See “UIC”.
Confidential Well	A temporary well status approved by the Division to protect certain information about a well from disclosure to public and presumably competing operators.
Constituent	A chemical used in a WST additive or base fluid; a chemical component of a WST fluid.
Diatomite	A rock of very high porosity and usually low permeability that may contain oil or gas. Diatomite is found within the Monterey Formation and other petroleum-bearing rock formations in California and elsewhere.
Directionally Drilled Well	A well that has been intentionally constructed away from vertical, on or close to a pre-planned pathway. Some directionally-drilled wells are curved upward during drilling to be finished as horizontal wells.

Disclosure	The electronic report of a WST submitted to the Division under the Interim or Final WST regulations.
(Master WST) Disclosures Index	A web-based, publically-downloadable Microsoft Excel workbook that contains all of the Disclosures that the Division has received and approved as complete.
Disposition	Term used in WST statutes for the management or disposal of water or other wastes from WST operations.
Recovered Fluid	Fluid that flows into a well and possibly upward to the wellhead after a WST is performed.
Gas	Natural gas. Natural gas consists of methane and other simple hydrocarbon molecules that are gasses rather than liquids at room temperature and pressure. Natural gas is present both dissolved in oil and in pore space above oil, within the Earth.
Geotracker	The California State Water Board's data management system for data and sites of groundwater monitoring and cleanup.
Groundwater Monitoring Plan	The plan and obligation of an operator to test groundwater before and after a WST. SB 4 amended section 10783 of the (State of California) Water Code to require that a Groundwater Monitoring (GWM) Plan be approved by the Division (prior to 7/1/2015) or the State Water Board (7/1/2015 or later) for any WST. SB 4 requires that a GWM Plan be approved and implemented for any WST unless the SWB has provided a written exclusion (Statement of Non-Applicability) from the requirement to perform GWM. See "Statement of Non-Applicability" and "State Water Board".
Horizontally Drilled	Refers to a wellbore that is deviated or curved upward from vertically downward as it is drilled, until the drilling assembly approaches approximately horizontal, and then extended further horizontally or nearly horizontally for some distance.
Hydraulically Fracture Stimulation	Refers to the intentional, short-term injection of fluid at sufficient pressure to break apart rock to enhance the permeability of (stimulate) a portion of rock or sediment formation intercepted by a well.
Independent Scientific Study	An expert assessment of WST and potential environmental impacts of WST, especially as or potentially performed in California. The Study was a statutory requirement of SB 4. The Study was commissioned by the Natural Resources Agency and written by the California Council on Science and Technology.
Interim Period	Eighteen months, from 1/1/2014 through 6/30/2015, during which the Division had limited authority and responsibility in the implementation of WST oversite. See "Interim Regulations".
Interim Regulations	Regulations that were developed under an Emergency Rulemaking process and approved by the Office of Administrative Law. The Interim Regulations were in effect for the 18-month interim period.
Interim Well Stimulation Treatment Notices Index	A web-based, searchable, publically-accessible database that contains all of the Division's approvals to perform WSTs issued through 6/30/2015.
Kerogen	Kerogen is a mixture of organic chemical compounds that make up a portion of the organic matter in sedimentary rocks.

Statement of Non-Applicability	A written approval from the State Water Board concurring with the technical and regulatory rationale provided by an oil or gas well operator that is seeking a waiver from the requirement to perform groundwater monitoring for WST. See “Groundwater Monitoring Plan” and “State Water Board”.
Measured Depth	The distance along the actual path of wellbore, from the ground surface, drilling mat, Kelly bushing, drill floor or other aboveground reference point used during drilling. Measured Depth can be thought of as the total length of drill pipe in the ground to reach the end of a wellbore, no matter how curved and twisted the well bore path may be from the reference point.
Memorandum of Agreement	A formal written relationship between two different units of state (or other) government that assigns duties and responsibilities of each and addresses the coordination process between the agencies for the implementation of SB 4 (or other) statutes or regulations.
Ministerial Review Process	An approval process that cannot deny an applicant a permission when the application is complete and meets the specifications published by an agency in California. The Division’s review and approval of Interim WST Notices during the interim period was a ministerial decision process.
Monterey Formation	The name used in much of California for a portion of the Miocene-aged, fine-grained (i.e., commonly shaley) sedimentary rock deposited and still present along the margin of the Pacific Ocean.
Neighbor Notification	The requirement and process for notifying landowners and occupants of parcels of property located within specified distances of a well where a WST is to be performed. The notification allows landowners or occupants to request that ground or surface waters that are suitable for drinking or irrigation be sampled and tested to assess possible impact from WST.
Notice	The statutory and regulatory term for a written approval made during the interim period by the Division to an operator to perform a WST.
Notice of Violation	Written notification made to an oil or gas well operator from the Division’s Oil and Gas Supervisor, of violation of a regulation or statute. A Notice of Violation is commonly the first formal correspondence to an operator preceding an Order or other potential enforcement action.
Notice to Operators	A written clarification, transmission of or request for information made by the Division to oil and gas well operators about a specific topic.
Notices Index	See “Interim Well Stimulation Treatment Notices Index.”
Notification	The process of providing information about an upcoming action, an opportunity, or an action taken, made in writing, to a party. See “Neighbor Notification” for one example of a notification required by SB 4.
Operator	A party that owns or has legal responsibility for the maintenance and operation of an oil or gas well or other well that falls within the jurisdiction of the Division.
Original Oil In Place	An estimate of the amount (volume) of oil within a study area (for example, the Monterey Formation as it is found throughout the San Joaquin Basin) prior to the start of oil extraction by humans.
Overburden Pressure	This is the pressure or stress imposed on a layer of soil or rock by the weight of overlying material.

Permanent regulations	Regulations that became effective July 1, 2015 and deemed final and permanent, for permitting, performing and reporting of WSTs in California. The Permanent regulations were developed using the Regular Rulemaking Process in accordance with California's Government Code, regulations of the Office of Administrative Law and SB 4.
Permeability	The property of or rate at which a solid can or does transmit oil, water, air or other fluids. See "Porosity".
Porosity (Pore Space)	The presence within and amount of a solid that is void (potentially empty) space. Pore space within rocks and soil is filled with oil, water, air or other gasses or fluids. See "Permeability".
Pressure Testing	The requirement implemented 7/1/2015 (Permanent regulations) that an operator notify the Division of and record pressure tests of all well casings and tubings to be used in a WST operation. See "Zonal Isolation" and "Well Integrity".
Produced Water	Water that is extracted from beneath the ground surface as a byproduct of oil or gas production. In mature oil fields such as those common in California most of the fluid that is pumped from the ground is produced water. In California most produced water is naturally salty.
Public Resources Code	One (of 29) groupings of California statutes (laws). The Public Resources Code contains the majority of key statutes affecting oil and gas resources, wells and operations. SB 4 added language primarily to the Public Resources Code to give the Division greater authority and responsibility for the regulation of WST.
Recovered Water or Fluid	Fluids (e.g., water, oil and gas) that come out (either naturally or by pumping or other assistance) of an oil or gas well after WST and prior to the routine production or other stabilized use and flow of fluids from a well. SB 4 requires operators to chemically test and provide information to the Division about Recovered Fluids.
Rulemaking Process	The procedure used by any component of the Executive Branch (of the State of California government) in adopting regulations and rules that will have the force of law. The Division followed both the Emergency Rulemaking Process and Regular Rulemaking Process in implementing SB 4.
SB 4	California Senate Bill 4 (2013, author Pavley). SB 4 was passed by the Legislature and signed by the Governor in September 2013 to better regulate WST.
SB 861	California Senate Bill 861 (2014). SB 861 extended the interim period (of WST regulation) by 6 months by amending the interim period to end 6/30/2015.
Seismicity	Earthquake activity
Spot Check (Inspection)	The term used in SB 4 to describe a visit by Division staff to a WST operation for the specific purpose of comparing the additives, chemicals and base fluid at the WST location with the information about the additives, chemicals and base fluid that was supplied in the Notice.
Stage	A subset or smaller portion of the total interval or portion of a well that is stimulated. A typical WST has several to more than ten stages that are performed in rapid succession in a single effort.

State Water Board	State of California Water Board issues exclusions form the requirements to monitor groundwater that are a default requirement per SB 4 and section 10783 of the Water Code, as well as reviews any groundwater monitoring plans submitted or unapproved after June 30, 2015 (e.g., during the Permanent Period). See “Statement of Non-Applicability” and “Groundwater Monitoring Plan”.
Stratum	A layer or a series of layers of rock in the ground.
Thermal Maturity	The increased temperature that is necessary for kerogen and other organic matter to be converted into hydrocarbons. Temperature increase in terms of thermal maturity is related to how deeply a rock system is buried, and for the length of time it is buried near that depth.
Thermal Window	The oil (or thermal) window is a temperature dependent interval in the subsurface where oil is generated and expelled from the source rocks. The oil window is often found in the 60-120 degree Celsius interval (approx. 2-4 km depth), while the corresponding gas window is found in the 100-200+ degree Celsius interval (3-6 km depth).
Trade Secret	The withholding of certain information about one or more WST additives from the public and presumably competitors. SB 4 allows an operator to request Trade Secrecy from the Division through a rigorous and formal process.
True Vertical Depth	The straight-line extent of a well vertically down into the Earth, calculated without regard to actual twists, curves or intentional deviations of the well bore. It is measured from the ground surface, drilling mat, Kelly bushing, drill floor or other aboveground reference point used during drilling.
UIC	Underground Injection Control. The Division has responsibility and authority to regulate the injection of any fluid into the ground via any oil or gas or other well under its jurisdiction. The Division’s UIC regulations and authority conform to and were granted by federal authority in compliance with the federal Safe Drinking Water Act of 1974. See “Class II well.”
Wellbore	A wellbore is a hole that is drilled to aid in the exploration and recovery of natural resources including oil, gas or water.
Well Construction Standards	Division requirements for construction of any wells under its authority. The standards serve to ensure zonal isolation and minimize risk to groundwater, oil and gas resources, humans and the environment. See “Zonal Isolation”.
Well (Casing) Integrity	The reliability of a well to perform its functions. This includes intact and functioning casing and cement that can durably resist all foreseeable changes (such as pressures, corrosive fluids or earth settlement or lateral shift) in conditions within and outside the well and ensure zonal isolation. See “Zonal Isolation.”
Well Finder	The Division’s web-based, publically-accessible, searchable database that allows a user to find and research wells under Division jurisdiction and/or make geographically-focused searches.
WellStat	An internal Division database that contains information about the monthly production and/or injection of fluids through every well that has active status under Division authority.

Well Stimulation	The brief and intentional application of pressure, chemicals or potentially other method to rock or sediment intercepted by a well, for the purpose of increasing the rock or sediment permeability in order to enhance oil or gas production, or potentially to increase water production or the ability of rock or sediment to accept injection water or other fluid.
Well Stimulation Treatment	Performing well stimulation.
Well Stimulation Treatment Notice	The written approval to perform a WST that is given the Division to an operator. Interim WST Notices were signed (e.g., approved) from December 2013 through June 30, 2015.
Witnessing (Inspection)	The term used in SB 4 to describe a general or all-purpose visit by Division staff to a WST operation, to observe, monitor or verify any regulated or required aspect of the WST.
Zonal Isolation	The principal of constructing, verification-testing and maintenance of a well to ensure that fluids are not migrating along or inside a well from one zone to another. Zones of concern that are protected from contamination of one another include oil or gas-bearing zones, zones of abnormally high pore pressures, zones of fresh water, zones of water of actual or potential beneficial use, zones of saline water, and zones of water contaminated by human activity.