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From: Alicia Roessler <aroessler@environmentaldefensecenter.org>
Sent: Friday, November 04, 2016 3:55 PM
To: sbcob
Cc: Linda Krop; Brian Trautwein
Subject: EDC comment letter re Gaviota Coast Plan
Attachments: EDC BOS comment ltr w attachments re Gaviota Coast Plan and FEIR_2016_11_4.pdf

Please accept EDC's letter to the Board of Supervisors regarding the draft Gaviota Coast Plan and Final EIR.

Many thanks,
Alicia

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environmental
DEFENSE CENTER

November 4, 2016

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Email to sbcob@co.santa-barbara.ca.us

Re: Draft Gaviota Coast Plan and Final EIR

Dear Honorable Supervisors:

This comment letter is submitted by the Environmental Defense Center (“EDC”) regarding the Draft Gaviota Coast Plan (“Plan”) and will also provide comments regarding the Plan’s Impact Analysis and Findings related to the Draft Final Environmental Impact Report (“FEIR”). EDC protects and enhances the environment through education, advocacy and legal action. Our program areas include the Santa Barbara Channel, clean water, open space and wildlife, and climate and energy. EDC has worked to protect the Gaviota Coast for decades and appreciates the County’s desire to develop a long-term plan for this region, which is one of the most biologically rich on the planet.

While the evolution of the Plan has been a very long process, we urge the Board of Supervisors (“BOS”) to carefully consider the following comments that represent a broad spectrum of community support to ensure the Gaviota Coast is preserved and protected as a resource for the entire community. This comment letter serves to supplement EDC’s August 29, September 12 and September 16, 2016, comment letters on the FEIR. We urge the BOS to address the remaining unresolved issues identified below, to ensure Gaviota’s resources are protected for generations to come.

It is critical to highlight that the FEIR concludes that **the Plan will result in thirteen Class I environmental impacts**. These impacts occur in three areas: Biological Resources, Cultural and Historical Resources, and Parks, Recreation and Trails. The California Environmental Quality Act (“CEQA,” Pub. Res. Code § 21000 *et seq.*) mandates that agencies refrain from approving projects with significant environmental impacts when there are “feasible alternatives or mitigation measures that can substantially lessen or avoid those impacts.” CEQA

§ 21002; CEQA Guidelines §§ 15002 (a)(3), 15021 (a)(2); *Mountain Lion Foundation v. Fish and Game Commission* (1997) 16 Cal. App. 4th 105, 134 Pursuant to CEQA, the County is required to make Findings, supported by substantial evidence, that it has mitigated these thirteen significant impacts to the maximum extent feasible and that no further feasible mitigation measures are known. CEQA § 21081. Unfortunately, these Findings cannot be made based on evidence in the record introduced by EDC. As such, we urge the BOS to adopt the following amendments and necessary mitigation.

Summary of EDC Recommendations for the Plan

Environmentally Sensitive Habitat (“ESH”) Policies

- The BOS should require ESH mapping for the Plan area by a date certain. Action NS-7 should be amended to state, “The County *shall* seek funding and shall map biological habitats, including ESH, by *December 31, 2019*.”
- To mitigate a Class I impact to Gaviota’s ESH, the BOS should amend the ESH-GAV Overlay Ordinance to protect ESH from *new and expanded* agricultural land clearing on inland Agricultural-zoned lands.

Fracking Policy

- Amend TEI -12 to prohibit the use of all enhanced oil and gas recovery techniques, such as hydraulic fracturing and steam injection, in the Gaviota Coast Plan Area.

Incentives Program

- The Incentives Program should be amended to ensure proportionality of the public benefit to the landowner’s benefit and require that the dedicated trail easement be accessible and open to the public before the landowner can construct an Incentives Dwelling Unit.
- The Incentives Program ordinance must define “premise” in order to ensure clarity and consistency in its application.

Incentivize Farmstays

- To ensure that Farmstays are incentivized as the preferred lodging option on Ag-II zoned lands within the Plan Area, we urge the BOS to revise the Farmstay section of the Zoning Ordinances.

Protect Railroad Views

- Revise VIS-12 and VIS 13 to protect views from the railroad and require that development be screened to the maximum extent feasible.

I. The FEIR's Class I Impacts to ESH are not mitigated to the maximum extent feasible.

The EIR identifies four Class I impacts to Biological Resources, which include impacts to sensitive plant species, sensitive wildlife species, and sensitive vegetation communities, and a cumulative impact to cumulative impacts to biological resources. (FEIR at 4.6) These impacts occur as a result of Plan buildout from development and agricultural activities. (FEIR at 4.6-42) According the FEIR, the ESH Ordinance does provide some protection and mitigate impacts to sensitive habitats, with the exception of ESH removal from land clearing and grading associated with exempt agricultural activities as provided for in the proposed ESH-GAV Overlay ordinance. (FEIR at 4.6-42; and Attachment D-2: CLUDC Ordinance Amendment at 21.) EDC has suggested several feasible mitigation measures, *many of which are implemented in the County's other community plans*, that would lessen and substantially decrease impacts to the Plan's Biological Resources.¹ These mitigation measures include ESH mapping, re-zoning qualifying private parcels to mountainous zoning, and amending the ESH-GAV Overlay ordinance to apply to new and expanded agricultural activities. While a re-zone at this stage in the Plan process might cause delay, ensuring ESH is mapped and amending the ESH-GAV Overlay Ordinance is feasible and would significantly lessen impacts to ESH without impacting any existing agricultural. Without these additional mitigation measures, the BOS lacks evidence to make the CEQA Findings that BIO Impacts BIO 1 through 4, and cumulative impacts to biological resources, have been mitigated to the maximum extent feasible.

A. Removing the ESH Overlay's exemption for ESH removal from agricultural land clearing from *new and expanded agricultural cultivation* is feasible to mitigate BIO Impacts 1 through 4, and cumulative impacts to biological resources.

One of the largest threats to sensitive vegetation communities is from land clearing for agricultural activities and development. (FEIR at 4.6) While the Coastal Act requires the Plan to protect ESH in the Coastal Zone from these activities, the Plan fails to map ESH and exempts ESH from protection in the Inland area on Agricultural zoned parcels from agricultural activities, which include land clearing. EDC has proposed several feasible mitigation measures, such as removing the exemption for agriculture in the ESH Overlay and proposing a more generous permit trigger applicable to ESH removal for new and expanded agricultural cultivation, which mirrors the same policy as that applied to the Coastal Zone. Yet, this proposed mitigation, which would significantly lessen impacts to ESH, and is feasible in both the coastal zone and inland zone, has also been ignored and not analyzed in the FEIR. As such, the CEQA Findings that BIO Impacts BIO 1 through 4, and cumulative impacts to biological resources, have been mitigated to the maximum extent feasible is not supported by evidence in the record.

¹ See EDC Letters submitted to the Planning Commission dated: September 4, 2015, July 26, 2016, September 4, 2016, and September 12, 2016.

In order to achieve a balance that accommodates agricultural expansion while protecting sensitive habitats from large scale removal, we propose a more relaxed permit threshold. Specifically we support adding the following section to the ESH –GAV section of the Zoning Ordinance:

35.28.230(C)(4): Land Use Permit Requirements for Agriculture. Within an area zoned as Agriculture, a Land Use Permit in accordance with Section 35.28.110 (Land Use Permits) shall be required for the following **new or expanded agricultural cultivation**, in addition to those required to have a Land Use Permit by the primary zone.

- a. The removal of vegetation from an area greater than **5 acres** or removal that, when added to the previous removal of vegetation from an area, would total **5 acres** or more of vegetation.
- b. The removal of a significant amount of vegetation along **250 linear feet** or more of creek bank, or the removal of vegetation that, when added to the previous removal of vegetation, would total **250 linear feet** or more of vegetation along a creek bank.
- c. The removal of vegetation that, when added to the previous removal of vegetation within the affected habitat, would total **5 acres** or more, or longer than **250 linear feet** of vegetation along a creek bank.
- d. Grading in excess of **250 cubic yards** of cut or fill.
- e. The removal of any five native trees greater than six inches in diameter measured four feet above the existing grade, or more than six feet in height, or non-native trees used as raptor nesting habitat unless the Department makes one of the following findings:
 - (1) The tree is dead and not of significant habitat value.
 - (2) The tree prevents the installation of an orchard or crops.
 - (3) The trees are diseased and pose a danger to healthy trees in the immediate vicinity. The Department may require evidence of this to be presented by an arborist, or licensed tree surgeon.
 - (4) The tree is so weakened by age, disease, storm, fire, removal of adjacent trees or any injury so as to pose an imminent threat to persons or property. The Department may require evidence of this to be presented by an arborist, or licensed tree surgeon.

We urge the BOS to adopt this new section to ensure that the Plan properly balances the needs of farmers with the protection of the Gaviota Coast's sensitive biological habitats.

B. Mapping ESH is a feasible measure to protect ESH and mitigate impacts to BIO 1 through 4, and cumulative impacts to biological resources.

The Plan only maps inland riparian ESH, and only suggests an Action item to seek funding to map the remaining ESH. EDC has submitted many letters into the record that show that mapping ESH is feasible and has been accomplished in the County's other community plans as a measure to mitigate ESH impacts. We urge the BOS to require ESH mapping for the Plan

area by a specific date and amend Action NS-7 to state, “The County shall seek funding and shall map biological habitats, including ESH, by December 31, 2019.”

II. Proposed prohibition on new oil and gas projects using enhanced well stimulation techniques and operations.

The purpose of a community plan such as the Gaviota Coast Plan is to provide for future development for a geographically distinct area. Now is the time to hear input from the community and create a framework for Gaviota’s future development that takes into account the area’s unique resources and constraints. (Plan at 1-2)

The Plan Area’s rich biodiversity, steep slopes and unique watersheds are not conducive to new oil and gas projects using enhanced oil and gas recovery techniques such as hydraulic fracturing and steam injection. These extreme oil extraction techniques, including cyclic steam injection, have appalling impacts on the environment, such as oil seeps, ground upheavals, cracks, and well casing failure, as documented during the BOS’s recent review and denial of Pacific Coast Energy Company’s cyclic steam drilling project in Orcutt Hills. There is a substantial amount of evidence documenting the harmful effects and prolific contamination these extreme oil extraction projects leave behind.² (Attachment A)

The community has shown strong support for a proposed prohibition on these new projects in Gaviota, and a prohibition should be codified in the Plan to prevent the threat of future oil spills, seeps and water contamination. Even with the limited onshore oil and gas projects using conventional drilling technology in recent years, Gaviota has still suffered irreversible damage from two recent oil spills - the Torch oil spill in 1997 and the recent Refugio oil spill in 2015. According to the FEIR, all of the four onshore oil and gas production fields have been or will be soon closed on their own accord. (Plan at 7-7) Thus, now is the appropriate time to protect Gaviota in perpetuity from the threat of any *new* oil and gas projects proposing to use any enhanced oil and gas recovery techniques. This prohibition would be limited to only apply to new projects, and would be limited to only prohibit projects using these specific enhanced oil and gas recovery techniques.

The County has the legal authority to regulate oil and gas development in order to protect the community from the risks of impacts from those oil and gas projects. To date, six other California counties have adopted policies prohibiting projects using hydraulic fracturing, steam injection and other enhanced extraction technologies: Alameda, Los Angeles, Santa Cruz, San Benito, Mendocino and Butte.

² Pursuant to Senate Bill 4 (Pavley 2013), the California Natural Resources Agency commissioned the California Council on Science and Technology (CCST) to conduct an independent scientific assessment of well stimulation treatments, including hydraulic fracturing, in California, “An Independent Scientific Assessment of Well Stimulation in California” found at http://ccst.us/projects/hydraulic_fracturing_public/SB4.php. Attachment A attaches a copy of the Executive Summary of the Report.

The County's authority is based in the police power and its jurisdiction over local land use. The U.S. Supreme Court has highlighted the importance of the police power as the means by which local agencies protect the public health, safety and welfare of their residents. *Berman v. Parker* (1954) 348 U.S. 26. The Court described this power as "broad and inclusive" and noted that "[i]t is within the power of the legislature to determine that the community should be beautiful as well as healthy, spacious as well as clean, well balanced as well as carefully patrolled." *Id.* at 32-33; see also *Village of Belle Terre v. Boraas* (1974) 416 U.S. 1. The California Supreme Court has similarly recognized the broad police power authority of cities to enact legislation in the interests of their citizens. *Metromedia, Inc. v. City of San Diego* (1980) 26 Cal.3d 848 (holding that ban on billboards constituted proper exercise of the City's police power).

The California Constitution confers on all cities the power to "make and enforce within [their] limits all local police, sanitary and other ordinances and regulations not in conflict with general laws." Cal. Const. Art. XI, §7. The police power is "elastic" so that cities can respond to evolving issues and needs. *Rancho La Costa v. County of San Diego* (1980) 111 Cal.App.3d 54.

The courts construe the police power broadly and will uphold the legislative actions of cities so long as they are reasonably related to public health, safety or welfare. *Associated Home Builders, Inc. v. City of Livermore* (1976) 18 Cal.3d 582. "Welfare" includes such intangibles as aesthetics and the character of a community. *Metromedia, Inc.*, 26 Cal.3d at 861, relying on *Berman v. Parker* (1954) 348 U.S. 26, 33; see also *Ewing v. City of Carmel-by-the-Sea* (1991) 234 Cal.App.3d 1579, 1590-1591 (upholding ordinance intended to protect the "residential character" of neighborhoods by prohibiting the transient commercial use of residential properties).

Accordingly, the police power has been relied upon to prohibit certain uses and activities that are not within the identified interests of a city. See, for example, *Metromedia, Inc.*, 26 Cal.3d 848 (ban of offsite advertising billboards); *Wal-Mart Stores, Inc. v. City of Turlock* (2006) 138 Cal.App.4th 273 (prohibiting development of discount superstores).

These types of banned activities include oil and gas development. For example, in *Hermosa Beach Stop Oil Coalition v. City of Hermosa Beach* (2001) 86 Cal.App.4th 534, 555, the court held that a ballot initiative prohibiting all oil and gas exploration, drilling and production was a legitimate exercise of the City's police power. The court noted that the ban was founded on the desire to "preserve the environment, as well as to protect the public health, safety and welfare of people and property within Hermosa Beach. It is, therefore, presumptively a justifiable exercise of the City's policy power." *Id.*

Similarly, in *Higgins v. City of Santa Monica* (1964) 62 Cal.2d 24, the California Supreme Court upheld an ordinance prohibiting oil drilling and prospecting, holding that the City's desire to protect the public from the "inconvenience, noisome effects, and potential dangers that may accompany and follow the exploration for, and production of, oil" was a valid exercise of the City's police power. See also *Beverly Oil Co. v. City of Los Angeles* (1953) 40 Cal.2d 552 (the California Supreme Court found that a city zoning ordinance prohibiting

production of oil in designated areas was a reasonable exercise of the city's police power); *Pacific Palisades Assn. v. City of Huntington Beach* (1925) 196 Cal. 211, 217 (the state Supreme Court held that the city has "the unquestioned right to regulate the business of operating oil wells within its city limits, and to prohibit their operation within delineated areas and districts, if reason appears for doing so").

Thus, the courts affirmatively hold that the County may utilize its police powers, justified by its desire to protect the Gaviota Coast Plan Area, and effectuate a ban on new projects using hydraulic fracturing, steam injection and other enhanced oil and gas extraction techniques. We urge the BOS to listen to the numerous community groups and prohibit these projects from being a part of Gaviota's future and **amend Plan Policy TEI -12 to prohibit the use of all enhanced oil and gas recovery techniques, such as hydraulic fracturing and steam injection, in the Gaviota Coast Plan Area.**

III. Gaviota Incentives Program

EDC, like many other community groups, actively supports public trails in the Gaviota Plan area. While the intent of the Plan is to utilize an incentives program to entice landowners to dedicate PRT trail easements in exchange for additional homes, there are a few remaining concerns we urge the BOS to address, as described below.

A. ~~The incentives program allows for a loophole where the landowner benefit is not proportional to the public benefit.~~

The proposed Incentives Program seeks to entice landowners by offering additional homes above and beyond what is allowed in the zoning ordinance. In exchange the landowner must execute and record an irrevocable offer to dedicate a trail easement that runs on their land. However, if the dedicated trail easement is not connected or accessible to the public, the landowner is still permitted to build the additional units. The result is a disproportionate benefit provided to the landowner. However, if the program was revised to ensure that the landowner could not build or get permitted for additional incentives units until the trail easement is open and accessible to the public, the program could incentivize owners to work together to donate connecting pieces of trails. Given this loophole, the Incentives Program must be amended by the BOS to correct this inequality.

B. The Incentives program requires a clear definition of the word "premises" in order to prevent ambiguity and uncertainty in its application towards the eligibility of the incentive.

The proposed CLUDC Ordinance Amendment, Article 35.2, Zones and Allowable Land Uses in Attachment D-2 includes the incentive units program, and uses the word "premises" to define the area in which the dedication of a trail easement can result in the eligibility for an incentive dwelling unit³. For example, to be eligible, "the easement shall be for the entire length

³ CLUDC Ordinance Amendment Article 35.2, Section 35-1 at p. 28.

of the trail that is located on the *premises* on which the incentive dwelling unit is proposed.” (*Id.*, emphasis added.) The use of the program’s application per landowner “premise” is also identified in article 35 I.1(e)(8) Maximum Number of Incentive Dwelling Units. While it appears that the incentives units are only issued on a per “premise” basis and not on a per parcel basis, the term is not defined in the Plan.

To add to the confusion, there is an inconsistency with how the County’s LUDC and Uniform Rules define the word premises. Article 35.11 of the LUDC defines *premises* as “the area of land in one ownership surrounding a house or building” (CLUDC § 11-44), and it defines winery *premises* as an approved lot *or* group of lots which shall be considered to be contiguous even if separated by infrastructure (CLUDC § 11-64). In contrast, the Santa Barbara County Uniform Rules define premises as an “area of land under a single Williamson Act or Farmland Security Zone contract” and state that it may comprise of either a single parcel *or* multiple parcels under the same ownership.⁴

In order to ensure a consistent application of the Gaviota Incentives program, we urge the BOS to either apply the incentive program on a *per holding* basis (i.e., land under one ownership), or provide a definition of “premises” that clearly applies to the entire property under one ownership.

C. The number of potential incentive units and their resulting impacts need to be analyzed.

According to the Gaviota Coast Plan PRT Maps, when considering the incentive units on a per premises basis, there are approximately twelve premises that would be eligible for the incentive unit program, not including the Township of Naples. When including the Township of Naples that adds an additional approximately thirty-seven lots to the already twelve premises. (Plan at 4-11)

As discussed above, if the word premises is not clearly defined, it could potentially allow the interpretation of premises to be on a lot by lot basis, which according to the PRT Maps, would result in a total of approximately *sixty-nine* eligible lots including the township of Naples, and *thirty-two* lots without Naples (Plan at 4-11), which could result in the potential buildout of an additional 48-101 homes granted as an incentive. These additional units would clearly increase the potential impacts of the Plan.

According to the FEIR’s truncated analysis, the incentive program will have similar impacts as the proposed Plan (FEIR at 6-44); however, it is clear that the program could substantially increase the number of second units that have not been accounted for in the FEIR’s impact analysis. The FEIR’s conclusory statements are not supported by any facts or analysis, in contradiction to CEQA. *Californians for Alternatives to Toxics v. Department of Food and Agriculture* (2005) 136 Cal.App.4th 1, 11-12 (an EIR must present facts and analysis, not bare conclusions).

⁴ Santa Barbara County Uniform Rules at p. 7.

IV. Farmstays should be incentivized as the only short term lodging option in the Plan Area.

EDC shares the Gaviota Coast Conservancy's ("GCC") perspective that Farmstays should be encouraged as the only appropriate short term lodging available in the Plan area. To ensure that Farmstays are incentivized as the preferred lodging option on Ag-II zoned lands within the Plan Area, we urge the BOS to adopt the following revision to the Farmstay section of the Zoning Ordinances:

b. A Farmstay operation that may not be allowed in compliance with Subsection D.3.a., above, as well as all other forms of Lodging (including but not limited to Guest ranches and Hostels) may be allowed with a Conditional Use Permit approved in compliance with Section 35.82.060 (Conditional Use Permits and Minor Conditional Use Permits) provided the following additional findings are first made.

- (a) The operation will not result in significant adverse impacts to visual resources.
- (b) The operation will not include a new at-grade crossing of Highway 101.

This addition would go far to ensure new Lodging uses, such as short term rentals, would require a higher tier permit than a Farmstay and serve to incentivize a more appropriate option for the Plan area.

V. Critical Viewshed Corridor Policies should be amended to Protect against Blufftop Development Impacts.

EDC supports GCC's proposed amendment to protect views from the railroad in the Plan area and agrees that preserving Gaviota's prized coastal bluff area from readily visible development can only be accomplished by expressly requiring that development be screened to the maximum extent feasible as seen from the railroad.

We propose the following specific policy changes:

Policy VIS-12: Critical Viewshed Corridor. Protection of the ocean and mountain views of the Gaviota Coast from Highway 101 and the Railroad is critically important. Therefore, a Critical Viewshed Corridor Overlay, providing more protective viewshed policies for development permits within the overlay, is designated for the Gaviota Coast.

Policy VIS-13: Development Visibility. Development within the Critical Viewshed Corridor shall be screened to the maximum extent feasible as seen from Highway 101 and the Railroad. Screening shall be achieved through adherence to the Site Design Hierarchy and Design Guidelines.

Without these changes, the Plan fails to include adequate protection from the potential impacts of development that the critically important coastal bluff requires. Accordingly we request that the

Board to include the above changes in the Plan.

VI. The Statement of Overriding Considerations

For the reasons stated above, that prove that many of the Plan's thirteen significant impacts have not been mitigated to the maximum extent feasible, the BOS cannot make the Statement of Overriding Considerations ("SOC"). The Plan is not "self-mitigating" as the SOC alleges, or else there would not be thirteen remaining Class I impacts. (SOC E.) The "policies, development standards and actions" that serve to mitigate the Plan's impacts do not qualify as a "benefit" of the Plan. (SOC E.) A SOC may not include mitigation measures, because they do not provide a benefit. Pursuant to CEQA, mitigation measures cannot exceed the scope of the impact. Instead, there must be a nexus between the impact and the mitigation measure, and the measure must be "roughly proportionate" to the impact. (CEQA Guidelines § 15126.4(a)(4), citing *Nollan v. California Coastal Commission*, 483 U.S. 825 (1987) and *Dolan v. City of Tigard*, 512 U.S. 374 (1994). Thus, it is inappropriate to cite to mitigation measures in a SOC.

Moreover, only designating federal land, that the County has no control over, with the resource protection of mountainous does not serve to limit or reduce any of the Plan's impacts as is falsely alleged in the SOC. (SOC §§ C and G.)

Accordingly, the SOC should be revised to eliminate these misleading items that do not provide any benefit to the County or community.

Conclusion

We urge the BOS to consider the above changes and ensure the Plan and the FEIR are ready to adopt with broad support from the community.

Sincerely,



Alicia Roessler,
Staff Attorney



Brian Trautwein,
Environmental Analyst / Watershed Program Coordinator

Attachments:

A: Executive Summary, *An Independent Scientific Study of Well Stimulation in California*

Attachment A

**An Independent Scientific
Assessment of
Well Stimulation in California**

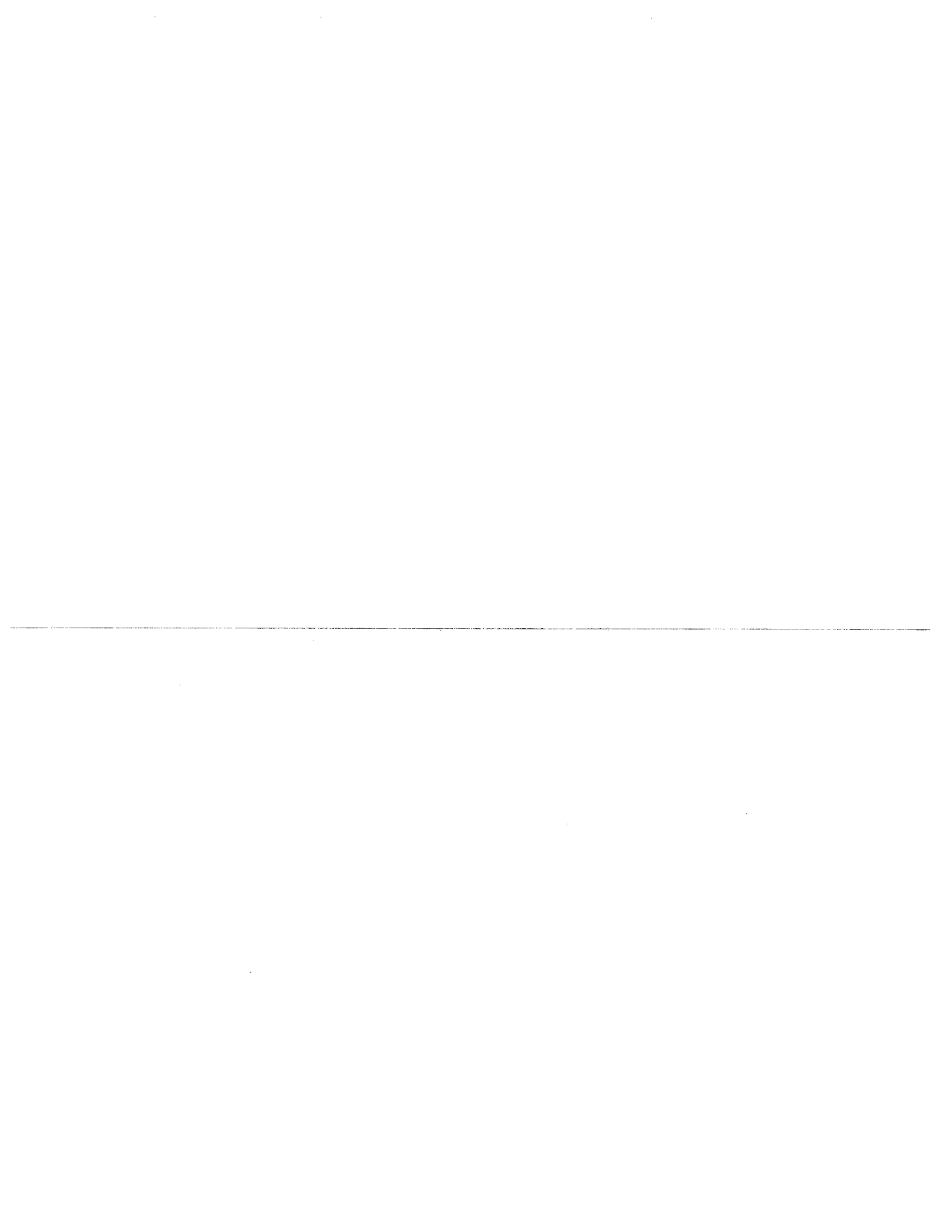
Executive Summary

**An Examination of Hydraulic Fracturing
and Acid Stimulations
in the Oil and Gas Industry**

July 2015



Lawrence Berkeley
National Laboratory



An Independent Scientific Assessment of Well Stimulation in California

Executive Summary

An Examination of Hydraulic Fracturing and Acid Stimulations in the Oil and Gas Industry

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An Independent Scientific Assessment of Well Stimulation in California:
Executive Summary. An Examination of Hydraulic Fracturing and Acid Stimulations
in the Oil and Gas Industry.

About CCST

CCST is a non-profit organization established in 1988 at the request of the California State Government and sponsored by the major public and private postsecondary institutions of California and affiliate federal laboratories in conjunction with leading private-sector firms. CCST's mission is to improve science and technology policy and application in California by proposing programs, conducting analyses, and recommending public policies and initiatives that will maintain California's technological leadership and a vigorous economy.

Note

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Executive Summary

In 2013, the California Legislature passed Senate Bill 4 (SB 4), setting the framework for regulation of hydraulic fracturing and acid stimulation technologies in California. SB 4 also requires the California Natural Resources Agency to conduct an independent scientific study to assess current and potential future well stimulation practices, including the likelihood that these technologies could enable extensive new petroleum production in the state; the impacts of well stimulation technologies (including hydraulic fracturing, acid fracturing and matrix acidizing) and the gaps in data that preclude this understanding; potential risks associated with current practices; and alternative practices that might limit these risks.

The California Council on Science and Technology (CCST) organized and led the study. Members of the CCST steering committee were appointed based on technical expertise and a balance of technical viewpoints. Lawrence Berkeley National Laboratory (LBNL) and subcontractors (the science team) developed the findings based on original technical data analyses and a review of the relevant literature. The science team studied each of the issues required by SB 4, and the science team and the steering committee collaborated to develop a series of conclusions and recommendations. Final responsibility for the conclusions and recommendations in this report lies with the steering committee. All steering committee members have agreed with these conclusions and recommendations. Any steering committee member could have written a dissenting opinion, but no one requested to do so.

This report has undergone extensive peer review; peer reviewers are listed in Appendix E of the Summary Report, “Expert Oversight and Review.” Eighteen reviewers were chosen for their relevant technical expertise. More than 1,500 anonymous review comments were provided to the authors. The authors revised the report in response to peer review comments. In cases where the authors disagreed with the reviewer, the response to review included their reasons for disagreement. Report monitors, appointed by CCST, then reviewed the response to the review comments and when satisfied, approved the report.

To create a hydraulic fracture, an operator increases the pressure of a mixture of water and chemicals in an isolated section of a well until the surrounding rock breaks, or “fractures.” Sand injected into these fractures props them open after the pressure is released. Acid fracturing, in which a high-pressure acidic fluid fractures the rock and etches the walls of the fractures, is hardly used in California and not discussed further. Matrix acidizing does not fracture the rock; instead, acid pumped into the well at relatively low pressure dissolves some of the rock and makes it more permeable. This study identified seven equally important major principles required for safe hydraulic fracturing and acid stimulation in California. Organized by principle, we draw conclusions and recommendations.

Principle 1. Maintain, expand and analyze data on the practice of hydraulic fracturing and acid stimulation in California.

Public records provide substantial information about the location, frequency of use, and water and chemical use for hydraulic fracturing and acid stimulation in California.

Conclusion 1.1. Most well stimulations in California are hydraulic fracturing and most hydraulic fracturing occurs in the San Joaquin Valley.

About 95% of reported hydraulic fracturing operations in California occur in the San Joaquin Basin, nearly all in four oil fields in Kern County. Over the last decade, about 20% of oil and gas production in California came from wells treated with hydraulic fracturing. Hydraulic fracturing accounts for about 90% of all well stimulations in California; matrix acidizing accounts for only 10%; and acid fracturing operations nearly none. Operators in California commonly use acid for well maintenance, but acid stimulation will not likely lead to major increases in oil and gas production due to the state's geology. Operators of dry (non-associated) gas wells located in Northern California rarely use hydraulic fracturing (Volume I, Chapter 3).

Conclusion 1.2. The California experience with hydraulic fracturing differs from that in other states.

Present-day hydraulic fracturing practice and geologic conditions in California differ from those in other states, and as such, recent experiences with hydraulic fracturing in other states do not necessarily apply to current hydraulic fracturing in California (Volume I, Chapters 2 and 3).

Conclusion 1.3. Hydraulic fracturing in California does not use a lot of fresh water compared to other states and other human uses.

Operators in California use about 800 acre-feet (about a million cubic meters [m³]) of water per year for hydraulic fracturing. This does not represent a large amount of freshwater compared to other human water use, so recycling this water has only modest benefits. However, hydraulic fracturing takes place in relatively water-scarce regions. Where production was enabled by hydraulic fracturing, at least twice and possibly fourteen times as much fresh water was used for subsequent enhanced oil recovery using water or steam flooding than all the water used for hydraulic fracturing throughout the state. The state has recently begun requiring detailed reporting of water use and produced water disposal in California's oil and gas fields under Senate Bill 1281 (SB 1281). In the future, these data could help optimize oil and gas water practices, including water use, production, reuse, and disposal.

Recommendation 1.1. Identify opportunities for water conservation and reuse in the oil and gas industry.

When roughly a year of water data becomes available from implementation of SB 1281, the state should begin an early assessment of these data to evaluate water sources, water production, reuse, and disposal for the entire oil and gas industry. Early assessment will shed light on the adequacy of the data reporting requirements and identify additional requirements that could include additional information about the quality of the water used and produced. When several years of data become available, a full assessment should identify opportunities to reduce freshwater consumption or increase the beneficial use of produced water, and regularly update opportunities for water efficiency and conservation (Volume I, Chapter 3).

Conclusion 1.4. A small number of offshore wells use hydraulic fracturing.

California operators currently use hydraulic fracturing in a small portion of offshore wells, and we expect hydraulic fracturing to remain incidental in the offshore environment. Policies currently restrict oil and gas production offshore, but if these were to change in the future, production could largely occur without well stimulation technology for the foreseeable future (Volume III, Chapter 2 [Offshore Case Study]).

Conclusion 1.5. Record keeping for hydraulic fracturing and acid stimulation in federal waters does not meet state standards.

Current record-keeping practice on stimulations in federal waters (from platforms more than three nautical miles offshore) does not meet the standards set by the pending SB 4 well treatment regulations and does not allow an assessment of the level of activity or composition of hydraulic fracturing chemicals being discharged in the ocean. The National Pollutant Discharge Elimination System permits that regulate discharge from offshore platforms do not effectively address hydraulic fracturing fluids. The limited publicly available records disclose only a few stimulations per year.

Recommendation 1.2. Improve reporting of hydraulic fracturing and acid stimulation data in federal waters.

The state of California should request that the federal government improve data collection and record keeping concerning well stimulation conducted in federal waters to at least match the requirements of SB 4. The U.S. Environmental Protection Agency should conduct an assessment of ocean discharge and, based on these results, consider if alternatives to ocean disposal for well stimulation fluid returns are necessary (Volume III, Chapter 2 [Offshore Case Study]).

Principle 2. Prepare for potential future changes in hydraulic fracturing and acid stimulation practice in California.

Conclusion 2.1. Future use of hydraulic fracturing in California will likely resemble current use.

Future use of hydraulic fracturing will most likely expand production in and near existing oil fields in the San Joaquin Basin that currently require hydraulic fracturing. Oil resource assessment and future use of hydraulic fracturing and acid stimulation in the Monterey Formation of California remain uncertain. In 2011, the U.S. Energy Information Administration (EIA) estimated that 15 billion barrels (2.4 billion m³) of recoverable shale-oil resources existed in Monterey source rock. This caused concern about the potential environmental impacts of widespread shale-oil development in California using hydraulic fracturing. In 2014 the EIA downgraded the 2011 estimate by 96%. This study reviewed both EIA estimates and concluded that neither one can be considered reliable. Any potential for production in the Monterey Formation would be confined to those parts of the formation in the “oil window,” that is, where Monterey Formation rocks have experienced the temperatures and pressures required to form oil. The surface footprint of this subset of the Monterey Formation expands existing regions of oil and gas production rather than opening up entirely new oil and gas producing regions.

Recommendation 2.1. Assess the oil resource potential of the Monterey Formation.

The state should request a comprehensive, science-based and peer-reviewed assessment of source-rock (“shale”) oil resources in California and the technologies that might be used to produce them. The state could request such an assessment from the U.S. Geological Survey, for example.

Recommendation 2.2. Keep track of exploration in the Monterey Formation.

As expansive production in the Monterey Formation remains possible, Division of Oil, Gas, and Geothermal Resources (DOGGR) should track well permits for future drilling in the “oil window” of the Monterey source rocks (and other extensive source rocks, such as the Kreyenhagen) and be able to report increased activity (Volume I, Chapter 4; Volume III, Chapter 3 [Monterey Formation Case Study]).

Principle 3. Account for and manage both direct and indirect impacts of hydraulic fracturing and acid stimulation.

Hydraulic fracturing or acid stimulation can cause direct impacts. Potential direct impacts might include a hydraulic fracture extending into protected groundwater, accidental spills of fluids containing hydraulic fracturing chemicals or acid, or inappropriate disposal or reuse of produced water containing hydraulic fracturing chemicals. These direct impacts

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do not occur in oil and gas production unless hydraulic fracturing or acid stimulation has occurred. This study covers potential direct impacts of hydraulic fracturing or acid stimulation.

Hydraulic fracturing or acid stimulation can also incur indirect impacts, i.e., those not directly attributable to the activity itself. Some reservoirs require hydraulic fracturing for economic production. All activities associated with oil and gas production enabled by hydraulic fracturing or acid stimulation can bring about indirect impacts. Indirect impacts of hydraulic-fracturing-enabled oil and gas development usually occur in all oil and gas development, whether or not the wells are stimulated.

Conclusion 3.1. Direct impacts of hydraulic fracturing appear small but have not been investigated.

Available evidence indicates that impacts caused directly by hydraulic fracturing or acid stimulation or by activities directly supporting these operations appear smaller than the indirect impacts associated with hydraulic-fracturing-enabled oil and gas development, or limited data precludes adequate assessment of these impacts. Good management and mitigation measures can address the vast majority of potential direct impacts of well stimulation.

Recommendation 3.1. Assess adequacy of regulations to control direct impacts of hydraulic fracturing and acid stimulations.

Over the next several years, relevant agencies should assess the adequacy and effectiveness of existing and pending regulations to mitigate direct impacts of hydraulic fracturing and acid stimulations.

Conclusion 3.2. Operators have unrestricted use of many hazardous and uncharacterized chemicals in hydraulic fracturing.

The California oil and gas industry uses a large number of hazardous chemicals during hydraulic fracturing and acid treatments. The use of these chemicals underlies all significant potential direct impacts of well stimulation in California. This assessment did not find recorded negative impacts from hydraulic fracturing chemical use in California, but no agency has systematically investigated possible impacts. A few classes of chemicals used in hydraulic fracturing (e.g. biocides, quaternary ammonium compounds, etc.) present larger hazards because of their relatively high toxicity, frequent use, or use in large amounts. The environmental characteristics of many chemicals remain unknown. We lack information to determine if these chemicals would present a threat to human health or the environment if released to groundwater or other environmental media. Application of green chemistry principles, including reduction of hazardous chemical use and substitution of less hazardous chemicals, would reduce potential risk to the environment or human health.

Recommendation 3.2. Limit the use of hazardous and poorly understood chemicals.

Operators should report the unique Chemical Abstracts Service Registry Number (CASRN) identification for all chemicals used in hydraulic fracturing and acid stimulation, and the use of chemicals with unknown environmental profiles should be disallowed. The overall number of different chemicals should be reduced, and the use of more hazardous chemicals and chemicals with poor environmental profiles should be reduced, avoided, or disallowed. The chemicals used in hydraulic fracturing could be limited to those on an approved list that would consist only of those chemicals with known and acceptable environmental hazard profiles. Operators should apply green chemistry principles to the formulation of hydraulic fracturing fluids, particularly for biocides, surfactants, and quaternary ammonium compounds, which have widely differing potential for environmental harm. Relevant state agencies, including DOGGR, should as soon as practical engage in discussion of technical issues involved in restricting chemical use with a group representing environmental and health scientists and industry practitioners, either through existing roundtable discussions or independently (Volume II, Chapters 2 and 6).

Conclusion 3.3. The majority of impacts associated with hydraulic fracturing are caused by the indirect impacts of oil and gas production enabled by the hydraulic fracturing.

Impacts caused by additional oil and gas development enabled by well stimulation (i.e. indirect impacts) account for the majority of environmental impacts associated with hydraulic fracturing. A corollary of this conclusion is that all oil and gas development causes similar impacts whether the oil is produced with well stimulation or not. As hydraulic fracturing enables only 20-25% of production in California, only about 20-25% of any given indirect impact is likely attributable to hydraulically fractured reservoirs.

Recommendation 3.3. Evaluate impacts of production for all oil and gas development, rather than just the portion of production enabled by well stimulation.

Concern about hydraulic fracturing might cause focus on impacts associated with production from fractured wells, but concern about these indirect impacts should lead to study of all types of oil and gas production, not just production enabled by hydraulic fracturing. Agencies with jurisdiction should evaluate impacts of concern for all oil and gas development, rather than just the portion of development enabled by well stimulation. As appropriate, many of the rules and regulations aimed at mitigating indirect impacts of hydraulic fracturing and acid stimulation should also be applied to all oil and gas wells (Volume II, Chapters 5 and 6).

Conclusion 3.4. Oil and gas development causes habitat loss and fragmentation.

Any oil and gas development, including that enabled by hydraulic fracturing, can cause habitat loss and fragmentation. The location of hydraulic-fracturing-enabled development coincides with ecologically sensitive areas in the Kern and Ventura Counties.

Recommendation 3.4. Minimize habitat loss and fragmentation in oil and gas producing regions.

Enact regional plans to conserve essential habitat and dispersal corridors for native species in Kern and Ventura Counties. The plans should identify top-priority habitat and restrict development in these regions. The plan should also define and require those practices, such as clustering multiple wells on a pad and using centralized networks of roads and pipes, which will minimize future surface disturbances. A program to set aside compensatory habitat in reserve areas when oil and gas development causes habitat loss and fragmentation should be developed and implemented (Volume II, Chapter 5; Volume III, Chapter 5 [San Joaquin Basin Case Study]).

Principle 4. Manage water produced from hydraulically fractured or acid stimulated wells appropriately.

Large volumes of water of various salinities and qualities get produced along with the oil. Oil reservoirs tend to yield increasing quantities of water over time, and most of California's oil reservoirs have been in production for several decades to over a century. For 2013, more than 3 billion barrels (.48 billion m³) of water came along with some 0.2 billion barrels (.032 billion m³) of oil in California. Operators re-inject some produced water back into the oil and gas reservoirs to help recover more petroleum and mitigate land subsidence. In other cases, farmers use this water for irrigation; often blending treated produced water with higher-quality water to reduce salinity.

Conclusion 4.1. Produced water disposed of in percolation pits could contain hydraulic fracturing chemicals.

Based on publicly available data, operators disposed of some produced water from stimulated wells in Kern County in percolation pits. The effluent has not been tested to determine if there is a measureable concentration of hydraulic fracturing chemical constituents. If these chemicals were present, the potential impacts to groundwater, human health, wildlife, and vegetation would be extremely difficult to predict, because there are so many possible chemicals, and the environmental profiles of many of them are unmeasured.

Recommendation 4.1. Ensure safe disposal of produced water in percolation pits with appropriate testing and treatment or phase out this practice.

Agencies with jurisdiction should promptly ensure through appropriate testing that the water discharged into percolation pits does not contain hazardous amounts of chemicals related to hydraulic fracturing as well as other phases of oil and gas development. If the presence of hazardous concentrations of chemicals cannot be ruled out, they should phase out the practice of discharging produced water into percolation pits. Agencies should investigate any legacy effects of discharging produced waters into percolation pits including the potential effects of stimulation fluids (Volume II, Chapter 2; Volume III, Chapters 4 and 5 [Los Angeles Basin and San Joaquin Basin Case Studies]).

Conclusion 4.2. The chemistry of produced water from hydraulically fractured or acid stimulated wells has not been measured.

Chemicals used in each hydraulic fracturing operation can react with each other and react with the rocks and fluids of the oil and gas reservoirs. When a well is stimulated with acid, the reaction of the acid with the rock minerals, petroleum, and other injected chemicals can release contaminants of concern in the oil reservoirs, such as metals or fluoride ions that have not been characterized or quantified. These contaminants may be present in recovered and produced water.

Recommendation 4.2. Evaluate and report produced water chemistry from hydraulically fractured or acid stimulated wells.

Evaluate the chemistry of produced water from hydraulically fractured and acid stimulated wells, and the potential consequences of that chemistry for the environment. Determine how this chemistry changes over time. Require reporting of all significant chemical use, including acids, for oil and gas development (Volume II, Chapters 2 and 6).

Conclusion 4.3. Required testing and treatment of produced water destined for reuse may not detect or remove chemicals associated with hydraulic fracturing and acid stimulation.

Produced water from oil and gas production has potential for beneficial reuse, such as for irrigation or for groundwater recharge. In fields that have applied hydraulic fracturing or acid stimulations, produced water may contain hazardous chemicals and chemical byproducts from well stimulation fluids. Practice in California does not always rule out the beneficial reuse of produced water from wells that have been hydraulically fractured or stimulated with acid. The required testing may not detect these chemicals, and the treatment required prior to reuse necessarily may not remove hydraulic fracturing chemicals.

Recommendation 4.3. Protect irrigation water from contamination by hydraulic fracturing chemicals and stimulation reaction products.

Agencies of jurisdiction should clarify that produced water from hydraulically fractured wells cannot be reused for purposes such as irrigation that could negatively impact the environment, human health, wildlife and vegetation. This ban should continue until or unless testing the produced water specifically for hydraulic fracturing chemicals and breakdown products shows non-hazardous concentrations, or required water treatment reduces concentrations to non-hazardous levels (Volume II, Chapter 2; Volume III, Chapter 5 [San Joaquin Basin Case Study]).

Conclusion 4.4. Injection wells currently under review for inappropriate disposal into protected aquifers may have received water that contains chemicals from hydraulic fracturing.

DOGGR is currently reviewing injection wells in the San Joaquin Valley for inappropriate disposal of oil and gas wastewaters into protected groundwater. The wastewaters injected into some of these wells likely included stimulation chemicals because hydraulic fracturing occurs nearby.

Recommendation 4.4. In the ongoing investigation of inappropriate disposal of wastewater into protected aquifers, recognize that hydraulic fracturing chemicals may have been present in the wastewater.

In the ongoing process of reviewing, analyzing, and remediating the potential impacts of wastewater injection into protected groundwater, agencies of jurisdiction should include the possibility that hydraulic fracturing chemicals may have been present in these wastewaters (Volume II, Chapter 2; Volume III, Chapter 5 [San Joaquin Basin Case Study]).

Conclusion 4.5. Disposal of produced water by underground injection has caused earthquakes elsewhere.

Fluid injected in the process of hydraulic fracturing will not likely cause earthquakes of concern. In contrast, disposal of produced water by underground injection could cause felt or damaging earthquakes. To date, there have been no reported cases of induced seismicity associated with produced water injection in California. However, it can be very difficult to distinguish California's frequent natural earthquakes from those possibly caused by water injection into the subsurface.

Recommendation 4.5. Determine if there is a relationship between wastewater injection and earthquakes in California.

Conduct a comprehensive multi-year study to determine if there is a relationship between oil and gas-related fluid injection and any of California's numerous earthquakes. In parallel, develop and apply protocols for monitoring, analyzing, and managing produced water injection operations to mitigate the risk of induced seismicity. Investigate whether future changes in disposal volumes or injection depth could affect potential for induced seismicity (Volume II, Chapter 4).

Conclusion 4.6. Changing the method of produced water disposal will incur tradeoffs in potential impacts.

Based on publicly available data, operators dispose of much of the produced water from stimulated wells in percolation pits (evaporation-percolation ponds), about a quarter by underground injection (in Class II wells), and less than one percent to surface bodies of water. Changing the method of produced water disposal could decrease some potential impacts while increasing others.

Recommendation 4.6. Evaluate tradeoffs in wastewater disposal practices.

As California moves to change disposal practices, for example by phasing out percolation pits or stopping injection into protected aquifers, agencies with jurisdiction should assess the consequences of modifying or increasing disposal via other methods (Volume II, Chapter 2; Volume II, Chapter 4).

Principle 5. Add protections to avoid groundwater contamination by hydraulic fracturing.

Conclusion 5.1. Shallow fracturing raises concerns about potential groundwater contamination.

In California, about three quarters of all hydraulic fracturing operations take place in shallow wells less than 2,000 feet (600 meters) deep. In a few places, protected aquifers exist above such shallow fracturing operations, and this presents an inherent risk that hydraulic fractures could accidentally connect to the drinking water aquifers and contaminate them or provide a pathway for water to enter the oil reservoir. Groundwater monitoring alone may not necessarily detect groundwater contamination from hydraulic fractures. Shallow hydraulic fracturing conducted near protected groundwater resources warrants special requirements and plans for design control, monitoring, reporting, and corrective action.

Recommendation 5.1. Protect groundwater from shallow hydraulic fracturing operations.

Agencies with jurisdiction should act promptly to locate and catalog the quality of groundwater throughout the oil-producing regions. Operators proposing to use hydraulic fracturing operation near protected groundwater resources should be required to provide adequate assurance that the expected fractures will not extend into these aquifers and cause contamination. If the operator cannot demonstrate the safety of the operation with reasonable assurance, agencies with jurisdiction should either deny the permit, or develop protocols for increased monitoring, operational control, reporting, and preparedness (Volume I, Chapter 3; Volume II, Chapter 2; Volume III, Chapter 5 [San Joaquin Basin Case Study]).

Conclusion 5.2. Leakage of hydraulic fracturing chemicals could occur through existing wells.

California operators use hydraulic fracturing mainly in reservoirs that have been in production for a long time. Consequently, these reservoirs have a high density of existing wells that could form leakage paths away from the fracture zone to protected groundwater or the ground surface. The pending SB 4 regulations going into effect July 2015 do address concerns about existing wells in the vicinity of well stimulation operations; however, it remains to demonstrate the effectiveness of these regulations in protecting groundwater.

Recommendation 5.2. Evaluate the effectiveness of hydraulic fracturing regulations designed to protect groundwater from leakage along existing wells.

Within a few years of the new regulations going into effect, DOGGR should conduct or commission an assessment of the regulatory requirements for existing wells near stimulation operations and their effectiveness in protecting groundwater with less than 10,000 TDS from well leakage. This assessment should include comparisons of field observations from hydraulic fracturing sites with the theoretical calculations for stimulation area or well pressure required in the regulations (Volume II, Chapter 2; Volume III, Chapters 4 and 5 [San Joaquin Basin and Los Angeles Basin Case Studies]).

Principle 6. Understand and control emissions and their impact on environmental and human health.

Gaseous emissions and particulates associated with hydraulic fracturing can arise from the use of fossil fuel in engines, outgassing from fluids, leaks, or proppant. Emissions can also result from all production processes. Such emissions have potential environmental or health impacts.

Conclusion 6.1. Oil and gas production from hydraulically fractured reservoirs emits less greenhouse gas per barrel of oil than other forms of oil production in California.

Burning fossil fuel to run vehicles, make electricity, and provide heat accounts for the vast majority of California's greenhouse gas emissions. In comparison, publicly available California state emission inventories indicate that oil and gas production operations emit about 4% of California total greenhouse gas emissions. Oil and gas production from hydraulically fractured reservoirs emits less greenhouse gas per barrel of oil than production using steam injection. Oil produced in California using hydraulic fracturing also emits less greenhouse gas per barrel than the average barrel imported to California. If the oil and gas derived from stimulated reservoirs were no longer available, and demand for oil remained constant, the replacement fuel could have larger greenhouse gas emissions.

Recommendation 6.1. Assess and compare greenhouse gas signatures of different types of oil and gas production in California.

Conduct rigorous market-informed life-cycle analyses of emissions impacts of different oil and gas production to better understand GHG impacts of well stimulation (Volume II, Chapter 3).

Conclusion 6.2. Air pollutant and toxic air emissions from hydraulic fracturing are mostly a small part of total emissions, but pollutants can be concentrated near production wells.

According to publicly available California state emission inventories, oil and gas production in the San Joaquin Valley air district likely accounts for significant emissions of sulfur oxides (SO_x), volatile organic compounds (VOC), and some air toxics, notably hydrogen sulfide (H₂S). In other oil and gas production regions, production as a whole accounts for a small proportion of total emissions. Hydraulic fracturing facilitates about 20% of California production, and so emissions associated with this production also represent about 20% of all emissions from the oil and gas production in California. Even where the proportion of air pollutant and toxic emissions caused directly or indirectly by well stimulation is small, atmospheric concentrations of pollutants near production sites can be much larger than basin or regional averages, and could potentially cause health impacts.

Recommendation 6.2. Control toxic air emissions from oil and gas production wells and measure their concentrations near production wells.

Apply reduced-air-emission completion technologies to production wells, including stimulated wells, to limit direct emissions of air pollutants, as planned. Reassess opportunities for emission controls in general oil and gas operations to limit emissions. Improve specificity of inventories to allow better understanding of oil and gas emissions sources. Conduct studies to improve our understanding of toxics

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concentrations near stimulated and un-stimulated wells (Volume II, Chapter 3; Volume III, Chapter 4 [Los Angeles Basin Case Study]).

Conclusion 6.3. Emissions concentrated near all oil and gas production could present health hazards to nearby communities in California.

Many of the constituents used in and emitted by oil and gas development can damage health, and place disproportionate risks on sensitive populations, including children, pregnant women, the elderly, and those with pre-existing respiratory and cardiovascular conditions. Health risks near oil and gas wells may be independent of whether wells in production have undergone hydraulic fracturing or not. Consequently, a full understanding of health risks caused by proximity to production wells will require studying all types of production wells, not just those that have undergone hydraulic fracturing. Oil and gas development poses more elevated health risks when conducted in areas of high population density, such as the Los Angeles Basin, because it results in larger population exposures to toxic air contaminants.

Recommendation 6.3. Assess public health near oil and gas production.

Conduct studies in California to assess public health as a function of proximity to all oil and gas development, not just stimulated wells, and develop policies such as science-based surface setbacks, to limit exposures (Volume II, Chapter 6; Volume III, Chapters 4 and 5 [San Joaquin Basin and Los Angeles Basin Case Studies]).

Conclusion 6.4. Hydraulic fracturing and acid stimulation operations add some occupational hazards to an already hazardous industry.

Studies done outside of California found workers in hydraulic fracturing operations were exposed to respirable silica and VOCs, especially benzene, above recommended occupational levels. The oil and gas industry commonly uses acid along with other toxic substances for both routine maintenance and well stimulation. Well-established procedures exist for safe handling of dangerous acids.

Recommendation 6.4. Assess occupational health hazards from proppant use and emission of volatile organic compounds.

Conduct California-based studies focused on silica and volatile organic compounds exposures to workers engaged in hydraulic-fracturing-enabled oil and gas development processes based on the National Institute for Occupational Safety and Health occupational health findings and protocols (Volume II, Chapter 6).

Principle 7. Take an informed path forward.

Conclusion 7.1. Data reporting gaps and quality issues exist.

Significant gaps and inconsistencies exist in available voluntary and mandatory data sources, both in terms of duration and completeness of reporting. Because the hydrologic and geologic conditions and stimulation practices in California differ from other unconventional plays in this country, many data gaps are specific to California.

Recommendation 7.1. Improve and modernize public record keeping for oil and gas production.

DOGGR should digitize paper records and organize all datasets in databases that facilitate searches and quantitative analysis. DOGGR should also institute and publish data quality assurance practices, and institute enforcement measures to ensure accuracy of reporting. When a few years' reporting data become available, a study should assess the value, completeness, and consistency of reporting requirements for hydraulic fracturing and acid treatment operations—and as necessary, revise or expand reporting requirements. The quality and completeness of the data collected by the South Coast Air Quality Management District provides a good example of the completeness and availability the state should seek to emulate. The Department of Conservation should reevaluate well stimulation data trends after 3–5 years of reporting.

Conclusion 7.2. Future research would fill knowledge gaps.

Questions remain at the end of this initial assessment of the impacts of well stimulation in California that can only be answered by new research and data collection. Volumes II and III of this report series provide many detailed recommendations for filling data gaps and additional research. Some examples of key questions include:

- Has any protected groundwater been contaminated with stimulation chemicals in the past, and what would protect against this occurrence in the future? No records of groundwater contamination due to hydraulic fracturing were found, but there were also few investigations designed to look for contamination.
- What environmental risks do stimulation chemicals pose, and are there practices that would limit these risks?
- Can water being produced from hydraulically fractured wells become a resource for California?
- How does oil and gas production as a whole (including that enabled by hydraulic fracturing) affect California's water system?

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- Does California's current or future practice of underground injection of wastewater present a significant risk of inducing earthquakes?
- How can the public best be protected from air pollution associated with oil and gas production?
- What are the ecological impacts of oil and gas development in California?

Recommendation 7.2. Conduct integrated research to close knowledge gaps.

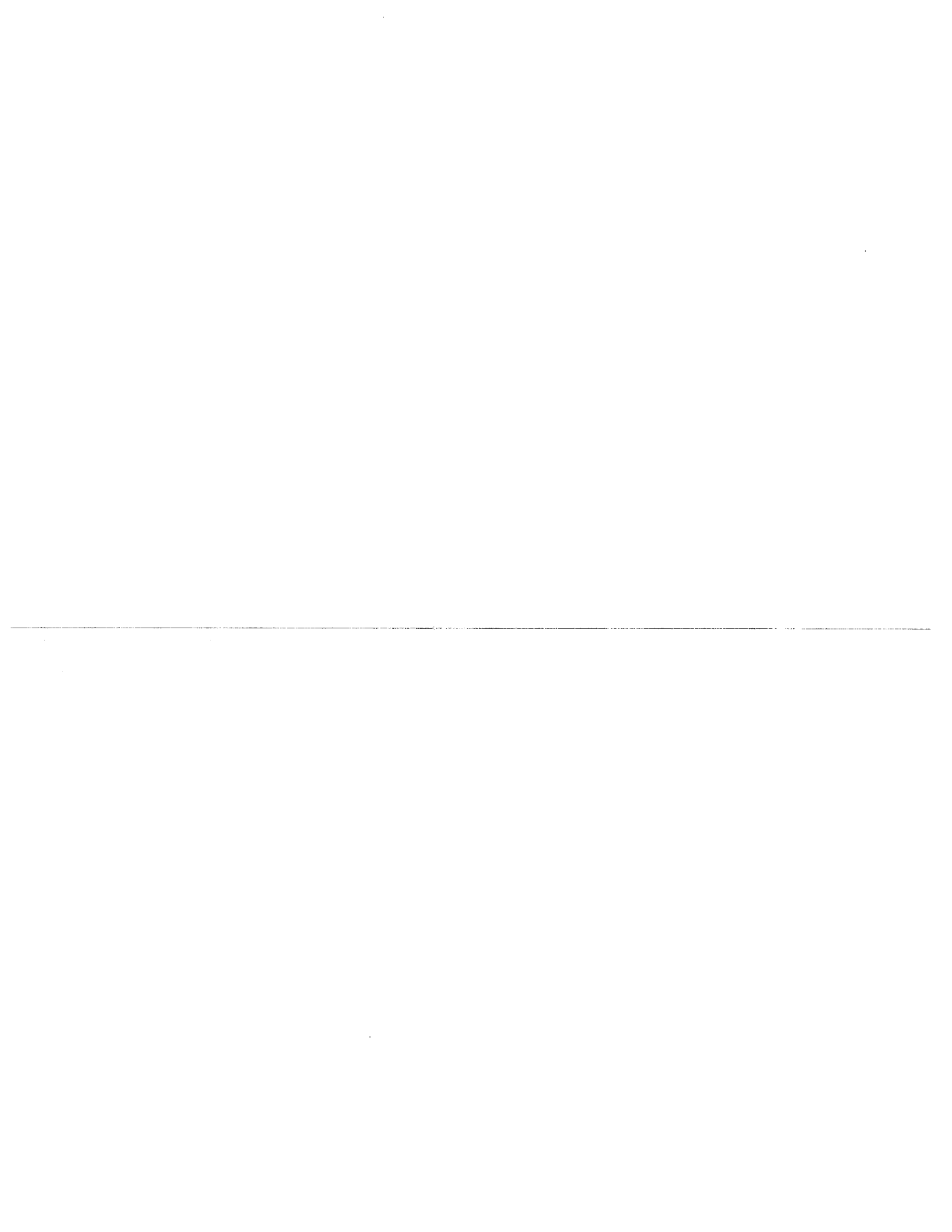
Conduct integrated research studies in California to answer key questions about the environmental, health, and seismic impacts of oil and gas production enabled by well stimulation. Integrated research studies should include regional hydrologic characterization and field studies related to surface and groundwater protection, induced seismicity, ecological conditions, as well as air and health effects.

Conclusion 7.3. Ongoing scientific advice could inform policy.

As the state of California digests this assessment and as more data become available, continued interpretation of both the impacts of well stimulation and the potential meaning of scientific data and analysis would inform the policy framework for this complex topic.

Recommendation 7.3. Establish an advisory committee on oil and gas.

The state of California should establish a standing scientific advisory committee to support decisions on the regulation of oil and gas development.





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