Appendix A

Senate Bill 4 Language Mandating the Independent Scientific Study on Well Stimulation Treatments

The following is the language from Senate Bill 4 (Pavley, Statutes of 2013) that required the independent scientific study on well stimulation treatments, of which this volume comprises the first installment.

3160. (a) On or before January 1, 2015, the Secretary of the Natural Resources Agency shall cause to be conducted, and completed, an independent scientific study on well stimulation treatments, including, but not limited to, hydraulic fracturing and acid well stimulation treatments. The scientific study shall evaluate the hazards and risks and potential hazards and risks that well stimulation treatments pose to natural resources and public, occupational, and environmental health and safety. The scientific study shall do all of the following:

1. Follow the well-established standard protocols of the scientific profession, including, but not limited to, the use of recognized experts, peer review, and publication.

2. Identify areas with existing and potential conventional and unconventional oil and gas reserves where well stimulation treatments are likely to spur or enable oil and gas exploration and production.

3. (A) Evaluate all aspects and effects of well stimulation treatments, including, but not limited to, the well stimulation treatment, additive and water transportation to and from the well site, mixing and handling of the well stimulation treatment fluids and additives onsite, the use and potential for use of nontoxic additives and the use or reuse of treated or produced water in well stimulation treatment fluids, flowback fluids and handling, treatment, and disposal of flowback fluids and other materials, if any, generated by the treatment. Specifically, the potential for the use of recycled water in well stimulation treatments, including appropriate water quality requirements and available treatment technologies, shall be evaluated. Well stimulation treatments include, but are not limited to, hydraulic fracturing and acid well stimulation treatments.

(B) Review and evaluate acid matrix stimulation treatments, including the range of acid volumes applied per treated foot and total acid volumes used in treatments, types of acids, acid concentration, and other chemicals used in the treatments.

4. Consider, at a minimum, atmospheric emissions, including potential greenhouse gas emissions, the potential degradation of air quality, potential impacts on wildlife, native plants, and habitat, including habitat fragmentation, potential water and surface contamination, potential noise pollution, induced seismicity, and the ultimate disposition, transport, transformation, and toxicology of well stimulation treatments, including acid well stimulation fluids, hydraulic fracturing fluids, and waste hydraulic fracturing fluids and acid well stimulation in the environment.

5. Identify and evaluate the geologic features present in the vicinity of a well, including the well bore, that should be taken into consideration in the design of a proposed well stimulation treatment.

6. Include a hazard assessment and risk analysis addressing occupational and environmental exposures to well stimulation treatments, including hydraulic fracturing treatments, hydraulic fracturing treatment-related processes, acid well stimulation treatments, acid well stimulation treatment-related processes, and the corresponding impacts on public health and safety with the participation of the Office of Environmental Health Hazard Assessment.

7. Clearly identify where additional information is necessary to inform and improve the analyses.

Appendix B

CCST Steering Committee Members

CCST Steering Committee Members

Full curricula vitae for Steering Committee members are available upon request. Please contact California Council on Science and Technology (916)-492-0096.

Jane Long, Ph.D.

Principal Associate Director at Large, Lawrence Livermore National Laboratory, Retired

Dr. Long recently retired from Lawrence Livermore National Laboratory where she was the Principal Associate Director at Large, Fellow in the LLNL Center for Global Strategic Research and the Associate Director for Energy and Environment. She is currently a senior contributing scientist for the Environmental Defense Fund, Visiting Researcher at UC Berkeley, Co-chair of the Task Force on Geoengineering for the Bipartisan Policy Center and chairman of the California Council on Science and Technology's California's Energy Future committee. Her current work involves strategies for dealing with climate change including reinvention of the energy system, geoengineering and adaptation. Dr. Long was the Dean of the Mackay School of Mines, University of Nevada, Reno and Department Chair for the Energy Resources Technology and the Environmental Research Departments at Lawrence Berkeley National Lab. She holds a bachelor's degree in engineering from Brown University and Masters and PhD from U. C. Berkeley. Dr. Long is a fellow of the American Association for the Advancement of Science and was named Alum of the Year in 2012 by the Brown University School of Engineering. Dr. Long is an Associate of the National Academies of Science (NAS) and a Senior Fellow and council member of the California Council on Science and Technology (CCST) and the Breakthrough Institute. She serves on the board of directors for the Clean Air Task Force and the Center for Sustainable Shale Development.

Roger Aines, Ph.D.

Senior Scientist, Atmospheric, Earth, and Energy Division and Carbon Fuel Cycle Program Leader E Programs, Global Security, Lawrence Livermore National Laboratory

Roger Aines leads the development of carbon management technologies at Lawrence Livermore National Laboratory, working since 1984 in US national laboratory system. Dr. Aines's work has spanned nuclear waste disposal, environmental remediation, applying stochastic methods to inversion and data fusion, managing carbon emissions and sequestration monitoring and verification methods. Aines takes an integrated view of the energy, climate, and environmental aspects of carbon-based fuel production and use. His current focus is on efficient ways to remove carbon dioxide from the atmosphere and safer methods for producing environmentally clean fuel. He holds 13 patents and has authored more than 100 publications. Aines holds a Bachelor of Arts degree in Chemistry from Carleton College, and Doctor of Philosophy in geochemistry from the California Institute of Technology.

Jens Birkholzer, Ph.D.

Deputy Director, Earth Sciences Division, Lawrence Berkeley National Laboratory

Dr. Birkholzer joined Lawrence Berkeley National Laboratory in 1994 as a post-doctoral fellow and has since been promoted to the second-highest scientist rank at this research facility. He currently serves as the deputy director of the Earth Sciences Division and as the program lead for the nuclear waste program, and also leads a research group working on environmental impacts related to geologic carbon sequestration and other subsurface activities. His area of expertise is subsurface hydrology with emphasis on understanding and modeling coupled fluid, gas, solute and heat transport in complex subsurface systems, such as heterogeneous sediments or fractured rock. His recent research was mostly in the context of risk/performance assessment, e.g., for geologic disposal of radioactive wastes and for geologic CO_2 storage. Dr. Birkholzer has authored about 90 peer-reviewed journal articles and book chapters, and has over 230 conference publications and abstracts.

Donald L. Gautier, Ph.D.

Consulting Petroleum Geologist, DonGautier L.L.C.

With a career spanning almost four decades, Dr. Donald L. Gautier is an internationally recognized leader and author in the theory and practice of petroleum resource analysis. As a principal architect of modern USGS assessment methodology, Gautier's accomplishments include leadership of the first comprehensive evaluation of undiscovered oil and gas resources north of the Arctic Circle, the first national assessment of United States petroleum resources to be fully documented in a digital environment, and the first development of performance-based methodology for assessment of unconventional petroleum resources such as shale gas or light, tight oil. He was lead scientist for the San Joaquin Basin and Los Angeles Basin Resource Assessment projects. His recent work has focused on the analysis of growth of reserves in existing fields and on the development of probabilistic resource/cost functions. Gautier is the author of more than 200 technical publications, most of which concern the evaluation of undiscovered and undeveloped petroleum resources. He holds a Ph.D. in geology from the University of Colorado.

Peter H. Gleick, Ph.D.

President, Pacific Institute

Dr. Peter H. Gleick is an internationally recognized environmental scientist and co-founder of the Pacific Institute in Oakland, California. His research addresses the critical connections between water and human health, the hydrologic impacts of climate change, sustainable water use, privatization and globalization, and international security and conflicts over water resources. Dr. Gleick was named a MacArthur "genius" Fellow in October 2003 for his work on water, climate, and security. In 2006 Dr. Gleick was elected to the U.S. National Academy of Sciences, Washington, D.C. Dr. Gleick's work has redefined water from the realm of engineers to the world of social justice, sustainability, human rights, and integrated thinking. His influence on the field of water has been long and deep: he developed one of the earliest assessments of the impacts of climate change on water resources, defined and explored the links between water and international security and local conflict, and developed a comprehensive argument in favor of basic human needs for water and the human right to water – work that has been used by the UN and in human rights court cases. He pioneered the concept of the "soft path for water," developed the idea of "peak water," and has written about the need for a "local water movement." Dr. Gleick received a B.S. in Engineering and Applied Science from Yale University and an M.S. and Ph.D. from the Energy and Resources Group of the University of California, Berkeley. He serves on the boards of numerous journals and organizations, and is the author of many scientific papers and ten books, including Bottled & Sold: The Story Behind Our Obsession with Bottled Water and the biennial water report, The World's Water, published by Island Press (Washington, D.C.).

A. Daniel Hill, Ph.D.

Department Head, Professor and holder of the Noble Chair, Petroleum Engineering Department at Texas A&M University

Dr. A. D. Hill is Professor, holder of the Noble Endowed Chair, and Department Head of Petroleum Engineering at Texas A&M University. Previously, he taught for twenty-two years at The University of Texas at Austin after spending five years in industry. He holds a B. S. degree from Texas A&M University and M. S. and Ph. D. degrees from The University of Texas at Austin, all in chemical engineering. He is the author of the Society of Petroleum Engineering (SPE) monograph, Production Logging: Theoretical and Interpretive Elements, co-author of the textbook, Petroleum Production Systems (1st and 2nd editions), co-author of an SPE book, Multilateral Wells, and author of over 170 technical papers and five patents. He has been a Society of Petroleum Engineers (SPE) Distinguished Lecturer, has served on numerous SPE committees and was founding chairman of the Austin SPE Section. He was named a Distinguished Member of SPE in 1999 and received the SPE Production and Operations Award in 2008. In 2012, he was one of the two inaugural winners of the SPE Pipeline Award, which recognizes faculty, who have fostered petroleum engineering Ph.Ds. to enter academia. He currently serves on the SPE Editorial Review Committee, the SPE Global Training Committee, and the SPE Hydraulic Fracturing Technology Conference Program Committee. Professor Hill is an expert in the areas of production engineering, well completions, well stimulation, production logging, and complex well performance (horizontal and multilateral wells), and has presented lectures and courses and consulted on these topics throughout the world.

Larry Lake, Ph.D.

Professor, Department of Petroleum and Geosystems Engineering, University of Texas, Austin

Larry W. Lake is a professor of the Department of Petroleum and Geosystems Engineering at The University of Texas at Austin and director of the Center for Petroleum Asset Risk Management. He holds B.S.E and Ph.D. degrees in Chemical Engineering from Arizona State University and Rice University. Dr. Lake has published widely; he is the author or co-author of more than 100 technical papers, the editor of 3 bound volumes and author or co-author of four textbooks. He has been teaching at UT for 34 years before which he worked for Shell Development Company in Houston, Texas. He was chairman of the PGE department twice, from 1989 to 1997 and from 2008- 1010. He formerly held the Shell Distinguished Chair and the W.A. (Tex) Moncrief, Jr. Centennial Endowed Chair in Petroleum Engineering. He currently holds the W.A. (Monty) Moncrief Centennial Chair in Petroleum Engineering. Dr. Lake has served on the Board of Directors for the

Society of Petroleum Engineers (SPE) as well as on several of its committees; he has twice been an SPE distinguished lecturer. Dr. Lake is a member of the US National Academy of Engineers and won the 1996 Anthony F. Lucas Gold Medal of the SPE. He won the 1999 Dad's Award for excellence in teaching undergraduates at The University of Texas and the 1999 Hocott Award in the College of Engineering for excellence in research. He also is a member of the 2001 Engineering Dream Team awarded by the Texas Society of Professional Engineers. He is an SPE Honorary Member.

Tom McKone, Ph.D.

Deputy for Research Programs in the Energy Analysis and Environmental Impacts Department, Lawrence Berkeley National Laboratory (LBNL)

Thomas E. McKone, is a senior staff scientist and Deputy for Research Programs in the Energy Analysis and Environmental Impacts Department at the Lawrence Berkeley National Laboratory (LBNL) and Professor of Environmental Health Sciences at the University of California, Berkeley School of Public Health. At LNBL he leads the Sustainable Energy Systems Group. His research focuses on the development, use, and evaluation of models and data for human-health and ecological risk assessments and the health and environmental impacts of energy, industrial, and agricultural systems. Outside of Berkeley, he has served six years on the EPA Science Advisory Board, has been a member of more than a dozen National Academy of Sciences (NAS) committees including the Board on Environmental Studies and Toxicology, and has been on consultant committees for the Organization for Economic Cooperation and Development (OECD), the World Health Organization, the International Atomic Energy Agency, and the Food and Agriculture Organization. McKone is a Fellow of the Society of Risk Analysis and has received two major awards from the International Society of Exposure Analysis—one for lifetime achievement in exposure science research and one for research that has impacted major international and national environmental policies.

William A. Minner, P.E.

Principal Consultant, StrataGen, Inc.

Minner is a principal consultant with StrataGen, Inc., a petroleum engineering consulting firm with a focus on hydraulic fracture well stimulation treatments. After receiving B.S. and M.S. degrees in mechanical engineering with a petroleum option from the University of California, Berkeley, Minner joined Unocal in 1980, and began to focus on hydraulic fracturing well stimulation in 1985. In 1995, he opened an office for Pinnacle Technologies in Bakersfield. Pinnacle's focus was on the development and

commercialization of hydraulic fracture mapping technologies; His role was engineering consulting, using fracture diagnostics and mapping to assist clients with hydraulic fracture engineering design, execution, and analysis. His engineering consulting role continued after the fracture mapping business was sold in 2008, and the name was changed to StrataGen. Minner is a registered Petroleum Engineer in California, and received a Society of Petroleum Engineers Production and Operations Award in 2011 for his contribution to technical progress and interchange. He has authored or coauthored 21 industry technical papers on hydraulic fracturing.

Amy Myers Jaffe

Executive Director, Energy and Sustainability, UC Davis

Amy Myers Jaffe is a leading expert on global energy policy, geopolitical risk, and energy and sustainability. Jaffe serves as executive director for Energy and Sustainability at University of California, Davis with a joint appointment to the Graduate School of Management and Institute of Transportation Studies (ITS). At ITS-Davis, Jaffe heads the fossil fuel component of Next STEPS (Sustainable Transportation Energy Pathways). She is associate editor (North America) for the academic journal, Energy Strategy Reviews. Prior to joining UC Davis, Jaffe served as director of the Energy Forum and Wallace S. Wilson Fellow in Energy Studies at Rice University's James A. Baker III Institute for Public Policy. Jaffe's research focuses on oil and natural gas geopolitics, strategic energy policy, corporate investment strategies in the energy sector, and energy economics. She was formerly senior editor and Middle East analyst for Petroleum Intelligence Weekly. Jaffe is widely published, including as co-author of "Oil, Dollars, Debt and Crises: The Global Curse of Black Gold" (Cambridge University Press, January 2010 with Mahmoud El-Gamal). She served as co-editor of "Energy in the Caspian Region: Present and Future" (Palgrave, 2002) and "Natural Gas and Geopolitics: From 1970 to 2040" (Cambridge University Press, 2006). Jaffe was the honoree for Esquire's annual 100 Best and Brightest in the contribution to society category (2005) and Elle Magazine's Women for the Environment (2006) and holds the excellence in writing prize from the International Association for Energy Economics (1994).

Seth B. Shonkoff, Ph.D., MPH

Executive Director, Physicians Scientists & Engineers for Healthy Energy

Dr. Shonkoff is the executive director of the energy science and policy organization, Physicians Scientists & Engineers for Healthy Energy (PSE), and a visiting scholar in the Department of Environmental Science, Policy and Management at UC Berkeley. An environmental and public health scientist by training, he has many years of experience

in water, air, climate, and population health research. Dr. Shonkoff completed his PhD in the Department of Environmental Science, Policy, and Management and his MPH in epidemiology at the School of Public Health from the University of California, Berkeley. He is a contributing author to Chapter 11, Human Health: Impacts, Adaptation, and Co-Benefits the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment report (AR5). He has worked and published on topics related to air and water quality and the environmental and public health dimensions of energy choices and climate change from scientific and policy perspectives. Dr. Shonkoff has also researched interaction between the climate and human health dimensions of shorter-live climate forcing emissions (i.e., ozone, black carbon, sulphate particles, etc.) and on the development of more effective anthropogenic climate change mitigation policies that generate socioeconomic and health co-benefits. Dr. Shonkoff's current work focuses on the human health, environmental and climate dimensions of oil and gas development in the United States and abroad.

Dan Tormey, Ph. D., P.G.

Principal, ENVIRON International Corporation

Dr. Daniel Tormey is an expert in energy and water and conducts environmental reviews for both government and industry. He works with the environmental aspects of all types of energy development, with an emphasis on oil and gas, including hydraulic fracturing and produced water management, pipelines, LNG terminals, refineries and retail facilities. Dr. Tormey was the principal investigator for the peer-reviewed, publicly-available, Hydraulic Fracturing Study at the Baldwin Hills of southern California, on behalf of the County of Los Angeles and the field operator, PXP. He conducts projects in sediment transport, hydrology, water supply, water quality, and groundwater-surfacewater interaction. He has been project manager or technical lead for over two hundred projects requiring fate and transport analysis of chemicals in the environment. He has a Ph.D. in Geology and Geochemistry from MIT, and a B.S. in Civil Engineering and Geology from Stanford. He is a Principal at ENVIRON International Corporation; was named by the National Academy of Sciences to the Science Advisory Board for Giant Sequoia National Monument; is a Distinguished Lecturer for the Society of Petroleum Engineers; is on the review committee on behalf of IUCN for the UNESCO World Heritage Site List; is volcanologist for Cruz del Sur, an emergency response and contingency planning organization in Chile; was an Executive in Residence at California Polytechnic University San Luis Obispo; and is a Professional Geologist in California. He has worked throughout the USA, Australia, Indonesia, Italy, Chile, Ecuador, Colombia, Venezuela, Brazil, Senegal, South Africa, Armenia and the Republic of Georgia.

Sam Traina, Ph.D.

Vice Chancellor of Research, University of California, Merced

Dr. Traina is the Vice Chancellor for Research and Economic Development at the University of California, Merced where he holds the Falasco Chair in Earth Sciences and Geology. He serves as a Board Member of the California Council of Science and Technology. Prior to joining UC Merced in 2002 as a Founding Faculty member and the Founding Director of the Sierra Nevada Research Institute, Dr. Traina was a faculty member for 17 years at the Ohio State University, with concomitant appointments in the School of Natural Resources and the Environment, the department of Earth Science and Geology, Civil and Environmental Engineering, Microbiology and Chemistry. He has served on the National Research Council's Standing Committee on Earth Resources. In 1997-1998 he held the Cox Visiting Professorship in the School of Earth Sciences at Stanford University. Dr. Traina's past and current research has dealt with the fate, transformation and transport of contaminants in the soils and natural waters with an emphasis on radionuclides, heavy metals, and mining wastes. Dr. Traina holds a B.S. In soil resource management and Ph.D. in soil chemistry. He is a fellow of the Soil Science Society of American and of the American Association for the Advancement of Science as well as a recipient of the Clay Scientist Award of the Clay Minerals Society.

Disclosure of Conflict of Interest: Prof. Dan Hill

In accordance with the practice of the California Council on Science and Technology (CCST), CCST makes best efforts to ensure that no individual appointed to serve on a committee has a conflict of interest that is relevant to the functions to be performed, unless such conflict is promptly and publicly disclosed and CCST determines that the conflict is unavoidable. A conflict of interest refers to an interest, ordinarily financial, of an individual that could be directly affected by the work of the committee. An objective determination is made for each provisionally appointed committee member whether or not a conflict of interest exists given the facts of the individual's financial and other interests, and the task being undertaken by the committee. A determination of a conflict of interest for an individual is not an assessment of that individual's actual behavior or character or ability to act objectively despite the conflicting interest.

We have concluded that for this committee to accomplish the tasks for which it was established, its membership must include among others, individuals with research and expertise in the area of acid treatments for petroleum wells who have studied oil and gas industry operations in the United States and are internationally recognized for this expertise. Acid treatment is of particular public concern in California and is the subject of regulation under SB4.

To meet the need for this expertise and experience, Dr. Dan Hill is proposed for appointment to the committee, even though we have concluded that he has a conflict of interest because of investments he holds and research services provided by his employer.

As his biographical summary makes clear, Dr. Hill is a recognized expert in petroleum reservoir engineering with many publications to wit. He is also known as one of the world's key experts in acid treatment.

After an extensive search, we have been unable to find another individual with the equivalent combination of expertise in acid treatment as Dr. Hill, who does not have a similar conflict of interest. Therefore, we have concluded that this potential conflict is unavoidable.

Disclosure of Conflict of Interest: William Minner

In accordance with the practice of the California Council on Science and Technology (CCST), CCST makes best efforts to ensure that no individual appointed to serve on a committee has a conflict of interest that is relevant to the functions to be performed, unless such conflict is promptly and publicly disclosed and CCST determines that the conflict is unavoidable. A conflict of interest refers to an interest, ordinarily financial, of an individual that could be directly affected by the work of the committee. An objective determination is made for each provisionally appointed committee member whether or not a conflict of interest exists given the facts of the individual's financial and other interests, and the task being undertaken by the committee. A determination of a conflict of interest for an individual is not an assessment of that individual's actual behavior or character or ability to act objectively despite the conflicting interest.

We have concluded that for this committee to accomplish the tasks for which it was established its membership must include, among others, individuals with direct experience in the area of well stimulation practice, specifically in California. Well stimulation is of particular public concern in California and is the subject of regulation under SB4. The practice in California is significantly different than in other states so we require someone with direct experience in the state.

To meet the need for this expertise and experience, William Minner is proposed for appointment to the committee even though we have concluded that he has a conflict of interest because of investments he holds and research services provided by his employer.

As his biographical summary makes clear, William Minner is a recognized expert in petroleum reservoir stimulation with a long history of practice in California as well as around the world. He is one of the most recognized experts in California well stimulation design and execution.

After an extensive search, we have been unable to find another individual with the equivalent combination of expertise as William Minner, who does not have a similar conflict of interest. Therefore, we have concluded that this potential conflict is unavoidable.

Appendix C

Report Author Biosketches

- **Jens Birkholzer**, Lawrence Berkeley National Laboratory
- **Patrick F. Dobson**, Lawrence Berkeley National Laboratory
- **Laura Feinstein**, California Council on Science and Technology (CCST)
- **Donald Gautier**
- **Matthew Heberger**, Pacific Institute
- **James E. Houseworth**, Lawrence Berkeley National Laboratory
- **Preston D. Jordan**, Lawrence Berkeley National Laboratory
- **Jane Long**, California Council on Science and Technology (CCST)

Full curricula vitae for authors are available upon request. Please contact California Council on Science and Technology (916)-492-0096

Jens T. Birkholzer

Earth Sciences Division, MS 74-R316C
Lawrence Berkeley National Laboratory, Berkeley, CA 94720
(510) 486-7134 fax: (510) 486-5686
jtbirkholzer@lbl.gov
http://esd.lbl.gov/ESD_staff/birkholzer/index.html

Education

1982-1985	University of Technology, Aachen. B.Sc. in Civil Engineering, 1985.
1985-1988	University of Technology, Aachen. M.Sc. in Water Resources, Hydraulic Engineering, Soil and Rock Mechanics, 1988.
1989-1994	University of Technology, Aachen. Ph.D. in Subsurface Hydrology, 1994.

Research and Professional Experience

Dr. Birkholzer joined LBNL in 1994 as a post-doctoral fellow and has since been promoted to the second-highest scientist rank at this research facility. He currently serves as the deputy director of the Earth Sciences Division and as the program lead for the nuclear waste program, and also leads a research group working on environmental impacts related to geologic carbon sequestration and other subsurface activities. His area of expertise is subsurface hydrology with emphasis on understanding and modeling coupled fluid, gas, solute and heat transport in complex subsurface systems, such as heterogeneous sediments or fractured rock. His recent research was mostly in the context of risk/performance assessment, e.g., for geologic disposal of radioactive wastes and for geologic CO_2 storage. Dr. Birkholzer has authored about 90 peer-reviewed journal articles and book chapters, and has over 230 conference publications and abstracts.

Current and past Positions

Since 2014	Deputy Director, Earth Sciences Division, Lawrence Berkeley National Laboratory (LBNL)
Since 2008	Program Lead, Nuclear Energy and Waste, Earth Sciences Division, LBNL
Since 2001	Staff Scientist and Group Leader, Earth Sciences Division, LBNL
1999 - 2001	Chief Engineer and Project Manager, Construction of the New International Airport in Dusseldorf, HOCHTIEF AG, Germany
1994 - 1998	Geological Scientist, Earth Sciences Division, LBNL

1989 - 1994	Research Associate (since 1993 Group Leader), Institute of Hydraulic Engineering and Water Resources Management (IWW), University of Technology, Aachen, Germany

Honors and Awards:

2012	Director's Award for Exceptional Achievement (TOUGH codes), by LBNL
2007, 1997	Outstanding Performance Award, by LBNL
1995 - 1996	Postdoctoral fellowship granted by the Humboldt-Stiftung
1995	Friedrich-Wilhelm Award for Summa Cum Laude Ph.D. Thesis
1995	Borchers Award for Summa Cum Laude Ph.D. Thesis
1994 - 1995	Postdoctoral fellowship granted by the DAAD
1989	Research-fellowship granted by the DAAD
1989	Springorum Award for Summa Cum Laude M.Sc.
1989	Hünnebeck Award for best Master Thesis
since 1986	Studienstiftung des Deutschen Volkes

Patrick F. Dobson

Earth Sciences Division, MS 74-R316C
Lawrence Berkeley National Laboratory, Berkeley, CA 94720
(510) 486-5373 fax: (510) 486-5686
pfdobson@lbl.gov

Education

1977-1981	Williams College, Williamstown, MA, BA in Geology (magna cum laude)
1981-1984	Stanford University, Stanford, CA, M.S. in Geology
1984-1986	Stanford University, Stanford, CA, Ph.D. in Geology

Research and Professional Experience

Dr. Dobson has been a research scientist in the Earth Sciences Division of LBNL since 2000. His expertise is in the study of water-rock interaction related to geothermal systems and high-level radioactive waste repositories. His most recent work has focused on radioactive waste disposal in shales, use of He isotopes in characterization of geothermal systems, and developing methodologies for assessing geothermal resources.

Current and Past Positions

2010-present	Career Geological Staff Scientist, Earth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA
2007-2009	Deputy Program Manager, Geosciences Program, Office of Basic Energy Sciences, US Department of Energy, Germantown, MD (on detail from LBNL)
2003-2010	Career Geological Research Scientist, Earth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA
2000-2003	Geological Scientist, Earth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA
1999-2001	Consultant, Empresa Nacional del Petroleo (ENAP), Santiago, Chile
1998-1999	Advising Geologist, Unocal Geothermal and Power Operations, Unocal Corporation, Santa Rosa, CA

1994-1998	Senior Geologist, Unocal Geothermal and Power Operations, Unocal Corporation, Santa Rosa, CA
1989-1994	Research Geologist, Unocal Science and Technology Division, Unocal Corporation, Brea, CA
1989	Postdoctoral Research Fellow, Department of Geological Sciences, University of California, Santa Barbara, CA
1986-1989	Postdoctoral Research Fellow, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA

Honors and Awards

2012	Geothermal Special Achievement Award, Geothermal Resources Council
2012	Fulbright Specialist Grant in Environmental Science, University of Chile
2009	Outstanding Contributions in Geosciences Research Award, DOE BES
2002, 2006	SPOT Awards (3), Lawrence Berkeley National Laboratory
1995, 1998	Special Recognition Awards (3), Unocal Corporation
1992	Fred L. Hartley Research Center Creativity Award, Unocal Corporation

Laura C. Feinstein

California Council on Science and Technology
1130 K Street, Suite 280, Sacramento, CA 95814-3965
(530) 204 - 8325
laura.feinstein@ccst.us

Education

1994-1998	University of California at Berkeley, Berkeley, CA. B.A. in Anthropology, 1998.
2006-2012	University of California at Davis, Davis, CA. Ph.D. in Ecology, 2012.

Research and Professional Experience

Dr. Feinstein has worked for the California Council on Science and Technology (CCST) since January 2014. She previously served as a CCST Science and Technology Fellow with the California Senate Committee on Environmental Quality. Her graduate student research focused on the ecology and genetics of an invasive plant species in the San Francisco Bay's tidal wetlands. She has worked on a diverse array of ecological problems, including restoration of coastal marshes, biogeochemical cycles in redwood forests, and the genetics of adaptation. Laura has published and presented at numerous conferences on ecological genetics and tidal wetland plant communities.

Current and past Positions

Since 2014	Project Manager, Well Stimulation Technology in California, California Council on Science and Technology (CCST)
Since 2012	Postdoctoral researcher, restoration of San Francisco Bay tidal marshes, U.C. Davis
2012-2013	CCST Science and Technology Policy Fellow with the California Senate Committee on Environmental Quality
2006 - 2012	Ph.D. student, U.C. Davis

Honors and Awards

2007	CALFED Bay-Delta Science Fellow
2006	National Science Foundation Integrative Graduate Education and Research Traineeship on Invasive Species Research Award
2006	California Native Plant Society Research Award

Donald Gautier

Consulting Geologist
University of Adelaide (Adjunct Professor); U.S. Geological Survey (Scientist Emeritus)

Research: During a career spanning almost four decades I have conducted basic and applied research to address problems of petroleum geology and resource analysis. An extensive publication record and a global reputation for excellence in speaking, writing and teaching document this body of work.

My research has contributed to significant advancements, which include: (1) the first comprehensive evaluation of undiscovered oil and gas resources north of the Arctic Circle (Gautier and others 2009; Gautier and others 2011), (2) the first assessment of United States petroleum resources to be fully documented in a digital environment (Gautier and others 1995a; Gautier and others 1995b), (3) quantification of the relationship between porosity and time-temperature exposure in quartz-rich sandstones (Schmoker and Gautier 1988; Gautier and Schmoker 1989), and (4) the linkage of authigenic mineral precipitation in fine-grained sediments to the microbial geochemistry of early diagenetic environments (Gautier 1982; Gautier and Claypool 1984).

Recent work has focused on the quantitative evaluation of unconventional resources, the analysis of reserve growth in existing fields, and the development of probabilistic resource/cost analysis techniques to support interdisciplinary resource decisions.

Teaching: For the last ten years, my teaching has emphasized intensive graduate or professional-level training for university, government, and industrial groups. Courses and workshops have addressed the geology of unconventional resources, resource evaluation, quantitative assessment methodology, and geopolitical and economic issues related to the global distribution and quality of petroleum resources. Recent course offerings have included: Geology and Assessment of Unconventional Reservoirs, Play Assessment Methodology, and Integration of Resource Geology and Microeconomics

Outreach and Public Service: Lots of my time goes to providing information and guidance to governmental and non-profit organizations such as the California Division of Oil, Gas, and Geothermal Resources, California Council on Science and Technology, Central Intelligence Agency, EuroGeoSurveys, United States Coast Guard, U.S. Department of State, Energy Information Administration, International Energy Agency, Geological Survey of Denmark and Greenland, National Intelligence Council, The Nature Conservancy, Norwegian Petroleum Directorate, Massachusetts Institute of Technology, University of California, and the World Bank.

Professional societies seek me out as a meeting convener, technical session chair, short course teacher, expert panelist and speaker. I have enjoyed contributing my expertise

to the World Petroleum Congress, the International Geological Congress, the American Association of Petroleum Geologists, the European Association of Geoscientists and Engineers, the Geological Society of London, and many other organizations.

The international press and scientific journalists regard me as a trusted source of objective information on issues of global petroleum resources and their development. I routinely grant print, radio, and television interviews to organizations such as the BBC, CBC, CNN, National Geographic, the New York Times, PBS, Der Spiegel, Science Magazine, and the Wall Street Journal.

Matthew G. Heberger

Pacific Institute
654 13th Street, Oakland, CA 94612
Tel: 510-251-1600 x128 Fax: 510-251-2203
mheberger@pacinst.org
http://www.pacinst.org/

Education

1992–1996	Cornell University, Ithaca, New York. B.S. in Agricultural and Biological Engineering, 1996.
2001–2003	Tufts University, Medford, Massachusetts. M.S. in Water Resources Engineering, 2003.

Research and Professional Experience

Mr. Heberger has been a research associate in the Water Program of the Pacific Institute since 2007. He is a water resource engineer and hydrologist specializing in hydraulic, hydrologic, and water quality analyses and modeling, the nexus between water and energy, and impacts of climate change on water resources. Prior to joining the institute Mr. Heberger worked as a consulting engineer at the consulting firm of Camp, Dresser, and McKee (CDM) where he was responsible for building and calibrating rainfall-runoff, hydraulic and water quality models for major waterways across the US.

Current and past Positions

Since 2007	Research Associate, Pacific Institute, Oakland, California
2003 – 2007	Water Resources Engineer, Camp Dresser & McKee, Cambridge, Massachusetts
2001 – 2003	Research Assistant, Department of Civil and Environmental Engineering, Tufts University, Medford, Massachusetts
1999 – 2001	Coordinator, International Network on Participatory Irrigation Management, Washington, DC
1996 – 1998	Water and Sanitation Extension Agent, United States Peace Corps, Mali, West Africa

Honors and Awards:

2007	Registered Professional Engineer, Commonwealth of Massachusetts
2004	Certified Floodplain Manager, Association of State Floodplain Managers

James E. Houseworth

Earth Sciences Division, MS 74-R316C
Lawrence Berkeley National Laboratory, Berkeley, CA 94720
(510) 486-6459 fax: (510) 486-5686
jehouseworth@lbl.gov
http://esd.lbl.gov/about/staff/jameshouseworth/

Education

1973-1977	California Institute of Technology, Pasadena, CA. B.S. in Environmental Engineering, 1977.
1977-1978	California Institute of Technology, Pasadena, CA. M.S. in Environmental Engineering, 1978.
1979-1984	California Institute of Technology, Pasadena, CA. Ph.D. in Environmental Engineering, 1984.

Research and Professional Experience

Dr. Houseworth has been a program manager in the Earth Sciences Division of Lawrence Berkeley National Laboratory (LBNL) since 2000. His expertise is in single and multiphase flow and solute transport in porous and fractured geologic media and has worked on applications to petroleum recovery, nuclear waste disposal, and geologic CO_2 sequestration. His most recent work has centered on nuclear waste disposal in argillaceous rock, CO_2/brine leakage from geologic storage reservoirs, and risk assessments of petroleum recovery operations. Dr. Houseworth has authored over 30 peer-reviewed journal articles and conference publications.

Current and Past Positions

Since 2000	Program Manager, Earth Sciences Division, Lawrence Berkeley National Laboratory (LBNL)
1997 – 2000	Technical Systems Manager II, Duke Engineering and Services, Las Vegas, Nevada
1992 – 1997	Senior Staff Consultant, INTERA Inc., Las Vegas, Nevada
1984 – 1992	Research Engineer, Chevron Oil Field Research Company, La Habra, California
1979 – 1980	Engineer, Bechtel Inc., San Francisco, California

Honors and Awards

2012	Director's Award for Exceptional Achievement (TOUGH codes), by LBNL
2007, 2006	Outstanding Performance Award, by LBNL
1984	Ph.D. thesis - Richard Bruce Chapman Memorial Award

Preston D. Jordan

Earth Sciences Division, MS 74-R316C
Lawrence Berkeley National Laboratory, Berkeley, CA 94720
(510) 486-6774, fax: (510) 486-5686
PDJordan@lbl.gov

Education

1982-1987	University of California, Berkeley, B.A., Geology, 1988
1996-1997	University of California, Berkeley, M.S. in Eng. Sci., Geotechnical Engineering, 1997
Licenses:	California Professional Geologist (since 1998) California Certified Hydrogeologist (since 2007) California Certified Engineering Geologist (since 2012)

Research Interests

Mr. Jordan has been a geologist in the Earth Sciences Division at Lawrence Berkeley National Laboratory (LBNL) since 1990. His research over the last eight years has focused primarily on the risk of geologic carbon storage, with a focus on assessing leakage risk. His work on a risk assessment of one of the few industrial-scale geologic carbon storage projects in the world led the operator to reduce the injection pressure. Mr. Jordan has co-authored over 15 peer-reviewed journal articles and conference papers.

Professional Experience

Since 1990	Staff Research Associate currently (after five promotions), Earth Science Division, Lawrence Berkeley National Laboratory
1988-1989	Staff Geologist, Harlan Tait Associates, San Francisco
1988	Field Geologist, Department of Geology and Geophysics, University of California, Berkeley
1987	Assistant Field Geologist, Department of Geology and Geophysics, University of California, Berkeley

Honors and Awards

2010	Outstanding Performance Award, by LBNL
1987	USGS/NAGT program nominee, by University of California, Berkeley

Dr. Jane C. S. Long

California Council on Science and Technology
1130 K Street, Suite 280, Sacramento, CA 95814
916-492-0096

Dr. Long currently focuses on strategic approaches to the climate change problem. She has led efforts to define energy systems with radical emission cuts that can feasibly be built by mid century. In recognition that the outcomes of climate change might become extremely severe, she leads a national effort to begin research on intentional modification of the climate: geoengineering. Dr. Long also works to bring a factual basis to the debate about hydraulic fracturing and to develop standards for safe practice.

Dr. Long recently retired from Lawrence Livermore National Laboratory as Principal Associate Director at Large. Her leadership was focused on insuring that energy research was coordinated with climate research and the directorate she led was not just describing the climate problem, but developing solutions to this problem. Outside of the Lab, she was co-chair of the Task Force on Geoengineering for the Bipartisan Policy Center that issued a report recommending that the US begin research on this topic. She led the effort to propose concrete steps the government can take to start research that will be featured in an upcoming "Comment" piece in Nature. These steps recommend governance appropriate for this controversial topic, including review of scientific and social merit, risk assessment, transparency and vested interests management and legal constructs.

She is chairman of the California Council on Science and Technology's California's Energy Future committee, which produced a series of reports designed to show if and how California could reduce emissions by 80% by 2050. These reports contained a methodology – a four-step process -- for thinking about this problem that has had influence well beyond the California borders. Many advocates or plans for a new energy system do not take feasibility into account and they often use questionable accounting in counting emissions. The methodology contained in these reports explicitly assesses feasibility and presents an accounting framework for ensuring emission reductions are all counted and counted once. Dr. Long wrote the summary report in language understandable by policy makers and this report is cited frequently and she has presented the material in many places throughout the country.

She is now on the board of the Center for Sustainable Shale Gas Development in Pennsylvania which is an organization formed to provide voluntary environmental certification for hydraulic fracturing operators. On this board she has worked to help develop a standard for wastewater treatment and disposal, perhaps the most difficult environmental problem associated with hydraulic fracturing. She is the lead for a legislatively mandated study of hydraulic fracturing in the state of California. This multimillion dollar assessment includes a large team of scientists. In this role, she has served as the bridge between science and policy by working with scientists to tailor highly

technical assessments to the public concerns and to communicate both issues that are usually not discussed but are important and identify issues that are often discussed, but in reality not important.

As the Dean of the Mackay School of Mines, Dr. Long started the Director of the Great Basin Center for Geothermal Energy and through her initiative, the state instituted the Task Force on Renewable Energy and Energy Conservation, which was the first time Nevada had a state body devoted to promoting these technologies. She also initiated the Mining Life-Cycle Center designed to act like an extension service in promoting sustainable practice to the mining industry.. Dr. Long also worked at Lawrence Berkeley National Laboratory leading teams to clean up environmental contamination, develop geothermal energy, and store nuclear waste.

Appendix D

Glossary

Acid fracturing – a form of hydraulic fracture stimulation of a formation performed by injecting the acid over the parting pressure of the rock and using the acid to etch channels in the fracture face.

Androgens – steroid hormones that promote the development and maintenance of male characteristics of the body.

Anti-androgens – a substance that can prevent the full expression of androgen.

Anti-estrogens – a substance that can prevent the full expression of estrogen.

Aquifer – a zone of saturated rock or soil through which water can easily move.

Bactericide – a product that kills bacteria in the water or on the surface of the pipe.

Basement faults – faults that occur in the undifferentiated assemblage of rock underlying the oldest stratified rocks in any region.

Basement rock – the undifferentiated assemblage of rock underlying the oldest stratified rocks in any region.

Bedding planes – surfaces that separate sedimentary layers in a rock. The beds are distinguished from each other by grain size and composition, such as in shale and sandstone. Subtle changes, such as beds richer in iron-oxide, help distinguish bedding. Most beds are deposited essentially horizontally.

Biogenic methane – methane produced as a direct consequence of bacterial activity.

Biomarkers – complex molecular fossils used to correlate crude oil and petroleum source rocks, provide information on the type of organic matter, and characterize the thermal maturity.

Borehole cuttings – the small chips and fines generated by drilling through a formation with a drill bit. Most of the cuttings are removed from the drilling mud as the fluid pass through the solids control equipment (e.g., shakers, screens, cyclones, etc.,) at the surface.

Brittle – a rock characteristic that implies mechanical failure in the form of a fracture created with little or no plastic deformation.

BTEX (benzene, toluene, ethylbenzene, and xylene) – volatile aromatic compounds typically found in petroleum products such as gasoline and diesel fuel.

Buffer – a chemical used to maintain the pH of a solution within a limited range.

Cations – positively charged ions.

Chemical Abstracts Service (CAS) number – a unique numeric identifier, designates only one substance, has no chemical significance, and is a link to a wealth of information about a specific chemical substance within the CAS registry.

Chimneys – vertically oriented geological structures that may have circular or subcircular in planform if associated with faults or may be more disperse laterally if not associated with faults. Chimneys form from gas migration processes and are often found in association with mud volcanoes.

Class II wells – used for injection/disposal of fluids associated with oil and natural gas production. Most of the injected fluid is salt water (brine), which is brought to the surface in the process of producing (extracting) oil and gas. In addition, brine and other fluids are injected to enhance (improve) oil and gas production.

Clay stabilizer – a chemical additive used to prevent clay destabilization that results in clay migration or swelling caused by a reaction to an aqueous fluid.

Conductor casing – generally, the first string of casing in a well. It may be lowered into a hole drilled into the formations near the surface and cemented in place, or it may be driven into the ground by a special pile driver. Its purpose is to prevent the soft formations near the surface from caving in and to conduct drilling mud from the bottom of the hole to the surface when drilling starts.

Conventional reservoir – reservoirs that may be produced commercially without altering the reservoir permeability or associated hydrocarbon viscosity.

Corrosion inhibitor – a chemical or mixture of chemicals that prevents or reduces corrosion.

Coulomb criterion – a criterion for rock failure as a function of the normal and shear stress conditions.

Cross-link gel fracturing fluid – is generally an aqueous fluid containing a gelling agent like guar or xanthan and a crosslinker. It has even greater viscosity than a gel fracturing fluid.

Crosslinker – A substance that promotes or regulates intermolecular covalent bonding between polymer chains, linking them together to create a larger structure.

Diagenetic –physical and chemical changes that affect sedimentary deposits during burial and may culminate in lithification, i.e., turning sediment into solid rock.

Diagenetic trap – a trap formed as a result of diagenetic alteration of rocks within a sedimentary basin, resulting in decreased permeability.

Diatomite – a fine, soft, siliceous sedimentary rock composed chiefly of the silica-rich remains of diatoms.

Dip – A measure of the angle between the flat horizon and the slope of a sedimentary layer, fault plane, metamorphic foliation, or other geologic structure.

Directional drilling – drilling the wellbore in a planned angle of deviation or trajectory other than vertical.

Dissolved Organic Carbon (DOC) – mass of organic carbon from a measured water sample that is dissolved or colloidal that can pass through a filter, typically a 0.4 to 0.7 micron filter

Dolomites – carbonate rocks made up of dolomite (CaMg(CaCO3)2).

Downdip – located down the dip of a sloping planar surface.

Drilling mud – the fluid, water, oil or gas based, circulated through the wellbore during rotary drilling and workover operations that is used to establish well control, transport cuttings to the surface, provide fluid loss control, lubricate the string and cool the bottom hole assembly.

Ductile – a rock characteristic that implies mechanical failure in the form of a fracture created with a large amount of plastic deformation.

Earthquake magnitude – a measure of the amount of energy released during an earthquake, such as the Richter scale.

Effective stress – the total stress minus the pore pressure.

Endocrine-disrupting compounds – chemicals that may interfere with the body's endocrine system and produce adverse developmental, reproductive, neurological, and immune effects in both humans and wildlife.

EPA maximum contaminant level (MCL) – threshold concentration of a contaminant above which water is not suitable for drinking.

Epicenter – a point, directly above the true center of disturbance at the earth's surface, from which the shock waves of an earthquake apparently radiate.

Estrogens – steroid hormones that promote the development and maintenance of female characteristics of the body.

Evaporative emissions – hydrocarbons released into the atmosphere through evaporation from equipment or storage facilities.

Fault – a fracture in the Earth in which one side has moved relative to the other.

Flaring – the combustion of unwanted gases produced by an oil well.

Flowback – fracturing fluid, perhaps mixed with formation water and traces of hydrocarbon, that flows back to the surface after the completion of hydraulic fracturing.

Foaming agent – a material that facilitates formation of foam.

Formation – a body of rock of considerable extent with distinctive characteristics that allow geologists to map, describe, and name it.

Fracture aperture – the distance between fracture faces.

Fracture height – the vertical extent of a fracture.

Fracture length – the horizontal extent of a fracture.

Fracture propagation – enlargement or extension of a crack in a solid material.

Friction reducer – a material, usually a polymer that reduces the friction of flowing fluid in a conduit.

Fugitive emissions – emissions of gases or vapors due to leaks and other unintended or irregular releases.

Gel fracturing fluid – is generally an aqueous fluid containing a gelling agent like guar or xanthan. It has an enhanced viscosity relative to slickwater fracturing fluids.

Globally Harmonized System of Classification and Labeling of Chemicals (GHS) – a worldwide initiative to promote standard criteria for classifying chemicals according to their health, physical and environmental hazards.

Greenhouse gas emissions (GHG) – emissions of gases such as CO_2 and methane that trap heat in the atmosphere.

Horizontal drilling – a well drilled in a manner to reach an angle of 90 degrees relative to a level plane at its departure point at the surface. In practice, the horizontal section of most horizontal wells varies by several degrees.

Hybrid fracturing – hydraulic fracturing that utilizes more than one type of fracturing fluid for a given stage.

Hydraulic diffusivity coefficient – the ratio of the hydraulic conductivity to the volume of water that a unit volume of saturated soil or rock releases from storage per unit decline in hydraulic head. It is a parameter that combines transmission characteristics and the storage properties of a porous medium.

Hydraulic fracturing – an operation in which a specially blended liquid is pumped down a well and into a formation under pressure high enough to cause the formation to crack open, forming passages through which oil can flow into the wellbore.

Hydrostatic pressure – the pore pressure that results from the static weight of pore fluid above the point of interest.

Induced seismicity – earthquakes caused by human activities.

Intercalated turbiditic sandstones – sandstones deposited from a turbidity current (an underwater current flowing downslope owing to the weight of sediment it carries) that are alternately layered between other rock types.

Intermediate casing – the casing set in a well after the surface casing but before production casing to keep the hole from caving and to seal off formations.

Iron control agent – a chemical that controls the precipitation of iron from solution.

Kelly – the heavy square or hexagonal steel member suspended from the swivel through the rotary table and connected to the topmost joint of drill pipe to turn the drill stem as the rotary table turns.

Kerogen – solid, insoluble organic material in shale and other sedimentary rock that yields oil and/or gas upon heating.

Lithology – the physical characteristics (e.g., mineral content, grain size, texture and color) of a rock or stratigraphic unit.

Matrix acidizing – use of a mineral acid (typically hydrochloric acid (HCl) or HCl in combination with hydrofluoric acid (HF)) or an organic acid (typically acetic or formic) to remove damage or stimulate the permeability of a formation.

Maturation – the chemical transformation of kerogen into petroleum fluids.

Median lethal dose (LD50) – the dose required to kill half the members of a tested population after a specified test duration.

Microearthquakes – an earthquake of low intensity with a magnitude of 2 or less on the Richter scale.

Microscanner log – a geophysical measurement record from a downhole instrument that consists of four orthogonal imaging pads containing microelectrodes in direct contact with the borehole wall. It is used for mapping of bedding planes, fractures, faults, foliations, and other formation structures and dip determination.

Microseismic monitoring – a method of tracking a fracture by listening for the sounds of shear fracturing in the formation during the hydraulic fracturing process.

Migrated oil – oil that has moved from source rock to reservoir rock.

Miocene – the geologic time ranging from about 23 to 5.3 million years ago.

MODFLOW – the USGS's three-dimensional (3D) finite-difference groundwater model.

Multi-stage hydraulic fracturing – is where hydraulic fracturing is conducted repeatedly in isolated segments along the length of the well's production interval.

Nanoparticles – a microscopic particle of matter that is measured on the nanoscale, usually less than 100 nanometers.

Normal stress – the internal forces per unit area that are exerted in a material object and are also perpendicular to the selected area.

Oil window – the temperature and pressure ranges under which the organic matter in organic-rich sedimentary rocks is transformed into petroleum fluids.

Opening mode fractures – a fracture that opens in response to tensile stress, i.e., a stress that acts to pull a material object apart.

Organic shales – organic-rich shales.

Overburden – the rock layers lying above a point of interest in the subsurface.

Oxides of nitrogen (NOx) – consist of nitric oxide (NO), nitrogen dioxide (NO2) and nitrous oxide (N2O).

Ozone precursors – chemical compounds, such as carbon monoxide, methane, non-methane hydrocarbons, and nitrogen oxides, which in the presence of solar radiation react with other chemical compounds to form ozone.

Particulate matter (PM) and PM2.5 – a complex mixture of extremely small particles and liquid droplets. PM2.5 consist of particles less than 2.5 microns in diameter.

Permeability – The ability of a rock or other material to allow fluid flow through its interconnected spaces.

pH adjuster – chemical agents to reduce, or to increase, the acidity of a solution.

Phosphatic shales – phosphate-rich shales.

Pipes – vertically-oriented geologic structures commonly circular or subcircular in planform that may have formed as a result of hydrothermal activity, overpressure, or dissolution processes.

Play – hydrocarbon reservoirs within the same region that have common sourcing and trapping mechanisms.

Pore pressure – the normal stress exerted by pore fluids on the porous medium.

Poromechanical effects – phenomena that occur in porous materials whose mechanical behavior is significantly influenced by the pore fluid.

Portland cement – a general class of hydraulic cements (cements that can harden under water) usually made by burning a mixture of limestone and clay in a kiln and pulverizing into a powder.

Precipitate – a solid substance formed from a liquid solution during a chemical process.

Produced water – water, ranging from fresh to salty, produced with the hydrocarbons as a result of pressure drawdown and flow through the petroleum reservoir.

Production casing – the last string of casing set in a well that straddles and isolates the producing interval, inside of which is usually suspended a tubing string.

Production liner – similar to casing pipe but does not extend back to the ground surface. Liners may or may not be cemented.

Propagation of water front – the movement of a constant water saturation level through a porous medium.

Proppant – well sorted and consistently sized sand or man-made materials that are injected with the fracturing fluid to hold the fracture faces apart after pressure is released.

Quaternary fault – a fault that formed sometime between the present and about 2.6 million years ago.

Radiogenic material – material produced by radioactive decay.

Redox conditions – a quantitative description of the environment in question with respect to be oxidizing or reducing.

Reservoir – a subsurface accumulation of hydrocarbon fluids that resides in rock pores and fractures.

Scale inhibitor – a chemical that prevents scale from forming in scale mineral saturated produced waters.

Sedimentary basin – a depression in the Earth's surface that collects sediment.

Seismic hazard – a phenomenon such as ground shaking, fault rupture, or soil liquefaction that is generated by an earthquake.

Seismic moment – a measure of the size of an earthquake based on the area of fault rupture, the average amount of slip, and the force that was required to overcome the friction sticking the rocks together that were offset by faulting.

Seismometer – an instrument for measuring the direction, intensity, and duration of earthquakes by measuring the actual movement of the ground.

Seismometer array – numerous seismometers placed at discrete points in a well-defined configuration.

Semi-volatile organic compounds (SVOC) – organic compound which has a boiling point higher than water and which may vaporize when exposed to temperatures above room temperature.

Shale – sedimentary rock derived from mud and commonly finely laminated (bedded). Particles in shale are commonly clay minerals mixed with tiny grains of quartz eroded from pre-existing rocks.

Shear failure – brittle or ductile damage that results from shear stress of sufficient magnitude.

Shear stress – the internal forces per unit area that are exerted in a material object and are also tangential to the selected area.

Siliceous – a rock rich in a silica phase, such as opal, cristobalite, or quartz.

Siliceous shales – silica-rich shales.

Slickwater fracturing fluid - a water base fracturing fluid with only a very small amount of a polymer added to give friction reduction benefit.

Solvent - a substance that will dissolve a solid. In the oil field, oil based solvents may range from xylene for asphaltenes and sludges, to kerosene and diesel/xylene mixtures for paraffins.

Source rock – a rock rich in organic matter from the original sediment deposition that can generate petroleum fluids under certain temperature and pressure conditions.

Specific conductance – the measure of a material to conduct an electric current.

Stable isotopes – two or more forms of a chemical element having different numbers of neutrons that do not have any measurable radioactive decay.

Static fractures – fractures that are not changing over time.

Steam cycling – a form of steam injection in which injection and production take place in the same well, which is accomplished by alternating steam injection with oil production.

Steam injection – a thermally-enhanced oil recovery method in which steam is forced into the reservoir by applying pressure; the thermal energy of the steam heats the reservoir which reduces the viscosity of heavy oil that are usually the target of thermal oil recovery methods.

Storage coefficient – the volume of water released from storage per unit surface area of a confined aquifer per unit decline in hydraulic head.

Stratigraphic trap – a trap formed as a result of variations in porosity and permeability of the stratigraphic sequence.

Stratigraphic zone – a body of strata that is distinguished on the basis of lithology, fossil content, age, or other rock property.

Stress – the internal forces per unit area that are exerted in a material object.

Strike – is a geometrical characteristic of a planar geologic surface and is defined by the line of intersection between the geologic surface and a horizontal plane.

Structural features – geologic features that result from tectonic, diapiric, gravitational and compactional processes.

Structural trap – a trap formed as a result of faulting or folding of the rock.

Supercritical CO_2 – a fluid state of carbon dioxide which displays characteristics of both liquid and gas that occurs at conditions above its critical temperature and critical pressure.

Surface casing – the casing following the conductor casing in a well that protects fresh water aquifers from contact with fluids moving through the well. It is always cemented across the water zone and the cement usually extends to the surface.

Surfactant – a chemical that is attracted to the surface of a fluid and modifies the properties such as surface tension.

Tectonic features – features that are a result of forces or conditions within the earth that cause movements of the crust.

Tectonic stress – stress that results from forces or conditions within the earth that cause movements of the crust.

Televiewer log – a record of the amplitude of high-frequency acoustic pulses reflected by the borehole wall; provides location and orientation of bedding, fractures, and cavities.

Thermogenic methane – methane created by the thermal decomposition of buried organic material.

Tiltmeter – an instrument used to measure slight changes in the inclination of the earth's surface resulting from subsidence or uplift, usually in connection with volcanology and earthquake seismology.

Total dissolved solids (TDS) – total amount of all inorganic and organic substances – including minerals, salts, metals, cations or anions – that are dissolved within a volume of water.

Total Organic Carbon (TOC) – total mass of organic carbon from a measured sample.

Total Suspended Solids (TSS) - total mass retained on a filter per unit volume of water, typically a 0.4 to 0.7 micron filter.

Toxicity – the degree to which a substance can harm humans or other living organisms.

Trace metals – metals that do not affect chemical or physical properties of the system as a whole to any significant extent, and have ideal solution behavior characteristic of very high dilution.

Trap – a configuration of geologic layers and/or structures that has a very low permeability and is suitable for blocking the upward movement of buoyant hydrocarbons.

Turbidity – the measure of relative clarity of a liquid. It is an optical characteristic of water and is an expression of the amount of light that is scattered by material in the water when a light is shined through the water sample.

Unconventional reservoir – oil and gas resources whose porosity, permeability, fluid trapping mechanism, or other characteristics differ from conventional sandstone and carbonate reservoirs, such as shale gas, shale oil, heavy and viscous oil, gas hydrates, tight gas, and coal bed methane resources.

Updip – located up the dip of a sloping planar surface.

Viscosity – a measurement of a fluid's internal resistance to flow, expressed as the ratio of shear stress to shear rate.

Vitrinite – a type of woody kerogen that is used to measure source rock maturity.

Vitrinite reflectance – a measure of source rock maturity based on the reflectance of vitrinite, measured as % Ro. The onset of oil generation typically occurs at around Ro = 0.6%, with gas formation occurring when Ro = 1.2 %.

Volatile organic compounds (VOC) –organic chemicals whose composition makes it possible for them to evaporate under normal indoor atmospheric conditions of temperature and pressure.

Water flooding – purposely injecting water below and/or into the reservoir to drive the oil towards the producing wellbore.

Well completion – the activities and methods of preparing a well for the production of oil and gas or for other purposes, such as injection; the method by which one or more flow paths for hydrocarbons are established between the reservoir and the surface.

Well stimulation technology – refers to well stimulation methods of hydraulic fracturing, acid fracturing, and matrix acidizing.

Zonal isolation – the exclusion of fluids such as water or gas in one zone from mixing with fluids in another zone along pathways outside of a well casing, accomplished through cement that seals the rock to the casing.

Appendix E

Review of Information Sources

For this report, authors of the report reviewed many sources of public information, including some that are not easily accessible to all citizens, such as fee-based scientific journals. If a member of the public wishes to view a document referenced in the report, they may visit California Council on Science and Technology at 1130 K Street, Suite 280, Sacramento, CA 95814-3965. We cannot duplicate or electronically transmit copyright documents. Please make arrangements in advance by contacting CCST at (916) 492-0996.

CCST issued a request for public submissions of literature by July 15, 2014. All literature submitted by the deadline is listed below in the Bibliography of Submitted Literature. Our scientists reviewed the submissions and cited a given reference in the report if it met all three of the following criteria:

1. Fit into one of the five categories of admissible literature (described in a-e below).
    a. Published, peer-reviewed scientific papers.
    b. Government data and reports.
    c. Academic studies that are reviewed through a university process, textbooks, and papers from technical conferences.
    d. Studies generated by non-government organizations that are based on data, and draw traceable conclusions clearly supported by the data.
    e. Voluntary reporting from industry. This data is cited with the caveat that, as voluntary, there is no quality control on the accuracy or completeness of the data.
2. Was relevant to the scope of the report.
3. Added substantive information to the report.

Bibliography of Submitted Literature

Adams, M.B. (2011). Land application of hydrofracturing fluids damages a deciduous forest stand in West Virginia. Journal of Environmental Quality. 40 (4). pp. 1340–4. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21712604.

Adams, M.B., P.J. Edwards, W.M. Ford, J.B. Johnson, T.M. Schuler, M. Thomas-Van Gundy & F. Wood (2011). Effects of development of a natural gas well and associated pipeline on the natural and scientific resources of the Fernow Experimental Forest.

Adgate, J., B.D. Goldstein & L.M. McKenzie (2014). Potential public health hazards, exposures and health effects from unconventional natural gas development. Environmental Science & Technology. Available from: http://pubs.acs.org/doi/abs/10.1021/es404621d.

Ake, J., K. Mahrer, D. O'Connell & L. Block (2005). Deep-Injection and Closely Monitored Induced Seismicity at Paradox Valley, Colorado. Bulletin of the Seismological Society of America. 95 (2). pp. 664–683. Available from: http://bssa.geoscienceworld.org/cgi/doi/10.1785/0120040072.

Alberta Energy Regulator (2013). Directive 083: Hydraulic Fracturing - Subsurface Integrity Energy Resources Conservation Board, Calgary, Alberta Available from: http://www.aer.ca/rules-and-regulations/directives/directive-083.

Allan, M., M. Rahman & B. Rycerski (2006). Belridge Giant Oil Field, Diatomite Pool Learnings from an Unusual Marine Reservoir in an Old Field. In: AAPG National Convention, April 9-12. 2006, Houston, Texas, pp. 1–24.

Allan, M.E. & J.J. Lalicata (2012). The Belridge Giant Oil Field - 100 Years of History and a Look to a Bright Future. In: AAPG International Convention and Exhibition. 2012, American Association of Petroleum Geologists, Milan, Italy. Available from: http://www.searchanddiscovery.com/documents/2012/20124allan/ndx_allan.pdf.

Allan, M.E., D.K. Gold & D.W. Reese (2010). Development of the Belridge Field's Diatomite Reservoirs with Hydraulically Fractured Horizontal Wells: From First Attempts to Current Ultra-Tight Spacing. SPE Annual Technical Conference and Exhibition. September 2010, Society of Petroleum Engineers, Florence, Italy, pp. 1–19. Available from: http://www.onepetro.org/mslib/servlet/onepetropreview?id=SPE-133511-MS.

Allen, D., V. Torres, J. Thomas, D. Sullivan, M. Harrison, A. Hendler, S.C. Herndon, C. Kolb, M. Fraser, A. Hill, B. Lamb, J. Miskimins, R. Sawyer & J. Seinfeld (2013). Measurements of methane emissions at natural gas production sites in the United States. Proceedings of the National Academy of Sciences. Available from: http://www.pnas.org/cgi/doi/10.1073/pnas.1304880110.

America's Oil and Natural Gas Industry (2014). Hydraulic Fracturing: Unlocking America's Natural Gas Resources. Available from: http://www.api.org/policy-and-issues/policy-items/hf/~/media/Files/Oil-and-Natural-Gas/Hydraulic-Fracturing-primer/Hydraulic-Fracturing-Primer-2014-lowres.pdf.

American Petroleum Institute (2009). Hydraulic Fracturing Operations — Well Construction and Integrity Guidelines. Available from: www.shalegas.energy.gov/resources/HF1.pdf

American Petroleum Institute (2010a). Isolating Potential Flow Zones During Well Construction. Available from: www.shalegas.energy.gov/resources/65-2_e2.pdf

American Petroleum Institute (2010b). Water Management Associated with Hydraulic Fracturing. Available from: www.shalegas.energy.gov/resources/HF2_e1.pdf

American Petroleum Institute (2011). Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing. Washington, DC. Available from: http://www.shalegas.energy.gov/resources/HF3_e7.pdf.

American Petroleum Institute (2013). Shale Energy: 10 Points Everyone Should Know Available from: http://www.api.org/~/media/Files/Policy/Hydraulic_Fracturing/Hydraulic-Fracturing-10-points.pdf.

American Petroleum Institute (n.d.). Hydraulic Fracturing Best Practices Overview Available from: http://www.api.org/oil-and-natural-gas-overview/exploration-and-production/hydraulic-fracturing/hydraulic-fracturing-best-practices.

American Public Health Association (2012). The environmental and occupational health impacts of high-volume hydraulic fracturing of unconventional gas reserves. Policy. Available from: http://scholar.google.com/scholar?q=The+environmental+and+occupational+health+impacts+of+high-volume+hydraulic+fracturing+of+unconventional+gas+reserves&btnG=&hl=en&as_sdt=0,5#0.

Amos, C., P. Audet & W. Hammond (2014). Uplift and seismicity driven by groundwater depletion in central California. Nature. Available from: http://www.nature.com/nature/journal/vaop/ncurrent/full/nature13275.html?WT.ec_id=NATURE-20140515.

Arditsoglou, A. & D. Voutsa (2012). Occurrence and partitioning of endocrine-disrupting compounds in the marine environment of Thermaikos Gulf, Northern Aegean Sea, Greece. Marine Pollution Bulletin. Available from: http://www.sciencedirect.com/science/article/pii/S0025326X12003694.

Arthur, J.D., B. Bohm, B.J. Coughlin & M. Layne (2008). Evaluating the Environmental Implications of Hydraulic Fracturing in Shale Gas Reservoirs. In: SPE 121038-MS, SPE Americas E&P Environmental and Safety Conference. 2008, ALL Consulting, San Antonio, TX, pp. 1–21. Available from: http://www.all-llc.com/publicdownloads/ArthurHydrFracPaperFINAL.pdf.

Avalos, A. & D. Vera (2013). The Petroleum Industry and the Monterey Shale: Current Economic Impact and the Economic Future of the San Joaquin Valley. Available from: http://www.safeenergycalifornia.com/wp-content/uploads/2014/04/The-Petroleum-Industry-and-the-Monterey-Shale-CSU-Fresno-Study.pdf.

Ayotte, J., J. Gronberg & L. Apodaca (2011). Trace elements and radon in groundwater across the United States, 1992-2003. Available from: http://pubs.usgs.gov/sir/2011/5059/.

Bair, E.S., D.C. Freeman & J.M. Senko (2010). Expert Panel Technical Report Subsurface Gas Invasion, Geauga County, Ohio. Available from: http://oilandgas.ohiodnr.gov/resources/investigations-reports-violations-reforms#THR.

Bakke, T., J. Klungsøyr & S. Sanni (2013). Environmental impacts of produced water and drilling waste discharges from the Norwegian offshore petroleum industry. Marine Environmental Research. 92. Available from: http://www.sciencedirect.com/science/article/pii/S0141113613001621.

Balk, L., K. Hylland, T. Hansson & M. Berntssen (2011). Biomarkers in natural fish populations indicate adverse biological effects of offshore oil production. PloS one. 6 (5). Available from: http://dx.plos.org/10.1371/journal.pone.0019735.

Baltz, D., E. Chesney & M. Tarr (2005). Toxicity and sublethal effects of methanol on swimming performance of juvenile Florida pompano. Transactions of the American Fisheries Society. 134 (3). pp. 730–740. Available from: http://www.tandfonline.com/doi/abs/10.1577/T04-136.1.

Barree, R.D., M.K. Fisher & R.A. Woodroof (2002). A Practical Guide to Hydraulic Fracture Diagnostic Technologies. In: 2002 SPE Annual Technical Conference and Exhibtion. 2002, Society of Petroleum Engineers, San Antonio, Texas.

Barree, R.D., V.L. Barree & D.P. Craig (2007). Holistic Fracture Diagnostics. In: SPE Rocky Mountain Oil & Gas Technology Symposium proceedings: Making the unconventional conventional. 2007, Society of Petroleum Engineers, Denver, Colorado.

Battelle (2012). Review of EPA Hydraulic Fracturing Study Plan EPA/600/R11/122, November 2011. Lexington, MA. Available from: http://www.api.org/news-and-media/news/newsitems/2012/jul-2012/~/media/Files/Policy/Hydraulic_Fracturing/Battelle-Studies/Battelle-EPA-study-plan-review-071012.ashx.

Bavestrello, G. & C. Bianchi (2000). Bio-mineralogy as a structuring factor for marine epibenthic communities. Marine Ecology Progress Series. 193. pp. 241–249. Available from: http://www.researchgate.net/publication/240809091_Biomineralogy_as_a_structuring_factor_for_marine_epibenthic_communities/file/3deec51e172c22dc4b.pdf.

Bayne, E.M., L. Habib & S. Boutin (2008). Impacts of chronic anthropogenic noise from energy-sector activity on abundance of songbirds in the boreal forest. Conservation Biology. 22 (5). pp. 1186–93. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18616740.

BC Oil & Gas Commission (n.d.). Safety Advisory 2010-03 BC Oil & Gas Commission, Available from: https://www.bcogc.ca/node/5806/download.

BC Oil and Gas Commission (2012). Investigation of Observed Seismicity in the Horn River Basin. Available from: http://www.bcogc.ca/node/8046/download.

Beckmann, J.P., K. Murray, R.G. Seidler & J. Berger (2012). Human-mediated shifts in animal habitat use: sequential changes in pronghorn use of a natural gas field in Greater Yellowstone. Biological Conservation. 147 (1). pp. 222–233.

Bergquist, E., P. Evangelista, T.J. Stohlgren & N. Alley (2007). Invasive species and coal bed methane development in the Powder River Basin, Wyoming. Environmental Monitoring and Assessment. 128 (1-3). pp. 381–394.

Bibby, K.J., S.L. Brantley, D.D. Reible, K.G. Linden, P.J. Mouser, K.B. Gregory, B.R. Ellis & R.D. Vidic (2013). Suggested Reporting Parameters for Investigations of Wastewater from Unconventional Shale Gas Extraction. Environmental Science & Technology. 47 (23). pp. 13220–13221. Available from: http://pubs.acs.org/doi/abs/10.1021/es404960z.

Bilden, D., F. Efthin & J. Garner (1990). Evaluation and Treatment of Organic and Inorganic Deposition in the Midway Sunset Field, Kern County, California. In: 60th California Regional Meeting, Ventura, California, April 4-6, 1990. 1990, Society of Petroleum Engineers.

Black, J., J. Barnum & W. Birge (1993). An integrated assessment of the biological effects of boron to the rainbow trout. Chemosphere. 26 (7). pp. 1383–1413. Available from: http://www.sciencedirect.com/science/article/pii/004565359390189C.

Blickley, J.L., D. Blackwood & G.L. Patricelli (2012a). Experimental evidence for the effects of chronic anthropogenic noise on abundance of Greater Sage-Grouse at leks. Conservation Biology. 26 (3). pp. 461–71. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22594595.

Blickley, J.L., K.R. Word, A.H. Krakauer, J.L. Phillips, S.N. Sells, C.C. Taff, J.C. Wingfield & G.L. Patricelli (2012b). Experimental chronic noise is related to elevated fecal corticosteroid metabolites in lekking male greater Sage-Grouse (Centrocercus urophasianus). PLOS one. 7 (11). p. e50462. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3502302&tool=pmcentrez&rendertype=abstract.

Bohne-Kjersem, A., N. Bache & S. Meier (2010). Biomarker candidate discovery in Atlantic cod (Gadus morhua) continuously exposed to North Sea produced water from egg to fry. Aquatic Toxicology. 96 (4). pp. 280–289. Available from: http://www.sciencedirect.com/science/article/pii/S0166445X09003841.

Boyer, E., B. Swistock, J. Clark, M. Madden & D. Rizzo (2011). The Impact of Marcellus Gas Drilling on Rural Drinking Water Supplies. Available from: http://www.rural.palegislature.us/documents/reports/Marcellus_and_drinking_water_2011_rev.pdf.

Brandt, A.R., G.A. Heath, E.A. Kort, F. O'Sullivan, G. Petron, S.M. Jordaan, P. Tans, J. Wilcox, A.M. Gopstein, D. Arent, S. Wofsy, N.J. Brown, R. Bradley, G.D. Stucky, D. Eardley & R. Harriss (2014). Methane Leaks from North American Natural Gas Systems. Science. 343 (6172). pp. 733–735. Available from: http://www.sciencemag.org/content/343/6172/733.full.

Brantley, S.L., D. Yoxtheimer, S. Arjmand, P. Grieve, R. Vidic, J. Pollak, G.T. Llewellyn, J. Abad & C. Simon (2014). Water Resource Impacts during Unconventional Shale Gas Development: The Pennsylvania Experience. International Journal of Coal Geology. 126. pp. 140–156. Available from: http://www.sciencedirect.com/science/article/pii/S016651621300284X.

Brian, J., C. Harris, M. Scholze, A. Kortenkamp, P. Booy, M. Lamoree, G. Pojana, N. Jonkers, A. Marcomini & J.P. Sumpter (2007). Evidence of estrogenic mixture effects on the reproductive performance of fish. Environmental Science & Technology. 41 (1). pp. 337–344. Available from: http://pubs.acs.org/doi/abs/10.1021/es0617439.

Bringmann, G. & R. Kühn (1980). Comparison of the toxicity thresholds of water pollutants to bacteria, algae, and protozoa in the cell multiplication inhibition test. Water research. 14 (3). pp. 231–241. Available from: http://www.sciencedirect.com/science/article/pii/0043135480900937.

Briskin, J. (2013). Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Study Update US EPA, Available from: http://www2.epa.gov/sites/production/files/2013-12/documents/study_update-_potential_impacts_of_hydraulic_fracturing_on_drinking_water_resources.pdf.

British Geological Survey (2011). Blackpool earthquake Magnitude 1.5. Available from: http://www.bgs.ac.uk/research/earthquakes/BlackpoolMay2011.html.

Brooke, L.T. & G. Thursby (2005). Aquatic Life Ambient Water Quality Criteria - Nonylphenol. Washington, DC.

Brown, D. & B. Weinberger (2014). Understanding exposure from natural gas drilling puts current air standards to the test. Reviews on Environmental Health. Available from: http://www.degruyter.com/view/j/reveh.ahead-of-print/reveh-2014-0002/reveh-2014-0002.xml.

Brown, W.A. & C. Frohlich (2013). Investigating the cause of the 17 May 2012 M 4.8 earthquake near Timpson, east Texas. Seismological Research Letters. 84. p. 374.

Bruner, K. & R. Smosna (2011). A Comparative Study of the Mississippian Barnett Shale, Fort Worth Basin, and Devonian Marcellus Shale, Appalachian Basin. National Energy.

Bunch, a G., C.S. Perry, L. Abraham, D.S. Wikoff, J. a Tachovsky, J.G. Hixon, J.D. Urban, M. a Harris & L.C. Haws (2014). Evaluation of impact of shale gas operations in the Barnett Shale region on volatile organic compounds in air and potential human health risks. The Science of the Total Environment. 468-469. pp. 832–42. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24076504.

Bureau of Land Management (2003). Final Environmental Impact Statement and Proposed Plan Amendment for the Powder River Basin Oil and Gas Project. Buffalo, Wyoming.

Burnham, A., J. Han & C. Clark (2012). Life-cycle greenhouse gas emissions of shale gas, natural gas, coal, and petroleum. Environmental Science & Technology. 46 (2). pp. 619–627. Available from: http://pubs.acs.org/doi/full/10.1021/es201942m.

CA Department of Conservation Division of Oil Gas and Geothermal Resources (2013). Permit to Conduct Well Operations for “Indian Well 1” API No. 069-20082. Available from: ftp://ftp.consrv.ca.gov/pub/oil/BLM_Study Data/NewOCRSampleData/06920082_DATA_09-24-2013.pdf (Accessed: 24 June 2014).

CA Department of Conservation Division of Oil Gas and Geothermal Resources (2012). Producing wells and production of oil, gas, and water by county. Available from: ftp://ftp.consrv.ca.gov/pub/oil/temp/NEWS/Producing_Wells_OilGasWater_11.pdf (Accessed: 24 June 2014).

Cahill, A.E., M.E. Aiello-Lammens, M.C. Fisher-Reid, X. Hua, C.J. Karanewsky, H.Y. Ryu, G.C. Sbeglia, F. Spagnolo, J.B. Waldron & O. Warsi (2012). How does climate change cause extinction? Proceedings of the Royal Society B: Biological Sciences. p. rspb20121890.

Cailleaud, K., F. Michalec & J. Forget-Leray (2011). Changes in the swimming behavior of Eurytemora affinis (Copepoda, Calanoida) in response to a sub-lethal exposure to nonylphenols. Aquatic Toxicology. Available from: http://www.sciencedirect.com/science/article/pii/S0166445X1000473X.

California Coastal Commission (2013). Consistency Determination No. CD-001-13. San Francisco, California. Available from: http://documents.coastal.ca.gov/reports/2013/6/W13a-6-2013.pdf.

Canadian Council of Ministers of the Environment (2002). Canadian Water Quality Guidelines for the Protection of Aquatic Life: Nonylphenol and its Ethoxylates. In: Canadian Environmental Quality Guidelines, 1999. Winnipeg, Manitoba.

Cardno ENTRIX (2012). Hydraulic Fracturing Study, PXP Inglewood Oil Field. Los Angeles, CA. Available from: http://www.scribd.com/doc/109624423/Hydraulic-Fracturing-Study-Inglewood-Field10102012.

Carlton, A., E. Little & M. Moeller (2014). The data gap: can a lack of monitors obscure loss of clean air act benefits in fracking areas? Environmental Science & Technology. 48 (2). pp. 893–894. Available from: http://pubs.acs.org/doi/abs/10.1021/es405672t.

Carter, K.M., N. Kresic, P. Muller & L.F. Vittorio (2013). Technical Rebuttal to Article Claiming a Link between Hydraulic Fracturing and Groundwater Contamination Pennsylvania Council of Professional Geologists, Available from: https://pcpg.wildapricot.org/Resources/Documents/Shale Gas/PAGS PCPG Rebuttal to Frac Induced GW Contamination Article 1.pdf.

Cathles, L.M. (2012). Assessing the greenhouse impact of natural gas. Geochemistry, Geophysics, Geosystems. 13 (6). Available from: http://energyindepth.org/wp-content/uploads/2012/07/Cathles-Assessing-greenhouse-impact-natgas-June2012.pdf.

Caulton, D., P. Shepson, R. Santoro, J. Sparks, R. Howarth, A. Ingraffea, M. Cambaliza, C. Sweeney, A. Karion, K. Davis, B. Stirm, S. Montzka & B. Miller (2014). Toward a better understanding and quantification of methane emissions from shale gas development. Proceedings of the National Academy of Sciences. 111 (17). pp. 6237–6242. Available from: http://www.pnas.org/content/111/17/6237.short.

Center for Biological Diversity (2013). Dirty Dozen: The 12 Most Commonly Used Air Toxics in Unconventional Oil Development in the Los Angeles Basin. Available from: http://www.biologicaldiversity.org/campaigns/california_fracking/pdfs/LA_Air_Toxics_Report.pdf.

Chambers, K., J. Kendall & O. Barkved (2010). Investigation of induced microseismicity at Valhall using the Life of Field Seismic array. The Leading Edge. Available from: http://library.seg.org/doi/abs/10.1190/1.3353725.

Chen, J., M. Al-Wadei & R. Kennedy (2014). Hydraulic Fracturing: Paving the Way for a Sustainable Future? Journal of Environmental and Public Health. Available from: http://www.hindawi.com/journals/jeph/2014/656824/abs/.

Chepesiuk, R. (2009). Missing the dark: health effects of light pollution. Environmental Health Perspectives. 117 (1). Available from: http://ehp.niehs.nih.gov/117-a20/?utm_source=rss&utm_medium=rss&utm_campaign=117-a20.

Cipolla, C. & C. Wright (2002). Diagnostic techniques to understand hydraulic fracturing: what? why? and how? SPE production & facilities. 17 (1). Available from: https://www.onepetro.org/journal-paper/SPE-75359-PA.

Clark, C.E. & J.A. (Environmental S.D. Veil (2009). Produced Water Volumes and Management Practices in the United States.

Coday, B., P. Xu, E. Beaudry & J. Herron (2014). The sweet spot of forward osmosis: Treatment of produced water, drilling wastewater, and other complex and difficult liquid streams. Desalination. 333 (1). pp. 23–35. Available from: http://www.sciencedirect.com/science/article/pii/S0011916413005390.

Cohen, H., T. Parratt & C. Andrews (2013). Potential contaminant pathways from hydraulically fractured shale to aquifers. Groundwater. 51 (3). pp. 317–319. Available from: http://onlinelibrary.wiley.com/doi/10.1111/gwat.12015/full.

Colborn, T., C. Kwiatkowski, K. Schultz & M. Bachran (2011). Natural Gas Operations from a Public Health Perspective. Human and Ecological Risk Assessment: An International Journal. 17 (5). pp. 1039–1056. Available from: http://www.tandfonline.com/doi/abs/10.1080/10807039.2011.605662.

Colborn, T., K. Schultz, L. Herrick & C. Kwiatkowski (2014). An Exploratory Study of Air Quality Near Natural Gas Operations. Human and Ecological Risk Assessment: An International Journal. 20 (1). pp. 86–105. Available from: http://dx.doi.org/10.1080/10807039.2012.749447.

Colorado Division of Water Resources, Colorado Water Conservation Board & Colorado Oil and Gas Conservation Commission (2012). Water Sources and Demand for the Hydraulic Fracturing of Oil and Gas Wells in Colorado from 2010 through 2015. Available from: http://cogcc.state.co.us/Library/Oil_and_Gas_Water_Sources_Fact_Sheet.pdf.

Commonwealth of Pennsylvania Department of Environmental Protection (2010). DEP Fines Seneca Resources Corp. $40,000 for Violations at Marcellus Operation in Tioga County Available from: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=14655&typeid=1.

Concerned Health Professionals of NY (n.d.). Compendium of Scientific, Medial, and Media Findings Demonstrating the Risks and Harms of Fracking (Unconventional Gas and Oil Extraction).

Council of Canadian Academies (2014). Environmental Impacts of Shale Gas Extraction in Canada. Ottawa, Canada.

Coussens, C. & R. Martinez (2013). Health Impact Assessment of Shale Gas Extraction: Workshop Summary. Available from: http://books.google.com/books?hl=en&lr=&id=aVqfAwAAQBAJ&oi=fnd&pg=PT10&dq=Health+impact+assessment+of+shale+gas+extraction:+workshop+summary.&ots=3OvBbBCIio&sig=Re3fmYOePI99a9F7HJJlOPOuWA0.

Cypher, B.L., G.D. Warrick, M.R.M. Otten, T.P.O. Farrell, W.H. Berry, C.E. Harris, T.T. Kato, P.M. Mccue, J.H. Scrivner & B.W. Zoellick (2000). Population Dynamics of San Joaquin Kit Foxes at the Naval Petroleum Reserves in California. Wildlife Monographs. 145. pp. 1–43.

Cypher, B.L., L.R. Saslaw, C.L.V.H. Job, T.L. Westall & A.Y. Madrid (2012). Kangaroo Rat Population Response to Seismic Surveys for Hydrocarbon Reserves.

Dale, B.C., T.S. Wiens, L.E. Hamilton, T.D. Rich, C. Arizmendi, D.W. Demarest & C. Thompson (2008). Abundance of three grassland songbirds in an area of natural gas infill drilling in Alberta, Canada. In: Proceedings of the 4th International Partners in Flight Conference. 2008, pp. 13–16.

Daneshy, A. & M. Pomeroy (2012). In-situ Measurement of Fracturing Parameters from Communication Between Horizontal Wells. SPE Annual Technical Conference Exhibition, 8-10 October, San Antonio, Texas, USA. Available from: https://www.onepetro.org/conference-paper/SPE-160480-MS.

Davidson, C. (2013). California Democratic Party Resolution: Radioactive Shale Oil and Gas Drilling Wastewater Disposal California Democratic Party,

Davies, P. (2009). Radioactivity: A Description of its Nature, Dangers, Presence in the Marcellus Shale and Recommendations by the Town Of Dryden to The New York State. Cornell University.

Davies, R., G. Foulger, A. Bindley & P. Styles (2013). Induced seismicity and hydraulic fracturing for the recovery of hydrocarbons. Marine and Petroleum Geology. 45. pp. 171–185. Available from: http://www.sciencedirect.com/science/article/pii/S0264817213000846.

Davies, R., S. Almond & R. Ward (2014). Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation. Marine and Petroleum Geology. 56. pp. 239–254. Available from: http://www.sciencedirect.com/science/article/pii/S0264817214000609.

De Laender, F., K. De Schamphelaere, P. Vanrolleghem & C. Janssen (2009). Comparing ecotoxicological effect concentrations of chemicals established in multi-species vs. single-species toxicity test systems. Ecotoxicology and Environmental Safety. 72 (2). pp. 310–315. Available from: http://www.sciencedirect.com/science/article/pii/S0147651308002054.

Dean, G., C. Nelson, S. Metcalf, R. Harris & T. Barber (1998). New Acid System Minimizes Post Acid Stimulation Decline Rate in the Wilmington Field Los Angeles County California. SPE Western Regional Meeting, 10-13 May, Bakersfield, California. Available from: https://www.onepetro.org/conference-paper/SPE-46201-MS.

Dechesne, R. (n.d.). Limiting Oil Field Light Pollution for Safety and the Environment Available from: http://www.cpans.org/assets/Uploads/Presentations/NewFolder/Session-46Roland-Dechesne.pdf.

Department of Energy (2009). Modern Shale Gas Development in the United States: A Primer. Available from: http://www.netl.doe.gov/technologies/oilgas/publications/EPreports/Shale_Gas_Primer_2009.pdf.

Department of Energy National Energy Technology Laboratory & Ground Water Protection Council (2009). State Oil and Natural Gas Regulations Designed to Protect Water Resources. Available from: http://www.gwpc.org/sites/default/files/state_oil_and_gas_regulations_designed_to_protect_water_resources_0.pdf.

Department of Environmental Protection Common Wealth of Pennsylvania (2009). Inspection Report, May 27, 2009 Available from: http://www.marcellus-shale.us/pdf/CC%E2%80%90Spill_DEP%E2%80%90Insp%E2%80%90Rpt.pdf.

Diehl, J., S. Johnson, K. Xia, A. West & L. Tomanek (2012). The distribution of 4-nonylphenol in marine organisms of North American Pacific Coast estuaries. Chemosphere. 87 (5). pp. 490–497. Available from: http://www.sciencedirect.com/science/article/pii/S0045653511014093.

DiGiulio, D.C., R.T. Wilkin, C. Miller & G. Oberly (2011). DRAFT: Investigation of Ground Water Contamination near Pavillion, Wyoming.

Doherty, K.E., D.E. Naugle, B.L. Walker & J.M. Graham (2008). Greater Sage-Grouse Winter Habitat Selection and Energy Development. Journal of Wildlife Management. 72 (1). pp. 187–195. Available from: http://www.bioone.org/doi/abs/10.2193/2006-454.

Du, S. & B. McLaughlin (2002). In vitro neurotoxicity of methylisothiazolinone, a commonly used industrial and household biocide, proceeds via a zinc and extracellular signal-regulated kinase. The Journal of Neuroscience. 22 (17). pp. 7408–7416. Available from: http://www.jneurosci.org/content/22/17/7408.short.

Dusseault, M., R. Jackson & D. Macdonald (2014). Towards a Road Map for Mitigating the Rates and Occurrences of Long-Term Wellbore Leakage. Available from: http://www.geofirma.ca/Links/Wellbore_Leakage_Study compressed.pdf.

Dyrszka, L., K. Nolan & S. Steingraber (n.d.). Statement on Preliminary Findings from the Southwest Pennsylvania Environmental Health Project Study Available from: http://concernedhealthny.org/statement-on-preliminary-findings-from-the-southwest-pennsylvania-environmental-health-project-study/.

Dzialak, M.R., S.M. Harju, R.G. Osborn, J.J. Wondzell, L.D. Hayden-Wing, J.B. Winstead & S.L. Webb (2011). Prioritizing conservation of ungulate calving resources in multiple-use landscapes. PloS one. 6 (1). p. e14597.

East, L., M. Soliman & J. Augustine (2011). Methods for enhancing far-field complexity in fracturing operations. SPE Production & Operations. 26 (3). Available from: https://www.onepetro.org/journal-paper/SPE-133380-PA.

Eastern Research Group Inc. & Sage Environmental Consulting LP (2011). City of Fort Worth Natural Gas Air Quality Study. Available from: http://www.shaledigest.com/documents/2011/Air Quality Studies/Ft Worth Natural Gas Air Quality Study Final Report ERG Research 7-13-2011r.pdf.

Eisner, L., P. Styles & H. Clarke (2013). Felt Induced Seismicity Associated with Shale Gas Hydraulic Stimulation in Lancashire, UK. 75th EAGE Conference & Exhibition Incorporating SPE EUROPEC 2013. Available from: http://www.earthdoc.org/publication/publicationdetails/?publication=68868.

El Shaari, N. & W. Minner (2008). Northern California Gas Sands: Hydraulic Fracture Stimulation Opportunities and Challenges. SPE Western Regional and Pacific Section AAPG Joint Meeting, 29 March-4 April, Bakersfield, California, USA. Available from: https://www.onepetro.org/conference-paper/SPE-114184-MS.

El Shaari, N., M. Kedzierski & T.L. Gorham (2005). Quantifying Guar Polymer Recovery Post Hydraulic Fracturing to Determine theDegree of Fracture Cleanup: A Field Study of the Point of Rocks Formation, California. In: Proceedings of SPE Western Regional Meeting. 1 March 2005, Society of Petroleum Engineers. Available from: https://www.onepetro.org/conference-paper/SPE-93912-MS.

El Shaari, N., W. Minner & R. Lafollette (2011). Is there a “Silver Bullet Technique” For Stimulating California’s Monterey Shale? In: SPE Western North American Regional Meeting. May 2011, Society of Petroleum Engineers, Anchorage, Alaska, pp. 1–10. Available from: http://www.onepetro.org/mslib/servlet/onepetropreview?id=SPE-144526-MS.

El Shaari, N.A., A. Swint & L.J. Kalfayan (2008). Utilizing Organosilane With Hydraulic Fracturing Treatments To Minimize Fines Migration Into the Proppant Pack: A Field Application. In: SPE Western Regional and Pacific Section AAPG Joint Meeting, 29 March-4 April, Bakersfield, California, USA. 2008, Society of Petroleum Engineers.

Ellsworth, W.L. (2013). Injection-Induced Earthquakes. Science. 341 (6142). pp. 142–149. Available from: http://www.clas.ufl.edu/users/prwaylen/GEO2200 Readings/Readings/Fracking/Earthquakes and fracking.pdf.

Endocrine Society (2014). Hormone-disrupting activity of fracking chemicals worse than initially found. ScienceDaily. 23 June. Available from: www.sciencedaily.com/releases/2014/06/140623103939.htm.

Energy and Climate Change Committee (2011). Shale Gas. London, UK.

Engineers’ Society of Western Pennsylvania (2011). Pittsburgh Engineer: The Many Topics within the Marcellus Shale Engineers’ Society of Western Pennsylvania, Pittsburgh, Pennsylvania Available from: http://www.eswp.com/PDF/Spring 2011 Pgh ENG.pdf.

Entrekin, S., M. Evans-White, B. Johnson & E. Hagenbuch (2011). Rapid expansion of natural gas development poses a threat to surface waters. Frontiers in Ecology and the Environment. 9 (9). pp. 503–511. Available from: http://dx.doi.org/10.1890/110053.

Environment Canada (2014). Domestic Substances List. Available from: http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=5F213FA8-1 (Accessed: 3 June 2014).

Erickson, J. (2013). U-M technical reports examine hydraulic fracturing in Michigan. Michigan News. 5 September. Available from: http://www.ns.umich.edu/new/releases/21666-u-m-technical-reports-examine-hydraulic-fracturing-in-michigan.

Erickson, J.B. & M.K. Kumataka (1977). Hydraulic Fracturing Treatments in the Buena Vista Hills Field. In: Proceedings of SPE California Regional Meeting. 1 April 1977, Society of Petroleum Engineers. Available from: https://www.onepetro.org/conference-paper/SPE-6511-MS.

Esswein, E.J., M. Breitenstein, J. Snawder, M. Kiefer & W.K. Sieber (2013). Occupational Exposures to Respirable Crystalline Silica During Hydraulic Fracturing. Journal of Occupational and Environmental Hygiene. 10 (7). pp. 347–56. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23679563.

Evans, J.S. & J.M. Kiesecker (2014). Shale Gas, Wind and Water: Assessing the Potential Cumulative Impacts of Energy Development on Ecosystem Services within the Marcellus Play. PLOS ONE. 9 (2).

EVONIK Industries AG (2011). GPS Safety Summary: Isotridecanol Available from: http://corporate.evonik.de/_layouts/Websites/Internet/DownloadCenterFileHandler.ashx?fileid=1148.

Ferrar, K.J., D.R. Michanowicz, C.L. Christen, N. Mulcahy, S.L. Malone & R.K. Sharma (2013). Assessment of Effluent Contaminants from Three Facilities Discharging Marcellus Shale Wastewater to Surface Waters in Pennsylvania. Environmental Science & Technology. 47 (7). pp. 3472–3481. Available from: http://dx.doi.org/10.1021/es301411q.

Fiehler, C.M. & B.L. Cypher (2011). Ecosystem Analysis of Oilfields in Western Kern County, California.

Field, E.H., K.R. Milner & 2007 Working Group on California Earthquake Probabilities (2008). Forecasting California's Earthquakes - What can we expect in the next 30 years? US Geological Survey Fact Sheet 2008. 3027.

Fiore, A.M., D.J. Jacob, B.D. Field, D.G. Streets, S.D. Fernandes & C. Jang (2002). Linking ozone pollution and climate change: The case for controlling methane. Geophysical Research Letters. 29 (19). pp. 21–25.

Fisher, K. & N. Warpinski (2012). Hydraulic-Fracture-Height Growth: Real Data. SPE Production & Operations. 27 (1). pp. 8–19. Available from: https://www.onepetro.org/journal-paper/SPE-145949-PA.

Flewelling, S. & M. Sharma (2014). Constraints on upward migration of hydraulic fracturing fluid and brine. Ground Water. 52 (1). pp. 9–19.

Flewelling, S. a., M.P. Tymchak & N. Warpinski (2013). Hydraulic fracture height limits and fault interactions in tight oil and gas formations. Geophysical Research Letters. 40 (14). pp. 3602–3606. Available from: http://doi.wiley.com/10.1002/grl.50707.

Folger, P. (2013). Earthquakes: Risk, Detection, Warning, and Research.

Fontenot, B.E., L.R. Hunt, Z.L. Hildenbrand, D.D. Carlton, H. Oka, J.L. Walton, D. Hopkins, A. Osorio, B. Bjorndal, Q.H. Hu & K. a Schug (2013). An evaluation of water quality in private drinking water wells near natural gas extraction sites in the barnett shale formation. Environmental science & technology. 47 (17). pp. 10032–40. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23885945.

Forster, D. & J. Perks (2012). Climate Impact of Potential Shale Gas Production in the EU. Available from: http://ec.europa.eu/clima/policies/eccp/docs/120815_final_report_en.pdf.

FracFocus. FracFocus Chemical Disclosure Registry. Available from: http://fracfocus.org/welcome (Accessed: 9 February 2014a).

Francis, C.D., N.J. Kleist, C.P. Ortega & A. Cruz (2012). Noise pollution alters ecological services: enhanced pollination and disrupted seed dispersal. Proceedings of the Royal Society B: Biological Sciences. 279 (1739). pp. 2727–35. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3367785&tool=pmcentrez&rendertype=abstract.

Freyman, M. & R. Salmon (2013). Hydraulic Fracturing & Water Stress: Growing Competitive Pressures for Water. Ceres.

Freyman, M. (2014). Hydraulic Fracturing & Water Stress : Water Demand by the Numbers. Boston.

Fritschi, L., L. Brown & R. Kim (2011). Burden of disease from environmental noise: Quantification of healthy life years lost in Europe. Available from: http://scholar.google.com/scholar?q=Burden+of+disease+from+environmental+noise+-+Quantification+of+healthy+life+years+lost+in+Europe.&btnG=&hl=en&as_sdt=0,5#0.

Frohlich, C. & E. Potter (2013). What further research could teach us about “close encounters of the third kind” : intraplate earthquakes associated with fluid injection. In: J.-Y. Chatellier & D. M. Jarvie (eds.). Critical Assessment of Shale Resource Plays. 2013, American Association of Petroleum Geologists (AAPG), Tulsa, Oklahoma, pp. 109–119.

Frohlich, C. (2012a). A survey of earthquakes and injection well locations in the Barnett Shale, Texas. The Leading Edge. Available from: http://library.seg.org/doi/abs/10.1190/tle31121446.1.

Frohlich, C. (2012b). Two-year survey comparing earthquake activity and injection-well locations in the Barnett Shale, Texas. Proceedings of the National Academy of Sciences of the United States of America. 109 (35). pp. 13934–8. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3435170&tool=pmcentrez&rendertype=abstract.

Frohlich, C., C. Hayward, B. Stump & E. Potter (2011). The Dallas-Fort Worth Earthquake Sequence: October 2008 through May 2009. Bulletin of the Seismological Society of America. 101 (1). pp. 327–340. Available from: http://www.bssaonline.org/cgi/doi/10.1785/0120100131.

Frohlich, C., W. Ellsworth, W. Brown, M. Brunt, J. Luetgert, T. Macdonald & S. Walter (2014). The 17 May 2012 M4.8 earthquake near Timpson, East Texas: An event possibly triggered by fluid injection. Journal of Geophysical Research: Solid Earth. 119 (August 1982). pp. 1–13. Available from: http://onlinelibrary.wiley.com/doi/10.1002/2013JB010755/full.

Fulmer, J., G. Conroy & D. Sharbak (1993). Hydraulic Fracture Height Prediction and Evaluation-A Case Study in the Yowlumne Field Kern County California. Available from: https://www.onepetro.org/general/SPE-27423-MS.

Gan, W. & C. Frohlich (2013). Gas injection may have triggered earthquakes in the Cogdell oil field, Texas. Proceedings of the National Academy of Sciences of the United States of America. 110 (47). pp. 18786–91. Available from: http://www.pnas.org/cgi/content/long/1311316110v1.

Gandossi, L. (2013). An Overview of Hydraulic Fracturing and Other Formation Stimulation Technologies for Shale Gas Production. Luxembourg.

Ganong, B.L., C. Hansen, P. Connolly & B. Barree (2003). Rose Field: A McLure Shale, Monterey Formation Development Story. In: SPE Western Regional/AAPG Pacific Section Joint Meeting. May 2003, Society of Petroleum Engineers, Long Beach, California, pp. 1–9. Available from: http://www.onepetro.org/mslib/servlet/onepetropreview?id=00083501.

Geiszinger, A. & C. Bonnineau (2009). The relevance of the community approach linking chemical and biological analyses in pollution assessment. TrAC Trends in Analytical Chemistry. 28 (5). pp. 619–626. Available from: http://www.sciencedirect.com/science/article/pii/S0165993609000466.

Gentes, M.-L., A. McNabb, C. Waldner & J.E.G. Smits (2007). Increased thyroid hormone levels in tree swallows (Tachycineta bicolor) on reclaimed wetlands of the Athabasca Oil Sands. Archives of Environmental Contamination and Toxicology. 53 (2). pp. 287–292.

Gergs, A., A. Zenker, V. Grimm & T. Preuss (2013). Chemical and natural stressors combined: from cryptic effects to population extinction. Scientific Reports. 3. Available from: http://www.nature.com/srep/2013/130620/srep02036/full/srep02036.html?message-global=remove.

Gilbert, M.M. & A.D. Chalfoun (2011). Energy development affects populations of sagebrush songbirds in Wyoming. The Journal of Wildlife Management. 75 (4). pp. 816–824. Available from: http://doi.wiley.com/10.1002/jwmg.123.

Goodwin, S., K. Carlson, C. Douglas & K. Knox (2012). Life cycle analysis of water use and intensity of oil and gas recovery in Wattenberg field, Colorado. Oil & Gas Journal. 110 (5). pp. 48–59.

Gradient Corp (2013). National Human Health Risk Evaluation for Hydraulic Fracturing Fluid Additives. Cambridge, Massachusetts.

Green, C., P. Styles & B. Baptie (2012a). Shale Gas Fracturing Review & Recommendations for Induced Seismic Mitigation. Available from: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:SHALE+GAS+FRACTURING+REVIEW+&+RECOMMENDATIONS+FOR+induced+seismic+mitigation#0.

Green, J.J., G.L. Adams & R. Adams (2012b). Examining community level variables of fishes in relation to natural gas development. In: Southeastern Fishes Council, Annual Meeting Program, November 8-9, 2012. 2012, New Orleans, Louisiana.

Gross, S.A., H.J. Avens, A.M. Banducci, J. Sahmel, J.M. Panko & B.E. Tvermoes (2013). Analysis of BTEX groundwater concentrations from surface spills associated with hydraulic fracturing operations. Journal of the Air & Waste Management Association. 63 (4). pp. 424–432. Available from: http://dx.doi.org/10.1080/10962247.2012.759166.

Ground Water Protection Council and Interstate Oil and Gas Compact Commission (2014a). Chemical Use. Available from: http://fracfocus.org/chemical-use.

Ground Water Protection Council and Interstate Oil and Gas Compact Commission (2014b). Fracturing Fluid Management. Available from: http://fracfocus.org/hydraulic-fracturing-how-it-works/drilling-risks-safeguards.

Ground Water Protection Council and Interstate Oil and Gas Compact Commission (2014c). Groundwater & Aquifers. Available from: http://fracfocus.org/water-protection/groundwater-aquifers.

Ground Water Protection Council and Interstate Oil and Gas Compact Commission (2014d). Well Construction & Groundwater Protection. Available from: http://fracfocus.org/hydraulic-fracturing-how-it-works/casing.

Ground Water Protection Council and Interstate Oil and Gas Compact Commission (2014e). Groundwater Quality & Testing. Available from: http://fracfocus.org/groundwater-protection/groundwater-quality-testing.

Ground Water Protection Council and Interstate Oil and Gas Compact Commission (2014f). Hydraulic Fracturing: The Process. Available from: http://fracfocus.org/hydraulic-fracturing-how-it-works/hydraulic-fracturing-process.

Ground Water Research & Education Foundation (2013). A White Paper Summarizing a Special Session on Induced Seismicity. Available from: http://www.gwpc.org/sites/default/files/white paper - final_0.pdf.

Habib, L., E.M. Bayne & S. Boutin (2007). Chronic industrial noise affects pairing success and age structure of ovenbirds Seiurus aurocapilla. Journal of Applied Ecology. 44 (1). pp. 176–184.

Handy, R.M. (2014). Crude oil spills into Poudre near Windsor. The Coloradoan. 20 June. Available from: http://www.coloradoan.com/story/news/local/2014/06/20/crude-oil-spills-poudrenear-windsor/11161379/.

Hansen, J. & M. Sato (2004). Greenhouse gas growth rates. Proceedings of the National Academy of Sciences of the United States of America. 101 (46). pp. 16109–16114.

Hansen, J., M. Sato, P. Kharecha, G. Russell, D.W. Lea & M. Siddall (2007). Climate change and trace gases. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences. 365 (1856). pp. 1925–1954.

Harju, S.M., M.R. Dzialak, R.C. Taylor, L.D. HAYDEN-WING & J.B. Winstead (2010). Thresholds and Time Lags in Effects of Energy Development on Greater Sage-Grouse Populations. The Journal of Wildlife Management. 74 (3). pp. 437–448.

Hauksson, E., P. Hellweg, D. Oppenheimer, T. Shakal & D. Given (2011). California Integrated Seismic Network Strategic Plan: 2011-2016.

Hein, C.D. (2012). Potential Impacts of Shale Gas Development on Bat Populations in the Northeastern United States. Austin, Texas: Bat Conservation International.

Hejl, K., A. Madding, M. Morea, C. Glatz, J. Luna, W. Minner, T. Singh & G. Stanley (2007). Extreme multistage fracturing improves vertical coverage and well performance in the Lost Hills field. SPE Drilling & Completion. 22 (4). pp. 1–9. Available from: http://www.onepetro.org/mslib/servlet/onepetropreview?id=SPE-101840-PA.

Helmig, D., C.R. Thompson, J. Evans, P. Boylan, J. Hueber & J.-H. Park (2014). Highly Elevated Atmospheric Levels of Volatile Organic Compounds in the Uintah Basin, Utah. Environmental Science & Technology. 48 (9). pp. 4707–4715.

Henry, T. & K. Galbraith (2013). As Fracking Proliferates, So Do Wastewater Wells. The New York Times. 28 March. Available from: http://www.nytimes.com/2013/03/29/us/wastewater-disposal-wells-proliferate-along-with-fracking.html?pagewanted=all.

Henry, T. (2012). How Fracking Disposal Wells Are Causing Earthquakes in Dallas-Fort Worth. StateImpact. 6 August. Available from: http://stateimpact.npr.org/texas/2012/08/06/how-fracking-disposal-wells-are-causing-earthquakes-in-dallas-fort-worth/.

Hill, E.L. (2012). Unconventional natural gas development and infant health: Evidence from Pennsylvania. Charles H. Dyson School of Applied Economics and Management Working Paper. 12.

Holditch, S. & N. Tschirhart (2005). Optimal stimulation treatments in tight gas sands. SPE Annual Technical Conference and Exhibition, 9-12 October, Dallas, Texas. Available from: https://www.onepetro.org/conference-paper/SPE-96104-MS.

Holditch, S. (2012). Drillers must employ best practices to keep “fracking” boom alive. Houston Chronicle. 6 January. Available from: http://www.chron.com/opinion/outlook/article/Drillers-must-employ-best-practices-to-keep-2446773.php.

Holland, A. (2011). Examination of Possibly Induced Seismicity from Hydraulic Fracturing in the Eola Field, Garvin County, Oklahoma. Available from: http://theweeks.org/tmp/FILES/AustinHollandsEarthquakePaperAndFrackingOF1_2011.pdf.

Holland, A. (2013). Earthquakes Triggered by Hydraulic Fracturing in South-Central Oklahoma. Bulletin of the Seismological Society of America. 103 (3). pp. 1784–1792. Available from: http://www.bssaonline.org/cgi/doi/10.1785/0120120109.

Holloran, M.J., R.C. Kaiser & W. a. Hubert (2010). Yearling Greater Sage-Grouse Response to Energy Development in Wyoming. Journal of Wildlife Management. 74 (1). pp. 65–72. Available from: http://www.bioone.org/doi/abs/10.2193/2008-291.

Holth, T. & B. Beylich (2009). Genotoxicity of environmentally relevant concentrations of water-soluble oil components in cod (Gadus morhua). Environmental Science & Technology. 43 (9). pp. 3329–3334. Available from: http://pubs.acs.org/doi/full/10.1021/es803479p.

Hooper, M. & G. Ankley (2013). Interactions between chemical and climate stressors: A role for mechanistic toxicology in assessing climate change risks. Environmental Toxicology and Chemistry. 32 (1). pp. 32–48. Available from: http://onlinelibrary.wiley.com/doi/10.1002/etc.2043/full.

Horton, S. (2012). Disposal of Hydrofracking Waste Fluid by Injection into Subsurface Aquifers Triggers Earthquake Swarm in Central Arkansas with Potential for Damaging Earthquake. Seismological Research Letters. 83 (2). pp. 250–260. Available from: http://srl.geoscienceworld.org/cgi/doi/10.1785/gssrl.83.2.250.

Howarth, R. (2014). A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas. Energy Science & Engineering. Available from: http://onlinelibrary.wiley.com/doi/10.1002/ese3.35/full.

Howarth, R.W., R. Santoro & A. Ingraffea (2011). Methane and the greenhouse-gas footprint of natural gas from shale formations. Climatic Change. 106 (4). pp. 679–690. Available from: http://link.springer.com/10.1007/s10584-011-0061-5.

Huang, G. & J. London (2012). Cumulative environmental vulnerability and environmental justice in California's San Joaquin Valley. International Journal of Environmental Research and Public Health. 9 (5). pp. 1593–1608. Available from: http://www.mdpi.com/1660-4601/9/5/1593/htm.

Hughes, J.D. (2013). Energy: A reality check on the shale revolution. Nature. 494 (7437). pp. 307–308. Available from: www.postcarbon.org/reports/Drilling-California_FINAL.pdf.

Hultman, N., D. Rebois, M. Scholten & C. Ramig (2011). The greenhouse impact of unconventional gas for electricity generation. Environmental Research Letters. 6 (4). p. 44008.

Human and Environmental Risk Assessment (HERA) Project (2009). Human & Environmental Risk Assessment on Ingredients of European Household Cleaning Products: Alcohol Ethoxylates. Available from: http://www.heraproject.com/files/34-F-.

IHS (2012). America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy. Volume 1: National Economic Contributions. Available from: http://marcelluscoalition.org/wp-content/uploads/2012/10/IHS_Americas-New-Energy-Future.pdf.

Iledare, O. & A. Pulsipher (1997). Oil spills, workplace safety and firm size: evidence from the US Gulf of Mexico OCS. The Energy Journal. Available from: http://www.jstor.org/stable/41322751.

Ingelfinger, F. & S. Anderson (2004). Passerine response to roads associated with natural gas extraction in a sagebrush steppe habitat. Western North American Naturalist. 64 (3). pp. 385–395.

Ingraffea, A. & M. Wells (2014). Assessment and risk analysis of casing and cement impairment in oil and gas wells in Pennsylvania, 2000–2012. Proceedings of the National Academy of Sciences. 111 (30). pp. 10955–10960. Available from: http://www.pnas.org/content/111/30/10955.short.

Intermountain Oil and Gas BMP Project (n.d.). Hydraulic Fracturing. Available from: http://www.oilandgasbmps.org/resources/fracing.php.

International Energy Agency (2012). Golden Rules for a Golden Age of Gas - World Energy Outlook Special Report on Unconventional Gas. Paris, France. Available from: http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/WEO2012_GoldenRulesReport.pdf.

Jackson, R.B., A. Vengosh, T.H. Darrah, N.R. Warner, A. Down, R.J. Poreda, S.G. Osborn, K. Zhao & J.D. Karr (2013). Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction. Proceedings of the National Academy of Sciences of the United States of America. 110 (28). pp. 11250–5. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3710833&tool=pmcentrez&rendertype=abstract.

Janská, E. & L. Eisner (2012). Ongoing seismicity in the Dallas-Fort Worth area. The Leading Edge. Available from: http://library.seg.org/doi/abs/10.1190/tle31121462.1.

Jenner, S. & A. Lamadrid (2013). Shale gas vs. coal: Policy implications from environmental impact comparisons of shale gas, conventional gas, and coal on air, water, and land in the United States. Energy Policy. Available from: http://www.sciencedirect.com/science/article/pii/S0301421512009755.

Jeong, S., Y. Hsu, A.E. Andrews, L. Bianco, P. Vaca, J.M. Wilczak & M.L. Fischer (2013). A multitower measurement network estimate of California's methane emissions. Journal of Geophysical Research: Atmospheres. 118 (19). pp. 11–339.

Jiang, M., W.M. Griffin, C. Hendrickson, P. Jaramillo, J. VanBriesen & A. Venkatesh (2011). Life cycle greenhouse gas emissions of Marcellus shale gas. Environmental Research Letters. 6 (3). p. 34014.

Johnson, N., T. Gagnolet, R. Ralls, E. Zimmerman, B. Eichelberger, C. Tracey, G. Kreitler, S. Orndorff, J. Tomlinson & S. Bearer (2010). Pennsylvania Energy Impacts Assessment Report 1: Marcellus Shale Natural Gas and Wind. Harrisburg, PA, US: The Nature Conservancy-Pennsylvania Chapter.

Jones, J. & D. Soler (1999). Fracture Stimulation of Shallow, Unconsolidated Kern River Sands. In: SPE International Thermal Operations and Heavy Oil Symposium, 17-19 March 1999. 1999, Society of Petroleum Engineers, Bakersfield, California.

Jurado, E. & M. Fernández-Serrano (2009). Acute toxicity and relationship between metabolites and ecotoxicity during the biodegradation process of non-ionic surfactants: fatty-alcohol ethoxylates, nonylphenol. Water Science & Technology. 59 (12). pp. 2351–2358. Available from: http://www.iwaponline.com/wst/05912/wst059122351.htm.

Justinic, A.H., B. Stump, C. Hayward & C. Frohlich (2013). Analysis of the Cleburne, Texas, Earthquake Sequence from June 2009 to June 2010. Bulletin of the Seismological Society of America. 103 (6). pp. 3083–3093. Available from: http://www.bssaonline.org/cgi/doi/10.1785/0120120336.

Kalfayan, L. (2007). Fracture Acidizing: History Present State and Future. SPE Hydraulic Fracturing Technology Conference. Available from: https://www.onepetro.org/conference-paper/SPE-106371-MS.

Kaplan, B., C. Beegle-Krause, D. French McCay, A. Copping & S. Geerlofs (2010). Updated Summary of Knowledge: Selected Areas of the Pacific Coast. Camarillo, CA. Available from: http://www.data.boem.gov/PI/PDFImages/ESPIS/4/4955.pdf.

Kappel, W., J. Williams & Z. Szabo (2013). Water Resources and Shale Gas/Oil Production in the Appalachian Basin: Critical Issues and Evolving Developments. Available from: pubs.usgs.gov/of/2013/1137/pdf/ofr2013-1137.pdf.

Karion, A., C. Sweeney, G. Pétron, G. Frost, R. Michael Hardesty, J. Kofler, B.R. Miller, T. Newberger, S. Wolter, R. Banta, A. Brewer, E. Dlugokencky, P. Lang, S. a. Montzka, R. Schnell, P. Tans, M. Trainer, R. Zamora & S. Conley (2013). Methane emissions estimate from airborne measurements over a western United States natural gas field. Geophysical Research Letters. 40 (16). pp. 4393–4397. Available from: http://doi.wiley.com/10.1002/grl.50811.

Kassotis, C.D., D.E. Tillit, J.W. Davis, A.M. Hormann & S.C. Nagel (2013). Estrogen and Androgen Receptor Activities of Hydraulic Fracturing Chemicals and Surface and Ground Water in a Drilling-Dense Region - en.2013-1697. Endocrinology. 155 (3). pp. 897–907. Available from: http://press.endocrine.org/doi/pdf/10.1210/en.2013-1697.

Kell, S. (2011). State Oil and Gas Agency Groundwater Investigations.

Kenny, J.F., N.L. Barber, S.S. Hutson, K.S. Linsey, J.K. Lovelace & M.A. Maupin (2009). Estimated Use of Water in the United States in 2005. Reston, Virginia.

Keranen, K., M. Weingarten & G. Abers (2014a). Sharp increase in central Oklahoma seismicity since 2008 induced by massive wastewater injection. Science. 345 (6195). pp. 448–451. Available from: http://www.sciencemag.org/content/345/6195/448.short.

Keranen, K.M., H.M. Savage, G. a. Abers & E.S. Cochran (2013). Potentially induced earthquakes in Oklahoma, USA: Links between wastewater injection and the 2011 Mw 5.7 earthquake sequence. Geology. 41 (6). pp. 699–702. Available from: http://geology.gsapubs.org/cgi/doi/10.1130/G34045.1.

Keranen, K.M., M. Weingarten, B. Bekins, S. Ge & G.A. Abers (2014b). Triggered earthquakes far from the wellbore: Fluid pressure migration and the 2008-2014 Jones swarm, central Oklahoma. In: Seismological Society of America Annual Meeting. 2014, Anchorage, Alaska.

Kibble, A., T. Cabianca, Z. Daraktchieva, T. Gooding, J. Smithard, G. Kowalczyk, N.P. McColl, M. Singh, L. Mitchem, P. Lamb, S. Vardoulakis & R. Kamanyire (2014). Review of the potential public health impacts of exposures to chemical and radioactive pollutants as a result of shale gas extraction. London, UK. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/332837/PHE-CRCE-009_3-7-14.pdf.

Kielhorn, J., C. Pohlenz-Michel, S. Schmidt & I. Mangelsdorf (2004). Concise International Chemical Assessment Document 57, Glyoxal. Available from: http://whqlibdoc.who.int/publications/2004/924153057x.pdf.

Kille, L.W. (2014). Fracking, shale gas and health effects: Research roundup. Available from: http://journalistsresource.org/studies/environment/energy/fracking-shale-gas-health-effects-research-roundup#.

Kim, W.-Y. (2013). Induced seismicity associated with fluid injection into a deep well in Youngstown, Ohio. Journal of Geophysical Research: Solid Earth. 118 (7). pp. 3506–3518. Available from: http://doi.wiley.com/10.1002/jgrb.50247.

King, G.E. (2012). Hydraulic Fracturing 101: What Every Representative, Environmentalist, Regulator, Reporter, Investor, University Researcher, Neighbor and Engineer Should Know About Estimating Frac Risk and Improving Frac Performance in Unconventional Gas and O. In: SPE 152596, SPE Hydraulic Fracturing Technology Conference. 2012, Society of Petroleum Engineers, Woodlands, TX, pp. 1–80. Available from: http://fracfocus.org/sites/default/files/publications/hydraulic_fracturing_101.pdf.

Klins, M.A., D.W. Stewart, D.J. Pferdehirt & M.E. Stewart (1996). Fracturing Alliance Allows Economical Production of Massive Diatomite Oil Reserves: A Case Study. Journal of Petroleum Technology. 48 (01). pp. 68–74. Available from: https://www.onepetro.org/journal-paper/SPE-29662-JPT.

Kovats, S., M. Depledge, A. Haines, L. Fleming, P. Wilkinson, S. Shonkoff & N. Scovronick (2014). The Health Implications of Fracking. The Lancet. 383. pp. 757–758.

Kresse, T.M., N.R. Warner, P.D. Hays, A. Down, A. Vengosh & R.B. Jackson (2012). Shallow groundwater quality and geochemistry in the Fayetteville Shale gas-production area, north-central Arkansas, 2011. US Geological Survey Scientific Investigations Report. 5273.

Kretzmann, H. (2014). Horizontal and Directional Drilling in California.

Kurfirst, L. & C. O'Donovan (2012). Fracking Best Practices: Top 10 Recommendations. Available from: http://www.rigzone.com/news/article.asp?hpf=1&a_id=119442.

Landon, M.K. & K. Belitz (2012). Geogenic sources of benzene in aquifers used for public supply, California. Environmental Science & Technology. 46 (16). pp. 8689–97. Available from: http://dx.doi.org/10.1021/es302024c.

Leber, J. (2012). Studies Link Earthquakes to Wastewater from Fracking. MIT Technology Review. 14 December. Available from: http://www.technologyreview.com/news/508151/studies-link-earthquakes-to-wastewater-from-fracking/.

Lester, Y., T. Yacob, I. Morrissey & K. Linder (2014). Can We Treat Hydraulic Fracturing Flowback with a Conventional Biological Process? The Case of Guar Gum. Environmental Science & Technology Letters. 1 (1). pp. 133–136. Available from: http://pubs.acs.org/doi/abs/10.1021/ez4000115.

Levi, M.A. (2012). Comment on "Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study" by Gabrielle Pétron et al. Journal of Geophysical Research: Atmospheres. 117 (D21). p. 5.

Licata, A. (2009). Natural Gas Drilling Threatens Trout in Pennsylvania (and Other Appalachian States). Field & Stream. Available from: http://www.troutrageous.com/2009/08/field-stream-pa-natural-gas-drilling.html.

Lithner, D., Å. Larsson & G. Dave (2011). Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition. Science of the Total Environment. 409 (18). pp. 3309–3324. Available from: http://www.sciencedirect.com/science/article/pii/S0048969711004268.

Llenos, A.L. & A.J. Michael (2013). Modeling earthquake rate changes in Oklahoma and Arkansas: possible signatures of induced seismicity. Bulletin of the Seismological Society of America. 103 (5). pp. 2850–2861.

Logan, J., G. Heath, J. Macknick, E. Paranhos, W. Boyd & K. Carlson (2012). Natural Gas and the Transformation of the U.S. Energy Sector: Electricity. Golden, Colorado. Available from: http://www.nrel.gov/docs/fy13osti/55538.pdf.

Lonvik, K., B. Leinum, E. Heier, A. Serednicki, O. Gjorv, T. Myhre, B. Sogard, L. Moen, B. Sogstad & M. Saugerud (2006). Material Risk–Ageing offshore installations. Available from: http://www.ptil.no/getfile.php/z_Konvertert/Helse, milj%25C3%25B8 og sikkerhet/Hms-Aktuelt/Dokumenter/dnv_materialrisk2.pdf.

Los Padres Forest Watch (2013). Trashing the Sespe: How the Oil Industry is Littering Our Public Lands and Endangering Wildlife. Available from: http://lpfw.org/wp-content/uploads/2013/11/Trashing-The-Sespe-FULL-REPORT-WITH-APPENDIX.pdf.

Love, M.S., D.M. Schroeder & W.H. Lenarz (2005). Distribution of Bocaccio (Sebastes paucispinis) and Cowcod (Sebastes levis) Around Oil Platforms and Natural Outcrops off California with Implications for Larval Production. Bulletin of Marine Science. 77 (3). pp. 397–408.

Love, M.S., M.K. Saiki, T.W. May & J.L. Yee (2013). Whole-body concentrations of elements in three fish species from offshore oil platforms and natural areas in the Southern California Bight, USA. Bulletin of Marine Science. 89 (3). pp. 717–734.

Lowe, T., M. Potts, D. Wood & D. Energy (2013). A Case History of Comprehensive Hydraulic Fracturing Monitoring in the Cana Woodford. Available from: http://www.microseismic.com/brochures/SPE-166295-MS-P.pdf.

Lund, S., J. Manyika, S. Nyquist, L. Mendonca & S. Ramaswamy (2013). Game changers: Five opportunities for US growth and renewal. Available from: http://www.mckinsey.com/insights/americas/us_game_changers.

Lustgarten, A. (2009). In new gas wells, more drilling chemicals remain underground. ProPublica. 27 December. Available from: http://www.propublica.org/article/new-gas-wells-leave-more-chemicals-in-ground-hydraulic-fracturing.

Lustgarten, A. (n.d.). EPA Finds Fracking Compound in Wyoming Aquifer. Available from: http://www.propublica.org/article/epa-finds-fracking-compound-in-wyoming-aquifer.

Maclean, I.M.D. & R.J. Wilson (2011). Recent ecological responses to climate change support predictions of high extinction risk. Proceedings of the National Academy of Sciences. 108 (30). pp. 12337–12342.

Magill, B. (2014). Derelict Oil Wells May Be Major Methane Emitters Climate Central. Climate Central, Available from: http://www.climatecentral.org/news/abandoned-oil-wells-methane-emissions-17575.

Martin, M. & W. Castle (1984). Petrowatch: petroleum hydrocarbons, synthetic organic compounds, and heavy metals in mussels from the Monterey Bay area of Central California. Marine Pollution Bulletin. 15 (7). pp. 259–266.

Mato, Y., T. Isobe & H. Takada (2001). Plastic resin pellets as a transport medium for toxic chemicals in the marine environment. Environmental Science & Technology. Available from: http://pubs.acs.org/doi/abs/10.1021/es0010498.

Mauter, M., V. Palmer, Y. Tang & A. Behrer (2013). The next frontier in United States shale gas and tight oil extraction: Strategic reduction of environmental impacts. Cambridge, Massachusetts. Available from: http://belfercenter.ksg.harvard.edu/files/mauter-dp-2013-04-final.pdf.

McCabe, W.D., T.J. Hampton & M.E. Querin (1996). Acid Stimulation Increases Production in 31S C/D Shale Reservoirs, Monterey Formation, Elk Hills Field, California. In: Western Regional Meeting, Anchorage Alaska, 22-24 May. 1996, Society of Petroleum Engineers.

Mccawley, M. (2013). Air, Noise, and Light Monitoring Results For Assessing Environmental Impacts of Horizontal Gas Well Drilling Operations (ETD - 10 Project). Charleston, West Virginia.

McCrary, M., D. Panzer & M. Pierson (2003). Oil and gas operations offshore California: status, risks, and safety. Marine Ornithology. 31. pp. 43–49.

McDonald, R.I., J. Fargione, J. Kiesecker, W.M. Miller & J. Powell (2009). Energy sprawl or energy efficiency: climate policy impacts on natural habitat for the United States of America. PLOS one. 4 (8). p. e6802. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2728545&tool=pmcentrez&rendertype=abstract.

McKenzie, L.M., R. Guo, R.Z. Witter, D.A. Savitz, L.S. Newman & J.L. Adgate (2014). Birth outcomes and maternal residential proximity to natural gas development in rural Colorado. Environmental Health Perspectives. 122 (4). pp. 412–417.

McKenzie, L.M., R.Z. Witter, L.S. Newman & J.L. Adgate (2012). Human health risk assessment of air emissions from development of unconventional natural gas resources. The Science of the Total Environment. 424. pp. 79–87. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22444058.

McMahon, P.B., J.C. Thomas & A.G. Hunt (2011). Use of diverse geochemical data sets to determine sources and sinks of nitrate and methane in groundwater, Garfield County, Colorado, 2009. US Department of the Interior, US Geological Survey.

Mee, A., N.F.R. Snyder & L.S. Hall (2007). California Condors in the 21st Century—Conservation Problems and Solutions. California Condors in the 21st Century. pp. 243–279.

Michaels, Craig; Simpson, James; Wegner, W. (2010). Fractured Communities: Case Studies of the Environmental Impacts of Industrial Gas Drilling. Available from: http://www.riverkeeper.org/wp-content/uploads/2010/09/Fractured-Communities-FINAL-September-2010.pdf.

Mickley, S. (2011). Data Show Public Health Impacts from Natural Gas Production Overstated. Available from: http://energyindepth.org/marcellus/data-shows-natural-gas-public-health-impacts-overstated/.

Mielke, E., L. Diaz Anadon & V. Narayanamurti (2010). Water Consumption of Energy Resource Extraction, Processing, and Conversion. Energy Technology Innovation Policy Discussion Paper Series. Available from: http://live.belfercenter.org/files/ETIP-DP-2010-15-final-2.pdf.

Miller, S.M., S.C. Wofsy, A.M. Michalak, E.A. Kort, A.E. Andrews, S.C. Biraud, E.J. Dlugokencky, J. Eluszkiewicz, M.L. Fischer & G. Janssens-Maenhout (2013). Anthropogenic emissions of methane in the United States. Proceedings of the National Academy of Sciences. 110 (50). pp. 20018–20022.

Minner, W., C. Wright, G. Stanley, C. de Pater, T. Gorham, L. Eckerfield & K. Hejl (2002). Waterflood and production-induced stress changes dramatically affect hydraulic fracture behavior in Lost Hills infill wells. SPE Annual Technical Conference and Exhibition, 29 September-2 October, San Antonio, Texas. Available from: https://www.onepetro.org/conference-paper/SPE-77536-MS.

Minner, W.A., G.R. Molesworth, C.A. Wright & W.D. Wood (1997). Real-Data Fracture Analysis Enables Successful Hydraulic Fracturing in the Point of Rocks Formation, Kern County, California. In: Proceedings of SPE Western Regional Meeting. 1 June 1997, Society of Petroleum Engineers. Available from: https://www.onepetro.org/conference-paper/SPE-38326-MS.

Minner, W.A., J. Du, B.L. Ganong, C.B. Lackey, S.L. Demetrius & C.A. Wright (2003). Rose Field: Surface Tilt Mapping Shows Complex Fracture Growth in 2500' Laterals Completed with Uncemented Liners. In: Proceedings of SPE Western Regional/AAPG Pacific Section Joint Meeting. May 2003, Society of Petroleum Engineers, Long Beach, California, pp. 1–7. Available from: http://www.spe.org/elibrary/servlet/spepreview?id=00083503.

MIT Energy Initiative (2011). The future of natural gas: An interdisciplinary MIT Study. Massachusetts Institute of Technology, Cambridge, MA. Available from: http://web.mit.edu/ceepr/www/publications/Natural_Gas_Study.pdf.

Moe, S., K. De Schamphelaere, W. Clements, M. Sorensen, P. Van den Brink & M. Liess (2013). Combined and interactive effects of global climate change and toxicants on populations and communities. Environmental Toxicology and Chemistry. 32 (1). pp. 49–61. Available from: http://onlinelibrary.wiley.com/doi/10.1002/etc.2045/full.

Mohd, M.H. & J. Paik (2013). Investigation of the corrosion progress characteristics of offshore subsea oil well tubes. Corrosion Science. 67. pp. 130–141. Available from: http://www.sciencedirect.com/science/article/pii/S0010938X1200491X.

Molofsky, L.J., J. a Connor, S.K. Farhat & A.S.W. Jr (2011). Methane in Pennsylvania water wells unrelated to Marcellus shale fracturing. Oil and Gas Journal. December 5. pp. 54–67.

Moodie, W. & W. Minner (2004). Multistage Oil-Base Frac-Packing in the Thick Inglewood Field Vickers/Rindge Formation Lends New Life to an Old Producing Field. SPE Annual Technical Conference and Exhibition, 26-29 September, Houston, Texas. Available from: https://www.onepetro.org/conference-paper/SPE-90975-MS.

Moore, C. & B. Zielinska (2014). Air impacts of increased natural gas acquisition, processing, and use: A critical review. Environmental Science & Technology. 48 (15). pp. 8349–8359. Available from: http://pubs.acs.org/doi/abs/10.1021/es4053472.

Muehlenbachs, L., M. Cohen & T. Gerarden (2013). The impact of water depth on safety and environmental performance in offshore oil and gas production. Energy Policy. 55. pp. 699–705. Available from: http://www.sciencedirect.com/science/article/pii/S030142151201141X.

Muller, E., C. Osenberg, R. Schmitt, S. Holbrook & R. Nisbet (2010). Sublethal toxicant effects with dynamic energy budget theory: application to mussel outplants. Ecotoxicology. 19 (1). pp. 38–47.

Myers, T. (2012). Potential contaminant pathways from hydraulically fractured shale to aquifers. Groundwater. 50 (6). pp. 872–882.

Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura & H. Zhang (2013). Anthropogenic and Natural Radiative Forcing In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tig. In: Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, p. 714.

National Research Council (2013). Induced Seismicity Potential in Energy Technologies. The National Academies Press, Washington, D.C. Available from: http://www.nap.edu/catalog.php?record_id=13355.

Nelson, A. & D. May (2014). Matrix complications in the determination of radium levels in hydraulic fracturing flowback water from Marcellus Shale. Environmental Science & Technology Letters. 1 (3). pp. 204–208. Available from: http://pubs.acs.org/doi/abs/10.1021/ez5000379.

Neuzil, C. (2013). Can Shale Safely Host US Nuclear Waste? Eos, Transactions American Geophysical Union. 94 (30). pp. 261–262. Available from: http://onlinelibrary.wiley.com/doi/10.1002/2013EO300001/abstract.

New York State Department of Environmental Conservation (NYSDEC) (2011). Revised Draft Supplemental Generic Environmental Impact Statement On The Oil, Gas and Solution Mining Regulatory Program - Well Permit Issuance for Horizontal Drilling And High- Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Perm. Albany, NY. Available from: http://www.dec.ny.gov/data/dmn/rdsgeisfull0911.pdf.

Nicot, J. (2013). Hydraulic Fracturing and Water Resources: A Texas Study. Available from: http://archives.datapages.com/data/gcags/data/063/063001/359_gcags630359.htm.

Norton, M. & S. Hoffman (1982). The Use of Foam in Stimulating Fractured California Reservoirs. In: Proceedings of SPE California Regional Meeting. 1 March 1982, Society of Petroleum Engineers. Available from: https://www.onepetro.org/conference-paper/SPE-10769-MS.

Nurulnadia, M., J. Koyama & S. Uno (2014). Accumulation of endocrine disrupting chemicals (EDCs) in the polychaete Paraprionospio sp. from the Yodo River mouth, Osaka Bay, Japan. Environmental Monitoring and Assessment. 186 (3). pp. 1453–1463. Available from: http://link.springer.com/article/10.1007/s10661-013-3466-y.

NYC Environmental Protection (2013). Comments dated Jan. 7 2013 by NYC Environmental Protection to Joseph Martens, Commissioner NYS Deptartment of Environmental Conservation on the revised high-volume hydraulic fracturing regulations Available from: http://www.nyc.gov/html/dep/pdf/natural_gas_drilling/revised_high_volume_hydraulic_fracturing_regulations_comments_letter_010713.pdf.

Nygaard, K.J., J. Cardenas, P.P. Krishna, T.K. Ellison & E.L. Templeton-Barrett (2013). Technical Considerations Associated with Risk Management of Potential Induced Seismicity in Injection Operations. In: 5to. Congreso de Producción y Desarrollo de Reservas. 2013, Rosario, Argentina. Available from: https://pangea.stanford.edu/researchgroups/scits/sites/default/files/Argentina_Congress_May2013_TechConRiskManIndSeismicity_Final.pdf.

O'Sullivan, F. & S. Paltsev (2012). Shale gas production: potential versus actual greenhouse gas emissions. Environmental Research Letters. 7. p. 44030.

Ohio Department of Natural Resources (2008). Report on the Investigation of the Natural Gas Invasion of Aquifers in Bainbridge Township of Geauga County, Ohio.

Olmstead, S.M., L.A. Muehlenbachs, J.-S. Shih, Z. Chu & A.J. Krupnick (2013). Shale gas development impacts on surface water quality in Pennsylvania. Proceedings of the National Academy of Sciences of the United States of America. 110 (13). pp. 4962–7. Available from: http://www.pnas.org/cgi/content/long/1213871110v1.

Olsen, E. (2011). Natural Gas and Polluted Air New York Times Company, New York, NY Available from: http://www.nytimes.com/video/us/100000000650773/natgas.html.

Osborn, S.G., A. Vengosh, N.R. Warner & R.B. Jackson (2011a). Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. Proceedings of the National Academy of Sciences of the United States of America. 108 (20). pp. 8172–6. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3100993&tool=pmcentrez&rendertype=abstract.

Osborn, S.G., A. Vengosh, N.R. Warner, R.B. Jackson & B.R. Pearson (2011b). Research and Policy Recommendations for Hydraulic Fracturing and Shale-Gas Extraction. Durham, NC. Available from: https://nicholas.duke.edu/cgc/HydraulicFracturingWhitepaper2011.pdf.

Osenberg, C., R. Schmitt, S. Holbrook & D. Canestro (1992). Spatial scale of ecological effects associated with an open coast discharge of produced water. Produced Water. 46. pp. 387–402. Available from: http://link.springer.com/chapter/10.1007/978-1-4615-2902-6_31.

Ostro, B., M. Lipsett, P. Reynolds, D. Goldberg, A. Hertz, C. Garcia, K.D. Henderson & L. Bernstein (2010). Long-term exposure to constituents of fine particulate air pollution and mortality: results from the California Teachers Study. Environmental Health Perspectives. 118 (3). pp. 363–369. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2854764/.

Papoulias, D.M. & A.L. Velasco (2013). Histopathological Analysis of Fish from Acorn Fork Creek, Kentucky, Exposed to Hydraulic Fracturing Fluid Releases. Southeastern Naturalist. 12 (4). pp. 92–111.

Pennsylvania Department of Environmental Protection (2010). Southwestern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report. Available from: http://www.dep.state.pa.us/dep/deputate/airwaste/aq/aqm/docs/Marcellus_SW_11-01-10.pdf.

Pennsylvania Department of Environmental Protection (n.d.). DEP Fines Talisman Energy USA for Bradford County Drilling Wastewater Spill, Polluting Nearby Water Resource (August 2, 1010).

Pennsylvania Department of Environmental Protection Bureau of Air Quality (2011). Northeastern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report. Available from: http://www.dep.state.pa.us/dep/deputate/airwaste/aq/aqm/docs/Marcellus_NE_01-12-11.pdf.

Pérez-Casanova, J. & D. Hamoutene (2012). Effects of chronic exposure to the aqueous fraction of produced water on growth, detoxification and immune factors of Atlantic cod. Ecotoxicology and Environmental Safety. 86. pp. 239–249. Available from: http://www.sciencedirect.com/science/article/pii/S0147651312003491.

Pétron, G., A. Karion, C. Sweeney, B.R. Miller, S.A. Montzka, G.J. Frost, M. Trainer, P. Tans, A. Andrews, J. Kofler, D. Helmig, D. Guenther, E. Dlugokencky, P. Lang, T. Newberger, S. Wolter, B. Hall, P. Novelli, A. Brewer, S. Conley, M. Hardesty, R. Banta, A. White, D. Noone, D. Wolfe & R. Schnell (2014). A new look at methane and nonmethane hydrocarbon emissions from oil and natural gas operations in the Colorado Denver-Julesburg Basin. Journal of Geophysical Research: Atmospheres. Available from: http://dx.doi.org/10.1002/2013JD021272.

Pétron, G., G. Frost, B.R. Miller, A.I. Hirsch, S. a. Montzka, A. Karion, M. Trainer, C. Sweeney, A.E. Andrews, L. Miller, J. Kofler, A. Bar-Ilan, E.J. Dlugokencky, L. Patrick, C.T. Moore, T.B. Ryerson, C. Siso, W. Kolodzey, P.M. Lang, T. Conway, P. Novelli, K. Masarie, B. Hall, D. Guenther, D. Kitzis, J. Miller, D. Welsh, D. Wolfe, W. Neff & P. Tans (2012). Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study. Journal of Geophysical Research. 117 (D4). p. D04304. Available from: http://doi.wiley.com/10.1029/2011JD016360.

Phillips, S. (2011). Researchers Wade into Streams to Study Gas Drilling Impacts. StateImpact. 6 October. Available from: https://stateimpact.npr.org/pennsylvania/2011/10/06/researchers-wade-into-streams-to-study-gas-drilling-impacts/.

Piedrahita, R. & Y. Xiang (2014). The next generation of low-cost personal air quality sensors for quantitative exposure monitoring. Atmospheric Measurement Techniques Discussions. 7 (3). pp. 2425–2457. Available from: http://adsabs.harvard.edu/abs/2014AMTD....7.2425P.

Piette, B.B. (2012). BP oil spill, fracking cause wildlife abnormalities. Available from: http://www.workers.org/2012/us/bp_oil_spill_fracking_0503.

Rafferty, M. & E. Limonik (2013). Is shale gas drilling an energy solution or public health crisis? Public Health Nursing. 30 (5). pp. 454–462. Available from: http://onlinelibrary.wiley.com/doi/10.1111/phn.12036/full.

Rafiee, M., M. Soliman & E. Pirayesh (2012). Hydraulic fracturing design and optimization: A modification to zipper frac. SPE Annual Technical Conference and Exhibition, 8-10 October, San Antonio, Texas, USA. Available from: https://www.onepetro.org/conference-paper/SPE-159786-MS.

Ramanujan, K. (2012). Study suggests hydrofracking is killing farm animals, pets. Cornell Chronicle. 7 March. Available from: http://news.cornell.edu/stories/2012/03/reproductive-problems-death-animals-exposed-fracking.

Ramirez, P. (2010). Bird mortality in oil field wastewater disposal facilities. Environmental Management. 46 (5). pp. 820–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20844874.

Révész, K.M., K.J. Breen, A.J. Baldassare & R.C. Burruss (2010). Carbon and hydrogen isotopic evidence for the origin of combustible gases in water-supply wells in north-central Pennsylvania. Applied Geochemistry. 25 (12). pp. 1845–1859. Available from: http://www.sciencedirect.com/science/article/pii/S0883292710002131.

Rich, A.L. & E.C. Crosby (2013). Analysis of reserve pit sludge from unconventional natural gas hydraulic fracturing and drilling operations for the presence of technologically enhanced naturally occurring radioactive material (TENORM). New Solutions: A Journal of Environmental and Occupational Health Policy. 23 (1). pp. 117–35. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23552651.

Ritzel, B. (2013). Fracking industrialization and induced earthquakes: The mechanisms that connect the disposal of fracking wastewater into deep-injection wells to a significant increase in midcontinent seismic activity Available from: http://fullerfuture.files.wordpress.com/2013/12/frackingindustrializationandinducedearthquakes-12-2-13.pdf.

Root, T.L., J.T. Price, K.R. Hall, S.H. Schneider, C. Rosenzweig & J.A. Pounds (2003). Fingerprints of global warming on wild animals and plants. Nature. 421 (6918). pp. 57–60.

Rowe, G., R. Hurkmans & N. Jones (2004). Unlocking the Monterey Shale Potential at Elk Hills: A Case Study. In: Proceedings of SPE International Thermal Operations and Heavy Oil Symposium and Western Regional Meeting. March 2004, Society of Petroleum Engineers. Available from: http://www.onepetro.org/mslib/servlet/onepetropreview?id=00086993&soc=SPE.

Rubinstein, J., W. Ellsworth & A. McGarr (2012). The 2001-present triggered seismicity sequence in the Raton basin of southern Colorado/Northern New Mexico. American Geophysical Union, Fall Meeting 2012. Available from: http://adsabs.harvard.edu/abs/2012AGUFM.S34A..02R.

Rutqvist, J., A.P. Rinaldi, F. Cappa & G.J. Moridis (2013). Modeling of fault reactivation and induced seismicity during hydraulic fracturing of shale-gas reservoirs. Journal of Petroleum Science and Engineering. 107. pp. 31–44. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0920410513001241.

S.S. Papadopulos & Associates Inc. (2008). Phase II Hydrogeologic Characterization of the Mamm Creek Field Area, Garfield County, Colorado. Available from: http://www.garfield-county.com/oil-gas/documents/01-TEXT%20FINAL.pdf.

Saiers, J. & E. Barth (2012). Potential contaminant pathways from hydraulically fractured shale aquifers. Groundwater. 50 (6). pp. 826–828. Available from: http://onlinelibrary.wiley.com/doi/10.1111/j.1745-6584.2012.00990.x/full.

Sang, W., C. Stoof, W. Zhang, V. Morales, B. Gao, R. Kay, L. Liu, Y. Zhang & T. Steenhuis (2014). Effect of Hydrofracking Fluid on Colloid Transport in the Unsaturated Zone. Environmental Science & Technology. 48 (14). pp. 8266–8274. Available from: http://pubs.acs.org/doi/abs/10.1021/es501441e.

Sawyer, H., M.J. Kauffman & R.M. Nielson (2009). Influence of Well Pad Activity on Winter Habitat Selection Patterns of Mule Deer. Journal of Wildlife Management. 73. pp. 1052–1061. Available from: internal-pdf://sawyer_wellpadinfluenceonmuledeer-3392236546/Sawyer_WellPadInfluenceOnMuleDeer.pdf\n<Go to ISI>://WOS:000269484100004.

Sawyer, H., R.M. Nielson, F. Lindzey & L.L. McDONALD (2006). Winter habitat selection of mule deer before and during development of a natural gas field. Journal of Wildlife Management. 70 (2). pp. 396–403.

Schmidt, C.W. (2011). Blind Rush? Shale Gas Boom Proceeds Amid Human Health Questions. Environmental Health Perspectives. 119 (8). pp. a348–a353.

Schrope, M. (2013). Minor oil spills are often bigger than reported. Nature News. 28 January. Available from: http://www.nature.com/news/minor-oil-spills-are-often-bigger-than-reported-1.12307.

ScienceDaily (2011). Methane levels 17 times higher in water wells near hydrofracking sites, study finds. 10 May. Available from: http://www.sciencedaily.com/releases/2011/05/110509151234.htm.

ScienceDaily (2014). Toxicologists outline key health and environmental concerns associated with hydraulic fracturing. 9 May. Available from: www.sciencedaily.com/releases/2014/05/140509172545.htm.

Shires, T. & M. Lev-On (2012). Characterizing Pivotal Sources of Methane Emissions from Natural Gas Production: Summary and Analysis of API and ANGA Survey Responses. Available from: http://www.api.org/~/media/Files/News/2012/12-October/API-ANGA-Survey-Report.pdf.

Shonkoff, S., J. Hays & M. Finkel (2014). Environmental Public Health Dimensions of Shale and Tight Gas Development. Environmental Health Perspectives. 122 (8). pp. 787–795. Available from: http://catskillcitizens.org/learnmore/ehp.1307866.pdf.

Simons, E.A. & M. Akin (1987). Dead Endangered Species in a California Oil Spill. In: International Oil Spill Conference. 1987, American Petroleum Institute, pp. 417–418.

Skone, T., J. Littlefield & J. Marriott (2011). Life cycle greenhouse gas inventory of natural gas extraction, delivery and electricity production. Available from: http://scholar.google.com/scholar?q=Life+Cycle+Greenhouse+Gas+Inventory+of+Natural+Gas+Extraction,+Delivery+and+Electricity+Production&btnG=&hl=en&as_sdt=0,5#0.

Slonecker, E.T., L.E. Milheim, C.M. Roig-Silva & A.R. Malizia (2013). Landscape Consequences of Natural Gas Extraction in Allegheny and Susquehanna Counties, Pennsylvania, 2004–2010. Reston, Virginia. Available from: http://pubs.usgs.gov/of/2013/1025.

Sloto, R.A. (2013). Baseline Groundwater Quality from 20 Domestic Wells in Sullivan County, Pennsylvania, 2012. US Department of the Interior, US Geological Survey.

Soraghan, M. (2013a). 10% of U.S. earthquakes are in Okla. Is drilling to blame? E&E News. 2 December. Available from: http://www.eenews.net/energywire/stories/1059991119.

Soraghan, M. (2013b). States deciding not to look at seismic risks of drilling. E&E News. 25 March. Available from: http://www.eenews.net/energywire/stories/1059978378.

Spawn, A. & C. Aizenman (2012). Abnormal visual processing and increased seizure susceptibility result from developmental exposure to the biocide methylisothiazolinone. Neuroscience. 205. pp. 194–204. Available from: http://www.sciencedirect.com/science/article/pii/S0306452211014497.

State Impact. Exploring the Link Between Earthquakes and Oil and Gas Disposal Wells. Available from: http://stateimpact.npr.org/oklahoma/tag/earthquakes/.

Steinzor, N., W. Subra & L. Sumi (2013). Investigating links between shale gas development and

health impacts through a community survey project in Pennsylvania. NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy. 23 (1). pp. 55–83. Available from: http://baywood.metapress.com/index/K243K377L2348302.pdf.

Stocker, T., D. Qin, G. Plattner & M. Tignor (2013). Climate Change 2013. The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change-. Available from: http://inis.iaea.org/search/search.aspx?orig_q=RN:45042273.

Striolo, A., F. Klaessig, D. Cole & J. Wilcox (2012). Identification of Fundamental Interfacial and Transport Phenomena for the Sustainable Deployment of Hydraulic Shale Fracturing− Role of Chemicals.

Stromberg, J. (2013). Radioactive Wastewater From Fracking Is Found in a Pennsylvania Stream. Smithsonian.com. Available from: http://www.smithsonianmag.com/science-nature/radioactive-wastewater-from-fracking-is-found-in-a-pennsylvania-stream-351641/.

Strubhar, M., W. Medlin, S. Nabi & F. Andreani (1984). Fracturing Results in Diatomaceous Earth Formations, South Belridge Field, California. Journal of Petroleum Technology. 36 (3). pp. 495–502. Available from: https://www.onepetro.org/journal-paper/SPE-10966-PA.

Sumy, D., E. Cochran, K. Keranen, M. Wei & G. Abers (2014). Observations of static Coulomb stress triggering of the November 2011 M5.7 Oklahoma earthquake sequence. Journal of Geophysical Research: Solid Earth. 119 (3). pp. 1904–1923. Available from: http://onlinelibrary.wiley.com/doi/10.1002/2013JB010612/full.

Tague, J. (2000). Optimizing production in fields with multiple formation-damage mechanisms. 2000 SPE International Symposium on Formation Damage Control, Lafayette, Louisiana. Available from: http://cat.inist.fr/?aModele=afficheN&cpsidt=1304682.

Tang, F., H. Hu, Q. Wu, X. Tang, Y. Sun, X.-L. Shi & J.-J. Huang (2013). Effects of chemical agent injections on genotoxicity of wastewater in a microfiltration-reverse osmosis membrane process for wastewater reuse. Journal of Hazardous Materials. 260. pp. 231–237. Available from: http://www.sciencedirect.com/science/article/pii/S0304389413003609.

Taylor, D., B. Maddock & G. Mance (1985). The acute toxicity of nine “grey list” metals (arsenic, boron, chromium, copper, lead, nickel, tin, vanadium and zinc) to two marine fish species: Dab (Limanda limanda) and grey mullet (Chelon labrosus). Aquatic Toxicology. 7 (3). pp. 135–144. Available from: http://www.sciencedirect.com/science/article/pii/S0166445X85800011.

The Associated Press (2013). Calif. finds more instances of offshore fracking. USA Today. 19 October. Available from: http://www.usatoday.com/story/money/business/2013/10/19/calif-finds-more-instances-of-offshore-fracking/3045721/.

Thomas, C.D., A. Cameron, R.E. Green, M. Bakkenes, L.J. Beaumont, Y.C. Collingham, B.F.N. Erasmus, M.F. De Siqueira, A. Grainger, L. Hannah, L. Hughes, B. Huntley, A.S. Van Jaarsveld, G.F. Midgley, L. Miles, M.A. Ortega-Huerta, A.T. Peterson, O.L. Phillips & S.E. Williams (2004). Extinction risk from climate change. Nature. 427. pp. 145–148.

Thompson, J., J. Davis & R. Drew (1976). Toxicity, uptake and survey studies of boron in the marine environment. Water Research. 10 (10). pp. 869–875.

Thomson, J., T. Schaub, N. Culver & P. Aengst (2005). Wildlife at a Crossroads: Energy Development in Western Wyoming. Washington, D.C. Available from: http://wilderness.org/sites/default/files/wildlife-at-crossroads-report.pdf.

Thyne, G. (2008). Review of Phase II Hydrogeologic Study: Prepared for Garfield County. Available from: http://celdf.org/downloads/Gas - Thyne Study of methane in groundwater 2008.pdf.

Timoney, K.P. & R.A. Ronconi (2010). Annual bird mortality in the bitumen tailings ponds in Northeastern Alberta, Canada. The Wilson Journal of Ornithology. 122 (3). pp. 569–576.

Tollefson, J. (2013). Methane leaks erode green credentials of natural gas. Nature. 493. p. 12. Available from: http://www.nature.com/polopoly_fs/1.12123!/menu/main/topColumns/topLeftColumn/pdf/493012a.pdf.

Trail, P.W. (2006). Avian mortality at oil pits in the United States: A review of the problem and efforts for its solution. Environmental Management. 38 (4). pp. 532–544.

Trechock, M. (2013). Gone for Good: Fracking and Water Loss in the West. Billings, Montana. Available from: http://www.worc.org/userfiles/file/Oil Gas Coalbed Methane/Hydraulic Fracturing/Gone_for_Good.pdf.

Trehan, R., N. Jones & J. Haney (2012). Acidizing Optimization : Monterey Shale, California. In: SPE Western Regional Meeting. 2012, Society of Petroleum Engineers, Bakersfield, California, pp. 19–23.

Turnage, K., T. Palisch, M. Gleason, D. Escobar & J. Jordan (2006). Overcoming Formation Damage and Increasing Production Using Stackable Frac Packs and High-Conductivity Proppants: A Case Study in the Wilmington Field Long. In: SPE International Symposium and Exhibition on Formation Damage Control. 2006, Society of Petroleum Engineers, Lafayette, Louisiana. Available from: https://www.onepetro.org/conference-paper/SPE-98304-MS.

Tyrrell, J.P. (2013). Management of Produced Water from Oil and Gas Wells in California: Past Trends and Future Suggestions. In: Geological Society of America Abstracts with Programs. Vol. 45, No. 7, p.595. 2013, Geological Society of America, Denver, Colorado. Available from: https://gsa.confex.com/gsa/2013AM/webprogram/Paper233477.html.

U.S. Department of Agriculture (2014). OPP Pesticide Ecotoxicity Database Available from: http://www.ipmcenters.org/Ecotox/DataAccess.cfm.

U.S. Department of Energy, U.S. Department of the Interior & U.S. Environmental Protection Agency (2012). Multi-Agency Collaboration on Unconventional Oil and Gas Research Available from: http://unconventional.energy.gov/pdf/oil_and_gas_research_mou.pdf.

U.S. Department of Labor Occupational Safety & Health Administration (2012). Worker Exposure to Silica during Hydraulic Fracturing. Available from: https://www.osha.gov/dts/hazardalerts/hydraulic_frac_hazard_alert.html.

U.S. Energy Information Administration (2012). Annual Energy Outlook 2012: With Projections to 2035. Government Printing Office.

U.S. Environmental Protection Agency (1995). Response of the U.S. Environmental Protection Agency to Petition for Promulgation of Rule Withdrawing Approval of Alabama's Underground Injection Control Program. Available from: http://energyindepth.org/docs/pdf/Browner-Letter-Full-Response.pdf (Accessed: 24 June 2014).

U.S. Environmental Protection Agency (1996). Aqueous and Semi-Aqueous Solvent Chemicals: Environmentally Preferable Choices. Washington, DC.

U.S. Environmental Protection Agency (2004). Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs Study. Washington, DC.

U.S. Environmental Protection Agency (2008). Analysis of the Causes of a Decline in the San Joaquin Kit Fox Population on the Elk Hills, Naval Petroleum Analysis of the Causes of a Decline in the San Joaquin Kit Fox Population on the Elk Hills, Naval Petroleum Reserve # 1, California. Cincinnati, OH.

U.S. Environmental Protection Agency (2010). Nonylphenol (NP) and Nonylphenol Ethoxylates (NPEs) Action Plan. Washington, DC.

U.S. Environmental Protection Agency (2011). Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources. Washington, DC. Available from: http://www2.epa.gov/sites/production/files/documents/hf_study_plan_110211_final_508.pdf.

U.S. Environmental Protection Agency (2012a). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010. Washington, DC. Available from: http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-Main-Text.pdf.

U.S. Environmental Protection Agency (2012b). Minimizing and Manageing Potential Impacts of Induced-Seismicity from Class II Disposal Wells: Practical Appraoches. Washington, D.C. Available from: http://www.eenews.net/assets/2013/07/19/document_ew_01.pdf.

U.S. Environmental Protection Agency (2012c). Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Progress Report. Washington, DC. Available from: http://www2.epa.gov/sites/production/files/documents/hf-report20121214.pdf.

U.S. Environmental Protection Agency (2014a). Overview of Greenhouse Gases. Available from: http://epa.gov/climatechange/ghgemissions/gases/ch4.html.

U.S. Environmental Protection Agency (2014b). Summary of the Technical Roundtable on EPA's Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources. Available from: http://www2.epa.gov/sites/production/files/2014-03/documents/summary_of_the_technical_roundtable_on_epas_study_of_the_potential_impacts_of_hydraulic_fracturing_on_drinking_water_resources_december_9_2013.pdf.

U.S. Environmental Protection Agency (2014c). Web Conference Summary of December 9, 2013 Technical Roundtable on EPA's Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources U.S. Environmental Protection Agency, Available from: http://www.clu-in.org/conf/tio/frac9/slides/Dec-9-Roundtable-Webinar.pdf.

U.S. Environmental Protection Agency (2014d). Reissuance of National Pollutant Discharge Elimination System (NPDES) General Permit for Offshore Oil and Gas Exploration, Development and Production Operations Off Southern California. Washington, D.C. Available from: https://federalregister.gov/a/2014-00156.

U.S. Fish and Wildlife Service (2005). Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon. Portland, Oregon. Available from: http://www.fws.gov/sacramento/es/Recovery-Planning/Vernal-Pool/Documents/Vernal Pool Recovery Plan Executive Summary.pdf.

U.S. Fish and Wildlife Service Office of Law Enforcement (2009). Case at a Glance: U.S. v. Nami Resources Company, LLC U.S. Fish and Wildlife Service, Available from: http://www.fws.gov/home/feature/2009/pdf/NamiInvestigation.pdf.

U.S. Geological Survey (2014). Aquifers. Available from: http://water.usgs.gov/edu/earthgwaquifer.html.

U.S. Geological Survey (USGS) (2013). Earthquake Swarm Continues in Central Oklahoma. Available from: http://www.usgs.gov/newsroom/article.asp?ID=3710&from=rss#.VHY-FTHF98E.

U.S. Government Accountability Office (2012a). Oil and Gas: Information on Shale Resources, Development, and Environmental and Public Health Risks. Washington, D.C. Available from: http://www.gao.gov/assets/650/647791.pdf.

U.S. Government Accountability Office (2012b). Unconventional Oil and Gas Development: Key Environmental and Public Health Requirements. Washington, D.C. Available from: http://www.gao.gov/assets/650/647782.pdf.

U.S. Government Accountability Office (2012c). Energy-Water Nexus: Information on the Quantity, Quality, and Management of Water Produced during Oil and Gas Production. Energy-Water Nexus. Washington, DC. Available from: http://www.gao.gov/assets/590/587522.pdf.

Underdown, D.R., D.J. Schultz, A. Marino, R. Miranda & J.M. Kullman (1993). Optimizing Production by Fluid and Rock Studies for the Stevens Sands, North Coles Levee Field, Kern County, California. SPE Formation Evaluation. 8 (4). pp. 267–272. Available from: https://www.onepetro.org/journal-paper/SPE-21785-PA.

Union of Concerned Scientists (2012). California Refineries: The Most Carbon-Intensive in the Nation Union of Concerned Scientists. Union of Concerned Scientists, Cambridge, Massachusetts Available from: http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/California-Refineries-The-Most-Carbon-Intensive-in-the-Nation.pdf.

United Nations Environment Programme, International Labour Organisation & World Health Organization (1998). Environmental Health Criteria 204: Boron. Geneva. Available from: http://www.inchem.org/documents/ehc/ehc/ehc204.htm.

United States House of Representatives Committee on Energy and Commerce (2011). Chemicals Used in Hydraulic Fracturing. Washington, DC. Available from: http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic-Fracturing-Chemicals-2011-4-18.pdf.

University of Iowa Environmental Health Sciences Research Center (2012). Exposure Assessment and Outreat to Engage the Public on Health Risks from Frac Sand Mining. Available from: http://cph.uiowa.edu/ehsrc/fracsand.html.

Upper Monongahela River Association (2011). WV/PA Monongahela Area Watersheds Compact Minutes - Seventh Meeting, March 23, 2011. Available from: http://www.uppermon.org/Mon_Watershed_Group/minutes-23Mar11.html.

USR Corporation (2006). Phase I Hydrogeologic Characterization of the Mamm Creek Field Area in Garfield County. Denver, Colorado. Available from: http://www.garfield-county.com/oil-gas/documents/final_report_1.pdf.

Vaidyanathan, G. (2013). Fracking Spills Cause Massive Ky. Fish Kill. Available from: http://www.eenews.net/greenwire/2013/08/29/stories/1059986559.

Vazquez-Duhalt, R., F. Marquez-Rocha, E. Ponce, A. Licea & M. Viana (2005). Nonylphenol, an integrated vision of a pollutant. Applied Ecology and Environmental Research. 4 (1). pp. 1–25. Available from: http://www.ecology.uni-corvinus.hu/pdf/0401_001025.pdf?origin=publication_detail.

Vengosh, A., R.B. Jackson, N. Warner, T.H. Darrah & A. Kondash (2014). A Critical Review of the Risks to Water Resources from Unconventional Shale Gas Development and Hydraulic Fracturing in the United States. Environmental Science & Technology. 48 (15). pp. 8334–8348. Available from: http://pubs.acs.org/doi/abs/10.1021/es405118y.

Vidic, R.D., S.L. Brantley, J.M. Vandenbossche, D. Yoxtheimer & J.D. Abad (2013). Impact of shale gas development on regional water quality. Science. 340 (6134). pp. 826–835. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23687049.

Vlaming, V. De & T.J. Norberg-King (1999). A Review of Single Species Toxicity Tests: Are the Tests Reliable Predictors of Aquatic Ecosystem Community Responses?. US EPA, Washington, DC. Available from: http://nepis.epa.gov/Exe/ZyNET.exe/30003KUO.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1995+Thru+1999&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex Data%5C95thru99%5CTxt%5C00000009%5C30003KUO.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyAc.

Walker, B.L., D.E. Naugle & K.E. Doherty (2007). Greater Sage-Grouse Population Response to Energy Development and Habitat Loss. Journal of Wildlife Management. 71 (8). pp. 2644–2654. Available from: http://www.bioone.org/doi/abs/10.2193/2006-529.

Walker, T., S. Kerns, D. Scott, P. White, J. Harkrider, C. Miller & T. Singh (2002). Fracture Stimulation Optimization in the Redevelopment of a Mature Waterflood, Elk Hills Field, California. In: SPE Western Regional /AAPG Pacific Section Joint Meeting. May 2002, Society of Petroleum Engineers, Anchorage, Alaska, p. 22. Available from: https://www.onepetro.org/conference-paper/SPE-76723-MS.

Wallace, N.J. & E.D. Pugh (1993). An Improved Recovery and Subsidence Mitigation Plan for the Lost Hills Field, California. In: Proceedings of SPE Annual Technical Conference and Exhibition. 1 October 1993, Society of Petroleum Engineers, Houston, Texas, p. 10. Available from: https://www.onepetro.org/conference-paper/SPE-26626-MS.

Warco, K.O. (2010). Fracking Truck Runs Off Road; Contents Spill. Observer Reporter. 21 October. Available from: http://www.uppermon.org/news/Other/OR-Frac_Truck_Spill-21Oct10.html.

Warner, N.R., C. a Christie, R.B. Jackson & A. Vengosh (2013a). Impacts of shale gas wastewater disposal on water quality in western Pennsylvania. Environmental Science & Technology. 47 (20). pp. 11849–57. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24087919.

Warner, N.R., R.B. Jackson, T.H. Darrah, S.G. Osborn, A. Down, K. Zhao, A. White & A. Vengosh (2012). Geochemical evidence for possible natural migration of Marcellus Formation brine to shallow aquifers in Pennsylvania. Proceedings of the National Academy of Sciences. 109 (30). pp. 11961–11966. Available from: http://www.pnas.org/content/109/30/11961.full.

Warner, N.R., T.M. Kresse, P.D. Hays, A. Down, J.D. Karr, R.B. Jackson & A. Vengosh (2013b). Geochemical and isotopic variations in shallow groundwater in areas of the Fayetteville Shale development, north-central Arkansas. Applied Geochemistry. 35. pp. 207–220. Available from: http://www.sciencedirect.com/science/article/pii/S0883292713001133.

Warpinski, N., J. Du & U. Zimmer (2012). Measurements of Hydraulic-Fracture-Induced Seismicity in Gas Shales. SPE Production & Operations. 27 (3). pp. 240–252. Available from: https://www.onepetro.org/journal-paper/SPE-151597-PA.

Warren, R., J. Price, A. Fischlin, S. de la Nava Santos & G. Midgley (2011). Increasing impacts of climate change upon ecosystems with increasing global mean temperature rise. Climatic Change. 106 (2). pp. 141–177.

Warren, R., J. VanDerWal, J. Price, J.A. Welbergen, I. Atkinson, J. Ramirez-Villegas, T.J. Osborn, A. Jarvis, L.P. Shoo & S.E. Williams (2013). Quantifying the benefit of early climate change mitigation in avoiding biodiversity loss. Nature Climate Change. 3 (7). pp. 678–682.

Water Education Foundation (2012). Western Water September/October Water Education Foundation, Sacramento, CA

Weber, C. & C. Clavin (2012). Life cycle carbon footprint of shale gas: Review of evidence and implications. Environmental Science & Technology. 46 (11). pp. 5688–5695. Available from: http://pubs.acs.org/doi/abs/10.1021/es300375n.

Weijers, L., C. Cipolla, M. Mayerhofer & C. Wright (2005). Developing Calibrated Fracture Growth Models for Various Formations and Regions Across the United States. In: SPE Annual Technical Conference and Exhibition. 2005, Society of Petroleum Engineers, Dallas, Texas, p. 9. Available from: https://www.onepetro.org/conference-paper/SPE-96080-MS.

Weijers, L., C. Wright, S. Demetrius, G. Wang, E. Davis, M. Emanuele, J. Broussard & G. Golich (1999). Fracture Growth and Reorientation in Steam Injection Wells. In: 1999 International Operations and Heavy Oil Symposium. March 1999, Society of Petroleum Engineers, Bakersfield, California, p. 11. Available from: http://www.onepetro.org/mslib/servlet/onepetropreview?id=00054079.

Weller, C., J. Thomson, P. Morton & G. Aplet (2002). Fragmenting Our Lands: The Ecological Footprint from Oil and Gas Development. The Wilderness Society, Seattle, Washington. Available from: http://wilderness.org/sites/default/files/fragmenting-our-lands_0.pdf.

Wertz, J. (2013a). Five Things Oklahomans Need to Know About Earthquake Insurance. Available from: http://stateimpact.npr.org/oklahoma/2013/11/18/five-things-oklahomans-need-to-know-about-earthquake-insurance/.

Wertz, J. (2013b). Oklahomans Live With Shaking as Researchers Study Earthquake Swarm. Available from: http://stateimpact.npr.org/oklahoma/2013/11/14/oklahomans-live-with-shaking-as-researchers-study-earthquake-swarm/.

Whalen, C. (2014). The Environmental, Social, and Economic Impacts of Hydraulic Fracturing, Horizontal Drilling, and Acidization in California Claremont McKenna College Senior Theses, Available from: http://scholarship.claremont.edu/cmc_theses/969/.

White, E.I. (2012). Consideration of Radiation in Hazardous Waste Produced from Horizontal Hydrofracking. October. Available from: http://shalegasespana.files.wordpress.com/2012/10/whitereport.pdf.

Whiteman, G., C. Hope & P. Wadhams (2013). Climate science: Vast costs of Arctic change. Nature. 499 (7459). pp. 401–403.

Williams, D.F., E.A. Cypher, P.A. Kelly, K.J. Miller, N. Norvell, S.F. Phillips, C.D. Johnson & G.W. Colliver (1998). Recovery Plan for Upland Species of the San Joaquin Valley, California. Portland, Oregon. Available from: http://esrp.csustan.edu/publications/recoveryplan.php.

Williams, T. (2004). The Mad Gas Rush. Audubon. Available from: http://archive.audubonmagazine.org/incite/incite0403.html.

Wilson, S., W. Subra & L. Sumi (2013). Reckless Endangerment While Fracking the Eagle Ford: Government fails, public health suffers and industry profits from the shale oil boom. Earthworks. Earthworks, Washington, D.C. Available from: http://www.earthworksaction.org/files/publications/FULL-RecklessEndangerment-sm.pdf.

Witter, R., L. McKenzie, M. Towle, K. Stinson, K. Scott, L. Newman & J. Adgate (2010). Health Impact Assessment for Battlement Mesa, Garfield County Colorado. Denver, Colorado. Available from: http://www.garfield-county.com/public-health/documents/1_Complete HIA without Appendix D.pdf.

Wolf, S. (2014). Scientific Evidence on the Harms that Fracking Chemicals Pose to California's Coastal Marine Life Center for Biological Diversity, San Francisco, California Available from: http://www.indybay.org/uploads/2014/07/10/cbd_letter_to_ccc_on_offshore_fracking_impacts_to_wildlife.pdf.

Wood, W. & D. McKeon (1995). A Unique Method of Evaluating Stimulation Effectiveness in Production Damaged Slotted Liners. In: Proceedings of SPE Western Regional Meeting. 1995, Society of Petroleum Engineers. Available from: https://www.onepetro.org/conference-paper/SPE-29679-MS.

Wright, C.A., E.J. Davis, L. Weijers, W.A. Minner, C.M. Hennigan & G.M. Golich (1997). Horizontal Hydraulic Fractures: Oddball Occurrences or Practical Engineering Concern? In: Proceedings of SPE Western Regional Meeting. 1 June 1997, Society of Petroleum Engineers. Available from: https://www.onepetro.org/conference-paper/SPE-38324-MS.

Wright, P.R., P.B. McMahon, D.K. Mueller & M.L. Clark (2012). Groundwater-Quality and Quality-Control Data for Two Monitoring Wells near Pavillion, Wyoming, April and May 2012. Available from: http://pubs.usgs.gov/ds/718/DS718_508.pdf.

Wyoming Game and Fish Department (2010). Recommendations for Development of Oil and Gas Resources Within Important Wildlife Habitats. Available from: http://pbadupws.nrc.gov/docs/ML1108/ML110810642.pdf.

Yarbrough, C.L., B.B. McGlothlin & J.F. Muirhead (1969). Fracture Stimulation in a Soft Formation. In: Proceedings of SPE California Regional Meeting. 1 November 1969, Society of Petroleum Engineers. Available from: https://www.onepetro.org/conference-paper/SPE-2749-MS.

Ying, G., B. Williams & R. Kookana (2002). Environmental fate of alkylphenols and alkylphenol ethoxylates—a review. Environment International. Available from: http://www.sciencedirect.com/science/article/pii/S016041200200017X.

Zou, L., S.N. Miller & E.T. Schmidtmann (2006). Mosquito larval habitat mapping using remote sensing and GIS: Implications of coalbed methane development and West Nile virus. Journal of Medical Entomology. 43(5):1034-1041

Appendix F

California Council On Science And Technology Study Process

The reports of the California Council on Science and Technology (CCST) are viewed as being valuable and credible because of the institution's reputation for providing independent, objective, and nonpartisan advice with high standards of scientific and technical quality. Checks and balances are applied at every step in the study process to protect the integrity of the reports and to maintain public confidence in them.

Study Process Overview—Ensuring Independent, Objective Advice

For over 25 years, CCST has been advising California on issues of science and technology by leveraging exceptional talent and expertise.

CCST can enlist the state's foremost scientists, engineers, health professionals, and other experts to address the scientific and technical aspects of society's most pressing problems.

CCST studies are funded by state agencies, foundations and other private sponsors. CCST provides independent advice; external sponsors have no control over the conduct of a study once the statement of task and budget are finalized. Study committees gather information from many sources in public and private meetings but they carry out their deliberations in private in order to avoid political, special interest, and sponsor influence.

Stage 1: Defining the Study

Before the committee selection process begins, CCST staff and members work with sponsors to determine the specific set of questions to be addressed by the study in a formal "statement of task," as well as the duration and cost of the study. The statement of task defines and bounds the scope of the study, and it serves as the basis for determining the expertise and the balance of perspectives needed on the committee.

The statement of task, work plan, and budget must be approved by CCST's Board chair. This review often results in changes to the proposed task and work plan. On occasion, it results in turning down studies that CCST believes are inappropriately framed or not within its purview.

Stage 2: Committee Selection and Approval

Selection of appropriate committee members, individually and collectively, is essential for the success of a study. All committee members serve as individual experts, not as representatives of organizations or interest groups. Each member is expected to contribute to the project on the basis of his or her own expertise and good judgment. A committee is not finally approved until a thorough balance and conflict-of-interest discussion is held, and any issues raised in that discussion are investigated and addressed. Members of a committee are anonymous until this process is completed.

Careful steps are taken to convene committees that meet the following criteria:

An appropriate range of expertise for the task. The committee must include experts with the specific expertise and experience needed to address the study's statement of task. A major strength of CCST is the ability to bring together recognized experts from diverse disciplines and backgrounds who might not otherwise collaborate. These diverse groups are encouraged to conceive new ways of thinking about a problem.

A balance of perspectives. Having the right expertise is not sufficient for success. It is also essential to evaluate the overall composition of the committee in terms of different experiences and perspectives. The goal is to ensure that the relevant points of view are, in CCST's judgment, reasonably balanced so that the committee can carry out its charge objectively and credibly.

Screened for conflicts of interest. All provisional committee members are screened in writing and in a confidential group discussion about possible conflicts of interest. For this purpose, a "conflict of interest" means any financial or other interest which conflicts with the service of the individual because it could significantly impair the individual's objectivity or could create an unfair competitive advantage for any person or organization. The term "conflict of interest" means something more than individual bias. There must be an interest, ordinarily financial, which could be directly affected by the work of the committee. Except for those rare situations in which CCST determines that a conflict of interest is unavoidable and promptly and publicly disclose the conflict of interest, no individual can be appointed to serve (or continue to serve) on a committee of the institution used in the development of reports if the individual has a conflict of interest that is relevant to the functions to be performed.

Point of View is different from Conflict of Interest. A point of view or bias is not necessarily a conflict of interest. Committee members are expected to have points of view, and CCST attempts to balance these points of view in a way deemed appropriate for the task. Committee members are asked to consider respectfully the viewpoints of other

members, to reflect their own views rather than be a representative of any organization, and to base their scientific findings and conclusions on the evidence. Each committee member has the right to issue a dissenting opinion to the report if he or she disagrees with the consensus of the other members.

Other considerations. Membership in CCST and previous involvement in CCST studies are taken into account in committee selection. The inclusion of women, minorities, and young professionals are additional considerations.

Specific steps in the committee selection and approval process are as follows:

Staff solicit an extensive number of suggestions for potential committee members from a wide range of sources, then recommend a slate of nominees. Nominees are reviewed and approved at several levels within CCST. A provisional slate is then approved by CCST's Board. The provisional committee members complete background information and conflict-of-interest disclosure forms. The committee balance and conflict-of-interest discussion is held at the first committee meeting. Any conflicts of interest or issues of committee balance and expertise are investigated; changes to the committee are proposed and finalized. Committee is formally approved. Committee members continue to be screened for conflict of interest throughout the life of the committee.

Stage 3: Committee Meetings, Information Gathering, Deliberations, and Drafting the Report

Study committees typically gather information through:

1. meetings;

2. submission of information by outside parties;

3. reviews of the scientific literature; and

4. investigations by the committee members and staff.

In all cases, efforts are made to solicit input from individuals who have been directly involved in, or who have special knowledge of, the problem under consideration.

The committee deliberates in meetings closed to the public in order to develop draft findings and recommendations free from outside influences. The public is provided with brief summaries of these meetings that include the list of committee members present. All analyses and drafts of the report remain confidential.

Stage 4: Report Review

As a final check on the quality and objectivity of the study, all CCST reports whether products of studies, summaries of workshop proceedings, or other documents must undergo a rigorous, independent external review by experts whose comments are provided anonymously to the committee members. CCST recruits independent experts with a range of views and perspectives to review and comment on the draft report prepared by the committee.

The review process is structured to ensure that each report addresses its approved study charge and does not go beyond it, that the findings are supported by the scientific evidence and arguments presented, that the exposition and organization are effective, and that the report is impartial and objective.

Each committee must respond to, but need not agree with, reviewer comments in a detailed "response to review" that is examined by one or two independent report review "monitors" responsible for ensuring that the report review criteria have been satisfied. While feedback from the peer reviewers and report monitors is reflected in the report, neither group approved the final report before publication. The steering committee and CCST take sole responsibility for the content of the report. After all committee members and appropriate CCST officials have signed off on the final report, it is transmitted to the sponsor of the study and is released to the public. Sponsors are not given an opportunity to suggest changes in reports. All reviewer comments remain confidential. The names and affiliations of the report reviewers are made public when the report is released.

The report steering committee wishes to thank the oversight committee and the peer reviewers for many thoughtful comments that improved this manuscript.

Oversight committee co-chairs:

Maxine Savitz, Honeywell, Int. (Retired)

Peer reviewers:

David Allen, Professor of Chemical Engineering, and Director, Center for Energy and Environmental Resources, University of Texas at Austin

George E. King, Registered Professional Engineer (Oklahoma and Texas), George E. King Engineering

William A. Minner, Principal Consultant, StrataGen Engineering

Jim Boyd, Senior Advisor, Cleantech Advocates

Ziyad Duron, Jude and Eileen Laspa Professor of Engineering, Harvey Mudd College

Appendix G

Acknowledgements

The authors would like to acknowledge Hilary Ahearn, Whitney Sandelin, Amber Mace, Donna King, Susan Hackwood, Helen Prieto, and Dan Hawkes for project support and helpful editing on the report.

Chapter 2 Acknowledgements

This review of well stimulation technology benefitted from helpful comments and suggestions during its development. These were provided by Jane Long and Laura Feinstein (California Council on Science and Technology), Dan Tormey (ENVIRON Global), Dan Hill (Texas A&M), Larry Lake (University of Texas), Don Gautier (retired USGS), Peter Gleick (Pacific Institute), Tom McKone (Lawrence Berkeley National Laboratory), and Seth Shonkoff (Physicians Scientists & Engineers for Healthy Energy). Many additional improvements were a result of the helpful comments and suggestions from the anonymous peer review team. Technical editing was performed with great skill and efficiency by Dan Hawkes.

Chapter 3 Acknowledgements

Staff at DOGGR and the California Department of Conservation (DOC) advised on and provided much of the data analyzed in this section, for which the authors are grateful. In particular, Bill Winkler of DOGGR patiently worked with the authors to develop a well-record sampling plan for assessing hydraulic fracturing activity over a longer period than available from FracFocus. He arranged for the selected well records to be processed with text recognition software, in order to make them searchable, and then provided the records. Vincent Agusiegbe and Emily Reader of DOGGR provided data output from FracFocus that made possible the inclusion of its data for the period after May, 2013, in the analyses presented here. Undoubtedly, there were many DOGGR and DOC staff that participated in these efforts that are unknown to the authors, but we extend our appreciation. Ed Eckerle at the SCAQMD was particularly helpful regarding properly understanding the data held by that agency. He patiently spent considerable time on the phone with us as we sought to understand the details and resolve potential discrepancies with data available from DOGGR.

Chapter 4 Acknowledgements

This summary of petroleum resources and potential applications of well stimulation in California has benefited from the input and support of many people. Lynn Tennyson (USGS) kindly shared her extensive knowledge of petroleum systems in California. Rick

Behl (CSU Long Beach) provided many insights into the Monterey Formation, and shared the work of his students on the MARS (Monterey and Related Sediments) project. Steve Graham (Stanford), Pat McCrory (USGS), and Jim Boles (UC Santa Barbara) helped steer the authors to important data sources, as did Larry Beyer (USGS-emeritus). Tess Menotti (Stanford) generously shared some of the preliminary results of her Ph.D. study of the Salinas Basin. Don Sweetkind (USGS) allowed use of the GIS data that he generated for the Santa Maria and Cuyama Basins. Julie LeFever (North Dakota Geological Survey) shared GIS data for the Bakken Formation in the Williston Basin. Drew Mayerson of BSEE helped us understand the petroleum resources of the federal offshore areas and Joan Barminski and her colleagues at BOEM helped us access their most recent offshore resource evaluations. The staff geologists and engineers at the Cypress office of CDOGGR were particularly helpful in directing us to Los Angeles basin data. Tim Klett (USGS) helped us organize field-level data from Los Angeles and San Joaquin basins. Michael Golden (Lawrence Berkeley National Laboratory (LBNL)) tracked down a number of references used in this review. Dan Hawkes and Helen Prieto (LBNL) provided editorial assistance in a timely fashion, and Jane Long, Laura Feinstein (California Council on Science and Technology (CCST)), Jim Houseworth (LBNL), and Whitney Sandelin (University of the Pacific) provided helpful suggestions in their reviews of this section. Michelle Robertson and Craig Ulrich (LBNL) generated the basin GIS figures—without their long hours of work creating these figures, this report would not have been completed. Anonymous reviewers suggested additional improvements. Many thanks to all.