Real Estate Valuation Services
Phase 1-Fracking Impact Study

Fort Collins, CO

DATE OF REPORT

August 1, 2014

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August 1, 2014

Mr. John Duval, Esq.
Senior Assistant City Attorney
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Impact of Hydraulic Fracturing

Dear Mr. Duval:

Pursuant to our Professional Services Agreement, I am pleased to convey the following report.

I emphasize that my role in this study is as a real estate appraiser; as such, I am bound by the Uniform Standards of Professional Practice, even though the report contains no opinion of value.

The report that follows consists of nine major topics in addition to a complete bibliography of the literature reviewed. Although Hunsperger & Weston, Ltd. is referred to as the "Professional" in the Professional Services Agreement, the report was prepared jointly between Wayne L. Hunsperger and sub-contractor, Jean C. Townsend, President of Coley/Forrest, Inc.

Based on our review of the literature, Ms. Townsend and I have summarized our observations in Section 2. In general, the study of property value impacts related to hydraulic fracturing is in its infancy. To date, few scholarly property impact studies have been published, but the literature does suggest that a negative environmental event associated with fracking will likely have an adverse impact on property values in proximity to the event.

Thank you for the opportunity of working on this assignment. If you have questions or comments, please do not hesitate to contact me or Ms. Townsend.

Respectfully submitted,

Wayne L. Hunsperger

Wayne L. Hunsperger, MAI, SRA
Hunsperger & Weston, Ltd.

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1. ASSIGNMENT

This assignment:

- provides results of a literature and resources search relative to Ballot Measure 2A which imposes a 5-year moratorium on hydraulic fracturing in the City of Fort Collins[1] (Sections 2 through 7, Sections 10 and 11);

- identifies data gaps that would be necessary to describe potential property value impacts in Fort Collins that would also be acceptable in a court of law and approaches to complete an analysis of property value impacts attributable to fracking (Sections 8 and 9).

For purposes of this report, the definition of hydraulic fracturing and its potential, associated harms is set out in Section 2 of the citizen-initiated ordinance proposed in Ballot Measure 2A that was adopted by the City's voters on November 5, 2013. It reads:

> "The well stimulation process known as hydraulic fracturing is used to extract deposits oil, gas, and other hydrocarbons through the underground injection of large quantities of water, gels, acids or gases; sands or other proppants, and chemical additives, many of which are known to be toxic."
>
> The people of Fort Collins seek to protect themselves from the harms associated with hydraulic fracturing, including threats to public health and safety, property damage and diminished property values, poor air quality, destruction of landscape, and pollution of drinking and surface water."

In Colorado as well as elsewhere in the US, authors report that 90% or more of shale oil and gas production currently uses hydraulic fracturing or fracking technology to enhance production volumes. In this literature review, the definition of hydraulic fracturing or fracking is intended to be consistent Section 2 of the citizen-initiated ordinance. It is assumed that "harms associated with hydraulic fracturing", also in Section 2, are illustrative of potential harms and are not intended to be confined to only those impacts mentioned.

[1] Ballot Measure 2A, approved by Fort Collins voters in November 6, 2013 "An ordinance placing a moratorium on hydraulic fracturing and the storage of its waste products within the City of Fort Collins or on lands under its jurisdiction for a period of five years, without exemption or exception, in order to fully study the impacts of this process on property values and human health, which moratorium can be lifted upon a ballot measure approved by the people of the City of Fort Collins and which shall apply retroactively as of the date this measure was found to have qualified for placement on the ballot."

2. OBSERVATIONS

Based on our review of the literature, we offer these observations.

% of Natural Gas from Shale Formations in United States	
2000	1.6%
2005	4.0%
2010	22.8%
2015 (est)	40.4%

Source: US EIA, DOE/EIA-013 (2012)

- *(Production Volume from Shale Formations)* Not only has natural gas production increased substantially, but also the percent of production from shale formations has increased exponentially due to fracking technology that now enables cost-effective production from shale gas plays. Those involved in improving production methods, crafting regulations, performing inspections, measuring impacts and drafting scholarly analyses are "playing catchup." Due to the rapid increase in the use of fracking shale gas formations, there is insufficient information at this time to evaluate the cumulative effects.

- (*Types of Incidents and Impacts)* There are documented incidents of events from fracking shale oil and gas with potentially harmful impacts to humans, crops and livestock. Some cause-and-effect relationships have been challenged by industry specialists. Since there is relatively little "baseline" information, prior to fracking, it can be difficult to "prove" that a fracking event was the cause of an adverse condition. (Hall, 2013)

- *(Relationship to Property Values*) If an event is reported to be harmful to humans, crops or livestock and the event is publicized, then the literature suggests that it is reasonable to anticipate that, all other things being equal, the event will have an adverse impact on property values, due to real or perceived effects on the number of future buyers, the prices buyers are willing to pay, the insurability of the property and ability to secure a mortgage. (Jackson, 2002; Peters, 2013; Sucich, 2012)

- *(Scholarly Analyses.)* There are a handful of scholarly analyses regarding shale oil and gas activity and its impact on property values. (See Section 6.) In all analyses reviewed, the relationship is adverse unless royalty or lease payments to property owners are greater than anticipated adverse impacts to property values. In a number of these studies, the impacts of fracking overlap with impacts associated with conventional oil and gas operations in general. That is, the studies purport to measure the impacts of fracking but include effects such as proximity to wells, disturbed surface areas and noise & light, etc. associated with the conventional drilling operations. There are also several scholarly analyses of the broader economic impact of shale oil and gas development on communities. These generally show broad positive impacts to the community as a whole; the duration of these community impacts varies over time.

- *(Frequency of Adverse Events)* The frequency of reported adverse events per individual gas well drilled with fracking technology appears to be relatively small. However, the stigma associated with proximity to a shale oil or gas well that has been fracked is relatively, broadly publicized. Also, as the number of wells fracked increases, the probability of an

adverse event occurring also increases.

- *(Regulations and Disclosures*) Colorado has in place some of the most stringent requirements associated with fracking of any state in the country, including groundwater sampling, well pressure monitoring, secondary containment system development, in addition to disclosure of all chemical additives unless they constitute a trade secret. (www.cogcc.state.co.us) Chemical additives constitute 0.1% to 1% of the hydraulic fracturing fluid. At higher levels of concentration, many have hazardous qualities.

- *(Appraisal Methodology)* The appraisal literature identifies commonly used methodologies to study impacts to value on a universe of properties. The body of literature is augmented by the Uniform Standards for Professional Practice, which provides guidelines for usage. Together they generally satisfy the standards for admissibility of evidence in a court of law. (Jackson, 2004; Jackson, 2005)

- *(Property Value Impacts Affected by Buyer / Seller Information)* Impacts on property value from a detrimental condition may be viewed on a continuum. Property value is generally lowest when the condition occurs, before the extent of damage has been characterized. As more becomes known about the problem and how to mitigate it, value tends to recover. (Bell, 2008, page 21) With respect to fracking impacts, studies are ongoing and risks might not be fully characterized. As more data becomes available, good or bad, market perceptions will likely change, as will impacts to value. Consequently, a 2015 or 2016 damage study may well produce different results relative to a 2014 study that measures market attitudes in the current knowledge base.

- (*Perceptions about real estate, positive or negative, drive market value*) Perception is reality. Therefore, if someone thinks it is dangerous to live next to a nuclear power plant, eat apples, etc., the value to that person of a home near a nuclear power plant, an apple, etc., will be reduced regardless of whether any real danger exists or not. (Slovic, 2001, page 176) It is not the facts regarding a risk that creates property value diminution, but rather the perception of a risk or negative image. Thus, the media plays more of a role in shaping stigma than does the science. (Slovic, 2001, page 183)

3. FRACKING IMPACTS AND PROPERTY VALUES

There are many ways to categorize impacts potentially attributable to fracking and their effects on property values. Based on a review of the literature, this report organizes impact information into two broad categories: General Impacts and Health, Safety and Welfare Impacts. In addition, cited documents that also reference federal or state regulations or public policy issues are identified.

- General Impacts. Some impacts affect the community or local economy as a whole. These broad impacts may also have an inconsistent impact on individual properties, depending on their location and land use. These are labeled General Impacts.

- Health, Safety and Welfare Impacts. There are also impacts that affect the health, safety and welfare of residents, landowners and businesses.

    - Some impacts occur most prominently prior to or during well drilling or re-drilling and fracking processes while other impacts occur during long-term operations and maintenance of the well site. Wells might be re-fracked multiple times during their productive life.

    - Some impacts, such as noise and light impacts, occur relatively close to the well site and affect nearby property; earthquakes, can occur in areas removed from the well site; some impacts such as groundwater contamination and air emissions, can occur either close to or in locations away from the well site.

    - Most negative impacts accrue to the surface rights holder; positive impacts accrue to the mineral rights holder through lease or royalty payments. In Colorado, it is not unusual for the surface rights holder to be different from the mineral rights holder. The mineral rights holder is dominant in situations where there are conflicts.

Any property impact might be "real", perceived or anticipated. Stigma[2], which is an adverse public perception regarding a property, can affect property values. (Flynn, 2004) These impacts might affect homes, vacant land, businesses, agricultural property, schools, or parks.

No individual document in this literature search provides definitive information about a condition, a finding, an incident, or a cause-and-effect circumstance. However, each document contributes to an understanding about potential impacts or the perception of impacts on property. The types of impacts identified in the table below are taken from an amalgamation of the entire body of literature. Specific references by impact type may be found in the Annotated Bibliography spreadsheet attached to this report.

[2] The Dictionary of Real Estate Appraisal (Appraisal Institute, 5th ed., 2010, page 187) defines stigma as "An adverse public perception regarding a property with a condition (e.g., environmental contamination, a grisly crime) that exacts a penalty on the marketability of the property and may also result in a diminution in value".

TYPES OF IMPACTS TO PROPERTY VALUES REFERENCED IN THE LITERATURE	
TYPE	EXPLANATION OR DESCRIPTION
GENERAL IMPACTS	
Natural Resource Production	The volume of shale oil and gas production in the US, relative to other oil and gas, coal, or other natural resource development in increasing rapidly. Some authors remark that increased domestic production volume lessens US dependence on foreign energy.
Economic Impacts	Oil and gas production generates jobs and increases demand for housing, lodging, and retail as well as the need for related public and private sector services. The literature indicates that these are generally favorable economic impacts that a community will likely experience, particularly during well construction. The duration of these impacts may change over time.
Greenhouse Gas	Natural gas is a hydrocarbon gas mixture consisting primarily of methane, which is a greenhouse gas. Fracking flowback may result in methane leakage.
Water Quantity	The process of fracking requires substantial volumes of water per well relative to conventional oil and gas production. Each well that is fracked can require 2 to 8 million gallons, depending on its location. Wells may be fracked multiple times over their productive life. In some portions of the country, there are concerns about the availability of water supply and depletion of ground water aquifers.
HEALTH, SAFETY AND WELFARE IMPACTS	
Air Emissions	Air emissions of methane, benzene, radon, and other volatile organic compounds (VOCs) can occur at all stages of shale oil and gas development including well construction; fracking; fracked wastewater flowback, storage or treatment; use of compression equipment, and; transmission.
Chemical Exposure	In addition to air emissions, exposure to hazardous chemicals can occur due to compounds in fracking fluid that leak or spill during delivery to the well site, fracking and fracking flowback. Fracked wastewater that returns to the surface (15% to 80%) might be stored in on-site ponds, or delivered via truck or pipeline to a wastewater holding pits, wastewater injection wells or treatment facilities. The remainder of fracked wastewater remains below surface.
Crop and Livestock	Some report that ozone from fracking can diminish crop productivity and that fracking chemicals may be ingested by farm animals. Also, dust and exhaust produced by vehicles used in fracking has been reported to trigger livestock death from "dust pneumonia."
Earthquakes	Fracking and the underground disposal of fracked wastewater may trigger earthquakes. Earthquakes may increase in intensity, the longer the fracking fluid is in the ground.
Land Use	Future land use planning—zoning, densities, setbacks, well buffers, etc.—will be influenced by drilling activity.

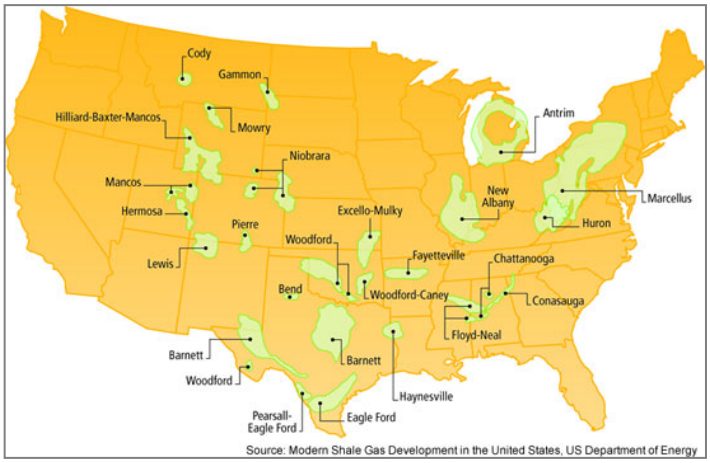
TYPES OF IMPACTS TO PROPERTY VALUES REFERENCED IN THE LITERATURE	
TYPE	EXPLANATION OR DESCRIPTION
Light & Noise Pollution	*Lighting:* 24-7 lighting of well-head and fenced property plus fume flares at the well-head *Noise:* Construction truck traffic and drilling activity; operations noise from compressors, mechanical and electrical equipment.
Mineral & Surface Rights & Royalties	In Colorado, landowner surface rights are separate from mineral rights. Mineral rights owners may use the surface property to extract oil and gas. If there is a conflict, then the mineral estate prevails. Revenue from leasing and royalties accrue to the mineral rights holder.
Mortgages and Property Insurance	Some lenders will not provide mortgages for property adjacent to oil and gas wells. Fannie Mae and Freddie Mac require prior approval of a drilling lease; otherwise, the mortgage guarantee is in default. Some insurance carriers will not insure damage from fracking.
Truck Traffic	This impact can occur during well exploration, well construction and fracking as well as continuing during wastewater disposal and routine maintenance. Wells that are fracked require significantly more truck deliveries relative to wells that are not fracked because of the water volume requirements.
Visual Disturbance	There are visual impacts attributable to the presence of drilling rigs, water towers, fencing, etc. for any oil and gas development. Additional equipment is on-site for a period of time, if a well is fracked.
Water Quality	Contamination of ground or surface water might occur at any step of the process: water acquisition, water withdrawal, chemical mixing, well injection, fracked wastewater flowback, and fracked waste water disposal.

4. Shale Oil and Gas Locations and Production Volume

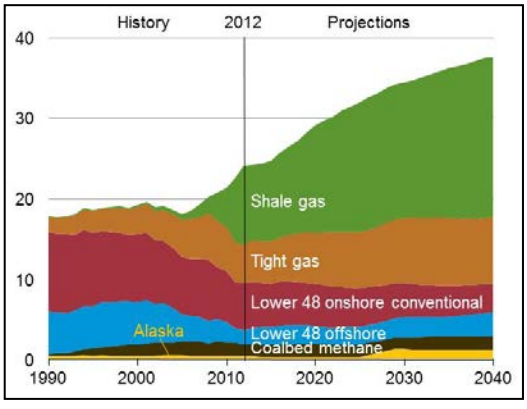
The literature cited in this report refers to instances of oil and gas impacts in at least 12 states. These are listed below. The fifteen states that contain the majority of major shale formations are listed below.

California	New York	Pennsylvania
Colorado	North Dakota	Texas
Montana	Ohio	Utah
New Mexico	Oklahoma	Wyoming

The map that follows, created by the US Department of Energy, provides locations of major shale formations in the United States. About 20 states contain shale formations.



Due to recent technological advances attributable to fracking, it is now cost-effective to produce natural gas from shale gas formations. In the US, the amount of natural gas production attributable to shale gas has increased from 1.5% in 2000, to 22.8% in 2010 and is forecasted to reach 40.4% by 2015. (US Energy Information Administration, 2014) These results are highlighted in the graph to the right.



Source: U.S. EIA, DOE/EIA-0131(2012)

5. SOURCES OF INFORMATION

Historic and Current Literature and Resources Review. This review includes:

- Peer-reviewed journal articles;
- Working papers, prepared by academics;
- White papers, prepared by researchers and consulting firms;
- Documents produced by federal and state governments, universities, and trade organizations, and;
- News reports from notable news organizations.

It excludes undocumented third party opinions.

This is a wide variety of data sources and documents that increases on a weekly basis; this report and bibliography is a representation of what is available at this time. Most documents have not been peer-reviewed by scholars. Nevertheless, the entire body of literature is available to real estate market participants and to some degree shapes their perceptions about fracking. The authors of this report do not represent that any of these documents is correct or incorrect.

Sources of information were researched proactively from appraisal organizations, oil and gas industry organizations, environmental and resource oriented organizations, government resources, newspapers and news organizations and publications, colleges and universities, and generically via key word web search engines such as Google, Ask and Bing. This list also represents the organizations that have written about potential property value impacts attributable to fracking.

Appraisal Professional Trade Associations & Trade Journals:

American Institute of Minerals Appraisers – Minerals Valuation Resources
The Appraisal Journal
The Appraisal Foundation

Oil and Gas Industry Organizations:

American Petroleum Institute – Energy from Shale
Coloradans for Responsible Energy Development
Colorado Oil and Gas Association
EnergyFromShale.com
Fracking Insider
Groundwater Protection Council
Interstate Oil and Gas Compact Commission
Interstate Petroleum Institute of America
StudyFracking.com

Real Estate Trade Associations & Trade Publications:

National Association of Realtors

Journal of Real Estate Literature
Realtor Magazine

Other Publications:

American Banker
Proceedings of the National Academy of Sciences

Private Environmental Organizations. There are several national or regional-scale environmental organizations that have either authored reports, sponsored seminars, funded research performed by others or maintain web sites on fracking with property value information. Most are private nonprofit organizations. One, FracFocus, is a chemical registry managed by two quasi-governmental trade organizations.

AirWaterGas (www.airwatergas.org)
Cooperative Institute for Research in Environmental Sciences (www.cires.colorado.edu)
Center for Sustainable Shale Development (www.sustainableshale.org)
Center of the American West (www.centerwest.org)
Earthworks (www.earthworksaction.org)
Environment America (www.environmentamerica.org)
Environmental Defense Fund (www.edf.org)
FracFocus (www.fracfocus.org)
Pacific Institute (www.pacinst.org)
Resources for the Future (www.rff.org)
State Review of Oil and Natural Gas Environmental Regulations (www.strongerinc.org)
Western Resource Advocates (www.westernresourceadvocates.org)

Colleges and Universities. A number of universities in the US and Canada have individuals who have become specialists in oil and gas and/or fracking impacts on property values. Notable among these are:

Bucknell University
Carnegie Mellon University
Cleveland State University
Colorado State University
Columbia University Law School
Cornell University
Duke University
Harvard Law School
Marietta College
Ohio State University & Law Journal
Pennsylvania State University
Stanford University Law School
University of Calgary
University of Colorado
University of Denver
University of North Texas
University of Pittsburgh
University of Texas – Austin
University of Texas at San Antonio
Wilfrid Laurier University

News Organizations. The primary national and Colorado-based news organizations that have published articles about fracking and its potential impacts on property values are listed below.

NATIONAL NEWS ORGANIZATIONS
Bloomberg
National Geographic
National Public Radio – StateImpact
ProPublica
Reuters
The New York Times
Time Magazine
Wall Street Journal
Vanity Fair

COLORADO NEWS ORGANIZATIONS
Fort Collins Coloradan
Northern Colorado Business Report
The Denver Business Journal
The Denver Post
The Colorado Independent
The Colorado Observer

One national newspaper, The New York Times, has invested a substantial effort to identify more than 30,000 pages (their account) of documents, classified by topic. These documents can be accessed here:
http://www.nytimes.com/interactive/2011/02/27/us/natural-gas-documents-1-intro.html

Federal and State Governments. A number of Federal and State governments impose regulations or have published findings about fracking and its impacts. Due to several federal exemptions, state and local governments bear primary responsibility for oil and gas regulations on private land. Two sources provide a comprehensive discussion of the federal and State regulatory environment. (Ground Water Protection Council, 2009; Neslin, 2013; Wiseman, 2012)

FEDERAL GOVERNMENT:
US Department of Energy
US Energy Information Administration
US Environmental Protection Agency
US Bureau of Land Management

STATE OF COLORADO:
CO Department of Public Health and Environment
CO Division of Water Resources
CO Oil and Gas Conservation Commission
CO Oil and Gas Commission

In addition there are two multi-state organizations that have published information about shale oil and gas production and fracking.

- The Interstate Oil and Gas Compact Commission is a multi-state government agency, formed in 1925 by an interstate compact.

- The Ground Water Protection Council, formed in 1983, is a nonprofit 501(c)(6) whose members consist of state ground water regulatory agencies.

Research Underway. In addition to these resources, there are two multi-faceted research initiative now under way that might provide important information and insight.

National Science Foundation. In October 2012, as part of its Science, Engineering and Education for Sustainability (SEES) work, the National Science Foundation announced two $12 million awards to two Sustainability Research Networks (SRNs); each are led by a university.

- The University of Colorado Boulder and eight partner organizations have been retained to explore "ways to maximize the benefits of natural gas development while minimizing potential negative effects on human communities and ecosystems." This study is also referred to as the AirWaterGas study. A particularly germane component of this study effort is a hedonic pricing analysis comparing thousands of data points going back to 1998 in an attempt to isolate the effects on property values related to wells that have been fracked. This study component is led by CU-Boulder economist Catherine Keske and is expected to be completed in 2015.

- Penn State University and nine other universities and research institutions have been retained to study "sustainable climate risk management strategies."

Environmental Defense Fund. Also in 2012, The Environmental Defense Fund (EDF) announced its plans to spearhead its largest scientific project to date to understand from where and how much ethane is lost across the US natural gas supply chain. The collaborative effort involves about 100 universities, research institutions and companies and is divided into 16 distinct projects. Completion of all studies is expected later in 2014.

The first study has been released (Allen, 2013). This study measured methane emissions at well pads during the extraction phase of the natural gas supply chain. It contains some of the first measurements collected from hydraulically fracture wells.

Four of the 16 projects involve either the University of Colorado or Colorado State University.

- NOAA – CU Boulder – Denver Flyover Study. This NOAA led effort will measure methane emissions in Colorado's most active oil and gas field using aircraft flying over the basin.

- NOAA – CU Boulder Barnett Flyover Study. This study will measure atmospheric concentrations of hydrocarbons to quantify regional methane emissions in the Barnett shale formation in Texas.

- Colorado State University Transmission and Storage Study. This study will measure methane lost during long-distance transportation and storage of natural gas.

- Colorado State University Gathering and Processing Study. This study will quantify national methane emissions associated with natural gas industry's gathering infrastructure and procession plants.

US Environmental Protection Agency. In 2011, the EPA began research under its *Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources*. Eighteen research projects are underway; each study focuses on a different primary research question. In September 2012, a progress report was released. (USEPA, December 2012)

6. ANALYTICAL PROPERTY VALUATION METHODS APPLIED IN LITERATURE CITED

Much has been written about fracking and its potential impacts on property values. Most work has been published only in the last 5 to 7 years as fracking technology has become used more widely in the United States and elsewhere. In part because this topic is relatively new to the research and analytical community, the majority of work to date has not been published in peer-reviewed and scholarly journals.

However, the work contributes to the body of information about fracking and its real, perceived or anticipated impact on property values. Real estate property values are influenced by the perception of the buyer or seller, regardless of whether the underlying source is from a scholarly journal or expert.

ANALYTICAL METHODS APPLIED IN LITERATURE CITED	
TYPE	EXPLANATION
Anecdotal / Incident / Event	Report on individual incident or event.
Contingent Valuation	This is a survey-based technique used for the valuation of non-market resources, such as the impact of contamination. Typically, the survey asks how much money people would be willing to pay (or willing to accept) to maintain the existence of (or be compensated for the loss of) an environmental feature.

ANALYTICAL METHODS APPLIED IN LITERATURE CITED	
TYPE	EXPLANATION
Hedonic Price Analysis	This analytical technique uses the premise that that price is determined both by internal characteristics of the good being sold and external factors affecting it. The hedonic pricing model is used to estimate the extent to which each factor affects the price. In this type of application, hedonic price analysis estimates the marginal willingness to pay for specific adverse conditions
Regression Analysis	This is a statistical method for estimating the relationships among variables, when the focus is on the relationship between a dependent variable and one or more independent variables. Regression analysis helps one understand how the value of the dependent variable (such as housing price) changes when any one of the independent variables is varied, while the other independent variables are held fixed. This technique is often a part of a hedonic price analysis.
Survey Research	Telephone, in-person or mail-in survey of impacted individuals that own affected property. Surveys may be *informal*, such as in-person confirmation of transaction details or *formal,* based on a statistically significant sample corrected for bias.
Analysis – Secondary Research	Analysis of information compiled from other resources; also known as meta-analysis.

Property Value Analyses Using Primary Empirical Data. In addition to many types of individual findings and summaries of prior studies that are presented in the Annotated Bibliography, our research has identified six reports that used empirical data to consider the impacts of oil and gas exploration on property values and applied analytical methods that are generally acceptable in a court of law. Except for the LaPlata County study, all reference fracking impacts, which actually overlap with the impacts of the entire drilling operation including well proximity, lights & noise, etc.

- LaPlata County, Colorado (2001). Having a well on a property was associated with a 22% reduction in the value of the property; having a well within 550 feet increased its value; having a well between 551 and 2,600 feet had a negative impact. Authors attributed the positive impact (within 550 feet) due to a spacing order and setback conditions that prevented additional well drilling close to existing wells. This study measures the impacts of oil and gas operations on property values, specifically related to coal bed methane, which is significantly different from conventional oil and gas production or unconventional production that uses fracking technology. The report is included because of the methodology applied and its Colorado context. The term

"hydraulic fracturing" is not mentioned in the study. (Bortz, Brown and Coddington, 2001)

- Alberta, Canada (2005). Authors found a statistically significant inverse relationship between property values and the presence of oil and gas facilities within about 2.5 miles of rural residential properties of between 4% and 8%, with the potential to double the impact, depending on the nearby industrial activities. The term "hydraulic fracturing" is not mentioned in the article. (Boxall, et. al., 2005)

- Flower Mound, Texas (2011). The authors found that within Flower Mound, for properties in excess of $250,000, proximity to a well had an adverse impact of 3% to 14% on values. Also, there was an adverse impact on the time required to sell a property. The authors used the term fracking one time, but weren't specific as to whether the well sites used in the data base were a product of fracking. (Integra Realty Resources, 2011)

- Weld County Colorado (2013). This study attempted to determine whether risk perceptions associated with hydraulic fracturing are capitalized into housing prices in Weld County. Price-distance relationships were studied at all stages of the drilling process. Housing sales data from 2009 through 2012 were plotted and compared to (fracked) well locations. Low level adverse impacts were found in rural locations as a function of distance; low level adverse impacts were found in urban locations as a function of the number and density of wells. (Bennett, Ashley , 2013)

- Texas and Florida (2013). Using contingent valuation survey research, the research shows a 5% to 15% reduction in bid values for homes located proximate to fracking scenarios, depending on the petroleum-friendliness of the venue and proximity to the drilling site. The authors use the term "fracking" in a broad context to include the process itself and all potential harm there from, including proximity to well sites. (Throupe, et.al, 2013)

- Pennsylvania and New York (2014). The authors found strong evidence of negative net impacts on the prices of properties that are dependent on private water wells located near shale gas development, presumably facilitated through the process of fracking; the negative impacts become more pronounced (-16.7%) when the well is within 1 km. At a broader geographic scale, (20 km from shale gas wells) there is a small positive impact likely due to the boost to the local economy. Undrilled well permits can offset these benefits due to an aesthetic dis-amenity. (Muehlenbachs, et.al., 2014)

7. TECHNICAL RESOURCES AND SPECIALISTS

A thorough study of the effects of environmental impacts on the value of a large population of properties commonly involves a "team" approach comprised of various specialties, in addition to an appraiser and economist.

TYPE OF SPECIALIST	FUNCTION OR SPECIALTY
Geographic Information Systems	Layer data from various sources on a common format map; produce results; provide precise distance calculations
Econometrician	Develop regression model specifications; produce analysis, measuring statistical significance of various potential correlations.
Geologist/Hydro-geologist	Provide well location and aquifer data
Survey Research Specialist / Statistician	Frame survey research questions; pull sample from valid sources; recommend method; calculate appropriate sample sizes; conduct survey; analyze results

8. DATA GAPS TO COMPLETE A PROPERTY IMPACT ANALYSIS

Literature Cited. While literature that references potential environmental and property value impacts associated with fracking is abundant, the direct correlation between fracking impacts and property values is more sparsely documented in a careful manner.

About one-third of the literature cited in the bibliography (Section 10) address impacts to property values.

- Among these documents, only a few are also supported by recognized methods of valuation using empirical data that could be acceptable in a court of law. (See Section 6.)

- The annotated bibliography (Section 11) identifies which of these documents use the term "fracking" in its remarks about property values and which do not. Among the three-fourths that use the term "fracking", some authors do not appear to distinguish carefully between fracking and conventional oil and gas development without fracking. Others authors, such as Bennett, Muehlenbachs and Throupe, specifically measure or reference impacts to wells that have been fracked. Almost all authors reference impacts on property values as a function of distance to a well. Some discuss impacts from fracking in the sense that the process generates more wells; density of fracked wells can negatively or positively impact property values.

- There are three documents that refer to specific impacts of fracking on property values. The law firm Ballard Spahr prosecuted a case involving the uncertainty of the composition of fracking chemicals (National Association of Realtors, 2014). A second article puts forth the legal theory that as fracking fluids fill fissures that extend off the drilling site, there may be a legal claim for trespass (Pierce, 2010). Another paper recounts a legal case against Cabot Oil & Gas based on the claim that properties were contaminated by fracking chemicals (Rubikam, 2012).

- None of these documents is specific to Fort Collins. A Colorado State University Study (Bennett, 2013) is the most proximate geographically, since it applies data from Weld County. This author points out that her research on sales data and proximity to fracked wells provides correlations between variables but does not address causation and does not distinguish between properties receiving or not receiving royalties. She concludes with a recommendation for further study.

Fracking Impacts Isolated. If Fort Collins pursues an analysis of property value impacts, it will be important to focus on potential impacts on property values that are consistent with the definition of fracking and its associated harms, as articulated in Section 2 associated with Ballot Measure 2A, approved by voters on November 5, 2013. (See Section 1.) More specifically, the analysis should address only impacts associated with fracking and its associated harms and exclude impacts that might be associated more generally with conventional oil and gas development.

In some circumstances, the presence of fracking might trigger an <u>incremental</u> impact relative to conventional oil and gas development without fracking. These incremental impacts might be marginal or substantial. In other circumstances, fracking might trigger a <u>different</u> type of impact that is not present without fracking. Based on a broad review of the literature, only some of which appears in scholarly peer-reviewed journals, the table below illustrates some potential types of impacts attributable to fracking.

POTENTIAL, ILLUSTRATIVE IMPACTS THAT MIGHT BE ATTRIBUTABLE TO FRACKING RELATIVE TO CONVENTIONAL OIL & GAS DEVELOPMENT *(Includes A Sampling of Documents that Reference the Impact)*	
Marginal Incremental Impacts	- Light and noise impacts might be greater with fracking because the drilling and construction stage is longer. *(Broomfield, 2012; Resource Media, 2014; Woodyard, 2014)*

POTENTIAL, ILLUSTRATIVE IMPACTS THAT MIGHT BE ATTRIBUTABLE TO FRACKING RELATIVE TO CONVENTIONAL OIL & GAS DEVELOPMENT *(Includes A Sampling of Documents that Reference the Impact)*	
Significant Incremental Impacts	- Truck traffic may be substantially greater because water delivery associated with fracking may generate the need for more loaded one-way truck trips. *(Barton, 2013; Felsburg, 2012)* - Water requirements for fracking might be substantially greater than water requirements for conventional oil and gas development. *(Freyman, 2014; Belanger, 2012; Riddington, 2013; CO Div. of Natural Resources, unknown date)*
Different Impacts	- Use of chemicals added to fracking fluids that are toxic to human and animals and related, potential surface and ground water contamination and air emissions. *(Horwath, 2011; Cooley, 2012; Minor, 2013; Riddington, 2013; Phillips, 2011; Throupe, 2013; Warner, 2012; Greene, 2013)* - Presence of fracking fluids in the ground may generate earthquakes. *(Brandes, 2014; Knox, 2014; McGarr, 2014; Nowlin, 2014; Frazell, 2014; Findley, 2012; Connelly, no date)*

If pursued, the analysis should make these distinctions to the fullest extent possible. That said, measuring impacts on property values is analyzed in a social science setting that measures how property owners might and have responded to circumstances. It is not prepared in a hard science setting conducted in a laboratory where variables can be isolated and controlled absolutely.

Possible Components of a Fort Collins Study. Assuming the need for a study that is specific to Fort Collins and consistently aligned with the Ballot Measure, information necessary to a property impact study would likely include but not be limited to the following.

1) Base layer GIS maps illustrating: topographic conditions; physical features of the land, including view sheds; zoning districts; comprehensive planning maps; oil and gas well locations; fracking storage sites; delivery system locations; and geologic and hydro-geologic conditions.

2) Multiple List Service sales and listing data, as well as sales data compiled by the Larimer County Assessor. Weld County data may be used as a surrogate or to augment Larimer County information. GIS maps of the sales data relative to oil & gas related improvements.

3) Survey research results relative to potential purchasers' willingness to buy or motivations behind actual purchaser's actions.

Keeping in mind the rules of evidence established *by Daubert v. Merrell Dow Pharmaceuticals*, Inc. and *People v. Shreck,* a work plan to measure the impacts of fracking on property values suitable for litigation might involve the following procedures or techniques:

1) **Survey Research**

   Survey research may be used formally or informally, quantitatively or qualitatively to determine market participants' likely responses to land use, technological or environmental conditions or risks. Survey responses are typically used to test the results of other quantitative methods or may be used to measure how much people would be willing to pay for property affected or unaffected by an environmental dis-amenity. The courts have imposed rigid standards for the admissibility of quantitative results.

   Fort Collins-Specific Survey Research Recommendations. Based on the limitations and lessons learned from prior research and on the need manage the analysis to fit Fort Collins' unique circumstances, we propose two specific types of survey research be conducted, if the City pursues an analysis.

- **Survey of Fort Collins Residents.** This survey would be used to measure the potential willingness of Fort Collins residents to pay for properties near wells that have been fracked. The analysis would be based on hypothetical circumstances presented in the survey since there have not been enough fracked wells near or in the City to establish a population based on proximity to fracked wells from which to draw a statistically significant sample. This survey would explore differences between fracked and conventional exploration and production practices, as well as possible. A discussion about surveying respondents other than residents who might purchase property should occur before the survey research methodology is finalized.

- **Survey of Weld County Purchasers.** After identifying properties purchased in Weld County locations near fracked wells and the history of the well(s), this survey would explore purchaser's motivations and attributable price adjustments, if any, to the presence of a fracked well(s), including but not limited to the type of property, knowledge of whether a well is present or was fracked, mineral and water rights ownership, price adjustment, if any, because of the presence of fracked well, reasons for the price adjustment, as appropriate, other purchaser motivations. The results of this analysis would be used in the GIS-based regression analysis, explained below.

  To our knowledge, this type of survey has not been conducted. Most research more simply correlates land sales to well proximity without knowledge about the purchaser's motivations. This survey might be a challenging, multi-step data collection process, since the owners might first be reached via mail.

2) **Case Study Analysis**
Case Study Analysis is a sub-set of the Sales Comparison Approach often used in appraising real estate. It involves the use of *analogous situations* when direct sale comparables are not available, and is particularly useful in area wide analysis like the one anticipated by the City of Fort Collins. Sales in another case study location involving a similar environmental situation are studied to estimate how the marketplace there responded to similar environmental issues. Case studies may be drawn from the appraisal literature or developed by the appraiser.

3) **Paired Data Analysis**
Paired Data Analysis is based on the premise that when two properties are equivalent in all respects but one, the value of the single difference can be measured by the difference in price between the two properties. In simple terms, a sale property adjacent to an oil or gas well may be paired against the sale of a more removed property to determine the effect on price of the well.

4) **GIS-based Regression Analysis (Hedonic Price Analysis)**
Regression analysis is a statistical technique in which a mathematical equation can be derived to quantify the relationship between a dependent variable and one or more independent variables. The model is especially effective in concert with GIS maps that allow property values to be measured as a function of distance or proximity to any number of attributes that make up property value. For example, prices may be analyzed as a function of proximity to or visibility of oil and gas wells.

The appraisal profession has adopted standards of practice that must be adhered to in the development of the above described methods. The guiding document is Advisory Opinion 9 to the Uniform Standards of Professional Practice. The profession recognizes the benefits of developing multiple appraisal techniques, as have the courts. Each serves as a check on the other, and the resulting conclusion may be more credible.

Advisory Opinion 9 also recognizes that it may be necessary to obtain the assistance of additional consultants in order to develop competent and credible results. In this case, it will likely be necessary to obtain the assistance of a GIS/mapping expert, an econometrician or statistician, a survey research expert and a hydro-geologist, among others.

9. ALTERNATIVE METHODS TO FILL DATA GAPS

While the techniques described above are commonly used to value the impact of an environmental dis-amenity, an alternative technique, called Contingent Valuation, is referenced in the appraisal literature. This method was originally developed to value what economists refer to as public goods for which there is no observable market. The obvious application

particularly relates to valuation of natural resources. For example, "willingness to pay" questions such as, "How much would you pay to see a wolf in the wild?" may be asked as part of a survey questionnaire. Because of the subjectivity of questions and answers, the National Oceanic and Atmospheric Administration (NOAA) has produced strict guidelines for the use of Contingent Valuation. Many in the appraisal profession question the usefulness of the technique in a quantitative way when there is an abundance of actual market data. Nonetheless, the technique provides a good qualitative measure of buyer preferences.

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TITLE	AUTHOR	PUBLICATION	Date	Page Est.	AREA STUDIED	ABSTRACT	Natural Resource Production	Economic Impacts	Greenhouse Gas	Water Quantity	Air Emissions	Chemical Exposure	Crop & Livestock Contamination	Geologic / Earth-quakes	Land Use	Light or Noise Pollution	Mineral & Surface Rights & Royalties	Mortgage & Insurance	Property Value	Property Values with Fracking Reference	Truck Impacts	Visual Disurbance	Water Quality	Other	Federal	State	Local	
Public Health Risks of Shale Gas Development	Adgate, et. al	NRC Shale Gas Committee Workshop #1 - Draft Paper	5/17/2013	4	General	Summarizes literature on human health risks associated with shale gas development in US. Loss of property values mentioned. Calls for more research. "There is a substantal public concern and uncertainties that need to be addressed…"					x	x				x			x	Yes	x							
How Hydraulic Fracturing Affects Property Values	Alcock	Unknown	unknown	6	New Foundland	Considers issues that may affect property values related to fracking in response to a proposal by Shoal Point Energy.					x			x		x		x	x	Yes	x	x					
Modern Shale Gas Development in the United States: A Primer	ALL Consulting, through Ground Water Protection Council	Prepared for US Department of Energy	4/1/2009	116	United States	Provides technical information on and additional insight into the relationship between natural gas development, environmental protection, especially water resource management.				x													x				
Measurements of Methane Emissions at natural gas production sites in the US	Allen	Proceedings of the National Academy of Sciences	10/29/2013	84	United States	This work reports direct measurements of methane emissions at 190 onshore natural gas sites in the US during the extraction phase of the supply chain. Total emissions are similar to recent EPA findings. However, emissions from certain sources, such as valves and compressors, were higher than the EPA figures..					x																
Shale Energy: 10 Points Everyone Should Know	American Petroleum Institute	American Petroleum Institute	10/1/2013	4	General	Summarizes information about fracking, economic impacts, regulatory environment, safeguards and statements of no impact.		x			x	x		x									x		x	x	
Facts about Shale Gas	American Petroleum Institue	American Petroleum Institue	accessed 6/17/2014	2	General	Provides brief summary about supply of unconventional natural gas resources.	x																				
Hydraulic Fracturing - Unlocking America's Natural Gas Resources	American Petroleum Institue	American Petroleum Institue	4/1/2014	21	General	Describes fracking, importance of shale plays, state and federal regulations, water protection and usage, air emissions and environmental friendly practices.	x			x	x												x	x	x	x	
Uniform Standards of Professional Appraisal Practice - 2014-2015 Edition - Advisory Opinioon 9	Appraisal Standards Board	The Appraisal Foundation	7/6/1905	6	General	Provides advice when appraising properties that may be impacted by environmental contamination													x	No							
Drilling Casts Shadow on Home Mortgages	Armbrister	Northern Colorado Business Report	3/7/2014	3	Colorado	Author points out that it is becoming more and more difficult to obtain financing and insurance on properties being eyed for oil and gas development. Loans to be sold in the secondary market are particularly suseptible. The factors that can cause a loan on properties with a gas lease to be denied are: The agreement adversely impacts the use of the surface of the property, including dwellings; The property does not qualify for hazard insurance; The insurance premiums cause the monthly payment to exceed an acceptable debt-to-income ratio; Investor guidelines prohibit mineral leases.											x										
Lessons Learned from the North Texas Barnette Shale: In Regards to the Pennsylvania Marcellus Shale, the Jewel of the Northeastern US	Baen	University of North Texas, College of Business, Dept. of Finance, Insurance, Real Estate and Law	November 18, 19, 2008	68	Texas	Considers the environmental costs/ benefits and lessons learned while limiting or reducing the environmental impact and loss in value of the suface estate.		x																		x	x	x
The Impact of Mineral Rights and Oil and Gas Activities on Agricultural Land Values	Baen	The Appraisal Journal	1/1/1996	9	General	Describes potential impacts of oil and gas activity on agricultural lands, including reduced income, reduction in highest and best use, environmental contamination, stigma and other factors.						x			x				x	No			x				
Fayettevile shale play and the need to rethink environmental regulation	Bailey	Arkansas Law Review	2010	34	Arkansas	Discusses the use and regulation of hydraulic fracturing - focusing primarily on Arkansas.				x	x	x															

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Impacts of Gas Drilling on Human and Animal Health	Bamberger, et. al	New Solutions: A Journal of Environmental and Occupational Health	3/1/2012	27	Colorado, Louisiana, Texas, New York, Ohio, Pennsylvania	Because animals often are exposed continually to air, soil and groundwater, they can be sentinels to monitor impacts to human health. These authors interviewed animal owners who live near gas drilling operations and identified which aspects of the drilling process may lead to health problems.							x																
Presentation to House Appropriations Subcommittee Committee on Budget Transparency and Reform	Barton	Texas Department of Transportation	3/11/2013		Texas	Provides data on number of trucks related to gas drilling and maintenance in Texas. 1,184 trucks to bring into production + 353 per year to maintain + 997 trucks every five years to refrac.															x								
A Colossal Fracking Mess	Bateman	Vanity Fair	6/21/2010	9	Primarily Dimrock PA	Presents an in- depth story of ground water contamination attributable to fracking			x												x		x	x				
How Fracking Decreases Property Value	Beans	Earthworks	7/1/2013	2	Pennsylvania Texas	References Duke University Study that found the most significant factor in the impact of oil and gas development near residential property is whether water is piped in or sourced on-site from a well. The study (in Washington County, PA) found that property with on-site wells lost 13% of their value. Author mentions another study by Integra Realty Resources in Flower Mound, Texas that concluded properties with house less than 750' away from the drill site experienced an average sales price of 2-7%.		x									x	x	Yes								
Fracking our Future	Belanger	Western Resource Advocates	6/1/2012	28	Colorado	This report describes oil and gas industry water needs, potential impacts and tradeoffs. Volume of water needed each year is equivalent to a sizeable water infrastructure project. Water is 100% consumptive. Recommendations are provided.				x														x		x	x	
Real Estate Damages: Applied Economic and Detrimental Conditions,2nd Edition	Bell	Appraisal Institute	2008	424	United States	This book provides appraisers with a straightforward set of analytical tools to address complex valuation situations when properties are subject to detrimental conditions.													x								
The Impact of Hydraulic Fracturing on Housing Values in Weld County, Colorado: A Hedonic Analysis	Bennett	CSU: Dept. of Agriculture and Resource Economics - for the Degree of Master of Science,	Summer 2013	90	Weld County, CO	This is a hedonic property study (based on a sample of 4,035 housing transactions between 2009 and 2012 in Weld County, CO) prepared at CSU to determine if fracking negatively affects property values. The results of the study show a low level of impact on housing values due to fracking related activities. The study found that rural property owners are affected by distance to drill sites but urban property are impacted by the volume of drill sites near the home. This suggests some policy regulation: the number of drill sites within a certain distance from another drill site may need to be regulated and minimum distances from residential properties may need to be set and/or increased in rural areas. The author suggests that any impacts from fracking are likely offset by economic gains from the industry.	x	x		x					x			x	x	Yes			x					x
A Plaintiff's Primer on Litigating Natural Gas Cases	Bern, et.al.	Westlaw Journal Enviornmental	6/8/2011	4	General	Authors provide practical advice to lawyers retained by clients who want to file a complaint.													x	Yes								
Golden Rules for a Golden Age of Gas - World Energy Outlook - Special Report on Unconventional Gas	Birol	International Energy Agency	7/4/1905	150	General	Proposes "golden rules" the for energy industry to address enviromental impacts such as fluid spills, greenhouse-gas emissions, groundwater contamination, air pollution, vehicle and equipment impacts, well abandonment, etc.																							x

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The Impact of Oil and Natural Gas Facilities on Rural Residential Property Values: A Spatial Hedonic Anlaysis	Boxall, et.al	Wilfrid Laurier University, Business and Economics, 2005-01-EC, Waterloo	7/26/2014	38	Central Alberta, Calgary	Summarizes the results of a hedonic analysis used to measure property value impacts to rural residential property in Alberta, Canada by virtue of proximity to oil and natural gas facilities. The analysis showed that property values were negatively correlated with the number of sour gas wells and flaring oil batteries within 4km of the property. These facilities had a significant effect on sale price.													x	No									
The Impact of Marcellus Gas Drilling on Rural Drinking Water Supplies	Boyer, et al	Pennsylania State University	10/1/2011	29	Pennsylvania	Summarizes study of water quality in 233 private water wells in rural Pennsylvania before and after drilling shale gas wells. 40% of the wells failed at least 1 water quality standard before drilling occurred. Analysis did not find major influence from gas well drilling or hydrofracking. .																	x					
There's Now A Run On Quake Insurance In Fracking-Heavy Oklahoma	Brandes	Business Insider	5/1/2014	3	Oklahoma	Discusses how the rate of earthquakes in Oklahoma has increased by about 50 percent since October 2013. Geologists say that fracking could be one of the causes. The USGS said that the water injection used in fracking can increase underground pressures, lubricate faults and cause earthquakes.								x													
Quake Warning adds new worries to tornado-prone Oklahoma	Brandes	Reuters	5/8/2014	2	Oklahoma	Reports that 183 earthquakes of 3.0 or greater have occurred since October 2013. Oklahoma Insurance Commission spokesperson said only 12% to 18% of homeowners have insurance that covers earthquakes								x													
Support to the Identification of Potential Risks for the Enviornment and Human Health Arising from Hydrocarbons Operations Involving Hydraulic Fracturing in Europe.	Broomfield	European Commission - DG Denvionment, AEA/R/ED57281 Issue No 17x.	10/8/2012	297	Europe	Sets out key environmental and health risk issues associated with the potential development and growth of high volume fracking in Europe and addresses impacts and risks over and above convention gas exploration..				x	x	x		x	x	x			x	Yes	x		x	x			
LaPlata County Impact Report - FINAL	Brown, Bortz, Coddington	LaPlata County	10/1/2002	99	Colorado	Identifies potential impacts to and mitigation measures in La Plata County from the development of coall bed methane. "Based on the average property profile for the 544 transactions with potential effects of well proximity, the total impact in the year 2000 was estimated to be an average reduction in sales value of $1,200, a decrease of 0.7 percent."	x	x							x				x	No			x				x
Colorado Officials Question Link of Fracking Water disposal to Quakes	Finley	The Denver Post	12/4/2012	3	Colorado, New Mexico	Article features remarks by Justin Rubinstein, USGS scientist, regarding the relationship between burial of drilling waste and earthquakes. New Mexico and Colorado incidents are cited.								x													
Life-cycle greenhouse gas emissions of shale gas, natural gas, coal and petroleum	Burnham, et al.	Environmental Science Technology	1/17/2012	16	General	Estimate the life-cycle greenhouse gas emissions. Analysis shows shale gas life-cycle emissions are 6% lower than convention gas. Due to the range in values, so there is statistical uncertainty whether shale gas emissions are lower than conventional gas.			x		x																
Assessing the Greenhouse Impact of Natural Gas	Cathles	Submitted to G3	1/7/2011	18	Texas, Louisiana, Colorado, Utah	Rebuts the Horwath study. States that if the leakage rate of natural gas is 1% or less, then the substitution of natural gas reduces global warming by 40% of that which could be attained by the immediate transition to low carbon energy sources.			x																		
A Commentary on "The Greenhouse-Gas footprint of Natural Gas in Shale Formations"	Cathles et al.	Climate Change	1/2/2012	11	Texas, Louisiana, Colorado, Utah	Rebuts Horwath study. States that the Horwath analysis is flawed; it overestimated the fugitive emissions associated with unconventional gas extraction and undervalued the contribution of "green technologies."					x																

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University of Colorado Boulder-led research network explores natural gas development effects	Cavanaugh	National Science Foundation	10/2/2013	5	Colorado, Pennsylvania	Announces two NSF sponsored studies regarding natural gas development. CU study will focus on effects on air and water resources in the Rocky Mountain region. There are 8 partners including CO School of Mines, CSU, National Renewable Energy Laborartory, NOAA, CO School of PUblic Health, CA State Poly Tech.				x	x												x						
Hudraulic Fracturing (Power Point)	CO Oil and Gas Conservation Commission	Colorado Oil and Gas Conservation Commission	5/1/2011	35	Colorado	Defines fracking, summarizes regulations, provides information about inspections and complaints																				x		x
Water Sources and Demand for Hydraulic Fracuring of Oil and Gas Wells in Colorado from 2010 through 2014	CO Water Conservation Board and CO Oil and Gas Conservation Commission	Prepared by the CO Division of Natural Resources	unknown	5	Colorado	Provides estimates of amount of acre feet needed per well start (5 AF, equivalent to 1,630,000 gallons of water. Discusses potential sources of water and related legal issues.				x								x									
Fracking Can Hurt Property Values of Nearby Homes With Wells, Study Suggests	Cockerham	mcclatchydc.com	11/1/2012	3	Washington County, PA	Summarizes the September 2012 Muehlenbachs, et al. study cited above.		x											x	Yes			x			x		
COGA - Hydraulic Fracturing Whitepaper	Colorado Oil and Gas Association	Colorado Oil and Gas Association	11/26/2012	4	Colorado	Trade association description of fracking and summary of selected impact work.																		x				
Natural Gas Operations from a Public Health Perspective	Colborn	Human and Ecological Risk Assessment, 17: No 5, 1039-1056	9/4/2011	19	General	Presents a list of 944 products containing 632 chemicals used during natural gas operations. The potential health effects of the 353 chemicals identified was researched. The results indicate that many chemicals used during the fracturing an drilling stages of gas opeations may have long-term health effects that are not immediately expressed.					x	x																
What is Fracking?	Coloradans for Responsible Energy	Coloradans for Responsible Energy Study Fracking			General	Discusses the process of hydraulic fracturing from start to finish.				x	x															x		x
The Basics: Colorado Water Supply and Hydraulic Fracturing	Colorado Oil and Gas Association	Colorado Oil and Gas Association	undated	2	Colorado	Defines fracking action and the amount of water used, and provides a glossary of terms.																		x				
COGA - Hydraulic Fracturing Whitepaper	Colorado Oil and Gas Association	Colorado Oil and Gas Association	11/26/2012	4	Colorado	Describes the fracking process, identifies studies that show frackign is safe, lists some concerns and explains why they are not problems.																		x				
"Background Report"	Colorado Oil and Gas Conservation Commission	Colorado Oil and Gas Conservation Commission	10/29/2010	4	Colorado	Responds to the documentary,Gasland. Colorado wells in question contain only biogenic methane. Staff research question whether examples used in the documentary were accurately protrayed.				x	x												x				
U.S. Drilling And Fracking Boom Leaves Some Homeowners In A Big Hole	Conlin	Reuters	12/12/2013	4	General	Cites anecdotal stories about loss in value near drill sites, as well as references the Throupe and Spiller studies cited above. Author interpreted Spiller's 2014 study as concluding that homes within .6 miles of a well lost 16.7% in value.	x	x				x							x	Yes			x		x	x		x
Special Report: US Builders hoard mineral rights under new homes	Conlin, et.al.	Reuters	10/9/2013	9	Florida, Colorado and other states	Homebuilders in Colorado, Florida and elsewhere are retaining mineral rights before selling homes. Some lenders deny mortgages to homes encumbered with leases. Insurance policies exclude coverage where mineral rights are severed.											x	x	x	Yes								
How Oil and Gas Disposal Wells Can Cause Earthquakes	Connelly	StateImpact Texas	not provided	5	Texas	Reports that the disposal of drilling wastewater used in fracking is scientifically linked to earthquakes (UT at Austin and SMU studies and USGS Earthquake Science Center)								x														

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The Economic Opportunities of Shale Energy Development	Considine	Center for Energy Policy and the Environment, at the Manhattan Institute	Mary 2011	36	Pennsylvania	Reviews environmental violations regelated to shale production from the Pennsylvania Department of Environmental Production. The value of the (adverse) environmental impacts is far smaller than the economic benefits. New York should consider lifting its moritorium.		x			x	x											x			x		
Hydraulic Fracturing and Water Resources: Separating the Frack from the Fiction	Cooley and Donnelly	The Pacific Institute	6/1/2012	35	General	Summarizes interviews to understand key issues regarding environmental and social impacts of fracking relative to water and systhesis of existing research. Issues: water withdrawals, groundwater contamination, wastewater management, truck traffic, surface spills, stormwater management.			x	x		x										x		x				
"Responding to Landowner Complaints of Water Contamination from Oil and Gas Practices: Best Practices"	Cranch, et. al	Harvard Law School, Environmental Law Program	5/1/2014	59	CO, IL, NC, PA, NY, Ohio, WVA, WY	Provides recommendations to implement policies to respond to landowner conplaints that shale oil or gas extraction contaminated private water supplies.																	x			x		
How do Pipeline Spills Impact Property Values	CRED	Conversations for Responsible Economic Development (CRED)		9	Maryland, Texas, Ohio, Mexico, Washington, Canada, Michigan	Investigates eight spills. In three cases, spills directly impacted properties; in two cases, the proximity and perceived impact devalued properties; in three cases, residents claimed losses but there is no independent confirmation.						x							x	No							
Texas Jury Awards Nearly $3 million to Family Alleging Health Problems from Natural Gas Wells	D'Angelo	Fracking Insider.com	5/1/2014	1	Texas	Describes decision where jury awarded $2.9 million to family for physical and mental pain and anguish,and loss of market value. Plaintiff alleged exposure to hazadous gases, chemicals and industrial wastes, foul odors and loud noise. Defendant (Aruba Petroleum) plans to challenge ruling.					x	x			x				x	Yes							
Mortgages and Hydraulic Fracturing	Derrick	US Finance Post April 2014	4/3/2014	1	No. Carolina Pennsylvania	Discusses how the mortgage industry has tightened its lending policies, consequently prohibiting properties with a well on them or properties that are the subject of leasing for the exploitation of unconventional fuels from receiving mortgages.Credit unions in North Carolina have decided not to approve mortgages on properties whose drilling rights are sold to third parties, as one CEO stated that their properties have been devalued. Quicken Loans, as well as other financial institutions in Pennsylvania, denied a loan secured by a mortgage on a person's farm because there was a drill sites across the street, and according to a financial statement, "gas wells and any other structures in the surrounding lots… could significantly degrade the value of a property."											x	x	Yes							
The Truth, the Partial Truth or Anything but the Truth: Survey Reliability and Property Valuation	Matthews, et.al.	Paper prepared for Symposium on Environmental and Property Damages, Toronto	April 4-6, 2002	38	General	Provides reliability standards for Contingent Valuation surveys.													x	No							
Guide to Dimrock's Water Problems	Detrow	StateImpact - Pennsylvania; a NPR member station report	10/20/2011	2	Dimrock, PA	Summarizesof prior events regarding property owners complaints about fracking.													x	Yes			x				
EPA Takes First Step Toward Regulating Fracking Chemicals	Drajem	Bloomberg May 2014	5/9/2014	3	General	Discusses how the EPA is considering tighter regulations of hydraulic fracturing and seeking public input on whether companies should be required to disclose the contents of fluids used in the oil and natural gas drilling technique.																			x			x

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Economic Assessment Report for the Supplemental Generic Environmental Impact Statement on New York State's Oil, Gas and Solution Mining Regulatory Program	Ecology and Environment, Inc.	Prepared for the New York State of Environmental Conservation	8/1/2011	251	New York	Examines the impact of gas drilling on property values by reviewing five prior studies. Conclusion: Residential properties in close promimity to new gas wells would likely see some downward pressure on price; this pressure would be particularly acute for residential properties that do not own subsurface mineral rights. There is a positive impact where owners receive royalty payments. Adverse contruction impacts include noise and vigration impacts and trucks servicing the wells. Gas compressor stations may generate noise and air emissions. The regional economic effect is of increasing values but not all proerties experience this.		x										x		x	Yes								
Douglas County Oil & Gas Production Transportation Impact Study	Felsburg, Holt & Ullevig	Prepared for Douglas County	1/24/2012	147	Douglas County, CO	Describes potential impacts on roadways attributable to oil and gas development and productin															x							
A Survey Approach for Demonstrating Stigma Effects in Property Value Litigation	Flynn, et al.	The Appraisal Journal	Winter 2004	10	General	Presents an approach for designing a survey to address stigma issues and meet the legal requirements for admitting survey data as evidence.													x	No								
Geologists: Fracking Likely Cause of Ohio Earthquakes	Frazelll	Time Magazine	4/12/2014	1	near Youngstown, Ohio	Geologists report that tremors in Ohio's Applachian Mountains are linked to fracking, leading the state to issue strick permit conditions								x														
Hydraulic Fracturing & Water Stress: Water Demand by the Numbers	Freyman	Ceres Report	Feburary 2014	85	General	Focuses primarily on water-related issues associated with hydraulic fracturing and unconventional shale or tight oil or gas formations. Notes that 89% of fracking water usage occurs in Garfield and Weld Counties. Each uses more than 1 billion gallons per year; total usage for Colorado is expected to be 6 billion gallons by 2015. Points out that 100% of wells in Colorado are located in high or extreme water stress areas. The effect of this water usage is driving up water prices, which in turn is likely to impact agricultural prices.				x																	
Water safe in town made famous by fracking - EPA	Gardner	Reuters	5/11/2012	1	Pennsylvania	EPA plans to re-sample four wells where previous data showed levels of contaminants but EPA's testing found no need for action.						x											x				
Drilling and the American Dream: Your perfect home in a Colorado gas patch	Greene	The Colorado Independent	11/2/2013	9	Colorado	Describes incident in Garfield County. Property owners alleged ground water contamination and recovered 40% of purchase price. Article mentions othere types of impacts in Colorado, including mortgage and insurance constraints.					x					x	x	x	x	Yes	x	x	x					
State Oil and Gas Regulations Designed to Protect Water Resources	Ground Water Protection Council	Ground Water Protection Council	5/1/2009	65	General	Identifies, quantifies and assesses the relative value of state oil and gas regulations. Does not evaluate the effectiveness of individual programs.																				x		
Long-term Effects of Income Specialization in Oil and Gas Extraction: The US West, 1980-2011	Haggerty, et.al	Headwaters Economics, Bozeman MT	No Date	19	US West (CO, MT, NM, DK, Utah, WY)	Evaluates the relationships between oil and natural gas specialization and socioeconomic well-being in a large sample of counties. Long-term oil and gas specialization is observed to have negative effects on change in per capita income, crime rate, and education rate. Participation in the early 1980s boom was positively associated with change in per capita income; however, the positive effect decreased the longer counties remain specialized in oil and gas. Findings contribute to a broader public dialogue about the consequences of resource specialization involving oil and natural gas and question the assumption that long-term oil and gas development confers economic advantages upon host communities.		x										x	No								
Hydraulic Fracturing Litigation Is On The Rise	Hagstrom	Sedgwick Law, Hydraulic Fracturing Digest	9/1/2011	6	Pennsylvania, New York, Texas, North Dakota and Arkansas	Article points out that litigation related to fracking is on the rise, particularly class action law suits. Legal theories include nuisance, trespass, breach of contract and in some cases even criminal liability.					x	x							x	Yes			x	x				

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Hydraulic Fracturing Contamination Claims: Problems of Proof	Hall	Ohio State Law Journal, Volume 74	2013	15	General	Addresses problems of proof in hydraulic fracturing contamination claims, methods for avoiding these problems and a procedure courts use in an effort to quickly resolve cases in which plaintiffs lack evidence to support an essential element of their claim.																	x							
Environmental Hazards and Residential property Values: Evidence from a Major Pipeline Event	Hansen, et al.	Land Economics, 82,4,529-541	2006	21	Bellingham Washington	Uses housing market data to test the impact of pipeline accident and a pipeline that is accident-free on property values. Both carry hazardous liquids. In atsence of a highly-publicized event, location near a pipeline is not perceived as a significant environmental risk. Following an event, there was a significant negative effect. Distance from the pipeline and lapsed time were significant factors.						x								x	No							
Effects of Natural Gas Production on Water Quality in Garfield County, Western Colorado	Hill	CU Honors Journal	7/3/1905	10	Garfield County, CO	Describes how concerned citizens and stakeholders are speaking out about what they believe is negligence on the part of the industry in maintaining environmental quality and preventing contamination. This study hypothesizes that drilling and extraction processes may generate wastewater in concentrations that could be harmful to surface and groundwater quality. The study seeks to understand these impacts and determine if they do present a serious problem to regions experiencing natural gas activity.The study could make no real case for natural gas activity seriously impacting water quality in Garfield County.																x			x			
Fracking: The Operations and Environmental Consequences of Hydraulic Fracturing	Holloway, et. al.	Wiley Publishers	2013	359 +	General	Proposes to increae awareness of new and emerging technologies and various ramificantions. Author encourages energy companies to use this work as a means to educate the general population.																						
Methane and the Greehouse-Gas Footprint of Natural Gas from Shale Formations	Horwath, et al.	Climatic Change Letters	3/13/2011	12	Texas, Louisiana, Colorado, Utah	Studies the greehouse gas footprint of natural gas obtained by fracking. 3.5% to 7.9% of the methane from shale gas production escapes into the atmosphere and leeks over the lifetime of a well. These methane emissions are at least 30% more than those from conventional gas. The higher emissions occur during fracking as methane escapes from flow-back return fluids.			x		x																
Fracking up	Huso	Valuation Insights, Appraisal Institute	1st Qtr, 2012	5	Texas	Notes that the effects of fracking are likely different depending on the depth of the wells and density of surrounding population. In rural areas of Texas, values went up as drilling commenced because of the increase in the value of mineral rights. In more dense populations, the opposite effect likely occurs.				x								x	x	Yes							
Evaluating Environmental Stigma with Multiple Regression Analysis	Jackson	The Appraisal Journal	Fall 2005	7	General	Describes how the use of multiple regression analysis has been likened to a form of the sales comparison approach. In a sale price regression analysis, the sale price (the dependent variable) is modeled as a function of a number of variables reflecting the property's physical and market characteristics (independent or predictor variables). The method is widely accepted in the appraisal profession, but the model must be properly specified.								x						x	No							
The Analysis of Environmental Case Studies	Jackson	The Appraisal Journal	1/1/2002	20	General	When properly selected and analyzed, studies of similarly impacted properties (case studies) can provide useful information for analyzing environmentally impacted properties. The method is widely accepted and endorsed by the real appraisal profession.													x	No							

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Surveys, Market Interviews and Environmental Stigma	Jackson	The Appraisal Journal	Fall 2004	11	General	Distinguishes between surveys and market interviews. Market interviews are used as secondary or supporting documentation for market data. Surveys are dependent upon statistically valid samples and correction for bias. The criteria for admissibility of survey results in court are more rigorous.													x	No									
Advisory Opinion 9 and Contingent Valuation	Jackson	The Appraisal Journal	Summer 2012	5	General	For the contingent valuation method, generally a survey instrument is read to a sample of property owners who are each asked their willingness to pay for a contaminated property or willingness to accept some environmental impact to their property. Respondent answers are aggregated to provide a diminution range or value attributable to the alleged contamination. A significant portion of appraisers believes that this method falls outside the guidelines or Advisory 9 to the Uniform Standards of Professional Practice.														x	No									
Increased Stray Gas Abundance in a Subset of Drinking Water Wells Near Marcellus Shale Gas Extraction	Jackson, et. al	Proceedings of the National Academy of Sciences, Early Edition	12/17/2012	13	Pennsylvania	Researchers analyzed 141 drinking water wells in northeastern Pennsylvania. Methane was detected in 82% with average concentrations 6 times higher for homes within 1 km of natural gas wells. Ethane was 23 times higher.						x												x				
When drought occurs, fracking and farming collide	Jaffe	The Denver Post	Feruary 2014	4	Colorado	Reports that in Colorado 97% of wells being drilled are in highly water-stressed areas. Operators are taking steps to conserve water. In some cases, water is being bid up to more than farmers can afford.		x		x																		
Life Cycle Greehouse Gas Emissions of Marcellus Shale Gas	Jiang, et al.	Environmental Research Letters 6 (2011)	2011	9	Pennsylvania	Estimates the life cycle of greenhouse gas emission from production of Marcellus shale natural gas and compares with the national average gas emissions prior to significant Marcellus shale development. Emissions of a shale well are above average domestic gas emissions. GHG emissions from shale gas have a lower life cycle than coal.			x																		
Case Before Ohio Court May Impact Future Coverage for Fracking Liability	Jones	Insurance Journal	1/27/2014	2	Ohio	Discusses the Warren Drilling Co., Inc. v. ACE American Ins. Co. In 2008, where a homeowner's well had become contaminated by the hazardous fracking fluid and homeowner sued Warren Drilling, and the driller eventually settled with the homeowner.Warren Drilling then sued ACE for coverage under the insured's energy pollution liability extension endorsement after the insurer refused to defend the case brought by the homeowner and indemnify the driller for its losses. The case is now before the court.						x																
Keep Tap Water Safe (List of fracking bans)	Keep Tap Water Safe	exceroted from keeptapwatersafe.org	Updated 5/21/2014	18	US and other countries	Provides a list of moritoria and bans on oil and gas wells and fracking with extensive web links																				x	x	x
Scientists Warn of Quake Risk From Fracking Operations	Kiger	National Geographic	5/2/2014	4	Mentioned: Oklahoma, Colorado, Ohio	Author states that Colorado and other states have experienced earth quakes that have been linked to underground disposal of fracking wastewater. Sciemologist are warning that such quakes can be difficult to predict.								x														
Hydraulic Fracturing 101: What Every Representative, Environmentalist, Regulator, (etc). Should know ….	King	Presented: SPE Hydraulic Fracturing Technology Conference	2/6/2012	80	General	Provides an explanation of well development activities from construction to production with estimates of frac risk and alternatives to reduce risk.			x	x	x	x		x		x					x		x		x	x		
Greenhouse Gas Emissions Associated with Marcellus Shale	Klemow	The Institute for Energy and Environmental Research for Northeastern Pennsylvania	12/9/2011	6	Pennsylvania	Summarizes the debate about shale gas greenhouse gas emissions (shale versus conventional gas and gas versus coal). Concludes that additional field research is needed.			x		x																	

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Fracking-Earthquake Link May Impact Insurance Policies	Knox	Columbus Business First	4/1/2014	3	General	The Ohio Department of Natural Resources acknowledgement of a "probable" link between earthquakes and fracking could lead to higher insurance costs.								x															
Don't Just Drill, Baby --- Drill Carefully	Krupp	Foreign Affairs	May / June 2014	6	United States	This article summarizes recently emerging concerns about the net environmental effects of natural gas production and progress regarding environmental protections.			x																x	x		
La Plata County League of Women Voters Fracking Study	League of Women Voters	LaPlata County	3/1/2013	39	Colorado	This study that is underway investigates the impact of hydrofracturing for natural gas, oil, and methane on the State of Colorado and its citizens, and to discern what public policies are in place or need to be in place for this activity.				x			x	x	x								x					x
The Effects of Mineral Interests on Land Appraisals in Shale Gas Regions	Lipscomb, et.al	The Appraisal Journal	Fall 2012	12	North Central Texas	Discusses appraisal complications when the mineral and surface estates are split. The mineral estate is dominant and trumps surface use.													x	No								
Buried Secrets: Is Natural Gas Drilling Endangering U.S. Water Supplies?	Lustgarten	ProPublica	11/19/2008	9	General	Questions the result of an EPA study claiming that fracking posed no risk to drinking water. The EPA study formed the basis for the 2005 Federal Energy Policy Act. The author notes that more than 1000 cases of contamination have been documented by courts and state and local governments in Colorado, New Mexico, Alabama, Ohio and Pennsylvania. The EPA can't vouch for the safety of the drilling process because the chemicals in the drilling fluids are trade secrets.																		x				
Pa. Residents Sue Gas Driller for Contamination, Health Concerns	Lustgarten	ProPublica	11/20/2009	4	Dimock, PA	15 families filed lawsuit in federal district court against Cabot Oil and Gas to halt future drilling - drinking water contamination																	x					
Hydrofracked? One Man's Mystery Leads to a Backlash Against Natural Gas Drilling	Lustgarten	ProPublica	2/25/2011	25	Pavillion, Wyoming	Extensive story about owners and EPA investigation regarding water contaminated potentially by by fracked wells. Mentions downward property adjustments by County Assessor						x							x	Yes		x	x		x			
Water Transporters ride the oil boom	Lynn	Northern Colorado Business Report	4/5/2013	3	Colorado	Describes uptick in water trucking company activity in Weld County. New water tanker trucks are able to cary about 6,400 gallons of water. Some O&G producers are contructing pipelines in lieu of using trucks				x													x					
Shale Gas Impact Fees in Pennsylvania Communities	McElfish	Environmental Law Institute	4/10/2014	22	Pennsylvania	Describes amount of impact fees and some uses of fees in Pennsylvania.		x													x						x	x
Factors that Enhance the Liklihood of Fluid Injection-Induced Earthquakes Large Enough to be Felt	McGarr, et al.	USGS	5/1/2014	1	None referenced	Felt earthquakes induced by fluid injection from wastewater disposal sometimes exceed 5.0 on the Richtor scale. The liklihood of induced earthquakes is largely independent of injection rate				x				x														
Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources	McKenzie, et.al.	Science of the Total Environment www.elsevier.com/locate/scitotenv	2/10/2012	9	Garfield County, Colorado	Health risk study based on EPA guidance to estimate cancer risks for two populations: >1/2 mile from wells and =1/2 mile from wells. Authors found risk to be higher =1/2 mile from wells but recommend further study on health effects associated with air pollution.					x	x																
Pollution Fears Crush Home Prices Near Fracking Wells	McMahon	Forbes	4/10/2014	3	Pennsylvania New York	Summarizes the January 2014 Muehlenbachs, Spiller & Timmons cited above. Shows a 22% loss in property value to houses on groundwater. The study makes no representation that wells contaminate groundwater; only measure the perception that they do.		x										x	x	Yes			x					
Stigma Damages and Diminution of Property Claims in Environmental Class Actions	McMeekin, et al	Environmental Claims Journal	2012	28	General	Explores environmental stigma damages and analyzes the growing use of class actions for recovery of the same. The article concludes with a discussion of specific strategies to challenge stigma damage claims in precertification discovery.													x	No								

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Fractured Communities	Michaels	Riverkeepers	9/1/2010	40	8 states	Describes hundreds of case studies demonstrating that industrial gas drilling, including horizontal drilling using fracturing, results in significant adverse environmental impacts.			x	x	x	x		x							x		x		x	x		
Local Government Fracking Regulations: A Colorado Case Study	Minor	Stanford Environmental Law Journal, Vol 33:1, pp 59-120	2013	62	Colorado	Uses Colorado as a case study to recite the impacts associated with fracking, including heavy usage of water, groundwater contamination, dust, the use of carcinogenic chemicals, etc., and discusses the cities' rights to regulate the process.				x		x												x				x	x
The Future of Natural Gas	Moniz, et, al.	Massachusets Instutte of Technology	2011, estimate	178	General	Explores how uncertanties (greenhouse gas emission, costs of production, etc) lead to different possible outcomes. "The environmental impacts of shale development are challenging but manageable."	x		x																				
The Housing Market Impacts of Shale Development	Muehlenbachs	www. voxeu.org	2/9/2014	3	Pennsylvania, New York	Summarizes author's prior work (published in the National Bureau of Economic Research) with some updated resources.				x	x	x							x	Yes	x		x				
The Housing Market Impacts of Shale Gas Development	Muehlenbachs, et al.	Resources for the Future RFF DP 13-39-REV	4/3/2014	50	Pennsylvania New York	Analyzing data from Pennsylvania and New York, authors conclude that impacts from shale gas development vary with geographic scale, water source, well productivity and visibility. The authors estimate the impacts on groundwater-dependent homes to be large and negative and report evidence that major national mortgage lenders are refusing to make loans for properties proximate to shale gas wells, and insurance providers are refusing to issue policies on those houses. On the other hand, shale gas development can positively impact small towns through economic expansion. Boom-town growth may result in increased property values, and lease payments can provide a great source of income for many homeowners. The positive impacts of boom-town expansion generally are not long lived. Any long-term benefits from shale gas development are most likely to be realized nationally through increased energy security and low fuel costs.		x			x							x	x	Yes			x				
Shale Gas Development and Property Values: Differences Across Drinking Water Sources	Muehlenbachs, et al.	National Bureau of Economic Research	9/1/2012	38	Washington County, PA	Focuses on groundwater risk associated with shale gas development. The authors found that proximity to wells increased housing values, though risk to groundwater fully offset those gains. By itself, groundwater risk reduces property values by up to 24%. Due to a dearth of lease data, the authors are unable to fully analyze the extent to which lease payments may mitigate the cost of groundwater risks.		x											x	Yes			x			x	
RFF Research on Property Values and Truck Traffic; Impact on the Housing Market	Muehlenbachs, et al.	Resources for the Future Presentation	4/10/2014	22	Pennsylvania and New York	Presents new work that quantifies the full housing market impacts of hydraulic fracturing.													x	Yes	x						
Duke Researchers Shop Dip in Home Value Caused by Nearby Fracking	Muoio	Duke Chronicle	11/15/2012	3	Washington County, PA	Summarizes a report authored by a Duke University professor (Christoper Timmins) and others. "Houses within the roughly one-mile radius experience an 11 percent property value boost because the fracking utility cannot drill without the jomeowners signing a lease" Homes with possibility of contaminated water forces property values to decrease by 24%.											x		x	Yes			x				
Fracking: A Growing Threat to Home Values	National Association of Realtors	Realtor Magazine April 2014	4/23/2014	1	General	Discusses a webinar presented by attorneys from the law firm of Ballard Spahr stating that fracking is taking place in populated neighborhoods, and because of the unknown and potentially dangerous elements involved in fracking, is causing nearby home values to fall from 4-15%.					x			x					x	Yes			x				

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Generating the Energy We need while protection the Environmen We Treature: the regulation of Hydraulic Fracturing in the United States	Neslin	americanbar.org		46	General	Discusses how hydraulic fracturing provides important benefits, but also raises environmental concerns. This article summarizes benefits and concerns associated with hydraulic fracturing. Identifies public benefits as : 1) energy production, 2) ecomomic improvement and 2) greenhouse gas reduction. Identifies public concerns as: 1) water contamination, 2) air omissions (two conflicting studies in Colorado), 3) chemical exposure and 4) other concerns such as earthquakes and traffic nuisances. Summarizes federal and state regulations and notes that the regulatory environment is becoming more strict.	x	x	x	x	x	x											x	xx	x	x		x
Fracking Leaves Property Values Tapped Out	Notte	msnmoney.com August 2013	8/21/2013	2	General	Talks about difficulties obtaining financing and insurance on properties near drilling sites. More specifically, states that the 2005 Energy Policy Act exempted the fracking industry from violations under the Federal Safe Drinking Water Act. Notes that FHA prohibits financing homes within 300' of a property with an active or planned drilling site. Signing a gas lease or keeping hazardous material on property puts a mortgage in default.													x	x	Yes					x	x		
Even in Wake of New Ohio Limits, Texas Regulators say Fracking Not Linked to Earthquakes	Nowlin	San Antonio Business Journal	4/17/2014	2	Texas	Texas Railroad Commission say they have not found a link between fracing and tremblers, adding that geology differs between Ohio and Texas.								x															
The Environmental Issues of Shale Gas Development - Current Situation and Countermeasures	Ogawa	The Institute of Energy Economics, Japan	11/1/2013	16	General	Uses information from "major stakeholders" in shale gas development to outline the development process, describes mechanisms that induce major environmental effects and observes environmental risks inherent in shale gas development.				x	x	x		x									x						
Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing	Osborn, et.al	Proceedings of the National Academy of Scientists	4/14/2011	5	Pennsylvania & New York	Documents systematic evidence for methane contamination of drinking water associated with shale-gas extraction in Pennsylvania and New York.					x												x						
Fracking Boom Gives Banks Mortgage Headaches	Peters	American Banker	11/12/2013	4	General	Cites institutions refusing to make mortgages on land where oil or gas rights have been sold to an energy company. The mortgage agreement, used by Fannie Mae and Freddie Mac, states that "you cannot cause or permit any hazardous materials to be on your property and it specifically references oil and gas." A credit union said it would stop making mortgages on properties that have mineral rights "severed," and the union's president said that oil rigs on a piece of land would affect the values of neighboring properties.Also states that insurance companies cancel renewals when they find a [gas or oil] lease on the property.													x	x	Yes								
Hydrocarbon Emissions Characterization in Colorado Front Range: A Pilot Study	Petron	Journal of Geophysical Research	3/1/2012	19	Colorado	Reports results of daily air samples collected at the NOAA Boulder Atmospheric Observatory (BAO) in Weld County since 2007. Shows highly correlated alkane enhancements caused by a regionally distributed mix of sources in the Denver-Julesburg Basin. Petron said that "We may have been significantly underestimating methane emissions by this industry in this region." Researchers also found that emissions of benzene, a known carcinogen, are underestimated. Benzene is tracked and regulated by the Environmental Protection Agency (EPA).			x		x																		
Colorado oil and gas wells emit more pollutants than expected	Petron	CIRES	3/1/2012	2	Colorado	Gas operations in Weld County leaked about twice as much methane as previously estimates. The infrastructure was leaking other air pollutants, including benzene.			x		x	x																	
EPA Blames Fracking for Wyoming Groundwater Contamination	Phillips	State Impact Pennsylvania, A Reporting Project of NPR	12/1/2011	3	Pavillion, Wyoming	Discusses contamination related to fracking particularly with respect to water pollution and methane generation. The direct link between fracking and groundwater contamination is resulting in creating new gas drilling regulations.						x											x						

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Dimock PA - "Ground Zero" in the Fight Over Fracking	Phillips	StateImpact - Pennsylvania; a NPR member station report	unknown	4	Dimock, PA	Reports on one resident (Fiorentino) whose backyard water well blew up. Also describes Consent Order and Agreement between DEP and Cabot including pay loss in property values.					x								x	Yes			x					
Trepass Issues in a Shale Play	Pierce	Development Issues in the Major Shale Plays, Paper 7, Rocky Mt. Mineral Law Foundation, 2010	12/6/2010	16	General	Describes trespass claims in a shale play that can occur when activities cross a property boundary or designated drilling window that is established by an oil and gas conservation authority.													x	Yes								
Fracking Moritorium could cost Boulder County $1 billion, study says	Proctor	Denver Business Journal	6/12/2014	2	Boulder County, CO	Summarizes study by Netherland, Sewell & Associates for the National Association of Royalty Owners. Estimates what royalty owners might be not receive due to a moritorium on new oil and gas wells in Boulder County											x										
Andarko Petroleum invests in reducing footprint, truck traffic in northern Colorado	Proctor	Denver Business Journal	5/19/2014	3	Colorado	Summarizes Anadarko plans to drill multiple wells on single pad, use closed loop or pitless operations, frack from a "stim center", use "field gas" for compression pumps, construct pipelines to carry water to and from well site to reduce impacts				x		x									x		x				
Homeowners and Gas Drilling Leases: Boon or Bust?	Radow	New York State Bar Assn. Journal Nov./Dec., 2011	Nov / Dec 2011	12	New York and Pennsylvania	Summarizes the risks associated with mortgages on properties where fracking may occur. For example, signing a gas lease may be a violation of the terms of the mortgage and homeowners insurance generally excludes the type of damages that may occur with fracking. The use of fracking expanded when congress exempted it from environmental laws governing safe water and/or (now known as the Halliburton loophole).		x		x		x				x			x	x	Yes			x				
Letter Nederland, Sewell & Associates to NARO	Rees, Green	National Association of Royalty Owners	6/3/2014	3	Boulder County, CO	Estimates what royalty (mineral rights) owners might no treceive due to a permanent moritorium on new oil and gas wells in Boulder County.											x										
Drilling vs. the American Dream: Fracking Impacts on Property Rights and Home Values	Resource Media	Resource Media	3/14/2014	9	Multiple: US & Canada	Broadly scoped research on types of impacts related and regulartory issues related to fracking. Reports some property devaluations. Exxon CEO and House Majority Leader filed lawsuits.					x	x				x	x	x	x	Yes	x		x				x	
Fracking the American Dream: Drilling Decreases Property Value	Resource Media, EcoWatch	Resource Media, EcoWatch	11/13/2013	7	Various	Cites anecdotal information about reductions in property value as well as cites some specific studies. For example, it references the 2002 LaPlata County study indicating a 22% loss in value to homes near coal-bed methane development. Also talks about difficulty in obtaining mortgages for properties with split estates and mentions Senate Bill 14-009 in the Colorado Legislature that would require sellers to notify prospective homebuyers about separated mineral rights.		x			x				x			x	x	Yes			x				
Fracking by the Numbers	Ridlington, et al	Environment America Research & Policy Center	10/1/2013	47	General	Quantifes some key impacts of fracking to date, including the production of toxic wastewater, water use, chemicals use, air pollution, land damage and global warming emissions.			x	x	x	x											x	x			x
Dimock, PA Water Tests Conducted by EPA Amid Fracking Concerns	Rubinkam	Huffington Post	7/25/2012	2	Pennsylvania	Reports that 32 of 36 Dimock households have agreed to a confidential settlement with Cabot Oil and Gas regarding contaminated well water.						x							x	Yes			x				
Blind Rush? Shale Gas Boom Proceeds Amid Human Health Questions.	Schmidt	Environmental Health Perspectives	8/1/2011	10	Texas, Pennsylvania, Colorado, General	Provides extensive list of potential environmental impacts from fracking and oil & gas development and footnotes each source.					x	x									x		x				
Risk, Media and Stigma: Understanding Public Challenges to Modern Science and Technology	Slovic	Earthscan Publications	2001	395 +	General	This book characterizes the phenomenon of stigma associated with places, products and technologies that arise from the association with an abnormal or unnatural degree of risk. It emerged from several prior conferences. Different authors prepared each chapter.													x								

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Understanding the Marcellus Shale Supply Chain	Seydor, et al	University of Pittsburgh Katz Graduate School of Business	5/1/2012	72	Pennsylvania	Describes the market supply chain from leasing through drilling, transportation, storage, distribution and marketing.		x																				
How Will Fracking Affect Your Property Value (and Mortgage)?	Sucich	zillow.com/blog CATEGORY:TIPS & ADVICE	8/1/2012	3	New York	Cites an August 2011 Economic Assessment Report for the State of New York finding that in general properties may benefit from increased economic activity associated with oil and gas production, but some property values nearest the wells may decrease. The author notes that Fannie Mae and Freddie Mac require borrowers to secure consent before signing a gas lease. Author also notes that a lender benefits from a lease on mortgaged property because bonus proceeds and revenue from gas production are subject lien.												x	x	Yes							x
Our Drinking Water at Risk	Sumi	Oil and Gas Accountability Project, a project of Earthworks	4/1/2005	76	General	Reviewed the 2004 EPA study and found that there is insufficient information for EPA to conclude that hydraulic fracturing does not pose a threat to drinking water.																	x					
Boulder County Could be Liable for $1 billion in petro "takings"	Svaldi	The Denver Post	6/12/2014	2	Boulder County, Colorado	Summarizes information released by National Association of Royalty Owners. Boulder County could owe royalty owners $1 billion or more if they ban oil and bas development.											x										
Fracking Wastewater Disposal Linked to Remotely Triggered Quakes	Than	National Geographic	7/11/2013	3	Texas, Oklahoma & Colorado Impact in Chile, Japan & Indonesia	References articles in *Science* and from researchers at Columbia University. Earthquakes in other countries linked to wastewater injection in CO, TX, and OK--- called "dynamic triggering"								x													
An Analysis of The Economic Potential for Shale Formations in Ohio	Thomas, et al.	Cleveland State University; Ohio State University; Marietta College	Undated, 2014?	81	Utica Shale formation in ohio	Provides descriptive information about major (upstream) investments needed, including buying mineral rights, new road construction ($1.1 million per drilling location with 6 to 8 well pads), drilling costs $5 -$6 million per well) and midstream infrastructure requirements. Economic impacts from this investment was estimated using an input-output model. Finds that the development will result in increased land and property values.		x									x		x	Yes							
A Review of Hydro "Fracking" and its Potential Effects on Real Estate	Throupe, et.al.	Journal of Real Estate Literature	2013	28	Colorado and other oil and gas states	Presents an overview of fracking; summarizes federal and state disclosure and management regulations; and, evaluation potential surface and subsurface effects. Based on survey results, found 5-15% discount in bid value for homes.	x	x				x							x	Yes			x		x	x	x
Economic Impact of the Eagle Ford Shale	Tunstall, et al.	UT at San Antonio - Institute for Economic Development	5/1/2012	88	14 counties in Texas	Using an input-output model, economic impacts of upstream, midstream and downstream impacts from oil and gas and pipeline construction on a 20 county region were measured. Analysis measured jobs, payroll, gross regional product, local government revenues and state revenues. Some economic impact management advice is included.		x									x										x	x
Energy Boom Puts Wells in America's Backyards	Bryson	Wall Street Journal	10/29/2013	6	Colorado, Texas	WSJ obtained data from 2.3 million wells in 11 states. > 15 million Americans live within a well that has been drilled and fracked since 2000.					x										x		x			x	
Ozone Mitigation Efforts Continue in Sublette County, Wyoming	Urbigkit	Star Tribune	3/9/2011	2	Wyoming	Ozone levels in county exceed national air quality standards. Wyoming Department of Environmental quality stated elevated ozone is primarily due to local emissions from oil and gas development activities. Production companies pledge to pursue more voluntary actions to reduce emissions.					x																
"Rush to Drill for Natural Gas Creates Conflicts with Mortgages"	Urbina	New York Times	10/20/2011	6	New York	Describes issues with technical defaults in mortgages with gas leases and related issues with Fannie Mae and Freddie Mac.													x	Yes							

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Deadliest Danger Isn't at the Rig but on the Road	Urbina	New York Times	5/14/2012	6	West Virginia	Reports on trucker fatalities due to long hours. 500 to 1,500 truck trips per well are required because fracking requires millions of gallons of water. National Transportation Safety Board strongly opposes oil field exemptions because they raise the risk of crashes.															x				x			x
Annual Energy Outlook 2014	US EIA	US EIA	5/7/2014	12	US	Summarizes historical information about consumption, national gas production and natural gas pricing and provides forecasts that the EIA prepared.	x																					
Evaluation of Impacts to Underground Sources of Drinking Water of Hydraulic Fracturing of Coalbed Methane Reservoirs	US EPA	US Environmental Protection Agency EPA 816r04003.	6/1/2004	22	General	Based on information collected and reviewed, EPA concludes in 2004 that the injection of hydraulic fracturing fluids into coalbed methane posed little or no threat. EPA also reviewed incidents of drinking water well contamination believed to be associated with hydraulic fracturing and found no confirmed cases that were linked to fracturing fluid injection into coalbed methane wells or subsequent underground movement of fracturing fluids. These conclusions have since been contested and EPA is in the process of updating their study.	x																x				
Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources - Progress Report	US EPA	EPA 601R- 12/011	12/1/2012	278	Colorado, North Dakota, Pennsylvania, Texas	"The purpose of the study is to assess the potential impacts of hydraulic fracturing on drinking water resources, if any, and to identify the driving factors that may affect the severity and frequency of such impacts"																	x		x		
EPA Issues Updated, Achieveable Air Pollution Standards for Oil and Gas +	US EPA	US Environmental Protection Agency	4/18/2012	3	General	EPA finalized standards to reduce air pollution associated with oil and natural gas production. "As wells are being prepared for production, they emit volatile organic compounds (VOCs) which contribute to smog formation an air toxics. Methane, a constituent of natural gas, is a greenhouse gas.			x		x																
Hydraulic Fracturing Research Study	US EPA	US EPA, Office of Research and Development	6/1/2010	2	General	Summarizes what fracking is, the connection between water and fracking, and why EPA is studying fracking.				x													x				
EPA Completes Drinking Water Sampling in Dimrock PA	US EPA	US Environmental Protection Agency Press Release	7/25/2012	1	Pennsylvania	EPA determined that there are not levels of contaminents present that would require additional action by the Agency.																	x				
The Seismic Link Between Fracking and Earthquakes	Walsh	Time Magazine, electronic edition	5/1/2014	3	Ohio, Oklahoma, Kansas	Reports information about earthquakes and new research released by the Siesmological Society of America, showing disposal wells are changing stress on existing faults, inducing earthquakes.								x													
A Retropersective Review of Shale Gas Development in the United States	Wang, et.al.	Resources For the Future	4/1/2013	42	United States	Provides historical production information, and describes market considerations. He concludes: " sound environmental regulations are needed to make shale production sustainable.	x																				
Geochemical Evidence for Possible Natural Migration of Marcellus Formation brine to shallow aquifers in Pennsylania	Warner et al.	Proceedings of the National Academy of Sciences, vol 109,	7/24/2012	15	Pennsylvania	Describes concerns about the potential for migration of stray gas, metal-rich formation brines, and hydraulic fracturing and/or flowback fluids to drinking water aquifers. The presence of these fluids suggests conductive pathways and specific geostructural and/or hydrodynamic regimes in northeastern Pennsylvania that are at increased risk for contamination of shallow drinking water resources.					x														x			
Pipelines and Property Values: An Eclectic Review of the Literature	Wilde	Journal of Real Estate Li	Fall 2012	21	General	Finds that there is no credible evidence based on actual sales data that proximity to pipelines reduces property values.													x	No							
Fracking Regulation Applied	Wiseman	Duke Environmental Law and Policy Forum	2012	24	General	Describes state regulations and finds that states have core regulatory responsibilities and face a daunting tasks as activity, need for inspections and violations increase. Improved analysis of existing violations and envorcement is needed.																				x	

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Hydraulic Fracturing Ban: The Economic Impact of a Statewide Fracturing Ban in Colorado	Wobbekind, et.al	Univ. of Colorado Boulder Leeds School of Business	3/1/2014	33	Colorado	Focuses on the economic impacts of a potential statewide ban on fracking. This paper provides an overview of the political landscape surrounding the industry, quantifies the current production and economic activities as reported via public sources, and quantifies the economic impacts of a statewide ban on fracking activities. The report concludes that a statewide fracking ban would prove damaging to the Colorado economy, setting the state back an average of 68,000 jobs in the first five years and $8 billion in GDP. Over the long term (2015-2040), the impact of a ban would result in average 93,000 fewer jobs and $12 billion in lower GDP when compared to a baseline scenario.	x	x																						
Exxon Mobile CEO: No Fracking Near My Backyard	Woodyard	USA Today	2/1/2014	2	Texas	Exxon Mobil's CEO has joined a lawsuit to stop construction of a water tower near his home that would be used to in the fracking process to drill for oil.The lawsuit contends the project would create "a noise nuisance and traffic hazards."										x			x	Yes	x			x				
Flower Mound Well Site Impact Study	Wright	Prepared for Town of Flower Mound, TX	8/17/2010	108	Texas	Consultation report about the impact of natural gas wells on improved residential properties, consistent with appraisal practices. Conclusion: residential properties valued at about $250,000 and immediately adjacen to wells sites can have a negative 3% to 14% impact on value. Valuation impact dissipates at around 1,000 feet.													x	yes		x						