

BY MICHELLE NIJHUIS

HOW HALLIBURTON'S TECHNOLOGY IS WRECKING THE ROCKIES

OUT ON THE WESTERN EDGE OF

Colorado, where the Rocky Mountains flatten into desert mesas and dusty canyons, there is a small town called Silt. Like the powdery soil beneath it, Silt seems a humble place, with a couple of gas stations, a couple of churches, and a town park offering shade from the persistent summer sun.

Laura Kunau moved here from Illinois about a dozen years ago to join her boyfriend, Larry Amos, whom she would marry a few years later. The couple ran a successful outfitting business in the nearby mountains, leading clients in search of bull elk or prime fly-fishing streams. In the winter they took to the road, promoting their business at hunting banquets and trade shows.

IMAGINE THIS IN YOUR
BACKYARD: EACH NEW WELL
BRINGS ITS OWN UNSIGHTLY
INFRASTRUCTURE.

PHOTOGRAPHS BY LYNN JOHNSON



But on the borders of their idyllic life, the Rocky Mountain energy boom was gaining momentum. The nation was thirsting for natural gas, and the Rockies had plenty to offer: Beneath the forests and deserts and ranchlands, beneath the gorgeous open country, lay some of the nation's largest remaining reserves of fossil fuels. With a sympathetic administration in Washington, and state and local governments unwilling or unable to stand in the way, the natural-gas industry tore into the new millennium, perforating landscapes from Montana to New Mexico.

The Powder River Basin of Wyoming is now studded with nearly 25,000 natural-gas wells, a number that is expected to more than double in the next 20 years. The San Juan Basin of southwestern Colorado is home to another 25,000 wells, with 15,000 more projected in the next two decades. The true costs of the boom—to land, to water, and to human health—remain largely unassessed and sometimes willfully obscured. And Laura Amos wonders if she is one of its uncounted casualties.

THE TOWN OF SILT, in Garfield County, may appear unremarkable, but it sits atop a geologic wonder. The Piceance (pronounced “pee-awnce”) Basin, the wide bowl of desert cradling Silt and the surrounding small towns, contains as much as 100 trillion cubic feet of natural gas—enough to supply the entire United States, at current consumption levels, for well over four years.

Most Piceance gas is locked inside “tight sands,” rock so fine-grained as to be almost impermeable. Though industry insiders have known about the Piceance for decades, its tight-sands gas has been too difficult—in other words, too expensive—to pull out of the ground. But in the late 1990s, when the price of natural gas shot upward, the impossible became possible.

The extraction of Piceance gas demands an awkwardly named technique known as hydraulic fracturing (sometimes called “frac’ing” and pronounced “fracking”). Fracturing, developed by Halliburton in the 1950s, uses a high-pressure blast of fluids to open cracks in gas- or oil-bearing rock formations, allowing trapped fuels to flow out of the underground rock and to the surface.

Most companies keep their particular “recipes” for hydraulic fracturing fluids under wraps, but many fluids are known to contain toxic chemicals intended to increase the efficiency of the process. Some, for example, include the carcinogen benzene and the powerful neurotoxins toluene and xylene. Studies have shown that residues of these and other substances can remain underground after fracturing is completed.

In the early decades of the technology, perhaps one in every 100 wells was frac’d. But as the nation’s fossil energy reserves shrank, fracturing became a common tool in both oil and gas operations. The process is now used in some 90 percent of the country’s tight-sands and coal-bed methane gas wells, which can require five or more separate “frac jobs” to keep the gas coming.

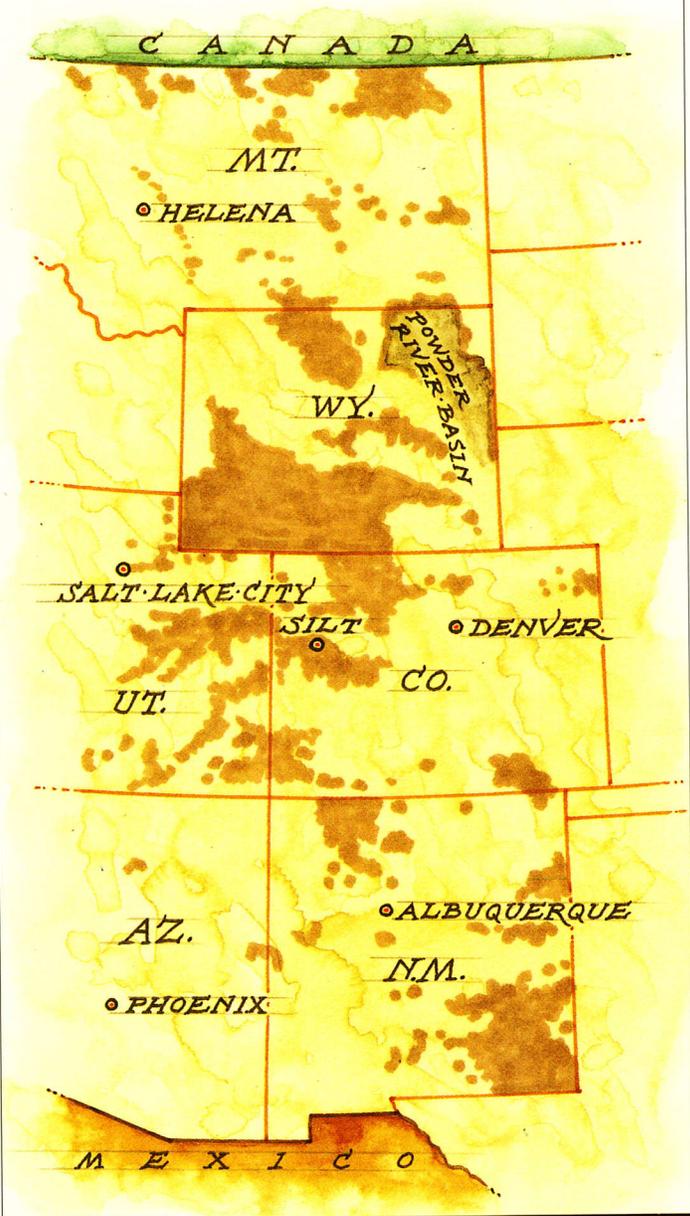
So thanks to high gas prices and the magic of frac’ing, Rocky Mountain gas fields are among the most lucrative in the country—and nowhere in Colorado are they growing more rapidly than in the Piceance Basin. There are now more than 3,000 wells in Garfield County alone, and various industry estimates predict another 10,000 wells during the next decade.

When you picture these wells, picture them not only in vast public forests and remote redrock deserts but also on ranches and in rural neighborhoods, in pastures and near private homes. Because of

a quirk in federal law dating back to the early 1900s, many landowners in the Rockies cannot keep gas wells off their own property. While residents control the surface of their land, the state or federal government often manages the riches in the earth below, and the rights to develop them can be leased to private companies. Though surface owners can negotiate conditions and restrictions with industry representatives, they frequently feel outwitted. “It’s like playing a complicated board game without being told the rules,” says former Silt resident Peggy Utesch, who watched gas wells surround her four-acre property until she finally moved away in frustration, blaming industrial pollution for her frequent headaches and skin rashes. “The industry succeeds in running over people who don’t know the rules.”

Once-peaceful ranches and neighborhoods have become industrial sites, invaded by drill rigs, concrete well pads, and networks of

LAND LEASED FOR DEVELOPMENT OF OIL AND GAS RESOURCES (Including Coal-Bed Methane)



busy access roads. Gas development has fragmented wildlife habitat and inundated pastures with groundwater. It has dumped pollutants into the air, shrouding vistas in haze and increasing the risk of lung damage and other health problems for nearby residents. The gas boom has also brought hydraulic fracturing uncomfortably close to the region's supplies of clean drinking water.

"Fracturing is causing these mini seismic events underground," explains Lisa Sumi, who has investigated the issue for the Oil and Gas Accountability Project (OGAP), a grassroots nonprofit group based in Durango, Colorado. The effects of these small earthquakes, she says, remain largely unknown. "We just don't have enough data. This is a huge experiment."

THE EXPERIMENT first touched the lives of Laura and Larry Amos in 1998, when a Montana-based company called Ballard Petroleum sent one of its landmen to call. He politely explained that Ballard had leased the rights to the gas under their land, and that the company was ready to break ground on the first set of wells in the neighborhood. The Amoses could either accept a check for \$3,000, he said, or refuse the payment—and watch the development move forward anyway.

The company agreed to build the concrete pad for the wells out of sight of the Amos house, and the Amoses learned to live with the disruption. But Ballard returned in 2000, this time with plans to drill on the property next door. Like the Amoses, the neighbor asked that the well pad be built as far from his home as possible. That placed it in full view of the Amoses' front porch—less than 250 yards from their kitchen sink.

On May 1, 2001, while Laura, Larry, and their 6-month-old daughter, Lauren, were visiting Laura's parents in Kansas, Ballard and its contractor, BJ Services, fractured three wells on the pad neighboring the Amos property. That same day, a family employee called the Amoses to report that the metal cap on their water well had blown into the air, flooding the surrounding pasture with a fountain of murky, fizzing water.

The geyser subsided, but the Amoses' tap water remained filled with dark gray sediment and bubbled as busily as soda pop. The Colorado Oil and Gas Conservation Commission, the agency that oversees oil and gas development in the state, sent a representative to inspect the damage, and tests showed that the well water was contaminated with methane gas. Though methane is believed to be non-toxic in drinking water, it poses other threats: At the concentration detected in the Amos well, the state warned, gas entering through the faucets could collect inside the house and explode. (The state advised the family to keep closets and crawl spaces ventilated).

The Amoses immediately blamed hydraulic fracturing for their troubles, but the oil and gas commission, and Ballard, argued that the fracturing had taken place more than a mile underground, far below the 225-foot-deep well. They also pointed out that instrument readings taken during the fracturing jobs showed no sign of a problem.

Yet Geoffrey Thyne, a geologist at the Colorado School of Mines in Golden, who has studied the incident as a consultant to Garfield County, concluded that the deep fracturing was at least an indirect cause of the backyard geyser. "Water wells just don't do that," he says, "unless you apply pressure to the bottom." Thyne surmises that the pressurized fracturing fluids shoved gas or liquid through a much

THE NATURAL GAS INDUSTRY TORE INTO THE NEW MILLENNIUM, PERFORATING LANDSCAPES FROM MONTANA TO NEW MEXICO

shallower leak in the side of one of the gas wells. That gas, he says, could then have found one of the natural underground fissures abundant in the area and moved through it into the Amos well.

Some two weeks after the well burst open, Ballard started delivering water to the Amos household, and the family began using that water for drinking and bathing. They occasionally had problems with the outdoor tank that held the water, and when disruptions occurred they often turned back to their own well water. It wouldn't hurt, the Amoses thought, to bathe their daughter in the water every once in a while, or even use it to make a cup of coffee when the sediment wasn't too thick.

In late August 2001, the state again tested the Amos well water and found only traces of methane gas. The levels were so low that further tests to pinpoint the source of the gas were impossible. Given this lack of evidence, the state decided, Ballard could not be held responsible for the contamination. Garfield County rock contains a lot of gas, and there was a chance that the methane in the Amos well had come from another source. By October, after about four months of service, Ballard had stopped delivering water to the Amos home. Yet water from the family well, Laura Amos says, remained foul-smelling and murky.

THE AMOSES soon learned that their domestic water troubles weren't the first to coincide with hydraulic fracturing. Families living on top of gas fields in Alabama, Virginia, New Mexico, and Wyoming, as well as in other parts of Colorado, had reported gas and other contaminants in their drinking water after fracturing operations. In the late 1980s, the McMillian family of central Alabama complained that immediately following fracturing of shallow coal seams near their home, black goo—possibly a gel used in the fracturing process—oozed out of their water taps. In the gas-rich San Juan Basin of southwestern Colorado, some families saw the water in their sinks and bathtubs fizz with methane gas after fracturing operations in the area's coal deposits.

Colorado oil and gas commission director Brian Macke states, "There have not been any known cases of [drinking water] contamination from hydraulic fracturing in Colorado." But Macke, along with the majority of the commission's seven-member board, has professional roots in the oil and gas industry, and many experts don't trust such reassurances.

"It's an old industry trick to say, 'There's absolutely no evidence of a problem,'" says Erik Olson, a senior attorney for the Natural Resources Defense Council (NRDC). "The question is, how hard have people looked? The answer is, not very hard."

Colorado, like many other states, does have a suite of rules for well

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A COMMUNITY TORN APART

According to the 2000 U.S. Census, Garfield County, Colorado, has a population of 43,713. Ninety percent are white; the median household income is \$47,016, slightly above that of the country as a whole. Nestled among mountains, canyons, forests, and velvet-green alpine meadows, small towns like Parachute, Rifle, and Silt—where Laura Amos lived until recently with her husband and 5-year-old daughter, Lauren—have long been a mecca for hunters, anglers, hikers, and other outdoor recreationists. But they are also at the epicenter of the Rocky Mountains' oil and gas boom. Tens of thousands of new wells now disfigure Colorado and its neighboring states. In Garfield County alone, where there are now 3,000, the number could quadruple over the next decade.

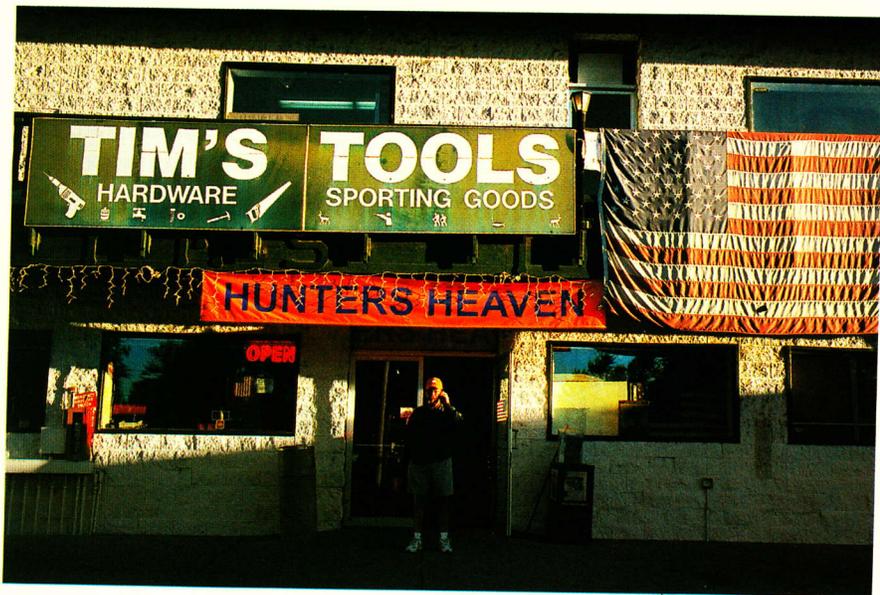
construction and operation, and these are designed to prevent fracturing fluids and the natural gas they release from reaching drinking-water supplies. Yet the state does not place any restrictions on the kind or quantity of chemicals that can be blasted into the earth.

Federal agencies offer scant additional protection. Though the Safe Drinking Water Act requires regulation of “underground injection” to ensure the protection of “underground sources of drinking water,” Environmental Protection Agency officials have

argued that hydraulic fracturing does not qualify as a type of underground injection. (Former EPA head Carol Browner stated in a 1995 letter that since underground injection was not the “primary purpose” of coal-bed methane wells, hydraulic fracturing should get a pass from the Safe Drinking Water Act.)

Gas-field residents in Alabama challenged the agency’s stance in the mid-1990s, when the Florida-based Legal Environmental Assistance Foundation (LEAF) brought their complaints to court. LEAF

argued that Alabama’s underground-injection control program—which operates with the approval of the federal EPA—was deficient because it did not address hydraulic fracturing in the state’s coal-bed methane wells. LEAF won its case in federal appeals court in 1997, but the ruling applied only to Alabama, Florida, and Georgia, the states within the court’s jurisdiction. Though the EPA could have chosen to enforce the ruling nationwide, says LEAF attorney David Ludder, it decided not to: “The agency took the attitude, ‘If it’s to be applied elsewhere, they’re going to have to sue us.’” Alabama, the only one of the three states where hydraulic fracturing is used in coal-bed methane wells, remains the only one required by the EPA to permit and oversee the injection of hydraulic fracturing fluids under the Safe Drinking Water Act.



Following the LEAF decision, the agency began a study of hydraulic fracturing in coal deposits and its possible effects on drinking water (the deeper tight-sands wells, like those near the Amos home, were not included in the study). In 2004 the EPA concluded that fracturing “poses little or no threat” to drinking water and that no further study of the issue was necessary. But NRDC’s Olson, a former EPA lawyer who still has contacts within the agency, says the report was polluted with politics. “There was a lot of pressure to come out the ‘right way’ on the issue,” he says. “There were pretty clear signals from a variety of people within the agency, and within the industry, that the agency shouldn’t be pushing too hard for a full-blown evaluation that would make the industry look bad.”

The EPA obtained safety data on the contents of hydraulic fracturing fluids from four companies, but OGAP researcher Sumi points out that these data are likely incomplete, since companies are permitted to withhold information about components they consider trade secrets. In a draft of the study, the agency identified nine chemicals that were injected underground at concentrations that exceeded state or federal water quality standards. But Sumi, in her 64-page review of the EPA report, noted that this list was missing from the final study. “That raised a lot of red flags,” she says.

A veteran EPA environmental engineer named Weston Wilson was also concerned. Wilson has worked in the agency’s Denver office for more than 30 years, and while he has a reputation among his colleagues for speaking his mind, he is by no means a partisan critic. In 2003 Wilson was one of a group who received an award from the head of the Bureau of Land Management, Kathleen Clarke, a Bush administration appointee. She applauded him for his work on the effects of energy development on water quality in Montana and Wyoming, and for upholding then Interior Secretary Gale Norton’s principles of “consultation, cooperation and communica-



THE WIZARDRY OF HYDRAULIC FRACTURING DELIVERS NATURAL GAS TO THE NATION AND HAS POWERFUL FRIENDS IN THE WHITE HOUSE

tion” with the public in the service of conservation.

Wilson was not involved in the development of the EPA report, but he took a close look at the final document and felt it was based on flimsy research. After much consideration, he decided to take his criticism public—and perhaps jeopardize his career.

In late 2004 Wilson sent a strongly worded letter and an 18-page supporting memorandum to the Colorado congressional delegation, calling the EPA study “scientifically unsound and contrary to the purposes of the law,” with a conclusion that “may result in danger to public health and safety.” The study lacked critical field research, he wrote, and relied on an external review panel dominated by current and former oil and gas industry employees, including a technical adviser for Halliburton Energy Services. “They had only preliminary data on what was in the fracturing fluids,” Wilson says now. “They just didn’t have enough information to conclude that hydraulic fracturing was not a risk.”

Wilson’s scathing and very public critique was echoed by other experts and sparked an investigation by the EPA’s inspector general. It also meant a great deal to Laura Amos, who had some new and more frightening worries about the gas well near her home.

IN THE SPRING of 2003, almost two years after the Amos well blew its top, Laura and Larry Amos were vacationing in Key West, Florida. Laura had been feeling unusually thirsty and her body seemed swollen—problems she attributed at first to the stresses of new motherhood. But during a day of snorkeling, she began to wonder if something else was wrong. “I could hardly get my breath,” she says. Even with a flotation device, she remembers, “I could barely make it back to land.”

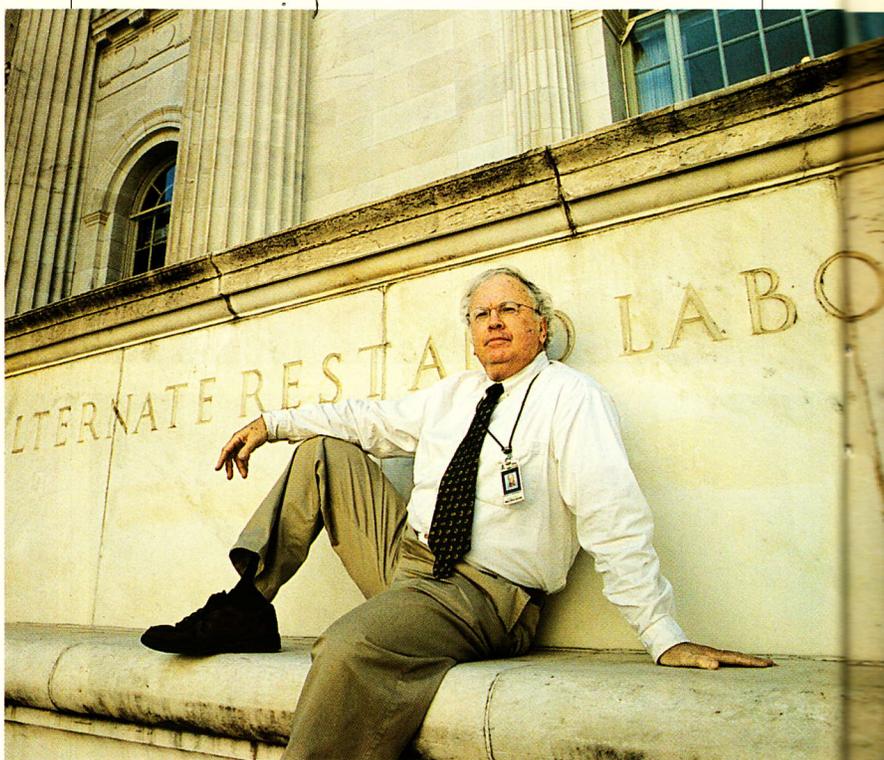
It turned out that Amos had extremely high blood pressure and dangerously low potassium levels, but her physician back in Colorado was unsure of the cause. Several office visits and weeks of worry later, a doctor in a nearby city diagnosed her with Conn syndrome, a benign tumor in one of her adrenal glands. After surgery that removed the tumor and the entire gland in July 2003, Amos’s blood pressure and potassium levels quickly returned to normal.

The National Organization for Rare Disorders classifies Conn syndrome as a rare, or “orphan,” condition, one affecting fewer than 200,000 people in the United States, and at first Amos blamed her health problems on a stroke of bad luck. But in the summer of 2004, she ran across a memo to a Colorado office of the U.S. Forest Service, written about two years earlier by Theo Colborn, author of the 1996 book *Our Stolen Future* and an internationally recognized expert on hormone-disrupting chemicals (see “Hundreds of Man-Made Chemicals Are Interfering With Our Hormones and Threatening

Our Children’s Future” by Gay Daly, *OnEarth*, Winter 2006). Colborn’s memo described the possible health effects of a solvent called 2-butoxyethanol (2-BE), known by the EPA to be used in some fracturing operations. The clear solvent is odorless and tasteless at low concentrations, and it can be swallowed, inhaled, or absorbed through the skin. Colborn reported that 2-BE was associated with higher-than-normal incidences of adrenal tumors in rats and mice and calculated that potentially toxic concentrations of 2-BE could contaminate domestic water wells near fractures.

“I thought, ‘Oh my gosh, did they use this?’” says Amos. She called Colborn, who also happens to live in western Colorado.

Colborn says that when she wrote the memo, she was concerned about the effects of hydraulic fracturing on domestic water supplies, but hadn’t expected associated health problems to crop up for a decade or more. “Then there was this sweet, lovely voice, telling me



The review panel criticized by EPA whistleblower Weston Wilson included two officials with ties to Halliburton and a third who worked for BP Amoco.

she had developed a rare adrenal tumor,” Colborn remembers. “It sent chills up and down my spine.”

Even so, Colborn’s first words were cautionary. “I made it very clear to her that I will never say that 2-BE caused her tumor,” Colborn says. “But I am concerned. It is a very rare tumor, and she was in a physical condition where her hormonal system was hyperactive—she had recently had a baby. She would have been what we would call the sensitive population.”

When Amos went public with her suspicions in late 2004, representatives of the Canadian company EnCana, which had bought Ballard Petroleum in 2001, told the press that they did not believe 2-BE had been used in fracturing operations near the Amos home. The official state report on the incident, published in January 2005, tells a different story. About five weeks after the Amos well turned into a geyser, a contractor opened a shallower fracture on the well pad next

to the Amos property. And it used the fracturing additive 2-BE.

Is it possible that this dose of 2-BE found its way into the Amos well? "My answer to that is no," says state oil and gas commission director Macke. Instrument records kept by the company, he says, would have revealed any problems with the gas well during fracturing. But School of Mines geologist Thyne thinks even a small crack in the underground rock could have quietly sent a trickle of fracturing fluid into the Amoses' nearby well. "We've just never had a situation where we tested [water] wells on a short enough time scale to see it happen," he says. In November 2004, tests of the Amos water for 2-BE came up clean, but they were a largely futile gesture: Three and a half years had passed since the water well had blown.

Laura Amos channeled her fear and anger into action. She testified at hearings of the oil and gas commission, buttonholed state legislators and congressional representatives, and spent hours strategizing with other activists about how to protect Rocky Mountain residents from the impacts of the gas boom. From as far away as Alberta, Canada, people with similar worries about fracturing—and a variety of health complaints—called her to share their stories and suspicions. One reporter dubbed Amos "the Erin Brockovich of Garfield County."

But the wizardry of hydraulic fracturing delivers natural gas to the nation, and it has powerful friends—notably in the White House. The 2001 report from Vice President Dick Cheney's energy task force specifically cited the value of hydraulic fracturing. The *Los Angeles Times* reported in October 2004 that Halliburton, Cheney's former company, which earns about \$1.5 billion each year from hydraulic fracturing and is one of the country's three dominant fracturing-services companies, had lobbied against federal regulation. Industry groups, such as the Domestic Petroleum Council and the Independent Petroleum Association of America, supported a provision in the Energy Policy Act of 2005 that exempted fracturing from regulation under the Safe Drinking Water Act.

In the spring of 2005, Amos spent several days in Washington, D.C., as part of a group of Rocky Mountain activists lobbying against the proposed fracturing exemption in the federal energy bill. When Jim Jeffords, the Independent senator from Vermont, later introduced the Hydraulic Fracturing Safety Act of 2005, which would have limited the ingredients in fracturing fluids to nontoxic products, he recounted her story on the Senate floor. "It is unconscionable to allow the oil and gas industry to pump toxic fluids into the ground," Jeffords told his colleagues. But the Jeffords bill went nowhere, and when the federal energy bill passed last July, it included the hydraulic fracturing exemption, explicitly prohibiting only the use of diesel fuels. "Basically, there's a handful of people who have been seriously threatened by this practice standing up against a multi-hundred-billion-dollar industry," says NRDC's Olson.

Though environmentalists applaud the prohibition on diesel fuel, historically a common ingredient in fracturing fluids, they point out that the ban will have little actual impact: The three largest hydraulic-fracturing companies had already signed a voluntary agreement with the EPA to eliminate diesel fuel from fracturing in coal beds, and the majority of fracturing jobs in tight-sands formations already eschew diesel. "Diesel is just the tip of the iceberg," says Sharon Bucino, a senior attorney with NRDC. "The real problem is that we just don't know what else is being used."

Olson says the flawed EPA report played a crucial role in the congressional debate. "Time and time again, we heard from congressional staffers, 'Well, the EPA doesn't think this is a problem, so

you're just overreacting,'" he says. "The report clearly gave the oil and gas industry cover to lobby for this thing."

For EPA whistleblower Weston Wilson, this was especially galling. Wilson has retained his post at the agency and even continues to work on oil and gas projects in Utah. But EPA Inspector General Nikki Tinsley, a Clinton appointee, dropped her investigation into Wilson's complaints in January—and shortly afterward announced her resignation. In a letter to Representative Mark Udall, Democrat of Colorado, one of several members of Congress who had requested the investigation, Tinsley said that her decision to end the probe was the result of the energy bill's exemption of hydraulic fracturing from the Safe Drinking Water Act.

"Congress has blocked the agency from doing what it should, by law, be required to do," says Wilson. "I'm afraid Congress was misled by the EPA's inappropriate conclusion that this was benign."

Laura Amos and her family recently reached a settlement with EnCana—the terms of which she is barred from discussing—and moved away from Silt. In March, the state oil and gas commission fined EnCana a total of \$176,800 for the contamination of the Amos well and another nearby water well with methane gas; however, it stated that the contamination was due not to hydraulic fracturing but to other problems with the gas well. Though EnCana has decided not to contest the fines, company spokesman Doug Hock says that "there is no evidence linking drilling activity [on the nearby well pad] with the presence of methane in the Amos well."

Amos will never know if hydraulic fracturing caused her adrenal tumor. She will never be certain if she was exposed to 2-BE or other toxic chemicals as she breastfed her daughter. The gas drilling near her home, and the complex events that followed, have filled her life with anxiety.

Wilson, who unsuccessfully tried to convince the EPA to investigate the Amos case, says citizens in such situations rarely have the data or technical skills to track down the answers they need. "There's a true mystery here," he says. "She was sick. But why?"

The state of Colorado is now collecting baseline water-quality data in some of its most active gas fields, including the Piceance, but it still does not require domestic water wells to be tested before gas wells are drilled nearby. "Can we design a gas field that's 100 percent safe? No," says Geoffrey Thyne. "The question is, how far do we go in making it safe? Garfield County—lucky Garfield—is right at the forefront of this discussion."

"Wouldn't it be great to get ahead of this problem?" Thyne asks. "What if the industry said, 'You know what, even if there's a one-in-a-million chance of something like this happening, we'll go green. We'll make sure there's nothing in the frac'ing fluid that could ever cause health problems.'" But for now, residents of the Piceance and elsewhere must count on the goodwill of the state, or the industry itself, to protect supplies of clean drinking water.

"The most precious thing we have here in the West is our potable water, and we have very little left," says Theo Colborn, who continues to research the contents of hydraulic fracturing fluids. "To inject something like [2-BE] underground, without knowing what was going to happen—I just can't believe we would do something so stupid." ❖

Michelle Nijhuis is a freelance writer in western Colorado and the winner of the 2006 Walter Sullivan Award for Excellence in Science Journalism.