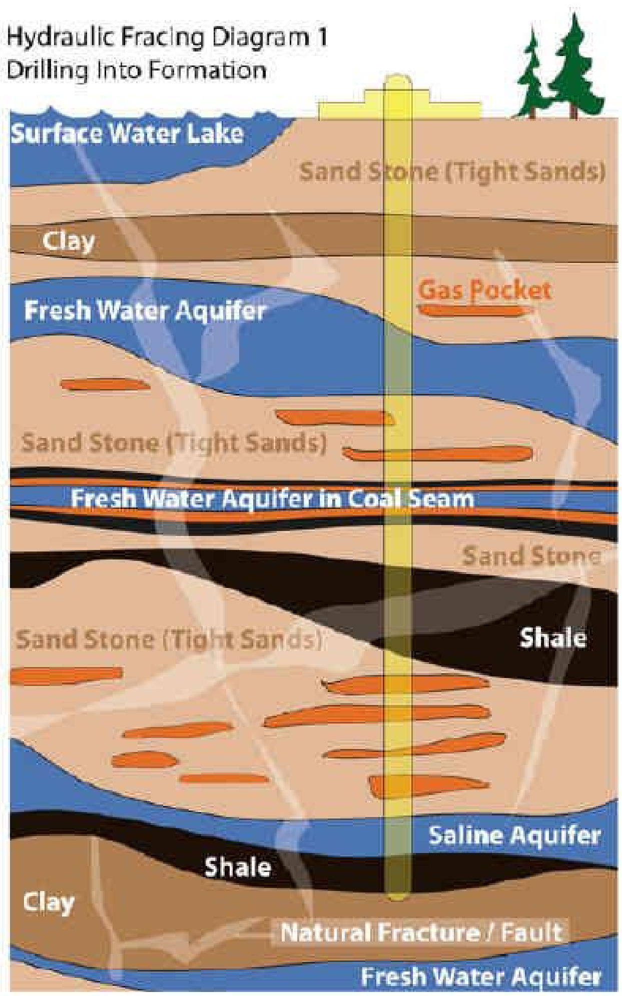
Welcome to my* (Lisa Bracken) *primer on hydraulic fracing, or, as I like to call it, "How to Destroy the Earth's Fresh Water Supplies Without Anyone Finding Out"

Welcome to this field lesson in hydraulic fracing: Today, we are observing Reprobate Energy of America, a gas company pursuing natural gas in the Rocky Mountains. The company has drilled the well bore, and has now brought in another subcontractor (Reprobate uses sub contractors all the time as a means of insulating themselves from accountability) - Schmucks-R-Us Frac Jobs. Let's watch how the process unfolds...



Step One

This diagram shows the well bore in place. It has gone down 6,700' into the Earth. On its way to its 'bottom-hole', the bore intersected a lot of different strata - like some layers of clay, and shale and sand stone packed so tightly together it's called 'tight sands' - under enormous Earth pressures, this stuff is like concrete - but it is also very porous. As you can see, the bore also intersects a number of water aquifers. Some of the aquifers are fresh water and some are not. The fresh water aquifers primarily get their water supply from water that seeps into the Earth's surface from rain or snow. In some areas, the aquifers rise to the surface of the ground in the form of springs. Springs can feed streams, rivers and lakes (many deep fresh water springs feed the waters of West Divide Creek). The well bore also intersects gas, coals and oil (oil pockets are not depicted in the diagram, even though they are often produced - to a lesser degree - along with natural gas in tight sands formations).

In tight sands formations - found in the Rocky Mountains - natural gas is located in thin pockets widely dispersed throughout the sandstone formation.

In conventional drilling, the well bore accesses 'producing zones' and the stuff - oil or gas - flows up the well bore under great pressure, exits out the wellhead and is collected into pipelines - usually after the water and condensate (like paraffin's and other hydrocarbons) are separated.

Because the gas pockets are so widely dispersed and occur in only small pockets, conventional drilling makes locating and producing gas in tight sand formations unprofitable by conventional means (conventional means consists of simply drilling a well bore into a vast pocket of gas or oil)

Gas companies, like EnCana, or Reprobate Energy, use a process called hydraulic fracturing as a way of making gas recovery in tight sands more profitable. Unfortunately, it can also be extremely destructive to fresh water supplies, as Reprobate Energy will demonstrate....

How it works

As the well bore is being drilled, the bit grinds past layers in the formation. Areas (zones) that produce gas are noted. After the bore is in place, the gas producing zones are set with charges at points where the company wants to perforate or blow holes in the well casing - which will allow the gas in the gas producing zones to flow into the well bore. The gas naturally wants to rise under great pressures which are exerted by the weight of the Earth, so will seek the easiest path out of its confinement. Ideally, that means straight up the well bore as a produced product.

The charges are detonated, blowing apart the formation. This causes additional faulting in the surrounding area - how much faulting is a matter of speculation and debate even among experts. [1] Hydraulic fluids are then forced into the new (and existing fractures) in order to prop them open. The idea behind this is to extend the reach of the well bore into the formation (because it is not cost effective to drill every ten feet to try and tap into the pockets where they may lie underground).

The sands or synthetic beads that are forced, with hydraulic fracing fluids, into the fractures remain lodged in the cracks but are less dense than the surrounding formation, so the gas will still flow through the fractures.

Acid (usually hydrochloric - the strongest acid) treatments are also typically injected into the formation. the acid helps dissolve the fractures deeper into the formation further extending the reach of the well bore. Theoretically, most of the fracing fluids are recovered and brought back up by acid flushing or with the gas that is encountered. But this is not always the case. Often, some fluids (as much as 20-40%) are left behind.

Diesel fuel and other products have been used as fracing fluids, and so has CO2 (carbon dioxide gas). Other components of 'frac' fluids are benzene, toluene, surfactants (soaps), solvents, polymers (plastics), foaming agents, anti-scaling agents, corrosion inhibitors and environmentally toxic biocides, as well as patented synthetics - of which there are hundreds and none of which companies have to disclose under special exemptions - plus a lot of whining by industry lawyers. Unfortunately, many of these fluids contain very toxic components, and in some cases, as with benzene, only small amounts can contaminate an entire aquifer.

Even if all the frac fluids are recovered, the raw natural gas (primarily methane) that can communicate with water sources contains benzene, ethyl benzene, toluene, xylene and other constituents that are harmful to humans and wildlife. And that is only what is known to be in raw natural gas. The fact is, there has never been a commercial motive to analyze everything in natural

[1] [additional info - see a scientific perspective of why fracing is flawed]

gas - so a lot of what can migrate into aquifers remains unknown. Now consider that of the known and unknown constituents, each can combine with other constituents and create chemical reactions - leading to all new compounds or physical changes underground - such as mobilizing harmful chemicals that otherwise would have remained locked in the formation. The potential for contamination is astronomical - and worst of all, largely unknown.

So, to get back to all the fluid/sand injection activity.... by fracturing the formation and forcing fluids and sand into the cracks at less of a density than the surrounding formation, the gas will migrate through these fissures and eventually end up in the well bore. Natural earth pressures will push the gas up to the surface where it will be processed and collected into a pipeline.

In short, then, fracing is simply a process tacked onto the end of conventional drilling where producing zones are identified, and the casing is perforated with explosives to fracture the surrounding formation and prop open the fractures with fluids and sand in order to stimulate gas to flow into the bore hole. This method is the method of choice in tight sands formations, like the Rocky Mountains, or anywhere gas exists in small dispersed pockets underground.

Reprobate may choose to frac this well more than once. If production slows down, in say a couple of years, more charges can be set, and the company will blow the hell out of the geology again. And again. And again.

You might ask, "What's the big deal if the geology gets messed up way underground?" Well, the problem is that these explosions cause seismic pulses to travel primarily along existing fault paths, extending the energy from that pulse into the formation in the way of new faults - small or otherwise. It also creates some new pathways. This seismic activity causes the underlying rock layers to slip and shift creating more faults - and possibly sealing others in a process that is often grossly underestimated. Introducing extreme hydraulic frac pressure (enough to counter the weight of the compressed rock formation and existing pressures from gas and water) only intensifies this effect. These activities combined with the interception of pressurized gas pockets creates even more disturbance - much of which is unpredictable due to the irregularities and fluidity of tight sand formations as well as the inability to predict pressure. Now, couple all of this with depressurization that occurs as gas (and water by as much as 1-5 million gallons) is tapped off the formation and collected up the well bore. Much greater shifts and instability arise, compounded by subsequent frac jobs that can lead to greater formation failure. Big time pressure encounters (gas kicks and over pressurized water as they exit the wellbore) can really put the whammy on the formation. To summarize: Both instant and continued degradation of the formation occurs over time affected by numerous primary factors: 1) the nature of the rock (faults, fissures, caverns, slip zones and other instability) 2) initial artificial seismic and hydraulic stimulation of the rock (fracing) 3) frac disruptions causing the formation to respond with its own seismic reactions leading to even more highly unpredictable instability in a round-robin cascade effect 4) encounters of pressurized and over-pressurized gas and/or water (gas kicks, light or heavy) 5) depressurization of the formation as gas and water are produced and, 6) artificial re-stimulation of the formation through repeated seismic and hydraulic stimulation of the rock (for each stimulation, factors 1, 3, 4 and 5 are compounded).

Now, introduce fresh water aquifers and underground springs into the equation and you have a recipe for environmental disaster.

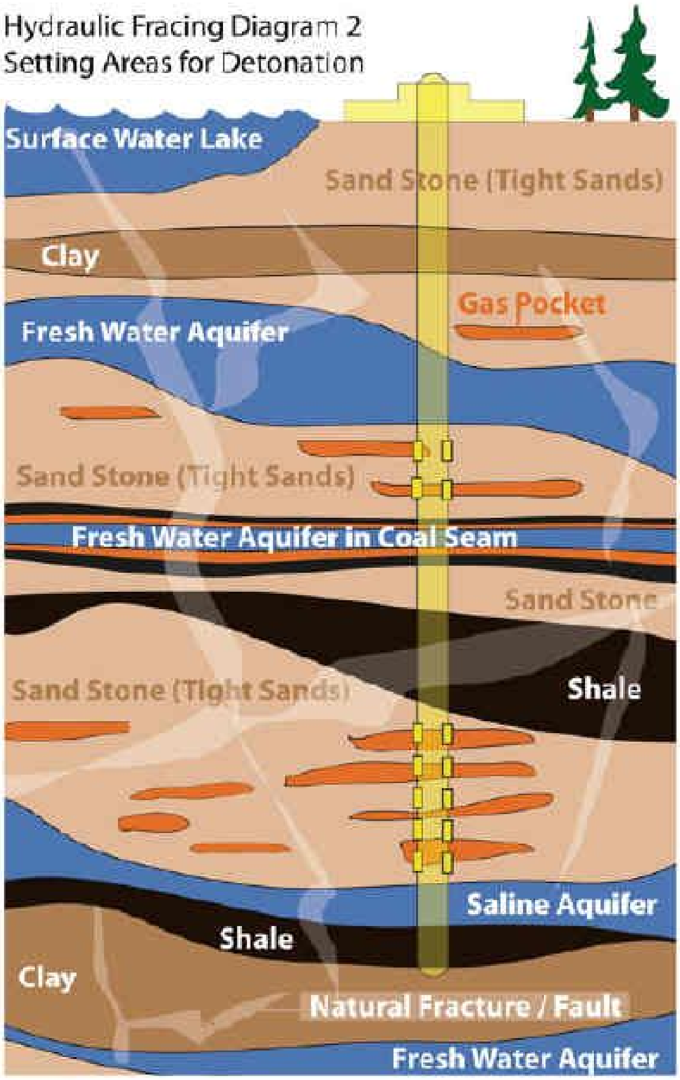
To make things even worse, let's toss extreme down-hole density into the mix - and now you have this level of geologic degradation going on every ten acres underground.

Unfortunately, all of this underground interplay makes predictability a pipe dream and can produce effects that are made worse over time. Some adverse effects may show up relatively immediately, but some may not manifest until the well is long into its lifespan or perhaps after.

Side note on Coal Bed Methane [CBM] and Microbial-Farming Methane Production

Coal seams often contain sweet, fresh water as well as gas deposits that cling to the coal's surface. In order for gas companies to get the gas trapped in coal seams, they have to tap-off or completely deplete the water inside the coal seam. This can amount to millions of gallons of fresh water pumped from underground which is wasted as 'produced water'. In some cases it is discharged onto the surface of the ground, or into streams. The depletion of these aquifers not only reduces the ability of the Earth's hydrosphere to recharge itself and contribute to surface waters by way of springs, it also removes yet another precious water resource wastefully and prematurely. Further, in areas where this method is practiced, it is causing the Earth to collapse and sink. Albuquerque is a good example of how ground water depletion has caused the region to collapse.

Interestingly, scientists in the oil and gas industry have found that the injection of tiny microbes into coal seams create sustainably harvested methane. That's because microbes ingest coal seam gases and, just like us, produce their own form of methane -- to such a prolific degree that it can be captured and sold commercially. This type of gas production is not widely known about in the United States, but in Canada, it has been marginalized because farmers who own land above the coal seams would have to be paid from the harvest of their product produced by hard working little microbes below the ground - which the farmers own. Canada has a farming law called 'heaven to hell', and farmers can earn income on anything that produces a commercial product above and below the farmstead. Profit sharing doesn't appeal to big gas and oil companies. They'd rather frac and pollute than share any profit.



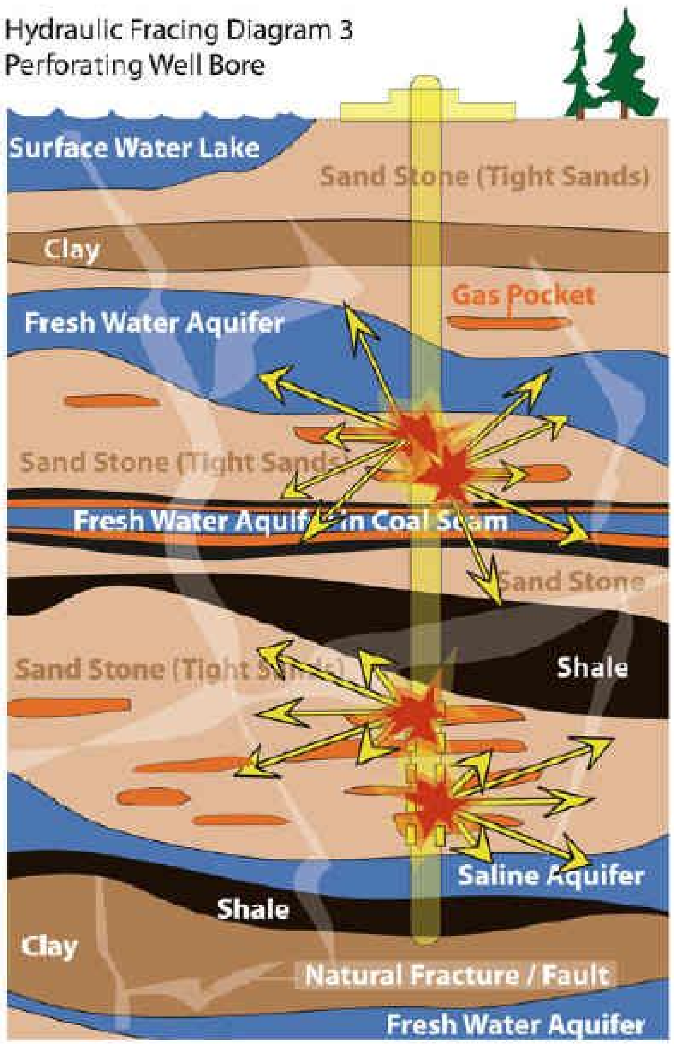
Step Two

In the second diagram, you'll see where the charges have been set in the producing zones.

The diagram is 2-dimentional, but, of course, in the real world, these geologic layers are 3-dimensional, so the transparent faults you see in the diagram may be ahead of, behind or run through some strata.

Gas companies like to testify in court when it's convenient, that they know all about the underlying geology - even seven-thousand feet down. When it's inconvenient for them to know about faulting, they will say they cannot really ever 'know'.

The problem is that they really don't know enough to be able to prevent a catastrophe - which is sadly becoming common where fracing is used.



Step Three

The charges are detonated and holes are blown in the well casing. The perforations will allow gas to migrate into the well bore.

Remember, the gas is under great natural pressure and the well bore provides an easy path of exit.

The explosions can extend a thousand feet or more - for you sports enthusiasts, that's three football fields.

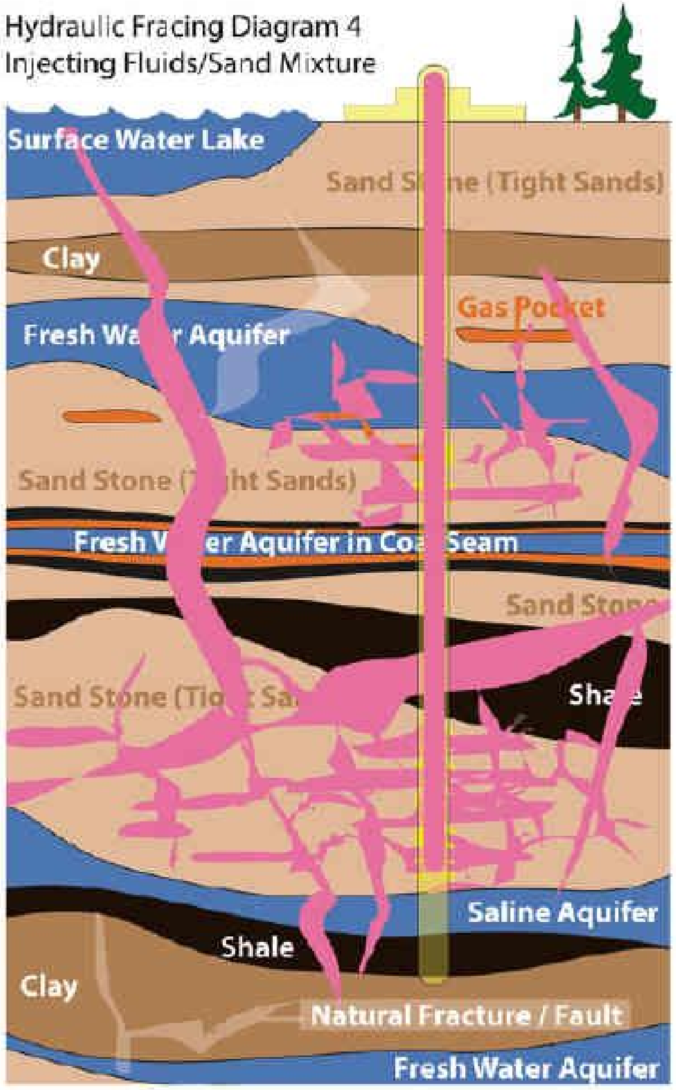
Do you suppose Reprobate can know every fissure, fault, and geologic feature and its characteristics seven-thousand feet down within an area like a giant ball having the volumetric capacity of three football fields in every direction?

Maybe. Maybe not.

The thing is, Reprobate and others like to keep information about fracing very secret. That way, during public hearings, it's a lot easier to either confirm or deny responsibility depending upon which is more convenient and likely to get them out of trouble.

And when I say "trouble", that term is loosely defined. High-paid lobotomists - oops, I mean lobbyists in Washington have made sure that polluting isn't a big deal, but boy howdy, these state Oil and Gas Conservation Commissions don't like to see one drop of gas lost - so these Reprobate companies get in trouble when all the gas doesn't go into the pipeline.

Reprobate will suffer later if they mess up.... you wait and see.



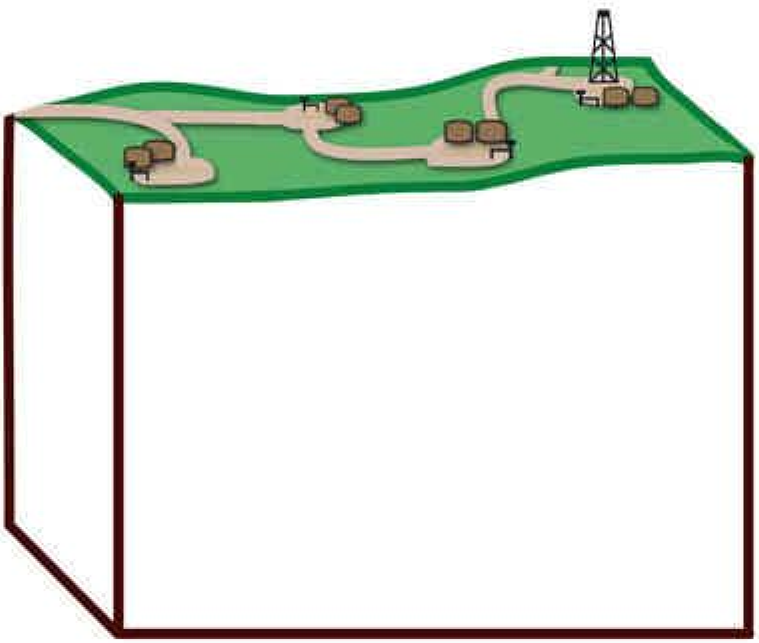
Step Four

The casing has been blown apart and so has the nearby formation, creating all sorts of new fractures near the well bore and beyond. That is what this process is supposed to do - create fractures, allowing the gas to migrate.

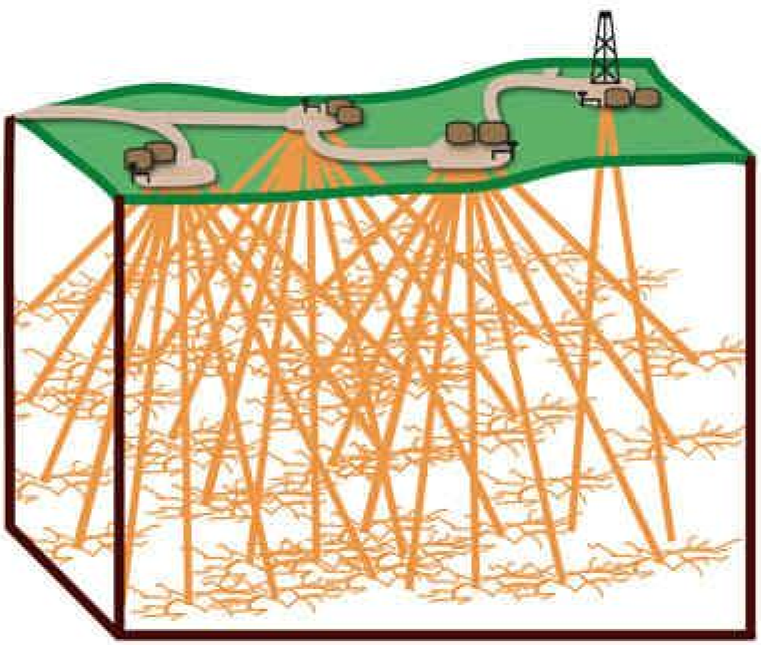
In this scenario, the fractures extend a little beyond the model. Boy, these Schmucks haven't been this accurate in a while. But what's that? An existing fault no one knew was there? Or maybe they did know. Either way, the pink hydraulic fracturing fluid is now being pumped in at great pressure. Whereas the company intended to pump fluids into some of the existing fractures and certainly create lots and lots of new fractures with the fluid, they weren't necessary anticipating pumping it all the way back to the surface... but there it goes. Right up a fracture that has now been intersected. Pretty soon gas will also migrate up the same pathway. Oh well. As long as they get the majority of the gas.

Frac crews have modeled how far out they thought these fractures would extend, but, like computer modeling anywhere, it is an inexact science based on assumptions and best guesses. We are talking almost seven- thousand feet underground.

The frac fluid is pumped in at higher pressures than the gas which is now wanting to race up the bore hole and other conduits made for it. So, we are talking about totally cramming stuff down into the geology under intense pressures to counteract the gas pressures and the heavy Earth pressures on the formation. On top of all this, as the fluid is forcing its way into newly created fractures, the process is causing "microseismic events" or little earthquakes which also cause slipping and faulting due to unknown or underestimated geologic characteristics such as its state of stress (which changes as pressure is removed from the formation when gas is pumped out). So, greater formation damage can occur even after the fracturing occurs because the formation will continue to degrade - even to the point of failure as the dynamic interaction of pressure and stress play out and shift....



A pad every hundred acres



Each pad sporting ten frac'd wells to achieve ten acre down-hole spacing. The new pad is only on its second well and hasn't frac'd either one, yet.

Let's digress a minute so you can get a sense of what all this means when it is compounded with multiple wells: The graphic immediately above shows Schmucks-R-Us fracing only one well. Now, imagine a pad (each with ten wells) occurring across the surface of the ground every hundred acres (graphic below on the left). That's a bad enough disruption to the surface land, but imagine drilling down into the formation to such a great density that the bottom of all these wells are only ten acres apart (graphic below right). This is referred to as "ten acre down-hole density". And Reprobate is only on it's second well on its most recent pad - plus they haven't even frac'd those two yet. I'll just let you imagine where all the faults, fractures and aquifers exist underground in these two graphics. Although, as you can see by the spider web of geologic destruction - it doesn't really matter. Pretty much anywhere they might be, ten acre down hole density is bound to intercept some of them.

Okay, thanks for sticking with me. Back to Schmucks and their last frac job....

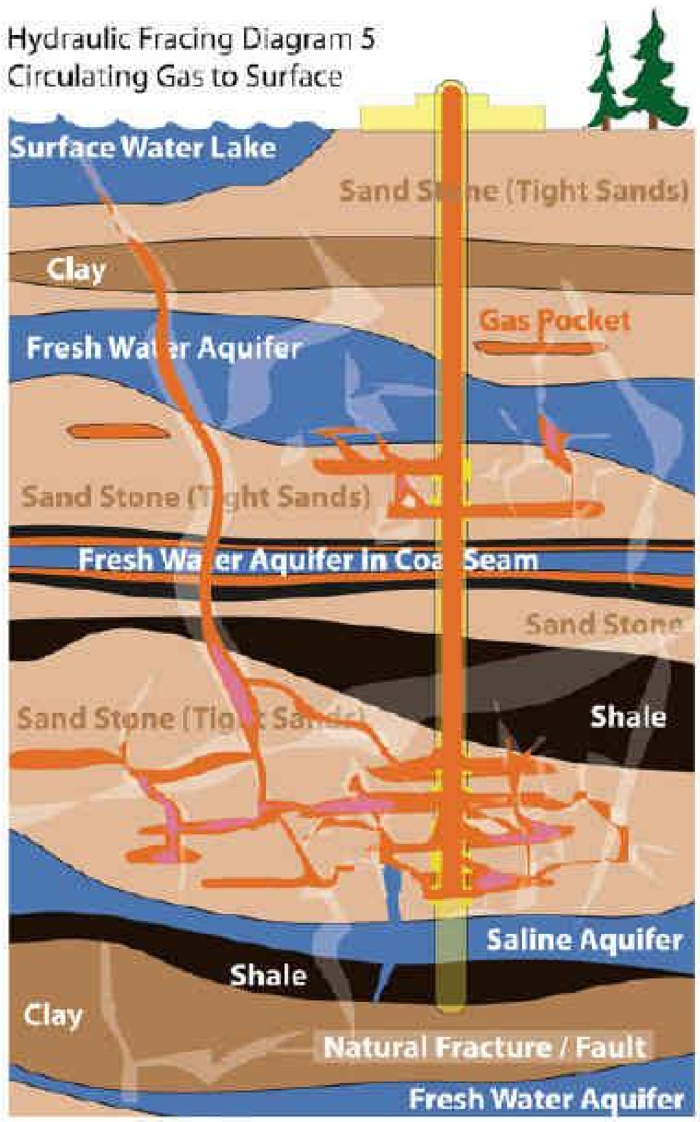
This particular frac mixture contains two hundred tons of CO2, and tens of thousands of gallons of fluids containing potassium chloride, four or five biocides, a surfactant, a de-scaler, a viscosity agent.... let's see.... some polymers (some of which are reactive and some of which will break down in the presence of enzymes, also injected), solvents, acid, oh, and 200 tons of sand. Its a new kind of synthetic sand that also contains special microscopic fibers which combine with the sands creating a kind of matrix which will help hold open the fractures better. These inventors.... they are always coming up with new and better stuff to help the gas and oil companies make more profit. Again, don't have to disclose it. Gotta love 'em.

So, in diagram 4 above, you can see that many of the newly created faults have now intersected some of the pre-existing natural faults. Ooops. Well, it isn't exactly a mistake. This is after all, what hydraulic fracturing is known and even supposed to do.**

The environmental folks with the big oil and gas companies like to tell the public that the shale formations overlaying the gas producing zones protect fresh water aquifers from migrating gas... you know, 'even if' fractures were to happen outside of modeling projections...

Uh huh. Nifty slide show, there, Mr. Fox.

What they don't' tell you is that the shale layers may be broken, mixed with other strata, or a fault may intersect them allowing gas to migrate right on up to the surface from seven-thousand feet down. And that CO2 that was pumped in? Well, now it is migrating all throughout the fractured geology and liberating things like manganese, fluoride and arsenic with it. Nice. Have a little arsenic in your well water.
Oh, and when there are no other excuses, they will tell you that gas escaping into the surface waters, or shallow aquifers is completely natural. That faults exist all over underground and seeps too. As old as God. Been there forever - since Moses.



Here we are at Step Five

Schmuck's crews have blown the hell out of the geology seven-thousand feet down, creating all kinds of new fractures and intersecting existing fractures. The gas is now all over the place and finding its way to the surface - by way of the well bore to be sure, but also through a few other convenient routes put in place my old Mother Nature millennia ago, which have now been intersected by all the new faults created by Schmucks and Reprobate.

Now, there are lots and lots of little pathways (and some big ones, too) where gas can migrate up through the geology. But before the gas gets to the surface, it may pass through an aquifer or two. Too bad for the neighbors who drink out of those wells. And, now the gas is in the lake also. Too bad for those fish, and the folks who eat them, or swim there. Too bad for the wildlife, like ducks and deer and elk who drink that water. Or even the cattle that run this area in the Summer and use this lake as a stock pond. Yes, even a little frac fluid has been left behind. Too bad for the communities down stream who rely upon these surface waters and aquifers for their municipal water sources.

But, more importantly, did you notice how the gas company got almost every pocket of gas? Pretty slick isn't it? Poisonous. But slick. And what's even slicker.... no one knows about the gas coming up in the lake, or the poisoned wells. And if anyone does discover it, they'll have a tough time proving the gas companies caused it. I mean, remember above in the CBM side notes how I talked about little microbes pooping out their own version of methane after they eat some of the gas from the formation? So, if methane is found in, say a private water well or in the creek - like, say Divide Creek, the gas company will say it is caused by microbes.

No? You don't' buy that?

The gas company will then say, "Too bad, loser. We're exempted from the Safe Drinking Water Act. Ha!" ** Then under their breath they whisper, 'thank you Mr. Cheney and Mr. Bush - we love you boys! That SOB EPA Whistle Blower is in f------ Africa where he damn well belongs."

Yep. Pretty damned slick.

Criminal. And morally reprehensible.

But slick.

Oh, I forgot to mention that since the bulk of a gas well is tapped off in the first couple of years, Reprobate hires Schmucks to come in from time to time and frac the well a total of maybe 16 more times throughout the course of its life. That's the only way they can keep squeezing gas out of it. And each time, you can figure on a whole bunch more cracks and a whole pile of chemicals, acids and the like being injected into the formation - a lot of which remains underground and/or can find its way back up into water supplies. It's been estimated that as much as 20-30% of frac fluid remain behind. Let's be conservative and say that only 10% is left behind. So, after 16 frac jobs, that's... hang on a minute.... yep, 160% frac fluid left behind in the formation - plus the original 10 percent from the first job.

And now you know.

The truth has been buried under a lot of scientific complexity and thousands of feet of rock. Who has the collective knowledge to figure this out before all the wells are drilled? And that's the point. Reprobate and Schmucks have figured that in probably seventy percent of the cases of environmental harm, evidence of irreparable devastation won't show up for twenty to forty years. By that time, they'll be long gone. Meanwhile, in the other thirty percent of cases, they have some options - apart from Safe Drinking Water exemptions... 1) buy influence among regulatory agencies to abstain from investigating, convincing the public it is unrelated to drilling; 2) if an investigation occurs, buy the science and manipulate the findings, convincing the public it is an isolated event and curtailing media exposure; and 3) those options failing - avoid court while continuing to apply principals 1 and 2, then buy off any affected parties able to continue legal proceedings thereby effectively silencing them and further isolating events.

Footnote

Don't think Reprobate and Schmucks got away with this.

Two years later, someone put 2 and 2 together and found out about the contaminated water. Two people became very ill and a neighbor died of cancer. No one could prove the link between the illnesses, consuming the water in their private water wells or even the contamination caused by fracing. Remember how heavily these companies rely on blaming naturally existing faults and little methane-pooping microbes? Plus, liability was worked out in the beginning when this process was exempted from the Safe Drinking Water Act. Not that Reprobate and their cronies anticipated that the process of hydraulic fracing would pollute. They wouldn't do that. Gee - that would be.... intentful.... premeditated, even.... evil.

So, anyway, the two families couldn't find a local attorney who was both knowledgeable and willing to take the case. When they finally found an attorney, three hundred miles away, they learned that proving a link between health and toxicity - even fatal toxicity is notoriously difficult.

So much so that the families couldn't afford the science to back up any claims if any claims could reasonably be made. This is the major loophole for companies who pollute. Well, that and exemptions from laws offering common-sense protections. What kind of exemptions? According to the Environmental Working Group in their paper: "Free Pass for Oil and Gas" the industry enjoys at least some important exemptions from: the Resource Conservation and Recovery Act; the Emergency Planning and Community Right to Know Act; the Safe Drinking Water Act; the Clean Water Act; the Clean Air Act; the Comprehensive Environmental Response, Compensation, and Liability Act; and the National Environmental Policy Act

The families are increasingly frowned upon for making a stink in the local community where so many of their friends and neighbors make a good living from Reprobate, depend upon the financial support of Reprobate's strategic contributions to community affairs in all the population centers, or conveniently assume that if Reprobate's activities weren't safe they wouldn't be allowed.

So the families think about selling their homes and moving away. Turns out, no one wants to buy the properties. Seems like even where science and law are manipulated to the point of absolving Reprobate from liability - human beings are smart enough to know what happened and won't buy into the façade of safety. All this sounds bleak, but wait. This state's Oil and Gas Conservation Commission is holding a hearing on this very issue - mainly because of the media attention this issue has gotten.

During the hearing Reprobate is found responsible for releasing gas into the environment. The Commission considers this a gross waste of resource that could have been captured and sent down a pipeline for which the state could have collected a royalty. The Commissioners huddle. Humuna humuna humuna. They come out of the huddle. They say, "Reprobate and Schmucks, you have wasted gas - and that is bad. Bad Reprobate, bad. But.... boy howdy, did you blow the hell out of the formation and capture some gas - making you and us more millions! Whoo hoo! Good Reprobate, gooooood. Wink. But there are reporters in the room, let us behave as though we are repentant. We will now fine you three-hundred and seventy-one thousand dollars. Do you agree?" Reprobate whips out the checkbook, shakes hands and schedules a martini lunch. Schmucks rush out the door to the next frac job.

As a part of Reprobate's punishment, they are ordered to 'fix' the problem. This looks good for the company and for the state... like someone is taking responsibility. But the problem can't be fixed.

Seven-thousand feet down and far out into the formation where natural faults have been intersected and gas has found pathways of escape to the surface - there is no way to fix the problem. Even locating the problem may be impossible. So the seep will continue indefinitely - in effect bringing everyone back in time tens of thousands of years when the Earth was designing a habit livable for human beings, shaking out gas pockets and creating reliable fresh water sources. What took the Earth millennia to fine tune, has taken Reprobate and Schmucks only a day or so to completely undo.

Now isn't that a happy ending?

What role does geology play?

The marriage of geology, drilling and hydraulic fracturing is ugly and complicated. But, if you know the intimacies of their interaction, suddenly the sordid and unnatural arrangement becomes clear.

The illustrations above show a cut-away side-view of the geology - complete with faults.

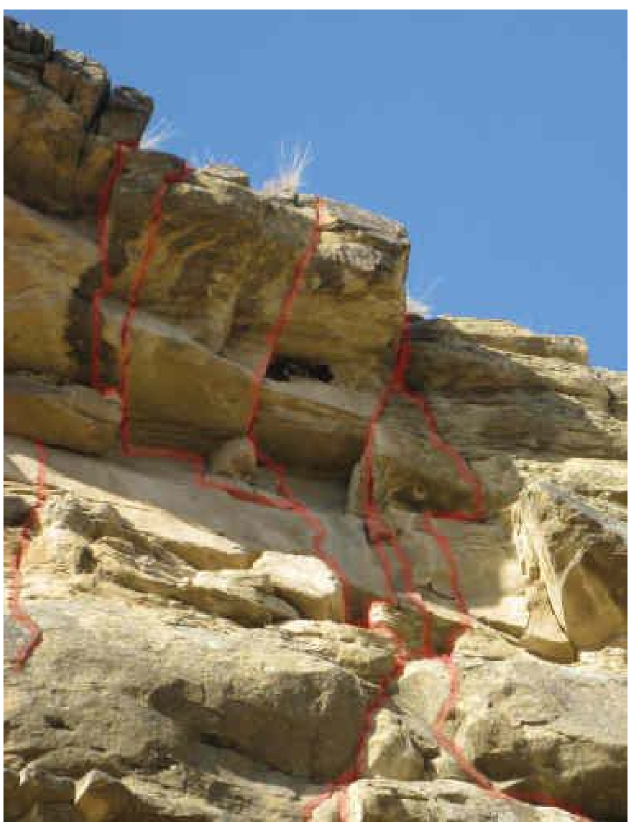
But what if you could see the same geology for real? Without tunneling underground?

You can.

Think of the ground beneath your feet as if it were a big wedding cake. You are one of the two happy people on top. Who knows what all lurks on the inside of one of those great big multi-layered things. Wooden dowels even. But what if we could just cut a big deep slice right out of it and suddenly see all the layers?

Well, the Colorado River has done exactly that! It has flowed for tens of thousands of years through geology and acted like a great big knife, slicing a big crevasse right out of the geology. The gap left behind is the Grand Canyon. And also Glenwood Canyon. West Divide Creek has done the same thing through Summerhawk valley - where the 2004 seep rages on and a new one popped up in 2008.

Anywhere you see a canyon, you are looking at exposed geology - what is called an outcrop. So, when we step down into the big crack, we get a view of all the geologic layers - the same layers that continue on in much the same fashion deeper underground. In time, rivers will expose them also.



The photos below are of the canyon (outcrop) created by West Divide Creek in Summerhawk valley. The canyon walls are around 200 feet high.

You can trace a number of vertical faults (highlighted in red) along this cliff face looming over West Divide Creek. Fissures and cracks like these can act as convenient conduits that transport formation gas (thermogenic methane) from deep production zones up to the surface and into water sources (underground aquifers, deep springs, creeks, rivers, lakes) OR along the dry ground where it may not be detected as easily. These faults lead to the surface (the surface that faces you as you look at the formation, and the surface above, on the ground)

This photo demonstrates voided pockets, vertical faults and horizontal bedding of sandstone layers

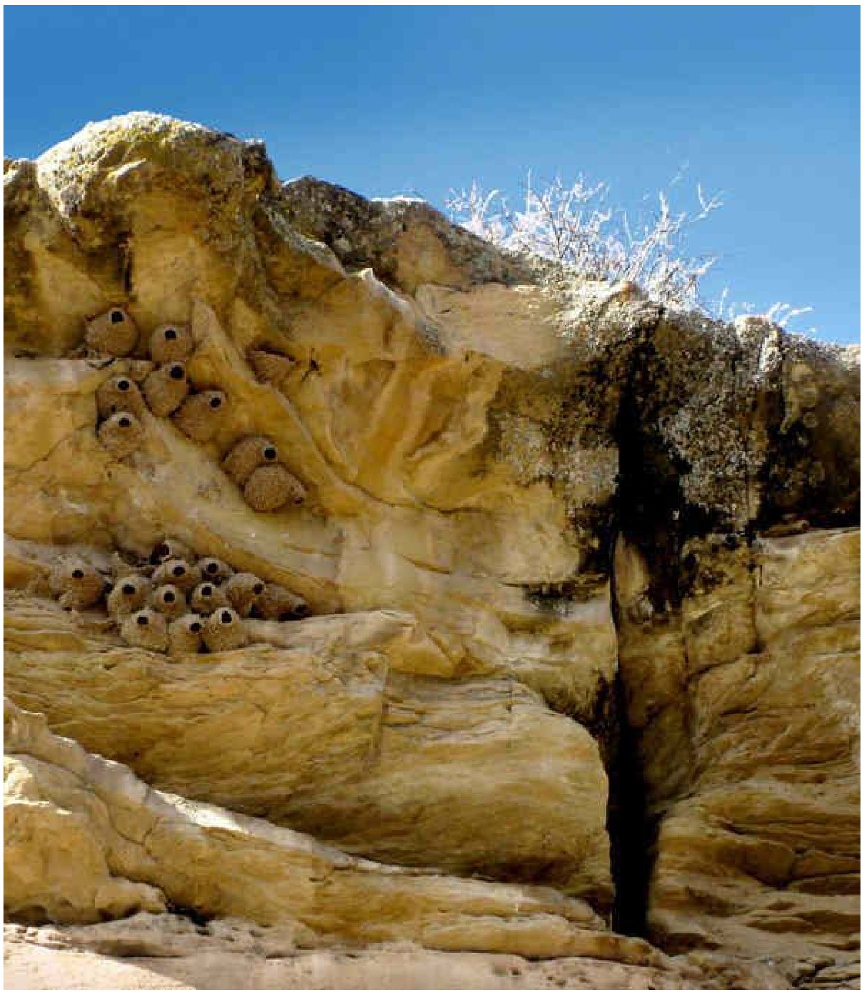
In this photo, you can see a big chunk of rock on the bottom and a layer of highly fractured sandstone bedded just beneath the surface of the ground. Even “solid” chunks of sandstone are highly permeable.

Here, you can see an exposed cavern and slanted fault that leads to the surface (again - the surface that faces you , and the surface just above)

What’s the big deal about sandstone geology? Sandstone is a sedimentary rock. It is just a bunch of sand squeezed together under tremendous earth pressures. It’s porous or permeable - meaning that water (and gas) can pass through it (though slowly), and it’s also relatively fragile. Once exposed to wind and water, it will degrade and crumble back into loose sand. It naturally layers under pressure. And it’s loaded with horizontal and vertical faults and fissures. Because it is packed in like concrete

7,000 feet underground, when it is blasted, it fractures. The physical energy of the fracing blast and subsequent forcing of fluid into the cracks stresses the unique tension of the sandstone which results in lots of larger and smaller fractures.

Imagine cramming damp sand into a 1-foot block (like you might do when building a sand castle) Now, let it set for a couple of days (it will be slightly damp toward the center, but pretty well dried into the form). Now dump it out onto a hard floor from a height of about two feet. Some of it will crumble, and some of it will crack apart. That's the nature of sand. Since it is just a bunch of tiny, irregular grains all packed in together, the opportunity to shatter in crazy (and unpredictable) ways under extreme force is great.



In this picture, you can see a deep fissure in the sandstone as well as many, many thin horizontal layers. When a drilling company loses cement while sealing a well bore, guess where it goes? Into fissures. In the West Divide Creek area, EnCana looses cement regularly. When the Schwartz well blew gas into Divide Creek in 2004, hundreds of feet of cement had been lost - but instead of re-cementing the well, EnCana frac'd anyway. BAM gas ended up in and around Divide Creek. But of course, EnCana denied responsibility. It took a formal hearing to get close to the truth and even then, EnCana denied causing it saying it had been there since Moses. Well, of course the geology has been in place that long. But it took one day's worth of irresponsible development to cause a problem that endures to this day.... and no one knows when or if it will end.

Since 2004, EnCana has resumed their old ways and in the years since has had at least three instances where gas and water have mixed in the wellbore during drilling operations. We don't know much more that that, EnCana and our state regulatory body, the COGCC keep that kind of info under tight wraps.

Think that simply abolishing the practice of fracing will solve the drilling/ hydrogeology problem? Think again....

Here’s something else that will or should scare the pee-diddly out of you.

You know how up in the first picture I show the well bore as a yellow tube? Well, there is something I didn’t depict, and that is the detail of the inside of the well bore.

The yellow area is a big hole in the ground, but inside that is the well casing otherwise known as a really, really long steel pipe which is fitted together in sections.

There’s an easy way to think about this. Visualize a fat milkshake straw with a skinny coffee stirrer straw tucked inside (same length). The milkshake straw represents the well bore hole. The skinny straw is the steel pipe. Gas is supposed to flow up the steel pipe, right....?

Well, often, it flows right on up the gap (annulus) between the two straws.

Imagine cramming the whole straw outfit into a chocolate raspberry layer cake (which represents - you guessed it - the formation). Let’s say the cake is full of fissures. Believe me it is unnatural but very possible to bake such a cake. But I digress. Now, let’s say the raspberry filling represents fresh-water aquifers. Look down into the straw configuration. See the space between the skinny straw and the fat straw? That’s called an annulus and there’s a rule that says you have to seal 1) the top of the annulus from the surface a little way down into the formation, and 2) within a hundred or so feet of any gas producing layers.

So, that means you have to pump something down into that hollow space that will seal certain sections of the straw - preventing water or gas from coming up other than where you want them to. But you also have to seal the gap a little bit from the top of the cake to about a half inch down. In a real geologic formation, this would mean pumping cement into the annulus and sealing the gap from the surface to about a thousand feet down - plus sealing off all the little production zones. You decide to use cream filling for your representation. And it’s a little messy, since you don’t have the equipment necessary to skip sections and seal producing areas separate from the top section. So, you decide to pump cream filling all the way to the bottom of the cake to the top, completely filling up that little gap between the straws. This is actually what drilling companies should be doing in order to keep gas and water from mixing in the annulus.

But why? Why is that necessary in practice even if it isn’t required by regulating agencies?

Drilling operators have the means to separate sealed areas of the bore hole from one another, and there is a financial incentive to do that, instead of “squeezing” or filling up the whole space. Cement is expensive. So, they leave big spaces from the bottom of the formation to the top which are just open to the air, only sealing those gap areas they are required to seal.

Here’s the problem with this practice: When the drill bit passes through the formation it doesn’t have a brain that says: “Holy cannoli, there was a fault.” grind grind grind...and then, “Hey, did you see that? A gas pocket. But only one. Let’s keep going...” grind grind grind “oh, another fault - a big one!!”... grind, grind, grind, etc.

The bit doesn't care what it grinds through. It grinds through everything... faults, clay, water, coal, sand, gas, oil, more sand, other stuff...

And the operator - even though they presumably have a brain - doesn't care either - unless they hit water (which they have to deal with and dispose of) or gas, and they wait for lots of that before they pay much attention.

All the operator cares about is sealing the well where they are supposed to (and someone is presumably looking over their shoulder and reviewing their drilling logs to make sure they do it).

So, remember, the bit ground its way past all sorts of faults and small areas of gas and whatnot. And even after the steel pipe is inserted and some of the gap areas are 'squeezed' or sealed, other open gap areas still remain unsealed. And, now, all the little undesirable gas pockets and interconnected faults (which may or may not be loaded with migrating gas) just dump straight into the open gaps. When that happens, any gas that dumps into the hole migrates on upward (outside of the collection pipe). Now remember, there is cement sealing the gap toward the surface (generally extending a thousand feet into the formation) and this top-seal creates even more pressure in the bore hole where gas continues to accumulate without being tapped off. (Williams - to their opportunistic credit - taps off this pressurized 'waste' gas and makes a fat wad of cash off it - to the tune of millions.) This is called bradenhead gas.

When you hear the term bradenhead pressure - this is the stuff... it's the gas outside the skinny production pipe but which is still within an unsealed bore hole that causes it. Bradenhead pressures can indicate methane leaking into the environment. If pressures are high (and who knows how high a particular geologic formation can withstand), there is greater incentive for gas to find another, easier way out through the bore hole via a fault pathway.

So, back to the bore hole. Where some faults and pockets act to bring gas into the open annulus, there are other faults that intersect with the hole and act as conduits to carry the gas back out another way - as in... up to the surface, as far as a mile or two away, depending on the fault structure.

This is what I believe is causing the massive vegetation die off seen here and around many other well pads. And it isn't just me that believes this. Operators, the state, just about everybody making a buck off industry denies there are any negative effects produced on vegetation by natural gas drilling activities. But this obscure little paper from way back in 1978 for gosh sakes, describes otherwise: Divide Creek Seep - page nine "The effects of natural gas on trees and other vegetation"

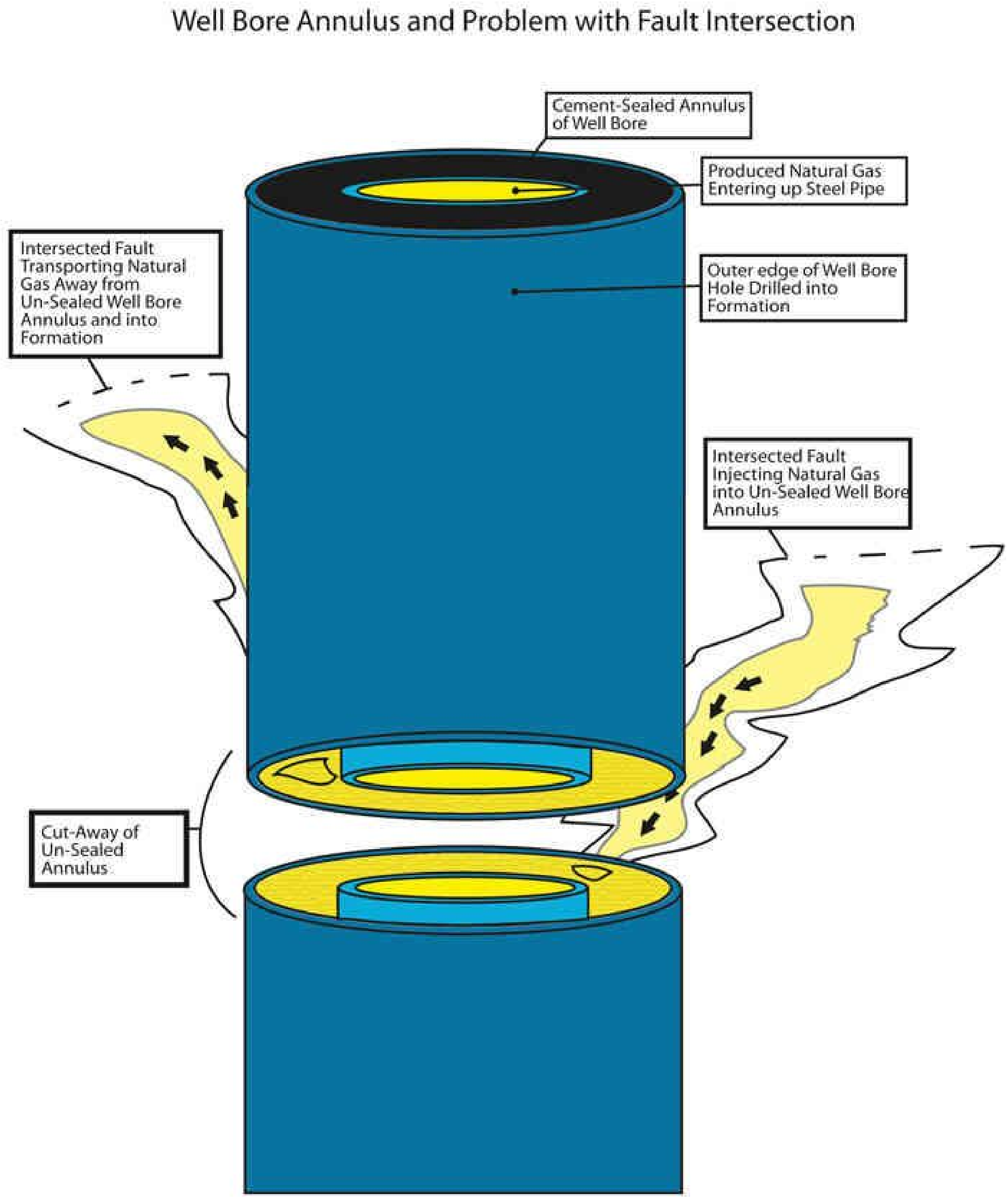
So, the sad conclusion is this: You don't just have to worry about fracing to contaminate your water well. You also have to worry about the way the wells are drilled and sealed.

Although it's a better practice than letting bradenhead pressures build, even when bradenhead gas is produced and sold, the gas is still getting into the environment.

This particular problem could be significantly mitigated by simply sealing the wells all the way to the bottom hole, but no company will justify that cost because it would then be passed on to consumers. And such a cost would not make natural gas the competitive alternative to oil. And would bring to light the real cost of this resource. Something industry doesn't want you to know. So, instead, these companies keep on polluting the ground water and surface

waters and killing the trees and driving off wildlife, because you know what? You didn't know about that cost either, until you read this.

The picture below illustrates the nature of the wellbore annulus (sealed and un-sealed) and steel pipe used for production.



P.S. - all that yellow color, above, is gas. The light blue is steel. The dark blue is just the gnarly raw dirt that forms the inner dimension of the hole. All the white is soil and stuff down in the ground (I know, I probably should have made it brown) The black is cement.

The OSHA image below is a better representation of the gnarly and pipe. I'm just trying to show the annulus, cement and gas invading the whole outfit. Hope that helps!

And Just When You Thought You Had it Figured Out....

Remember the unholy marriage between drilling and geology? Let me introduce you to their tumultuous spawn - the Gas Kick

Okay, so let's go back to the beginning. Way back, to when Reprobate had its drilling crew out on site, and they were in the process of drilling the well bore. You know, just the raw hole into the Earth - and the cemented annulus a thousand feet or so from the surface.

Right now the guys are just managing a hollow drill stem down in the hole, through which they are circulating drilling mud and other fluids to lubricate the bit as it chaws through the geology 6,700 feet down.

Suddenly, chaos erupts and faces whiten....”Holy shit - look out! Mud, Mud, Mud!”

The bit just encountered a pocket of gas so big and under such intense pressure that it is racing up the annulus and drill stem at pressures of 500 pounds per square inch. That's pretty big-time. Big-time enough that it caused a massive blow-out in West Divide Creek back in 2004.

Big-time enough that it can crack and crumble the geology as it rumbles and seeks exit to the surface.

The picture on the homepage of this website is of a gas kick. It shook the ground over a mile away - its energy finally exiting into Summerhawk canyon. The driller said he about lost his head looking into the hole as rocks and debris began shooting out like ballistic missiles.

When EnCana came into the area to start drilling again in 2006 (the same time as produced gas began showing up in ground water), yet another well on the Schwartz pad took a kick of 500 psi. And then you know what happened? We found another seep in Divide Creek.

A Juniper Group well also took a kick - of 325 psi.

The COGCC allows a pressure of 150 psi. maximum. But even at that - they have no idea what effect it can cause. The COGCC holds a very special place in my little black heart.

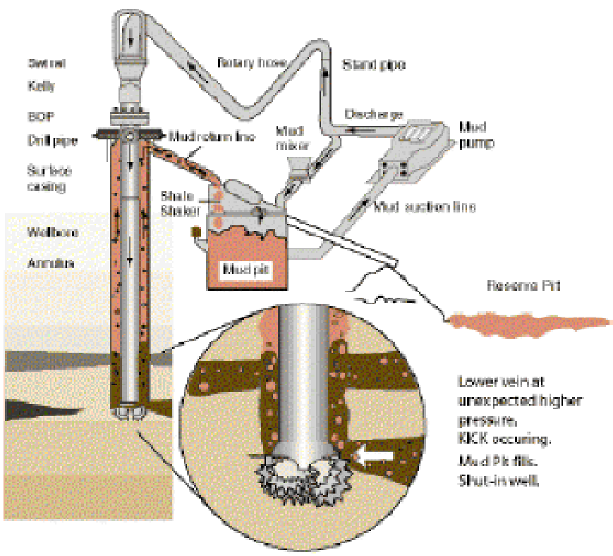
When drillers encounter these kicks, they try to control the pressure with heavier drilling mud. But what happens as that kind of pressure travels up the bore hole before they can get it under control? Massive degradation of the geology.

Oh, and industry loves to tell you - “Hey, man, there are all these layers of cement and steel to protect you.” The steel pipe may not fracture, but the many little seams where the pipe is connected is infamously prone to failure. And if such a massive rattling and cracking of the geology occurs, what do you think happens to cement? House foundations crack all the time, just because they have nothing better to do. Hit one with explosive vibrating force and see how it reacts.

Sometimes as the well gets away from a driller - the gas is just barreling along and no amount of heavier mud will shut it down. In that case, they just flare or vent the well until they can get a handle on it. One sour gas well in Lodgepole, Alberta blew for nearly two months.

But what happens after the well is in production? I mean, what happens if the gas starts to tear- ass up the borehole again after the well is brought on-line? No problem. Reprobate will just turn the valve and let er' rip right up into the atmosphere, venting off whatever is necessary to keep the bradenhead pressure to within whatever arbitrary threshold the regulatory agency has established. How about a little benzene in your water and in your air? Hey, guess what else? You have to guess how much raw gas they decide to vent. Oh, and you know what else? The EPA has no safety threshold for airborne benzene. Gas companies get a big pass on that one. EnCana is currently venting 7-9 wells around our home to keep the bradenhead pressure at below 150 psi. What the hell? This is dangerous and it wastes gas! Sadly, the COGCC has no idea whether that threshold is even sufficient to protect the groundwater. The seep event of 2008 tells us it's not. But that's another story.

Gas kicks are yet another, very powerful way these drilling operations can create more pathways for methane to travel into waterways. In fact, in my opinion, they are as dangerous as fracing.

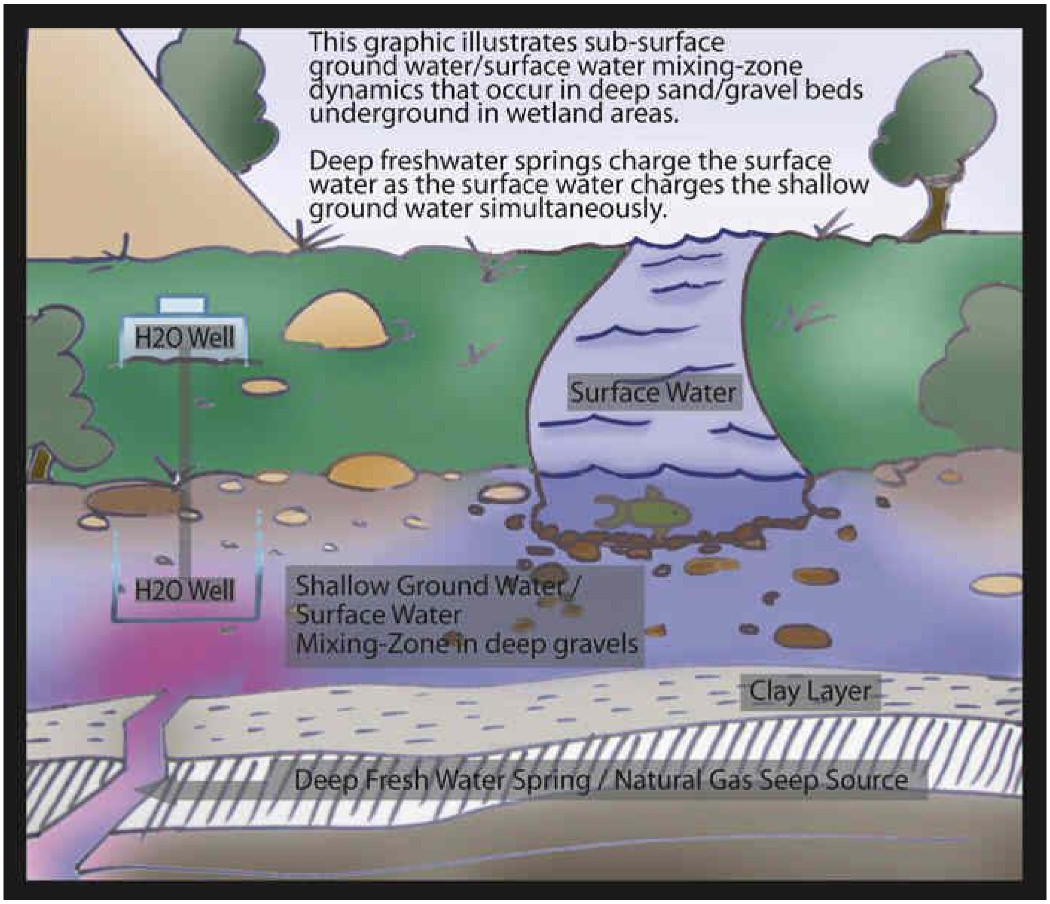


The link below will take you to the OSHA website which has a little page about gas kicks (encountering higher than anticipated pressures while drilling) and how drillers should attempt to safely deal with loss of well control.

http://www.osha.gov/SLTC/etools/oilandgas/images/kickback_still.gif The image to the left (above) is from that page and I can only presume is copyrighted by the US Gov. (OSHA).

When Domestic Water Wells and Gas Seeps Collide

The graphic below shows why fracing and current drilling practices threaten fresh water supplies. It shows where natural gas is seeping up through a fault into a groundwater mixing zone. The gas may eventually eek out into the surface water, but meanwhile, it lurks in the groundwater and threatens to infiltrate a domestic water well.



Methane and Water in the News

Drillers, sewer authority want state to lift waste limits
DEP blames bad tasting water on total dissolved solids
Saturday, November 22, 2008
By Don Hopey, Pittsburgh Post-Gazette
sorry - no link to this one, but it talks about waste in the form of dissolved solids from natural gas well waste mucking up the water back east.

More on this situation can be seen through the following blog:
: http://www.donnan.com/fracking-water.htm

Propublica - *How the west's energy boom could threaten drinking water for 1 in 12 Americans*
http://www.propublica.org/feature/how-the-wests-energy-boom-could-threaten-drinking-water-for-1-in-12-america

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Two recent (week of November 10th, 2008) articles have come out relative to "Phase Two" of the Hydro-geologic study commissioned by Garfield County as a result of fines collected from EnCana - found responsible by the Colorado Oil and Gas Conservation Commission for the 2004 Divide Creek Seep.

Following are links to the two articles. After that, you'll find the work itself...

Methane ending up in water: Geologist links gas to Silt-area drilling
GRAND JUNCTION SENTINEL
By DENNIS WEBB [11-10-08]
The article is excerpted below. Please view it in its entirety at
http://www.gjsentinel.com/news/content/news/stories/2008/11/10/111108_1a_wells.html

Consultant warns about methane in water wells south of Silt and Rifle:
May indicate the presence of natural gas and produced water
Glenwood Post Independent
By Phillip Yates [11-11-08]
The article is excerpted below. Please view it in its entirety at
http://www.postindependent.com/apps/pbcs.dll/article?AID=/20081111/VALLEYNEWS/811119988/-1/RSS01&template=printart

An Expert's Opinion on Risk

This is an excellent resource that really helps explain what is going on (in more scientific terms than I could muster) It is an outstanding, and I do mean outstanding presentation by **Dr. Geoffrey Thyne (of Science Based Solutions). Click the links below to view his presentation to Garfield County Re: "Sumary of PI and PII Hydrogeologic Characterization Studies - Mamm Creek Area, Garfield County, CO"** This key PowerPoint presentation and its companion conclusive report provide an outstanding perspective of the dynamics at play between the hydrology and the geology of this area in particular as it specifically relates to drilling operations and risks to water supplies.

Presentation - http://garfield-county.com/Index.aspx?page=1150
Conclusions - http://garfield-county.com/Index.aspx?page=1149

From: **Natural gas in water wells has N.Y. officials on alert**
Pennsylvania homeowners notified of dangers
By Tom Wilber • twilber@gannett.com • Staff Writer • January 25, 2009

http://www.pressconnects.com/article/20090125/NEWS01/901250335/1001

"It's possible, but not probable, that gas could migrate from the Marcellus Shale to the aquifer 6,000 feet above, said Terry Engelder, a Penn State University geoscientist with expertise in the Marcellus.

"The rock formations in and around the area carry a lot of fractures with them," he said. "There is a slim possibility that if a company like Cabot came along, man-made fractures in the Marcellus could connect up with other fractures in more shallow units."

A more likely scenario, he said, is gas from natural sources has been moving through shallow soils for some time, and residents are now just beginning to notice."

Frac Soup

"What's in that Fracking Fluid?"

This is an outstanding, must-read article on the damn-near-impossible-to-find-out ingredients of fracing fluids. The component chart below is provided courtesy of the author.

Complete with charts: http://www.riverreporter.com/issues/08-12-04/fracking.pdf
the on-line version of this article (without charts) is available on this site here (bottom of page): Perils of Fracing

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Endocrine Disruption Exchange Inc.
http://www.endocrinedisruption.com/home.php

Spreadsheet on Frac Chemicals Used in : Colorado, Wyoming, New Mexico, Washington Montana
http://www.endocrinedisruption.com/chemicals.spreadsheets.php

TDEX, founded by Dr. Theo Colborn, is a non-profit organization dedicated to compiling ad disseminating the scientific evidence on the health and environmental problems caused by low-dose exposure to chemicals that interfere with development and function, called endocrine disruptors.

Excerpted comments to COGCC during rule-making process. This is an excellent review of the dangers posed by these chemicals. The whole of her comments aren't represented here, but they are posted in part as a matter of convenience for cursory review.

State of New Jersey Department of Health and Senior Services
This is an outstanding and easily searchable free database of toxic substances and their health effect profiles.
http://web.doh.state.nj.us/rtkhsfs/indexfs.aspx
For example: Benzene
http://nj.gov/health/eoh/rtkweb/documents/fs/0197.pdf

Frac Water Chemicals - provided by P.A. DEP

Chemical Components from MSDS

2.2-Dibromo-3-Nitrilopropionamide	Glycol Ethers
2-butoxyethanol	Guar gum
2-methyl-4-isothiazolin-3-one	Hemicellulase Enzyme
5-chloro-2-methyl-4-isothiazotin-3-one	Hydrochloric Acid
Acetic Acid	Hydrotreated light distillate
Acetic Anhydride	Hydrotreated Light Distilled
Alphatic Acid	Isopropanol
Alphatic Alcohol Polyglycol Ether	Isopropyl Alcohol
Ammonia Persulfate	Magnesium Nitrate
Aromatic Hydrocarbon	Mesh Sand (Crystalline Silica)
Aromatic Ketones	Methanol
Boric Acid	Mineral Spirits
Boric Oxide	Monoethanolamine
Butan-1-01	Petroleum Distallate Blend
Citric Acid	Petroleum Distillates
Crystalline Silica: Cristobalite	Polyethoxylated Alkanol (1)
Crystalline Silica: Quartz	Polyethoxylated Alkanol (2)
Dazomet	Polyethylene Glycol Mixture
Diatomaceus Earth	Polysaccharide
Diesel (use discontinued)	Potassium Carbonate
Ethane-1,2-diol	Potassium Hydroxide
Ethoxlated Alcohol	Prop-2-yn-1-01
Ethoxylated Alcohol	Propan-2-01
Ethoxylated Octylphenol	Propargyl Alcohol
Ethylene Glycol	Propylene
Ethylhexanol	Sodium Bicarbonate
Ferrous Sulfate Heptahydrate	Sodium Chloride
Formaldehyde	Sodium Hydroxide
Glutaraldehyde	Sucrose
	Tetramethylammonium Chloride

Frac Stage #1

Hydrochloric Acid
Propargyl Alcohol
Methanol
Acetic Acid
Acetic Anhydride

Frac Stage#2

Methanol
Boric Oxide
Petroleum Distallate Blend
Polysaccharide
Potassium Carbonate
Sodium Chloride
Potassium Hydroxide
Ethylene Glycol
Boric Acid
Sodium Bicarbonate
Monoethanolamine

Frac Stage #3

Hydrotreated light distillate
Ethoxylated Alcohol
Glutaraldehyde
Dazomet
Sodium Hydroxide
Methanol
Diesel (use discontinued)
2,2-Dibromo-3-Nitrilopropionamide
Polyethylene Glycol Mixture
Mesh Sand (Crystalline Silica)

Despite all of this - we are still struggling against a political-economic structure determined to keep this frightening truth from coming fully into light. After reading this you can count yourself among the truly few who actually know what is going on in the gas fields.

Now.... if you really want to go on an exciting ride knowing what you now know, visit the Consortium of the Frac'd page.