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Written testimony of Theo Colborn, PhD, President of TEDX, Paonia, Colorado before the House Committee on Oversight and Government Reform, hearing on The Applicability of Federal Requirements to Protect Public Health and the Environment from Oil and Gas Development, October 31, 2007.

Good morning Mr. Waxman and members of the Committee. Thank you for this opportunity to speak to you about the emerging public health and environmental issues as a result of natural gas production in the west. My name is Theo Colborn. I am here to speak as an environmental health analyst and as a resident of western Colorado whose watershed and air are being threatened by natural gas production and delivery. I have a B.S. in pharmacy from Rutgers University, an M.A. in fresh water ecology from Western State College of Colorado, and a PhD in zoology, with distributed minors in epidemiology, toxicology, and water chemistry from the University of Wisconsin, Madison. My field and laboratory research for these degrees looked at the mobilization of low levels of toxic trace metals in high altitude streams in Colorado. In 1985 I moved to Washington DC on a Fellowship from the US Congress, Office of Technology Assessment and later established and ran the Wildlife and Contaminants Program at World Wildlife Fund until 2002. I have served on the EPA Science Advisory Board and several EPA panels; on a Canada/US International Joint Commission Health Committee since 1989; advised Environment Canada, Health Canada, the US Fish and Wildlife Service, the US Department of the Interior, the ATSDR; and advised similar government agencies in Europe, the UK, and Japan. I have published in scientific journals and books on the effects of low level and/or ambient exposure to toxic chemicals called endocrine disruptors which has triggered action at the state, national, and international level to improve the protocols for testing chemicals when determining their safety.

In 2002, I returned to Paonia, Colorado where I established TEDX (The Endocrine Disruption Exchange) and became its president. At that time I also accepted a Professorship at the University of Florida, Gainesville.

I had no intention of getting involved with natural gas development when I set up my non-profit until someone handed me the formula for the fracturing fluid to be used in 17 proposed gas wells on the Grand Mesa National Forest, which my family and I consider our back yard. After looking at the possible health effects of just one of the chemicals the company planned to use, I decided to submit a letter to the regional US Forest Service and BLM Director who were issuing the drilling permits. In the letter I described the structure and physical characteristics of the chemical 2-butoxy ethanol (2-BE), as well as a long list of bizarre health effects that were possible at relatively low levels of exposure. 2-BE is odorless, colorless, tasteless, and evaporates at room temperature. If this chemical were to surface as a gas or get into a drinking water supply, it could cause health problems in domestic and wild animals and humans that could baffle veterinarians or physicians. See Appendix A.

Two years later, a woman from Silt, Garfield County, Colorado called to tell me that she had developed a very rare adrenal tumor and had to have the tumor and her adrenal gland removed. One of the effects of 2-BE was adrenal tumors. She told me that she lived within 900 feet of a busy gas well pad where frac'ing took place frequently. During one frac'ing episode her domestic water well erupted. She also began describing the health problems of others who lived near her. This prompted me to begin to find out more about how natural gas is produced. When I found out that each fracturing incident, commonly called frac'ing, uses approximately one million gallons of fluid and that each well can be frac'ed 10 times or more, I became very interested.

Soon TEDX became a clearing house for information about the products that were being used in natural gas operations. In order to organize the data we set up computer spreadsheets. We also searched the peer reviewed literature and government and industry documents for the health effects of the chemicals on our list and added the information to the spreadsheets. We have over 1,700 citations to back up the Colorado data. See Appendix B.

It is impossible to provide quantitative information about what is being used at any stage of developing natural gas because much of this information is proprietary. For example, in what quantities and mixtures are the products being used? How much water or other fluids are used to attain the million gallons needed to fracture a well? TEDX believes that every citizen has a right to know what is being introduced into our pristine and very fragile, arid ecosystems where every drop of potable water is precious. Nonetheless, we are certain of one thing, even at extremely low levels one would not want to drink the majority of the chemicals on the list.

The last time TEDX updated the Colorado spreadsheet, there were 171 products and 245 chemicals on the list. 92% of the products had health effects. The other 8% are products for which there is no information because it is either proprietary or no health studies could be found. Most of the products had multiple health effects with some having as many as 14 effects. See Appendix B.

As the list of the products grew, a consistent pattern of health effects kept emerging. Taking into consideration that air and water were the most likely pathways of exposures, we broke out the chemicals into two groups: volatile chemicals and water soluble. We also realize now that air is the most immediate pathway. From 68% to 86% of the volatile chemicals cause mild to severe irritation of the skin, eye, sinuses, nose, throat, lungs, and the stomach, and cause effects on the brain and nervous system ranging from headaches, blackouts, memory loss, confusion, fatigue or exhaustion, and permanent neuropathies. Many of these chemicals are called sensitizers; they can lead to the development of allergic reactions. 35% to 55% of the chemicals cause disorders that develop slowly such as cardiovascular, kidney, immune system changes, and reproductive organ damage and are toxic to wildlife. Medical practitioners have no way to link health effects such as these with an environmental contaminant. See Appendix B.

We also found that the muds used in drilling are not as safe as industry claims. Using data from a drilling operation where there had been a blowout, the pattern of the possible health effects of the chemicals used in that operation, matched the general health pattern of our overall analyses. See Appendix C.

It is not general knowledge that when methane surfaces it brings along with it some very toxic gases that are being vented by the tons every year from each operational unit. These include benzene, toluene, ethyl benzene, and xylene, often referred to as BETX. These VOCs, (Volatile Organic Compounds) plus the VOCs in the products being used and the vast amounts of fugitive methane (which is a VOC and powerful greenhouse gas) plus the NOx (Nitrogen Oxide) produced from diesel and gas burning stationary and mobile equipment to produce and pump the gas are contributing to a growing increase in ozone in the west, that heretofore has been ignored.

And it is not general knowledge that when methane surfaces, it is wet, and this water, called condensate water, is often put into an evaporation pit on the well pad, or stored in condensate tanks and later picked up by “water trucks” and moved to large, receiving, open evaporation facilities. It takes fleets of water trucks to handle the volume of water surfacing. Last year, it was estimated that 5,500 condensate tanks across western Colorado released over 100 tons of VOCs each, including BTEX. This gas field activity will be a continuing source of NOx and VOCs for the life of each well, which can be as long as 20 years.

We had been unable to find any information on the chemical content of waste pits until we were sent results of a chemical analysis of the residues from six waste pits in New Mexico. The 51 chemicals that were detected in those pits produced a health pattern even more toxic than anything we found in the past. Most important is that 43 of the 51 chemicals detected in the pits were not on our list of chemicals being used during natural gas operations. And 13 of the chemicals were at concentrations above state and federal safety levels. We found out later that except for those eight chemicals, their study design did not include testing for the chemicals on our list of what is used during production and delivery. We also discovered that 84% of the chemicals detected in the pits are on the CERCLA superfund list. See Appendix D.

A finding such as this raises a number of questions that only adequately designed testing requirements and protocols can address --- **<u>and points out the need for full disclosure</u>**. Data such as this also suggests that eventually, as each pit and well pad is closed down, it has the potential to become a new superfund site.

APPENDIX A

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October 22, 2002

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RE: **An Analysis of Possible Increases in Exposure to Toxic Chemicals in Delta County, Colorado Water Resources as the Result of Gunnison Energy's Proposed Coal Bed Methane Extraction Activity**

BACKGROUND
Gunnison Energy is proposing to extract coal bed methane in Delta County, Colorado. In its notices to the public it makes claims that "…the threats posed by hydraulic fracturing of CBM wells to USDWs [US drinking water supplies] are low and do not justify additional study." They also claim that the "…fluids used to extract coal bed methane from the ground do not substantially threaten public health." [1] The following addresses these claims and looks at possible direct and indirect health effects of CBM extraction on the citizens, domestic animals, and wildlife in Delta County.

THE FRACTURING FLUIDS
Gunnison Energy proposes to use a solvent, ethylene glycol monobutyl ether (2-butoxyethanol), hereafter designated as 2-BE, in a liquid fracturing mixture to facilitate the extraction of coal bed methane in Delta County. 2-BE will be present in the liquid component of the fluid at approximately 7 ppm (parts per million) based on data provided to Delta County Commissioners following three local Area Planning Committee meetings by Gunnison Energy Corporation (GEC), May 29, 2002.

The structural formula for 2-BE is:

CH3-CH2-CH2-CH2-O-CH2-CH2-OH

2-BE is a highly soluble, colorless liquid with a very faint, ether-like odor.[2] At the concentration it is to be used in Delta County, it might not be detectable through odor or taste. 2-BE has low volatility, vaporizes slowly when mixed with water, and remains well dissolved throughout the water column.[Error! Bookmark not defined.] Photolysis (degradation by sunlight) is not a factor in the breakdown of 2-BE. It mobilizes in soil and can easily leach into groundwater.[Error! Bookmark not defined.] Because of these characteristics, it could remain entrapped underground for years and eventually migrate to a domestic well or to a surfacing spring. This contaminated water in

[1] The Daily Sentinel, Sunday, September 8, 2002. p. 8C
[2] Agency for Toxic Substances and Disease Registry . US Department of Health and Human Services. (1998) Toxicological Profile of 2-Butoxethanol and 2-Butoxyethanol Acetate.

some cases might not reach wells, springs, and rivers in Delta County until long after GEC will have gone out of business.

The half-life of 2-BE in natural surface waters ranges from 7 to 28 days.[2] With an aerobic bio-degradation rate this slow, humans, wildlife and domestic animals could come into direct contact with 2-BE through ingestion, inhalation, dermal sorption, and the eye in its liquid or vapor form as the entrapped water reaches the surface. Aerobic biodegradation requires oxygen and therefore the deeper 2-BE is injected underground the longer it will persist. To date the aerobic biodegradation breakdown products of 2-BE have not been identified. The chemistry to detect the glycol ethers, including 2-BE, in environmental samples is very difficult and therefore there are few laboratories with the ability to accurately quantify its presence.[Error! Bookmark not defined.]

DIRECT HEALTH EFFECTS OF 2-BE

Immediate/Direct

Following inhalation or swallowing, 2-BE is distributed rapidly to all tissues in the body via the blood stream in laboratory animals. When applied directly to the skin, 2-BE is rapidly absorbed.[Error! Bookmark not defined.] In solution, it is absorbed more rapidly. It is broken down to its toxic component, 2-butoxyacetic acid (BAA) in both humans and laboratory animals following all three exposure pathways[3]. Breakdown and excretion of BAA through the urine is identical regardless of the pathway of exposure according to laboratory studies[Error! Bookmark not defined.] No laboratory studies could be found that assessed cumulative effects from simultaneous ingestion, inhalation, and dermal exposure to 2-BE, which could be the scenario in Delta County.

Hemolytic Effects - Primary

The most critical direct effect of 2-BE as the result of laboratory studies is its impact on red blood cells. It causes hemolysis (breakdown of red blood cells) by dissolving the fat in the cell membrane and causing the membrane to break down. 2-BE causes hematuria (blood in the urine) and blood in the feces. Blood appears in the urine as a result of kidney damage which can eventually lead to kidney failure. It is especially toxic to the spleen, the bones in the spinal column, and bone marrow (where new blood cells are formed) and the liver, where chemicals are detoxified (broken down for easy excretion from the body).[Error! Bookmark not defined.] Chronic exposure can cause anemia, and in laboratory animals it leads to insufficient blood supply, cold extremities, and tail necrosis (a condition where the tail rots away.)[4]

Other Effects - Secondary

In a sub-chronic study over a period of 14 weeks, mice exposed to 2-BE exhibited the hemolytic effects mentioned above as well as a number of secondary problems involving the spleen and liver, and degeneration of kidney tubules.[5] In addition, females were more sensitive to fore-stomach necrosis, ulceration, and inflammation occurring at half the dose required to cause the same problems in males. Female fertility was also significantly reduced in mice because of embryo

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[3] US Environmental Protection Agency. Toxicological Review of Ethylene Glycol Monobutyl Ether (EGBE) In Support of Summary Information on the Integrated Risk Information System (IRIS), October 1999

[4] Nyska A, Maronpot RR, PH Long, JH Roycroft, JR Hailey, GS Traylor, BI Ghanayem (1999) Disseminated thrombosis and bone infarction in female rats following inhalation exposure to 2-butoxyethanol. Toxicol Pathol 27(3):287-294.

[5] National Toxicology Program (NTP). 1998 NTP Technical report on the toxicology and carcinogenesis studies of 2-butoxyethanol (Cas No. 111-76-2) in F344/N rats and B6C3F1 mice (inhalation studies). US Department of Health and Human Services, Public Health Service, National Institutes of Health, Research Triangle Park, NC NTP TR 484. NIH Draft Publ. No. 98 -3974.

mortality.[6] In this study, the dead embryos were discarded, and as a result, the prenatal effects of 2-BE on the embryos were not determined.

EPA recommends that 2-BE be classified as a mild eye irritant.**Error! Bookmark not defined.** However, a recent study published after EPA reached this classification could lead to a higher risk classification. Using oral exposure in rats, severe damage to the eye was discovered that led to retinal detachment, photoreceptor degeneration and occlusion resulting from multiple thrombosis of the blood vessels in the eye.[7] In this study, females were more susceptible.

With few exceptions most of the evidence mentioned above was derived from inhalation studies. All of the studies used standard, high-dose testing protocols to detect obvious birth defects and organ damage, cancer, mutations, convulsions, and skin and eye irritation. No long-term, multigenerational, chronic oral studies at environmentally relevant concentrations are available that could rule out prenatal damage.

Immunotoxicity

Early studies suggested that perhaps 2-BE does not affect the immune system[8],[9] more recent studies using more sophisticated measures and lower doses have determined otherwise. In an early immunotoxicity study, the lowest doses significantly increased the natural killer (NK) cell response in males and females, and the highest doses induced no response.**Error! Bookmark not defined.** The investigators never did find the lowest dose at which there would be no effect. However, they did not consider this an indication of adversity.

In another study, rats exposed to 2-BE in water for 21 days showed no structural effects in the liver or the testes, however their livers were significantly heavier and the animals experienced reduced body weight even at the lowest dose. However, they were surprised to find that at the lowest 2-BE dose NK cell responses were increased. A more recent study exposing female mice topically for 4 days once again confirmed the elevated NK cell response.[10]

A 2002 study reports that 2-BE at unusually low doses inhibits a normal contact hypersensitivity response in female mice.[11]

Carcinogenicity

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6 Heindel,JJ, Gulati, DK, Russell, VS, et al. (1990) assessment of ethylene glycol monobutyl and monoethyl ether reproductive toxicity using a continuous breeding protocol in Swiss CD-1 mice. Fundam Apply Toxicol 15:683-696.

7 Nyska A, RR Maronpot, BI Ghanayam. (1999) Ocular thrombosis and retinal degeneration induced in female F344 rats by 2-butoxyethanol. Hum Exp. Toxiol 18(9):577-582.

8 Smialowicz, RJ, Williams, WC, Riddle,MM. etal. (1992). Comparative immunosuppression of various glycol ethers orally administered to Fischer 344 rats. Fundam Apply Toxiocl 18:621-627.

9 Exon JH, GG Mather, JLBussiere, DP Olson, PA Talcott. (1991) Effects of subchronic exposure of rats to 2-methoxyethanol or 2-butoxyethanol: thymic atrophy and immunotoxicity. Fudam Appl Toxicol 16(4):830-840.

10 Singh P, Zhao S, Blaylock RL. ()2001). Topical exposure to 2-butoxyethanol alters immune responses in female BALB/c mice. Int Jrl Toxicol 20:383-390.

11 Singh P, Morris B, Zhao S, Blaylock RL. (2002) Suppresssion of the contact hypersensitivity response following topical exposure to 2-butoxyethanol in female BALB/c mice. Int Jrl Toxicol, 21:107-115.

At the end of a two year chronic bioassay, elevated numbers of combined malignant and non-malignant tumors of the adrenal gland were reported in female rats and male and female mice.[Error! Bookmark not defined.] Low survival rates in the male mice in this study may have been the result of the high rate of liver cancers in the exposed animals.[Error! Bookmark not defined.] This study revealed that long-term exposure to 2-BE often led to liver toxicity before the hemolytic effects were discernible. [Error! Bookmark not defined.]

No human epidemiological studies are available to assess the potential carcinogenicity of 2-BE. However, from the results of laboratory studies, using Guidelines for Carcinogenic Risk Assessment (1986), 2-BE has been classified by the USEPA as a *possible human carcinogen*. [Error! Bookmark not defined.]

SENSITIVE POPULATIONS

A number of laboratory studies confirmed that aging increases susceptibility to the effects of 2-BE. Older animals have reduced ability to metabolize the toxic metabolite BAA and this, combined with reduced kidney function that accompanies aging reduces their ability to excrete it in the urine.[Error! Bookmark not defined.]

Females are more susceptible to the hematological effects in laboratory animal and human studies. There is an obvious gender and age sensitivity to 2-BE in humans as determined from accidental poisonings with females being more sensitive. In addition, among humans there may be sub-populations that might be more sensitive than others.[Error! Bookmark not defined.]

A list of risk factors for people exposed to 2-BE includes those:
(1) using the pharmaceuticals hydralazine, dilantin, chloramphenicol, and sulfonamides;
(2) with infections, such as herpes, malaria, parasites, and rubella;
(3) with a family history of gallstones, cholestectomy, jaundice, Rh and APO positive;
(4) with iron deficiency; and
(5) with systemic illnesses, such as cardiac, gastrointestinal, liver, and kidney disease, and hypothyroidism.[Error! Bookmark not defined.,12]

From a wildlife and domestic animal perspective, it is important to note that a variety of studies with laboratory animals revealed that some species are more sensitive to 2-BE than others.[Error! Bookmark not defined.] For example, rats are more sensitive than mice to the toxic effects of 2-BE on the liver. No studies were found using wildlife or domestic animals.

INDIRECT HEALTH EFFECTS OF 2-BE

2-BE is widely used as an emulsifying agent and as a solvent for mineral oils[Error! Bookmark not defined.]. This makes it an excellent candidate for releasing the natural, oily, coal-tar hydrocarbons found in coal that have been recognized for over a century to cause cancer.

CUMULATIVE AND AGGREGATE HEALTH HAZARDS

As mentioned above, no cumulative exposure studies have been done that evaluate the simultaneous impact of ingestion, inhalation, and topical exposure to 2-BE, which could be the mode of exposure to residents in Delta County. If 2-BE comes directly into the home via a well it will be used for drinking, bathing, showering, and doing laundry and dishes. Laboratory studies have revealed that in the case of bathing or applying 2-BE to the skin, it is readily absorbed through the skin rather than volatilizing. If water containing 2-BE is heated, as it comes out of the tap some of the 2-BE will off-

[12] (Berliner N, Duffy, TP, Abelson HT. (1999) Approach to adult and child anemia. In: Hoffman, R ed. Hematology:Basic Principles and Practice. 2nd ed. New York, NY: Churchill Livingtsone, pp.468-483.

gas into the home environment. Most of the studies mentioned above used inhalation as the pathway of exposure to 2-BE. Inhalation of 2-BE in the home could become a problem. For example, concern about exposure to the volatile by-products (trihalomethanes or THMs) in chlorine treated tap water[13] led to the discovery that taking a bath or a shower can lead to excessively high dose exposure to THMs. This exposure can exceed the level of exposure from drinking the water and add to the dose from drinking the water. Because of the volatility of 2-BE, the same pathway of exposure could become of concern for Delta County residents if 2-BE reaches their wells and especially if the water is heated.

Of increasing concern by federal health agencies are the *unpredictable,* interactive effects of mixtures of chemicals.[14] Under the scenario described in Gunnison Energy's prospectus, the concentrations of three classes of chemicals that are toxic individually at very low concentrations could become introduced or increased in the environment of Delta County. These include (1) the trace elements arsenic, molybdenum, and selenium, already a problem in Delta county, (2) a synthetic solvent, 2-BE, and (3) the polyaromatic hydrocarbons and coal tars found in coal beds. Arsenic, 2-BE, and aromatic coal bed tar derivatives are known carcinogens. In aggregate, whether their effects would be additive or synergistic has not been determined. However, in one study, the authors were surprised to find that 2-BE potentiated the lethality of low level exposure to another toxicant, a bacterially produced lipopolysaccharide (LPS) that is found in the human gut under certain conditions.**Error! Bookmark not defined.**

Additional contamination of potable water could come from the impurities in the 2-BE product used in the extraction process. Commercial grade 2-BE can range in impurities depending upon the production process, manufacturer, and grade of the solvent. One impurity, sodium hydroxide (lye), a strong caustic, might possibly contribute to the alkalinity of the water. It was discovered in one product at 0.25%. Even high grade 2-BE with greater than 99% purity can contain 0.2% w/w ethylene glycol (anti-freeze), diethylene glycol, and diethyl monobutyl ether, sister compounds to 2-BE with much higher toxicity.**Error! Bookmark not defined.**

ENVIRONMENTAL EFFECTS

Increased salinity

2-BE leaves an alkaline residue upon evaporation which might slightly add to the alkalinity problem that increases as surface water approaches the lower reaches of Delta County. Because of the solubility of sodium salts they can travel long distances in rivers and could increase the salinity problem in the Colorado River downstream.

Locally, any additional water that increases the salinity could also increase the mobilization of some of the alkaline soluble, problem elements such as arsenic and selenium, already posing health risks in Delta County. Health advisories are already in effect for Sweitzer Lake warning people not to eat the fish because of the high levels of selenium in the fish tissue.

A peer reviewed report by the US Forest Service on the threat of increased selenium contamination in the Mancos and La Plata River drainages describes a scenario similar to the Gunnison River

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[13] Nester AM, Singer PC, Ashley DL, Lynberg MC, Mendola P, Langlois PH, Nichols JR. (2002). Comparison of trihalomethanes in tap water and blood. Env Sc Techn. 36(8):1692-1698.

[14] Department of Health and Human Services, Agency for Toxic Substances and Disease Registry , (2001). Guidance Manual for the Assessment of Joint Toxic Action of Chemical Mixtures. Draft for Public Comment.

drainage in Delta County where selenium is already at levels of concern.[15] The hazards include threats to wetlands, aquatic habitat, invertebrates, fish, birds and other wildlife reproduction. Delta County is in a unique and fragile situation – (1) it already has the natural geological existence of selenium, (2) its local hydrology that has been embellished and complicated through extensive irrigation activity, and (3) a climate prone to drought .

There is a growing collection of scientific papers on the adverse health effects of selenium in wildlife exposed to elevated concentrations of selenium in seep-like situations (natural and human-induced) in the West. Waterfowl, fish, and invertebrates have experienced decreased hatching success and increased birth defects as a result of exposure in the egg. Chicks of avocets, stilts, ducks, coots, etc. have been found with crossed bills, missing eyes, and other deformities in aquatic systems where irrigation run off water collects.

HEALTH RISKS TO BE TAKEN INTO CONSIDERATION

Although no standard has been established yet for 2-BE in drinking water, in 1993 the EPA set a minimum risk level (MRL) for 2-BE at 0.07 mg/kg/day based on an adult 70 kg male drinking two liters of water a day. This value is based on liver toxicity studies in rats and not on more sensitive immune, developmental, and functional health effects that have become of concern over the past decade. In 1998 EPA derived a reference dose RfD for 2-BE at 0.5 mg/kg/day for non-cancer effects. This is based on lifetime exposure. EPA admits " Since drinking water exposures are highly complex and variable, a simplifying assumption was used in all simulations ….". EPA had no human data to derive its value. [3]

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[15] Lemly AD (1997). Environmental hazard of selenium in the Animas La Plata water development project. Ecotoxicol Environ Safety 37:92-96.

GEC is planning to inject fluid into the ground in Delta County at 7 ppm. If this fluid reaches the taps in Delta County at that concentration, it will be providing 0.2 mg/kg/day per two liters of water, approximately three times higher than the MRL and a little more than half the RfD.

RECOMMENDATIONS

1. First and most important, it is imperative to understand the hydrology of Delta County better. In addition, the complex diversions of potable water for irrigation and domestic use throughout the county must be factored into this knowledge.

2. Second, it is imperative to determine the current concentrations of the toxic chemicals in the coal bed water to be released during extraction prior to introducing the fracturing liquids. This must include the entire scope of trace elements from alkaline to acid based derivatives in both their dissolved and suspended form. In addition, the entire scope of polyaromatic hydrocarbons (both parent and alkylated forms) in the underground coal bed water should be quantified prior to any activity. Because of the toxicity of the elements and compounds of concern, detection limits throughout this monitoring should be no higher than a part per trillion. Information such as this will allow for determining if the fracturing liquid releases additional toxic components, and in the case of the PAHs, through dissolution by the 2-BE.

3. Throughout the mining life of the well, the underground fluid with which it will interface should be monitored on a regular basis for its toxic components. See those components mentioned in Number 2. If the concentrations of the contaminants decrease, this could indicate that precious potable subsurface or surface water is being drained from above. This provides an approach for detecting dewatering before too much potable water is lost.

4. If exploration begins, GEC must keep daily inventories of the total amount of fracturing liquid injected, including the exact amount of each component in the fluid.

5. GEC should be required to retrieve all surfacing liquid for containment. The volume of the retrieved liquid should be reported and the concentrations of the chemicals in that liquid quantified on a regular basis for auditing purposes to account for the toxic chemicals that were introduced under Number 4.

5. GEC's plans for disposal of this toxic liquid should be presented to the residents of Delta County for approval before any leases are approved.

6. Any changes in the composition of the fracturing liquid must be reported to the citizens of Delta County for consideration before the liquid is used.

7. If GEC should find that it needs or wants to use anything other than sand for propping, it must provide to the citizens of Delta County for consideration all the components in the alternative material before the material is used. The purity of the alternative products used must be provided as well. Trade names will not be acceptable.

APPENDIX B

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ANALYSIS OF CHEMICALS USED IN NATURAL GAS DEVELOPMENT AND DELIVERY in COLORADO

April 4, 2007

Introduction

This project was designed to explore the health effects of the products and chemicals used in drilling, fracturing, and recovery of natural gas. It provides a glimpse at the pattern(s) of possible health hazards for those living in regions where gas development is taking place. In order to do this, we collected lists of products and chemicals which we placed in a spreadsheet. We make no claim that this list is complete.

In the process of researching the literature, we discovered that drilling companies have access to hundreds of products, the components of which are in many cases unavailable for public scrutiny. This analysis addresses only those chemicals and products for which there is evidence that they are being, or have been used in Colorado.

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1. Our list consists of 171 products used in natural gas development and delivery. These products contain 245 chemicals and cover all stages of production and development.

2. The four most common adverse health effects for the chemicals on the list are skin and sensory organ toxicity, respiratory problems, neurotoxicity, and gastrointestinal and liver damage.

3. Examination of the products used in gas development and delivery shows that 92% have one or more adverse health effects. Of the 14 products without health effects, we have little or no data on 8 of them.

4. The following figures are based on the data in the Chemicals Used in Natural Gas Development and Delivery in Colorado Spreadsheet. They include the percentage and the actual number of chemicals in each health category. They are presented to define a pattern of the possible health effects of the chemicals and products that are being used. Health effects of the 245 chemicals break out as follows:

Percentage	Number	Effect
63%	154	skin and sensory organ toxicants
58%	143	respiratory toxicants
50%	122	gastrointestinal and liver toxicants
34%	84	neurotoxicants
30%	73	kidney toxicants
28%	69	cardiovascular and blood toxicants
26%	63	immunotoxicants
23%	56	carcinogens
22%	55	reproductive toxicants
21%	52	wildlife toxicants
20%	50	developmental toxicants
14%	34	endocrine disruptors
14%	35	result in other disorders
12%	29	mutagens

Of the **65** (27%) of the chemicals on the list that can vaporize:

Percentage	Number	Effect
83%	54	skin and sensory organ toxicants
77%	50	respiratory toxicants
75%	49	gastrointestinal and liver toxicants
68%	44	neurotoxicants
55%	36	cardiovascular and blood toxicants
55%	36	kidney toxicants
43%	28	developmental toxicants
43%	28	reproductive toxicants
37%	24	immunotoxicants
37%	24	wildlife toxicants
35%	23	carcinogens
22%	14	mutagens
22%	14	endocrine disruptors
22%	14	result in other disorders

Of the **69** (28%) of the chemicals on the list that are soluble, or miscible:

Percentage	Number	Effect
86%	59	skin and sensory organ toxicants
83%	57	respiratory toxicants
75%	52	gastrointestinal and liver toxicants
52%	36	neurotoxicants
42%	29	cardiovascular and blood toxicants
36%	25	immunotoxicants
36%	25	kidney toxicants
32%	22	wildlife toxicants
29%	20	reproductive toxicants
28%	19	developmental toxicants
26%	18	result in other disorders
23%	16	carcinogens
22%	15	endocrine disruptors
17%	12	mutagens

5. Forty-nine percent of the 245 chemicals listed have between four and 14 different reported health effects. Twenty-four percent of the chemicals have between one and three known health effects, and 27% have no health effects.

6. Many of the citations used to establish the health effects of the chemicals are old. For some of the chemicals we were unable to find studies newer than those done in the 60's or 70's. In some cases we were able to get data only from an abstract, not the full report or manuscript. In other cases, we were able to get quotations about the health effect(s) from toxic chemical databases, such as TOXNET, HAZMET, etc. Many reports submitted to the Environmental Protection Agency for the registration of some of these chemicals are not accessible.

7. Several reasons led to the lack of data about the health effects of some of the products and chemicals on the spread sheet:

(a) We found no health effect data for a particular chemical or product.
(b) Some products list no ingredients.
(c) Some products provide only a general description of the content, such as "plasticizer", "polymer" etc.
(d) Some products list the ingredients as "proprietary" or provide only the name of one or two chemicals plus "proprietary".

8. Much of the information about the composition of the products on the list comes from the Materials Safety Data Sheet (MSDS) for that product. The information on these sheets is limited to only those chemicals that are required by law to be disclosed. Ingredients are often labeled as "proprietary", or "no hazardous ingredients" even when there are significant health effects listed on the MSDS.

9. MSDS sheets are designed to provide information to protect those who handle, ship, and use the product(s). The sheets are also designed to protect emergency response crews in case of accidents or spills. The data in the MSDSs do not generally take into consideration the health impacts resulting from chronic or long-term, continuous, and/or intermittent exposure. Many chemicals have not gone through a rigorous and extensive scientific peer-review process that would permit conclusions to be drawn about "safe" and "hazardous" exposure levels.

10. The MSDSs are often sketchy and provide health effects information for only one or two chemicals in a product. In many cases the chemicals listed equal less than 100% of the product. In the case of mixtures, the health effects warnings are often not chemical specific.

Comments

Chemical use and disposal

Fracturing of wells is a common practice in parts of the west, in which a million gallons of fluids are injected underground, creating a mini-earthquake that facilitates the release of natural gas. The gas industry claims that 70% of the material it injects underground is retrieved. While the fate of the remaining 30% is unknown, the recovered product is placed in holding pits on the surface and allowed to evaporate. This results in many highly toxic chemicals being released into the air, as well as being dispersed into local surface waters. The condensed residues remaining in the pits are taken off-site and dealt with in two ways: (1) They can be re-injected in the ground posing concerns for aquifers, or (2) they can be "land farmed" by which they are incorporated into the soil through tilling. Land farming can release toxic chemicals to the air via volatile substances and dusts, or result in accumulation of mixtures of toxic metals in the soil.

At some locations, because of regional differences in geology and technology, 100% of the injected material may remain underground. The mobility of these residues in the environment, or their ability to contaminate ground water and aquifers has not been evaluated.

After development ceases on a pad and the well(s) goes into production, the residues in the evaporation pits are often bulldozed over. It is impossible to predict how long the buried chemicals will remain in place. Highly persistent and mobile chemicals could migrate from these pits into underground water resources.

Prior to use, these products must be shipped to and stored somewhere before being transported to the well site. They pose a hazard on our highways, roads, and rail systems, as well as to people living and working near the storage facilities. The recent evacuation of a neighborhood in New Mexico after a leak at a storage facility is one example of the dangers posed by these facilities.

It is important to note that once a well goes into production, the gas passes through a dehydrator to remove the water which is often stored in holding tanks on the pad. It is sometimes re-injected on site or can be trucked or piped to an evaporation pit where volatile chemicals escape. Any chemicals used during drilling and fracturing could be mingling with this gas production source of water.

Health Effects

We were unable to find health effects associated with 66 of the chemicals on the list. Of these, only 14 had been assigned a chemical identification number (CAS number) by the American Chemical Society enabling us to search the literature. We found no adverse health effects for these. However, we were unable to determine the safety of the other 52 chemicals either because they were listed as mixtures, proprietary or unspecified (15), or had chemical names that were so general that the specific chemical could not be identified (37).

Many of the chemicals on this list have been tested for lethality and acute toxicity based on short-term contact. The majority have never been tested at realistic, environmentally relevant, chronic exposure levels, or for delayed effects that may not be expressed until long after exposure. Nor have adequate ecological studies been done. For example, most of the chemicals have not been tested for their effects on terrestrial wildlife or birds, fish, and invertebrates. It is reasonable to assume that the health endpoints listed above could very well be seen in wildlife, domestic animals, and pets.

The products labeled as biocides are among the most lethal on the list, and with good reason. Bacterial activity in well casings, pipes and joints can be highly corrosive, costly, and dangerous. Bacteria can also alter the chemical structure of polymers and make them useless. Nonetheless, when these products return to the surface either through deliberate retrieval processes or accidentally they pose a significant danger to workers and those living near the well and evaporation ponds. They can also sterilize the soil and inhibit normal bacterial and plant growth for many years.

In general, the volatile chemicals have more adverse health effects associated with them than the soluble chemicals. Not only are they more toxic, but in the area of skin and sensory organ toxicity, gastrointestinal and liver, and the respiratory system toxicity, over 75% of them cause harm. They also show a higher percentage of adverse effects overall than the soluble chemicals.

The soluble chemicals are associated with more adverse health effects than the total number of chemicals. While they do not show as high a percentage of effects as the volatile chemicals, between

75% and 86% can cause harm to the same systems as listed above. They are slightly more harmful than the volatiles in these systems only.

The use of respirators, goggles and gloves is advised on many of the MSDSs for products on this list. This indicates serious, acute toxicity problems that are not being addressed in the recovery process when the chemicals come back to the surface. It raises concern over possible hazards posed to those living in regions where development activity is taking place

Full Disclosure

When comparing the toxicity of the chemicals used in the four western states, the need for full disclosure became more evident. If it had not been for several accidents or spills where local citizens took it upon themselves to find out the names of products that were involved, TEDX would not have learned as much as we have. These accidents provided unique situations in which companies were inclined to more fully disclose product information and thus we gained greater insight about chemicals used to develop and deliver natural gas. We know for certain, that a great deal more than water and soap is being used to drill a gas well.

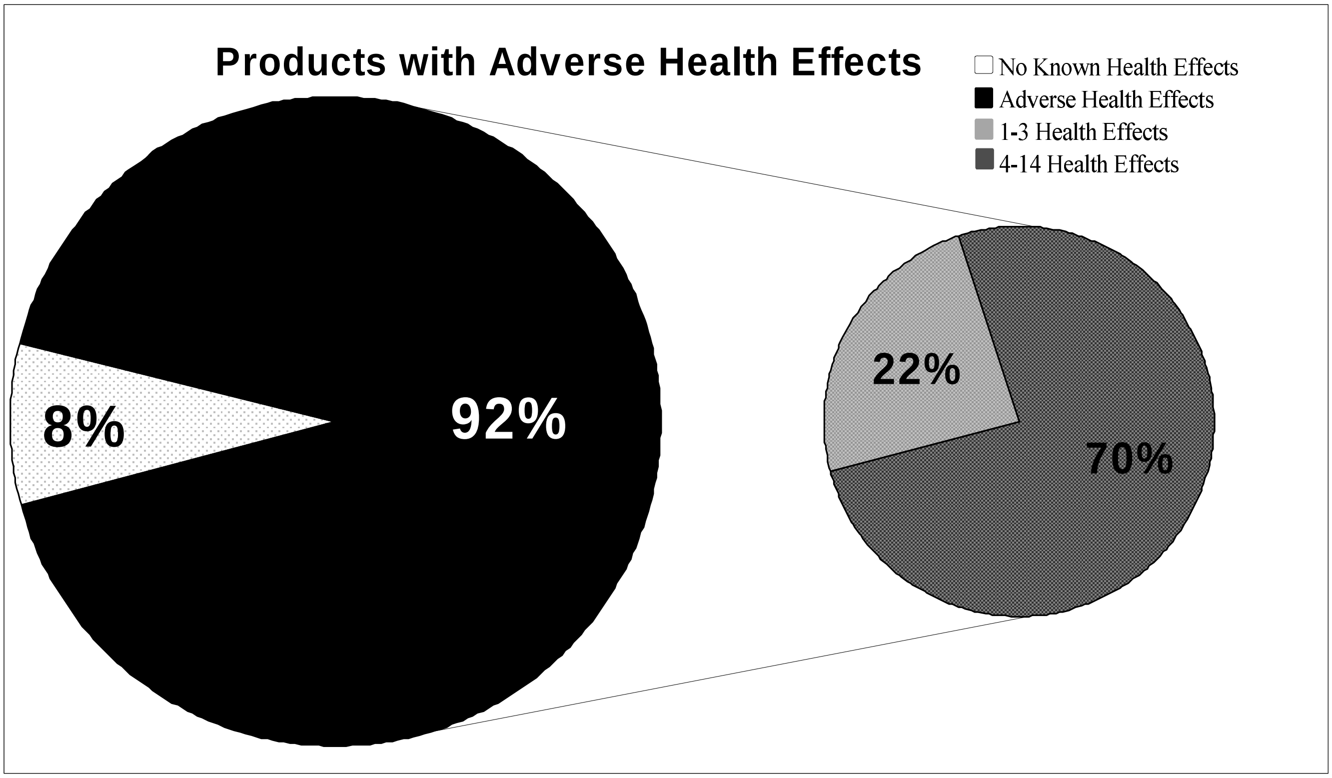
The information we have for many products in Colorado is limited. The health effects for the chemicals and products used in Colorado are consistently lower as compared with those in Wyoming, Washington or New Mexico. The percentage of health effects in Colorado are, in fact, between 4 and 14 percentage points lower than the averages for the other three states. The major difference between these states is the amount of information available on the products in use. In Wyoming and Washington we have all the MSDS sheets for the products on our list. In New Mexico we have a high proportion of MSDS sheets and data from Tier II reports, which are required by the Emergency Planning and Right to Know Act for stored materials. The Colorado information comes from far fewer MSDS sheets and other specific sources of product data. As we have gained access to product MSDS sheets from other states, this information has been incorporated into the same products on the Colorado list, with a corresponding rise in the percentage of adverse health effects.

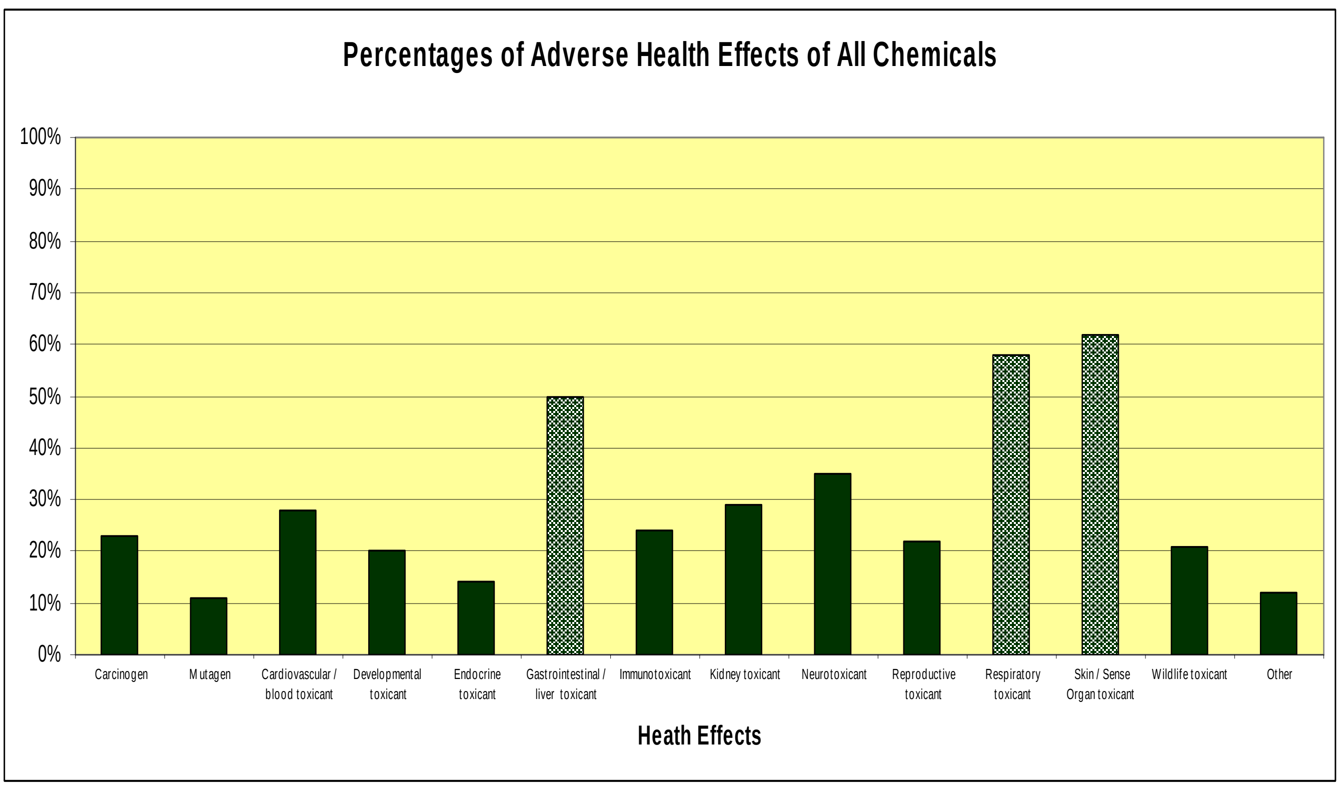
Through these comparisons we feel it is safe to say that our report *underestimates* the hazards of the situation.

A number of chemicals can be toxic when encountered in high concentrations, or, perhaps, during certain exposures (such as inhalation versus skin contact). Because only a small percentage of the total composition of most of the products on this list is available, we cannot say for certain whether such chemicals are harmless in their application. Under the present system, there are not enough data to determine the safety of products that contain mixtures of relatively “benign” ingredients and unknown chemicals, when the actual percentage composition is not provided.

This list provides only a hint of the combinations and permutations of mixtures possible and the possible aggregate exposure. Each drilling and fracturing incident is custom designed depending on the geology, depth, and resource available. The chemicals and products used, and the amounts or volumes used can differ from well to well. The only way to get a realistic picture of what is being introduced into our watersheds and air is for a complete record of information of the specific well site (state, county, township, section, etc.), the formulation of chemicals and products used at each stage, the quantity of each product (weight and/or volume), total volume injected and recovered, and the depths at which material/mixtures were injected and recovered, the composition of the recovered liquids and those liquids and solids removed from site. This needs to be public information.

As we have added products to the list, the percentages of health effects occasionally shifted. Changes such as this will continue as more products and chemicals are entered into the database. Thus far, despite small increases or decreases in percentage, the top four health effects of concern have remained the same. They are skin and sensory organ, gastrointestinal and liver, respiratory, and neurological system damage.





APPENDIX C

TEDX
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Crosby 25-3 Well – Windsor Energy, Park County Wyoming

Analysis of Products Used for Drilling

September 11, 2007

Introduction

This analysis was designed to explore the health effects of the products and chemicals used in drilling a natural gas well, Crosby 25-3, northwest of Clark, Park County, Wyoming. This well was directionally drilled with a total vertical depth of 8,038 feet. Natural gas, petroleum condensate, and drilling fluids were accidentally released from the ground adjacent to the well. The release occurred over a period of about 58 hours between 11 and 13 August 2006 and resulted in surface soil impacts in an area estimated to cover approximately 25,000 square feet.[16]

This analysis provides a glimpse at the pattern(s) of possible health hazards for those living in the region. We were able to do this analysis because we were provided the Materials Safety Data Sheets (MSDS) for the products in use at the time of the blowout. We make no claim that this list of products is complete.

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1. Our list consists of 25 products used in natural gas drilling. These products contain 36 chemicals.

2. The four most common adverse health effects for the chemicals on the list are skin and sensory organ toxicity, respiratory problems, cardiovascular and/or blood damage, and gastrointestinal and/or liver damage.

3. Examination of the products used in drilling in Wyoming on this list shows that 100% have one or more adverse health effects.

4. The following figures are based on the data in TEDX's Chemicals Used to Drill the Crosby 25-3 Well in Wyoming Spreadsheet. They include the percentage and the actual number of chemicals in each health category. They are presented to define a pattern of the possible health effects of the chemicals and products that are being used. Health effects of the 36 chemicals break out as follows:

[16] Monitoring Report, April 2007, Prepared by Terracon Consulting Engineers and Scientists.

Percentage	Number	Effect
94%	34	respiratory toxicants
89%	32	skin and sensory organ toxicants
72%	26	gastrointestinal and liver toxicants
50%	18	cardiovascular and blood toxicants
44%	16	immunotoxicants
44%	16	kidney toxicants
44%	16	neurotoxicants
39%	14	reproductive toxicants
39%	14	wildlife toxicants
33%	12	carcinogens
28%	10	developmental toxicants
28%	10	result in other disorders
25%	9	endocrine disruptors
11%	4	mutagens

Of the **8** (22%) of the chemicals on the list that can vaporize:

Percentage	Number	Effect
100%	8	gastrointestinal and liver toxicants
100%	8	respiratory toxicants
100%	8	skin and sensory organ toxicants
75%	6	neurotoxicants
63%	5	cardiovascular and blood toxicants
63%	5	immunotoxicants
63%	5	kidney toxicants
63%	5	reproductive toxicants
50%	4	wildlife toxicants
38%	3	developmental toxicants
38%	3	result in other disorders
25%	2	carcinogens
25%	2	mutagens
25%	2	endocrine disruptors

Of the **14** (39%) of the chemicals on the list that are soluble, or miscible:

Percentage	Number	Effect
100%	14	skin and sensory organ toxicants
93%	13	respiratory toxicants
86%	12	gastrointestinal and liver toxicants
64%	9	wildlife toxicants
50%	7	neurotoxicants
50%	7	result in other disorders
43%	6	cardiovascular and blood toxicants
43%	6	immunotoxicants
43%	6	kidney toxicants
36%	5	reproductive toxicants
21%	3	mutagens
21%	3	developmental toxicants
14%	2	carcinogens
7%	1	endocrine disruptors

5. Sixty-seven percent of the 36 chemicals listed have between four and 14 different reported health effects. Thirty-three percent of the chemicals have between one and three known health effects.

6. Many of the citations used to establish the health effects of the chemicals are old. For some of the chemicals we were unable to find studies newer than those done in the 60's or 70's. In some cases we were able to get data only from an abstract, not the full report or manuscript. In other cases, we were able to get quotations about the health effect(s) from toxic chemical databases, such as TOXNET, HAZMET, etc. Many reports submitted to the Environmental Protection Agency for the registration of some of these chemicals are not accessible.

7. Several reasons led to the lack of data about the health effects of some of the products and chemicals on the spread sheet:

(a) We found no health effect data for a particular chemical or product.
(b) Some products list no ingredients.
(c) Some products provide only a general description of the content, such as "no hazardous substances."

8. All of the information about the composition of the products on the list comes from either the MSDS for that product, or information disclosed in the Terracon Remedial Investigation Work Plan – Amended Draft, dated July 2, 2007. The information on the MSDSs is limited to only those chemicals that are required by law to be disclosed. Ingredients are often labeled as "no hazardous ingredients" even when there are significant health effects listed on the MSDS. The information disclosed by the Terracon report lists chemicals included in the products, but there is no indication if that information is the complete composition of the product.

9. A number of chemicals can be toxic when encountered in high concentrations, or, perhaps, during certain exposures (such as inhalation versus skin contact). Because only a small percentage of the total composition of most of the products on this list is available, we cannot say for certain whether such chemicals are harmless in their application. Under the present system, there are not enough data to determine the safety of products that contain mixtures of relatively "benign" ingredients and unknown chemicals, when the actual percentage composition is not provided.

10. MSDSs are designed to provide information to protect those who handle, ship, and use the product(s). The sheets are also designed to protect emergency response crews in case of accidents or spills. The data in the MSDSs do not generally take into consideration the health impacts resulting from chronic or long-term, continuous, and/or intermittent exposure. Many chemicals have not gone through a rigorous and extensive scientific peer-review process that would permit conclusions to be drawn about "safe" and "hazardous" exposure levels.

11. The MSDSs are often sketchy and provide health effects information for only one or two chemicals in a product. In many cases the chemicals listed equal less than 100% of the product. In the case of mixtures, the health effects warnings are often not chemical specific.

Comments

Health Effects

We found adverse health effects for all the chemicals on this list. This is true even though MSDSs for four of the products stated that they contained no hazardous substances. All of the MSDSs for these products contained information that the ingredients were eye or skin irritants or toxicants, 75% were respiratory toxicants, 50% were dangerous to wildlife, and one was a gastrointestinal toxicant.

Many of the chemicals on this list have been tested for lethality and acute toxicity based on short-term contact. The majority have never been tested at realistic, environmentally relevant, chronic exposure levels, or for delayed effects that may not be expressed until long after exposure. Nor have adequate ecological studies been done. For example, most of the chemicals have not been tested for their effects on terrestrial wildlife or birds, fish, and invertebrates. It is reasonable to assume that the health endpoints listed above could very well be seen in wildlife, domestic animals, and pets.

In general, the volatile chemicals have more adverse health effects associated with them than the soluble chemicals. Not only are they more toxic, but in the area of skin and sensory organ toxicity, gastrointestinal and liver, and the respiratory system toxicity, 100% of them cause harm.

The soluble chemicals are associated with more adverse health effects than the total number of chemicals. While they do not show as high a percentage of effects as the volatile chemicals, between 85% and 100% can cause harm to the same systems as listed above.

The use of respirators, goggles and gloves is advised on many of the MSDSs for products on this list. This indicates serious, acute toxicity problems that are not being addressed when the chemicals come back to the surface, either during the recovery process or, as in this case, during a blowout. It raises concern over possible hazards posed to those living in regions where development activity is taking place.

Prior to use, these products must be shipped to and stored somewhere before being transported to the well site. They pose a hazard on our highways, roads, and rail systems, as well as to people living and working near the storage facilities. The recent evacuation of a neighborhood in New Mexico after a leak at a storage facility is one example of the dangers posed by these facilities.

Full Disclosure

While this list was compiled from MSDS information, it is still far from a complete picture of what is in use. The limitations of MSDS data are outlined above. Also, this list provides only a hint of the combinations and permutations of mixtures possible and the possible aggregate exposure. Each drilling and fracturing incident is custom designed depending on the geology, depth, and resource available. The chemicals and products used, and the amounts or volumes used can differ from well to well. The only way to get a realistic picture of what is being introduced into our watersheds and air is for a complete record of information of the specific well site (state, county, township, section, etc.), the formulation of chemicals and products used at each stage, the quantity of each product (weight and/or volume), total volume injected and recovered, and the depths at which material/mixtures were injected and recovered, the composition of the recovered liquids and those liquids and solids removed from site. This needs to be public information. From the data in this list, we know for certain that a great deal more than water and soap is being used to drill a natural gas well.

APPENDIX D

TEDX
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Number of chemicals detected in reserve pits for 6 wells in New Mexico that appear on national toxic chemicals lists

November, 2007

Toxic chemicals lists and the 51 chemicals detected

LIST	# of chemicals on list	Percentage
CERCLA 2005	37	72.5%
EPCRA 2006	24	47%
EPCRA List of Lists	30	58.8%

Chemicals not on any list:

N-Propylbenzene	O-Terphenyl	2-Fluorobiphenyl	Dibromofluoromethane
4-Bromochlorobenzene	2,3,4-Trifluorotoluene	2-Fluorophenol	Tetrachloro-m-xylene
Diesel range organics[1]	2,4,6-Tribromophenol	Decachlorobiphenyl[2]	Uranium
Gasoline range organics[1]			

[1] Too general to be included on lists that categorize by CAS numbers
[2] a PCB

Toxic chemicals lists and the 13 chemicals detected over state limits

LIST	# of chemicals on list	Percentage
CERCLA 2005	11	84.6%
EPCRA 2006	9	69%
EPCRA List of Lists	9	69%

Chemicals not on any list:

N-Propylbenzene
Diesel range organics[1]

[1] Too general to be included on lists that categorize by CAS numbers

CERCLA 2005: Comprehensive Environmental Response, Compensation, and Liability Act Summary Data for 2005 Priority List of Hazardous Substances
EPCRA 2006: Emergency Planning & Community Right to Know Act Section 313 Chemical List For Reporting Year 2006 (including Toxic Chemical Categories)
EPCRA List of Lists: Consolidated List of Chemicals Subject to the Emergency Planning and Community Right-To-Know Act (EPCRA) and Section 112(r) of the Clean Air Act

Comparison of the patterns of adverse health effects associated with 175 chemicals on the TEDX Chemicals Used in Oil and Gas Development and Delivery in New Mexico spreadsheet:

1) **All chemicals**
2) **Soluble chemicals only**
3) **Chemicals detected in 6 reserve pits**