Cancer Association of South Africa (CANSA)

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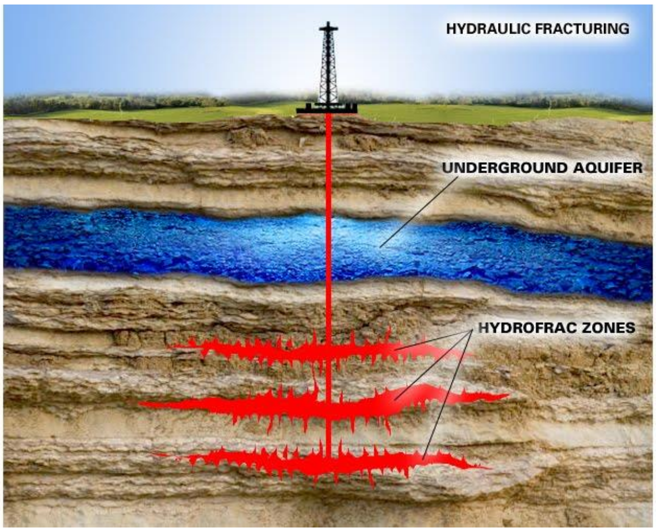
Fact Sheet
and
Position Statement on
Hydraulic Fracturing

Introduction

Hydraulic fracturing - also referred to as 'hydro-fracking' or 'fracking' - a process of horizontal drilling coupled with multi-stage hydraulic fracturing - is a relatively new process of natural gas extraction.



[Picture Credit: Fracking]

The basic process of hydro-fracking is as follows:

- A well is drilled vertically to the desired depth, then turns ninety degrees and continues horizontally for several hundreds of metres into the shale believed to contain the trapped natural gas
- Horizontal drilling may extend for several kilometres
- A mix of water, sand, and various chemicals is pumped into the well at high pressure in order to create fissures in the shale through which the gas can escape
- Natural gas escapes through the fissures and is drawn back up the well to the surface, where it is processed, refined, and shipped to market
- Wastewater (also called 'flowback water' or 'produced water') returns to the surface after the fracking process is completed. In Michigan, United States of America, this water is contained in steel tanks where it is stored long-term for later use by means of deep injection in other oil and gas waste wells.

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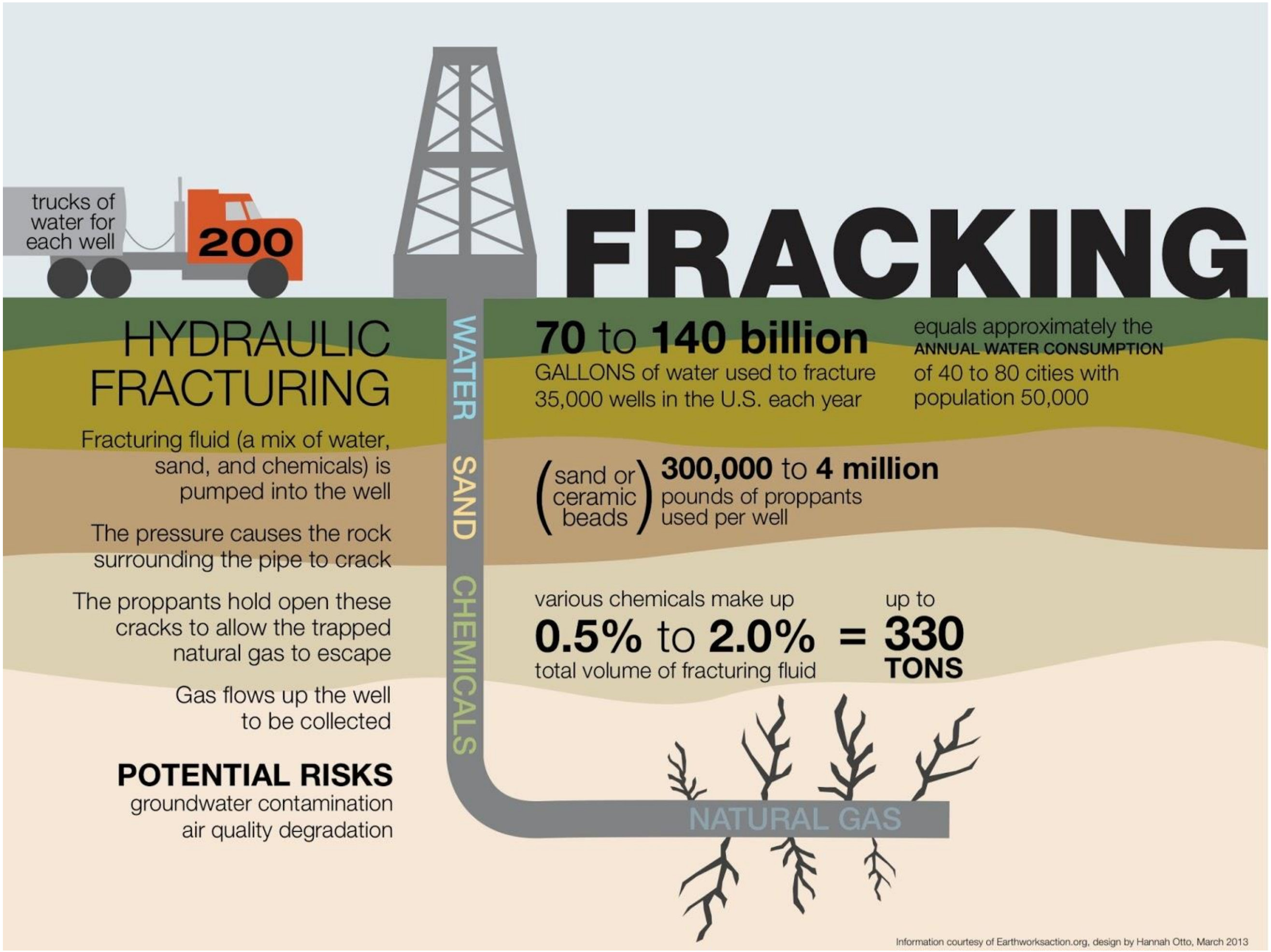
Fracking is fundamentally different from traditional gas extraction methods. Fracking wells can go thousands of metres deeper than traditional natural gas wells. Each fracking exercise requires between fifteen and twenty million litres of local freshwater per well - up to 100 times more than traditional extraction methods. It utilises 'fracking fluid', a mix of water, sand, and a cocktail of toxic chemicals.

While companies performing fracking have resisted disclosure of the exact contents of the fracking fluid by claiming that this information is proprietary, studies of fracking waste indicate that the fluid contains: formaldehyde, acetic acids, citric acids, and boric acids, among hundreds of other chemical contaminants. (Natural Resources Defence Council; Marcellus Drilling News; United States Environmental Protection Agency; Clean Water Action).

[Picture Credit: Infographics of Fracking Facts]



Perceptions Regarding Impact and Effect of Hydraulic Fracturing
A focus group and on-line survey conducted in South Africa reveals mostly negative perceptions among the populace around hydraulic fracturing.

Wollin, K.M., Damm, G., Foth, H., Freyberger, A., Gebel, T., Mangerich, A., Gundert-Remy, U., Partosch, F., Röhl, C., Schupp, T. & Hengstler, J.G. 2020.
"The use of hydraulic fracturing (HF) to extract oil and natural gas has increased, along with intensive discussions on the associated risks to human health. Three technical processes should be differentiated when evaluating human health risks, namely (1) drilling of the borehole, (2) hydraulic stimulation, and (3) gas or oil production. During the drilling phase, emissions such as NO_x, NMVOCs (non-methane volatile organic compounds) as precursors for tropospheric ozone formation, and SO_x have been shown to be higher compared to the subsequent phases. In relation to hydraulic stimulation, the toxicity of frac fluids is of relevance. More than 1100 compounds have been identified as components. A trend is to use fewer, less hazardous and more biodegradable substances; however, the use of hydrocarbons, such as kerosene and diesel, is still allowed in the USA. Methane in drinking water is of low toxicological relevance but may indicate inadequate integrity of the gas well. There is a great concern regarding the contamination of ground- and surface water during the production phase. Water that flows to the surface from oil and gas wells, so-called 'produced water', represents a mixture of flow-back, the injected frac fluid returning to the surface, and the reservoir water present in natural oil and gas deposits. Among numerous hazardous compounds, produced water may contain bromide, arsenic, strontium, mercury, barium, radioactive isotopes and organic compounds, particularly benzene, toluene, ethylbenzene and xylenes (BTEX). The sewage outflow, even from specialized treatment plants, may still contain critical concentrations of barium, strontium and arsenic. Evidence suggests that the quality of groundwater and surface water may be compromised by disposal of produced water. Particularly critical is the use of produced water for watering of agricultural areas, where persistent compounds may accumulate. Air contamination can occur as a result of several HF-associated activities. In addition to BTEX, 20 HF-associated air contaminants are group 1A or 1B carcinogens according to the IARC. In the U.S., oil and gas production (including conventional production) represents the second largest source of anthropogenic methane emissions. High-quality epidemiological studies are required, especially in light of recent observations of an association between childhood leukemia and multiple myeloma in the neighborhood of oil and gas production sites. In conclusion, (1) strong evidence supports the conclusion that frac fluids can lead to local environmental contamination; (2) while changes in the chemical composition of soil, water and air are likely to occur, the increased levels are still often below threshold values for safety; (3) point source pollution due to poor maintenance of wells and pipelines can be monitored and remedied; (4) risk assessment should be based on both hazard and exposure evaluation; (5) while the concentrations of frac fluid chemicals are low, some are known carcinogens; therefore, thorough, well-designed studies are needed to assess the risk to human health with high certainty; (6) HF can represent a health risk via long-lasting contamination of soil and water, when strict safety measures are not rigorously applied."

McGranahan, D.A. & Kirkman, K.P. 2019. Local perceptions of hydraulic fracturing ahead of exploratory drilling in Eastern South Africa. *Environ Manage*. 2019 Mar;63(3):338-351. doi: 10.1007/s00267-019-01138-x. Epub 2019 Feb 2.
"Applications for exploratory shale gas development via hydraulic fracturing (fracking) have raised concern about energy development impacts in South Africa. Initially, focus was on the arid Karoo, but interest now includes KwaZulu-Natal, a populous, agricultural province with high cultural, ecological, and economic diversity. We conducted focus groups and an online survey to determine how some South Africans perceive fracking. Focus group participants were unanimous in their opposition, primarily citing concerns over water quality and rural way-of-life. The survey confirmed broad consistency with focus group responses. When asked which provinces might be affected by fracking, KwaZulu-Natal ranked behind provinces in the Karoo, suggesting an awareness bias towards Karoo projects. Frequently-identified concerns regarding Agriculture and Natural Resources were Reduced

quality of water, Negative impacts to ecosystems and natural biodiversity, Reduced quantity of water, and Pollution hazards. Frequent concerns regarding Social, Cultural, and Local Community issues were Impacts to human health, Visual/aesthetic degradation of tourism areas, Degradation of local infrastructure, and Physical degradation of tourism sites. Most survey respondents were pessimistic about potential benefits of fracking to South Africa's domestic energy supply, and did not agree fracking would reduce negative impacts of coal mining or create jobs. Survey respondents were pessimistic about government's preparedness for fracking and agreed fracking created opportunity for corruption. Many respondents agreed they would consider fracking when voting, and identified needs for more research on fracking in South Africa, which focused heavily on environmental impacts, especially water, in addition to the welfare of local citizens and their communities."

Issues Around the Impact of Hydraulic Fracturing

The following issues and resultant impact of hydraulic fracturing have been raised:

Water Use

It was estimated by the US Environmental Protection Agency (EPA) in 2010 that 70 to 140 billion (US) gallons of water is used annually to fracture 35 000 wells in the United States each year. This is approximately the annual water consumption of 40 to 80 cities each with a population of 50 000.

The extraction of so much water for fracking has raised concerns about the ecological impacts to aquatic resources, as well as dewatering of drinking water aquifers. It has been estimated that the transportation of seven to nineteen million litres of water (fresh or waste water) requires 1 400 truck trips. Thus, not only does water used for hydraulic fracturing deplete fresh water supplies and impact aquatic habitat, the transportation of so much water also creates localised air quality, safety and road repair issues.

The UN Environment Programme classifies more than 90% of South Africa as arid, semi-arid or sub-humid. South Africa's National Botanical Institute is currently drawing up a report for the government to give some indication of the extent of land degradation across the country; this report suggests that land in 25% of magisterial districts in South Africa is already severely degraded (Environmental Monitoring Group).

Land degradation is more than just an environmental problem in rural areas – it is also one of the causes of migration to the cities, resulting in overcrowding and unemployment. It is therefore a social problem which affects us all, and must be tackled before many people's aspirations of a better life can be met.

Sand and Proppants

Conventional oil and gas wells use, on average, 140 000kg of proppant (a solid material, typically treated sand or man-made ceramic materials, designed to keep an induced hydraulic fracture open, during or following a fracturing treatment) and shale gas wells can use more than 2 million kilograms of proppant per well. 'Frac sand mines' are springing up across the country in the US, from Wisconsin to Texas, bringing with them their own set of impacts. Mining sand for proppant use generates its own range of impacts, including water consumption and air emissions, as well as potential health problems related to crystalline silica (a known carcinogen).

Toxic Chemicals
In addition to large volumes of water, a variety of chemicals are used in hydraulic fracturing fluids. The oil and gas industry and trade groups are quick to point out that chemicals typically make up just 0.5 and 2.0% of the total volume of the fracturing fluid. When millions of litres of water are being used, however, the amount of chemicals per fracking operation is very large. For example, a fifteen million litre fracturing operation would use from 80 to 330 tons of chemicals.

Many fracturing fluid chemicals are known to be toxic to humans and wildlife, and several are known to cause cancer. Potentially toxic substances include petroleum distillates such as kerosene and diesel fuel (which contain benzene, ethylbenzene, toluene, xylene, naphthalene and other chemicals); polycyclic aromatic hydrocarbons; methanol; formaldehyde; ethylene glycol; glycol ethers; hydrochloric acid; and sodium hydroxide.

Very small quantities of some fracking chemicals are capable of contaminating millions of litres of water. According to the US Environmental Working Group, petroleum-based products known as petroleum distillates such as kerosene (also known as hydrotreated light distillates, mineral spirits, and a petroleum distillate blends) are likely to contain benzene, a known human carcinogen that is toxic in water at levels greater than five parts per billion (or 0.005 parts per million).

Chen, H. & Carter, K.E. 2017.
"Hydraulic fracturing, coupled with the advances in horizontal drilling, has been used for recovering oil and natural gas from shale formations and has aided in increasing the production of these energy resources. The large volumes of hydraulic fracturing fluids used in this technology contain chemical additives, which may be toxic organics or produce toxic degradation byproducts. This paper investigated the chemicals introduced into the hydraulic fracturing fluids for completed wells located in Pennsylvania and West Virginia from data provided by the well operators. The results showed a total of 5071 wells, with average water volumes of 5,383,743 ± 2,789,077 gal (mean ± standard deviation). A total of 517 chemicals was introduced into the formulated hydraulic fracturing fluids. Of the 517 chemicals listed by the operators, 96 were inorganic compounds, 358 chemicals were organic species, and the remaining 63 cannot be identified. Many toxic organics were used in the hydraulic fracturing fluids. Some of them are carcinogenic, including formaldehyde, naphthalene, and acrylamide. The degradation of alkylphenol ethoxylates would produce more toxic, persistent, and estrogenic intermediates. Acrylamide monomer as a primary degradation intermediate of polyacrylamides is carcinogenic."

Surface Water and Soil Contamination
Spills of fracturing chemicals and wastes during transportation, fracturing operations and waste disposal have contaminated soil and surface waters. In 2013, 41 spills impacted surface water in the state of Colorado alone. These spills related to hydraulic fracturing have led to major environmental impacts.

Hanson, A.J., Luek, J.L., Tummings, S.S., McLaughlin, M.C., Blotevogel, J. & Mouser, P.J. 2019.
"Hydraulic fracturing fluids are injected into unconventional oil and gas systems to stimulate hydrocarbon production, returning to the surface in flowback and produced waters containing a complex mixture of xenobiotic additives and geogenic compounds. Nonionic polyethoxylates are commonly added surfactants that act as weatherizers, emulsifiers, wetting agents, and corrosion inhibitors in hydraulic fracturing fluid formulations. Understanding the biodegradability of these ubiquitous additives is critical for produced water pre-treatment prior to reuse and for improving

treatment trains for external beneficial reuse. The objective of this study was to determine the effect of produced water total dissolved solids (TDS) from an unconventional natural gas well on the aerobic biodegradation of alkyl ethoxylate and nonylphenol ethoxylate surfactants. Changes in surfactant concentrations, speciation and metabolites, as well as microbial community composition and activity were quantified over a 75-day aerobic incubation period. Alkyl ethoxylates (AEOs) were degraded faster than nonylphenol ethoxylates (NPEOs), and both compound classes and bulk organic carbon biodegraded slower in TDS treatments ($10\ g\ L^{-1}$, $40\ g\ L^{-1}$) as compared to controls. Short-chain ethoxylates were more rapidly biodegraded than longer-chain ethoxylates, and changes in the relative abundance of metabolites including acetone, alcohols, and carboxylate and aldehyde intermediates of alkyl units indicated metabolic pathways may shift in the presence of higher produced water TDS. Our key finding that polyethoxylated alcohol surfactant additives are less labile at high TDS has important implications for produced water management, as these fluids are increasingly recycled for beneficial reuse in hydraulic fracturing fluids and other purposes."

Sun, Y., Wang, D., Tsang, D.C.W., Wang, L., Ok, Y.S. & Feng, Y. 2019.
"Shale gas extraction via horizontal drilling and hydraulic fracturing (HF) has enhanced gas production worldwide, which has altered global energy markets and reduced the prices of natural gas and oil. Water management has become the most challenging issue of HF, as it demands vast amounts of freshwater and generates high volumes of complex liquid wastes contaminated by diverse potentially toxic elements at variable rates. This critical review focuses on characterizing HF wastewater and establishing strategies to mitigate environmental impacts. High prioritization was given to the constituents with mean concentrations over 10 times greater than the maximum contamination level (MCL) guidelines for drinking water. A number of potentially harmful organic compounds in HF wastewaters were identified via the risk quotient approach to predict the associated toxicity for freshwater organisms in recipient surface waters. Currently, two options for HF wastewater treatment are preferred, i.e., disposal by deep well injection or on-site re-use as a fracturing fluid. Supplementary treatment will be enforced by increasingly rigorous regulations. Partial treatment and reuse remain the preferred method for managing HF wastewater where feasible. Otherwise, advanced technologies such as membrane separation/distillation, forward osmosis, mechanical vapor compression, electrocoagulation, advanced oxidation, and adsorption-biological treatment will be required to satisfy the sustainable requirements for reuse or surface discharge."

<u>Air Quality</u>
In many oil and gas producing regions in the United States, there has been a degradation of air quality as drilling increases. For example, in Texas, high levels of benzene have been measured in the air near wells in the Barnett Shale gas fields. These volatile air toxics may be originating from a variety of gas-field source such as separators, dehydrators, condensers, compressors, chemical spills, and leaking pipes and valves. Increasingly, research is being conducted on the potential air emissions released during the fracturing flow back stage, when wastewater returns to the surface.

Shales contain numerous organic hydrocarbons, and additional chemicals are injected underground during shale gas drilling, well stimulation (e.g., hydraulic fracturing), and well work-overs.

Air quality is already a major concern in South Africa. Additional air pollution, especially in areas with little or no air pollution, like the Karoo, will exacerbate the situation:

According to the <u>State of Air in South Africa Report</u> (2013):

- South African air quality, especially in dense urban-industrial areas, remains a national cause for concern
- The fact that particulate matter annual ambient levels are in the vicinity of the minimum quality level, let alone above this level, i.e. in the red zone, is a real cause for concern
- It is clear that continued and increased national, provincial, and local action is required in order to meet the Presidential Outcome 10 Target of Compliance with regard to environmental assets and natural resources by 2020 (http://www.thepresidency.gov.za/dpme/docs/outcome10.pdf)
- Further, this shows that in air pollution 'hotspots', members of the public do not enjoy their constitutional right to air that is not harmful to their health and well-being
- It is evident that continuous effort to clean up the air is required.

Purvis, R.M., Lewis, A.C., Hopkins, J.R., Wilde, S.E., Dunmore, R.E., Allen G., Pitt, J. & Ward, R.S. 2019.
"Rural observations of air quality and meteorological parameters (NO_x, O_3, NMHCs, SO_2, PM) were made over a 2.5-year period (2016-2018) before, during and after preparations for hydraulic fracturing (fracking) at a shale gas exploration site near Kirby Misperton, North Yorkshire, England. As one of the first sites to apply for permits to carry out hydraulic fracturing, it has been subject to extensive regulatory and public scrutiny, as well as the focus for a major programme of long-term environmental monitoring. A baseline period of air quality monitoring (starting 2016) established the annual climatology of atmospheric composition against which a 20-week period of intensive activity on the site in preparation for hydraulic fracturing could be compared. During this 'pre-operational phase' of work in late 2017, the most significant effect was an increase in ambient NO (3-fold) and NO_x (2-fold), arising from a combination of increased vehicle activity and operation of equipment on site. Although ambient NO_x increased, air quality limit values for NO_2 were not exceeded, even close to the well-site. Local ozone concentrations during the pre-operational period were slightly lower than the baseline phase due to titration with primary emitted NO. The activity on site did not lead to significant changes in airborne particulate matter or non-methane hydrocarbons. Hydraulic fracturing of the well did not subsequently take place and the on-site equipment was decommissioned and removed. Air quality parameters then returned to the original (baseline) climatological conditions. This work highlights the need to characterise the full annual climatology of air quality parameters against which short-term local activity changes can be compared. Based on this study, changes to ambient NO_x appear to be the most significant air quality ahead of hydraulic fracturing. However, in rural locations, concentrations at individual sites are expected to be below ambient air quality limit thresholds."

Xy, Y., Saija, M. & Kumar, A. 2019.
"According to the United States Environmental Protection Agency (U.S. EPA), exposure to radon gas is the second leading cause of lung cancer after smoking. Extant research that has reported that fracking activity increases the radon levels. "Fracking" also known as hydraulic fracturing, which is a technology that is used to extract naturally occurring shale gas from the Marcellus and the Utica shales. Based on the data from the Ohio Radon Information System (ORIS) from 2007 to 2014 in Ohio, this research uses multilevel modeling (MLM) to examine the association between the incidences of hydraulic fracturing and elevated airborne radon levels. The ORIS data include information on 118,421 individual records of households geocoded to zip code areas. Individual records include radon concentrations, device types of the test, and seasons. Euclidean distances between zip code centroid to the 1,162 fracking wells are measured at the zip code level. Two additional zip code variables, namely the population density and urbanicity, are also included as control variables. Multilevel modeling results show that at the zip code level, distance to fracking wells and population density are significant and negative covariate of the radon concentration. By comparing with urban areas, urban clusters, and rural areas are significant which linked to higher radon concentrations. These findings

lend support to the effect of hydraulic fracturing in influencing radon concentrations, and promote public policies that need to be geographically adaptable."

Waste Disposal

It has been reported that anywhere from 25% to 100% of the chemical-laced hydraulic fracturing fluids return to the surface from Marcellus Shale operations. This means that for some shale gas wells, millions of litres of wastewater are generated, and require either treatment for re-use, or disposal. As the industry expands, the volume of waste generated is also increasing rapidly. Between 2010 and 2011 in Pennsylvania (US), it went up by 70% to reach more than 2,3billion litres. The sheer volume of wastes, combined with high concentrations of certain chemicals in the flow-back from fracturing operations, are posing major waste management challenges for the Marcellus Shale states.

The management of domestic waste in South Africa currently faces many real challenges. In terms of the South African Constitution (Act No. 108 of 1996), waste management service delivery is a local government function. The current status of waste management in South Africa is, therefore, an indication of how well municipalities succeed in performing this function.

Recent initiatives aimed at identifying the challenges experienced by municipalities, identified four broad themes of obstacles to effective waste management, namely financial management, equipment management, labour (staff) management, and institutional behaviour (management and planning). It was noted that these challenges are often symptoms of a number of underlying and inter-related root causes that need to be addressed first. Many of these underlying causes are also often outside of the mandate or control of local government and as such, require close cooperation between local, provincial and national government. The picture is much more bleak when toxic waste is included. As far as toxic and medical waste is concerned, the problems are far more involved and complicated.

Chemical Disclosure

One potentially frustrating issue for surface owners where fracking is implemented, is that it has not been easy to find out what chemicals are being used during the hydraulic fracturing operations in their neighbourhood. To obtain chemical compositions of hydraulic fracturing fluids is usually largely unsuccessful because oil and gas companies refused to reveal this 'proprietary information'.

Endocrine-disrupting activity linked to birth defects, infertility found near drilling sites

The controversial oil and natural gas drilling technique called hydraulic fracturing, or fracking, uses many chemicals that can disrupt the body's hormones, according to new research accepted for publication in The Endocrine Society's journal *Endocrinology.*

Endocrine-disrupting chemicals, or EDCs, are substances that can interfere with the normal functioning of the endocrine system. EDCs can be found in manufactured products as well as certain foods, air, water and soil. Research has linked EDC exposure to infertility, cancer and birth defects.

"More than 700 chemicals are used in the fracking process, and many of them disturb hormone function," said one of the study's authors, Susan C. Nagel, PhD, of the University of Missouri School of Medicine. "With fracking on the rise, populations may face greater health risks from increased endocrine-disrupting chemical exposure."

The study examined 12 suspected or known endocrine-disrupting chemicals used in natural gas operations and measured their ability to mimic or block the effect of the body's male and female reproductive hormones. To gauge endocrine-disrupting activity from natural gas operations, researchers took surface and ground water samples from sites with drilling spills or accidents in a drilling-dense area of Garfield County, CO – an area with more than 10,000 active natural gas wells – and from drilling-sparse control sites without spills in Garfield County as well as Boone County, MO.

The water samples from drilling sites had higher levels of EDC activity that could interfere with the body's response to androgens, a class of hormones that includes testosterone, as well as the reproductive hormone estrogen. Drilling site water samples had moderate to high levels of EDC activity, and samples from the Colorado River – the drainage basin for the natural gas drilling sites – had moderate levels. In comparison, little activity was measured in the water samples from the sites with little drilling.

"Fracking is exempt from federal regulations to protect water quality, but spills associated with natural gas drilling can contaminate surface, ground and drinking water," Nagel said. "We found more endocrine-disrupting activity in the water close to drilling locations that had experienced spills than at control sites. This could raise the risk of reproductive, metabolic, neurological and other diseases, especially in children who are exposed to EDCs."

Tachachartvanich, P., Azhagiya Singam, E.R., Durkin, K.A., Smith, M.T. & La Merrill, M.A. 2020.
"Hydraulic fracturing (HF) technology is increasingly utilized for oil and gas extraction operations. The widespread use of HF has led to concerns of negative impacts on both the environment and human health. Indeed, the potential endocrine disrupting impacts of HF chemicals is one such knowledge gap. Herein, we used structure-based molecular docking to assess the binding affinities of 60 HF chemicals to the human androgen receptor (AR). Five HF chemicals had relatively high predicted AR binding affinity, suggesting the potential for endocrine disruption. We next assessed androgenic and antiandrogenic activities of these chemicals in vitro. Of the five candidate AR ligands, only Genapol®X-100 significantly modified AR transactivation. To better understand the structural effect of Genapol®X-100 on the potency of AR inhibition, we compared the antiandrogenic activity of Genapol®X-100 with that of its structurally similar chemical, Genapol®X-080. Interestingly, both Genapol®X-100 and Genapol®X-080 elicited an antagonistic effect at AR with 20% relative inhibitory concentrations of 0.43 and 0.89 µM, respectively. Furthermore, we investigated the mechanism of AR inhibition of these two chemicals in vitro, and found that both Genapol®X-100 and Genapol®X-080 inhibited AR through a noncompetitive mechanism. The effect of these two chemicals on the expression of AR responsive genes, e.g. PSA, KLK2, and AR, was also investigated. Genapol®X-100 and Genapol®X-080 altered the expression of these genes. Our findings heighten awareness of endocrine disruption by HF chemicals and provide evidence that noncompetitive antiandrogenic Genapol®X-100 could cause adverse endocrine health effects."

Natural Gas Drilling and Hydraulic Fracturing Chemicals with 10 or more Health Effects
The following chemicals used in hydraulic fracturing are known to each have ten or more health effects:

2,2',2"-Nitrilotriethanol
2-Ethylhexanol
5-Chloro-2-methyl-4-isothiazolin-3-one
Acetic acid
Acrolein
Acrylamide (2-propenamide)
Acrylic acid
Ammonia
Ammonium chloride
Ammonium nitrate
Aniline

Benzyl chloride
Boric acid
Cadmium
Calcium hypochlorite
Chlorine
Chlorine dioxide
Dibromoacetonitrile 1
Diesel 2
Diethanolamine
Diethylenetriamine
Dimethyl formamide
Epidian
Ethanol (acetylenic alcohol)
Ethyl mercaptan
Ethylbenzene
Ethylene glycol
Ethylene glycol monobutyl ether (2-BE)
Ethylene oxide
Ferrous sulfate
Formaldehyde
Formic acid
Fuel oil #2
Glutaraldehyde
Glyoxal
Hydrodesulfurized kerosene
Hydrogen sulfide
Iron
Isobutyl alcohol (2-methyl-1-propanol)
Isopropanol (propan-2-ol)
Kerosene
Light naphthenic distillates, hydrotreated
Mercaptoacidic acid
Methanol
Methylene bis(thiocyanate)
Monoethanolamine
NaHCO3
Naphtha, petroleum medium aliphatic
Naphthalene
Natural gas condensates
Nickel sulfate
Paraformaldehyde
Petroleum distillate naptha
Petroleum distillate/ naphtha
Phosphonium, tetrakis(hydroxymethyl)-sulfate
Propane-1,2-diol
Sodium bromate
Sodium chlorite (chlorous acid, sodium salt)
Sodium hypochlorite
Sodium nitrate
Sodium nitrite
Sodium sulfite
Styrene
Sulfur dioxide
Sulfuric acid
Tetrahydro-3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione (Dazomet)
Titanium dioxide
Tributyl phosphate
Triethylene glycol
Urea
Xylene

(EarthWorksAction).

Fracking in the United States of America

In the United States, fracking has prompted the largest environmental movement in decades and several states have banned, or are considering banning it. A huge list of celebrities are on board - such as actors Matt Damon, who starred in the fracking film '*Promised Land*', and Alec Baldwin.

The picture below shows a typical scene in preparation for fracking at a new fracking site in the United States with hundreds of tanker trucks converging on the fracking site loaded with millions of litres of water and fracking fluid.

The state of Colorado introduced new fracking-fluid disclosure rules, the most comprehensive in the United States which is said to be the product of days of 'shuttle diplomacy', last-minute compromises and phone calls from the Governor of Colorado.

[Picture Credit: Fracking 2]

The rule, unanimously approved by the Colorado Oil and Gas Conservation Commission, requires drillers to disclose all the chemicals in hydraulic fracturing and their concentrations. No other state requires such a detailed disclosure, according to the Groundwater Protection Council, a national association of state water agencies.

Key requirements in Colorado's new fracking-fluid disclosure rules, adopted by the state Oil and Gas Conservation Commission include:

- Filing within 60 days of the fracking job a list of all the chemicals and their concentrations in the fracking fluid.
- The list is to be filed with FracFocus.org, a publicly accessible independent Internet database.
- Filing with the commission for any proprietary chemical a company does not want to disclose, claiming under penalty of perjury that the chemical is a trade secret.
- Filing the chemical family of any trade-secret chemical and its concentration as part of the disclosure form.
- Sending background information on fracking to property owners near wells awarded drilling permits, including details on how to have a baseline well-water test done.

New York Bans Hydraulic Fracturing

New York State will ban hydraulic fracturing after a long-awaited report concluded that the oil and gas extraction method poses health risks, Governor Andrew Cuomo's administration said on Wednesday.

New York Environmental Commissioner Joseph Martens said at a cabinet meeting he will issue an order early in 2015 banning fracking, which has been under a moratorium since 2008. Once that happens, New York will join Vermont as the only states to completely prohibit fracking. The decision ends what has been a fierce debate in New York over the benefits and pitfalls of fracking, a process that involves pumping water, sand and chemicals into a well to extract oil or gas. Many in the state saw gas drilling as a key economic resource while others argued it was too dangerous.

The state's health commissioner, Howard Zucker, said there is not enough scientific information to conclude that fracking is safe. "The potential risks are too great, in fact not even fully known, and relying on the limited data presently available would be negligent on my part", Zucker said.

New York sits atop a portion of the Marcellus shale, one of the largest natural gas deposits in the United States. The ruling is a blow for energy companies that had been waiting for years to tap the thousands of acres of land they have leased there.

The oil and gas industry immediately slammed Cuomo for the decision. Karen Moreau, the executive director of the New York State Petroleum Council, called it a reckless move that would deprive the state of thousands of jobs and hundreds of millions of dollars in revenue.

"We are resolved to continue to fight for these benefits in New York," she said. Environmental groups, meanwhile, hailed Cuomo as a national leader on the issue. "We hope that this determined leadership Governor Cuomo has displayed will give courage to elected leaders throughout the country and world," said Deborah Goldberg, an attorney with the group Earthjustice.

Cuomo, answering questions from journalists, said the decision on whether to allow this kind of drilling in New York was ultimately up to Martens. He said it was "probably the most emotionally charged issue I have ever experienced," more than gay marriage, gun control or the death penalty.

Watch a Youtube Animation of Hydraulic Fracturing (Fracking)
A Youtube animation of hydraulic fracturing can be viewed at the following URL:
http://www.youtube.com/watch?v=VY34PQUiwOQ

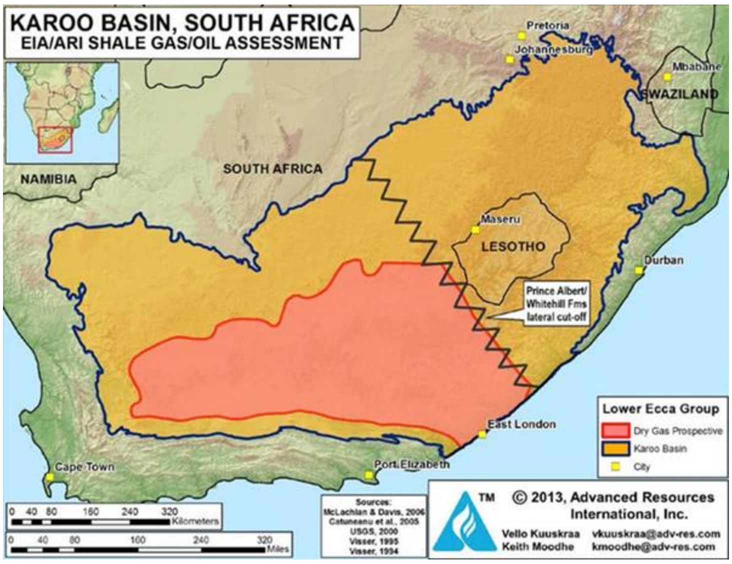
Fracking in the United Kingdom
No fracking has of yet been conducted in the UK but exploration wells have been drilled in Lancashire where the biggest shale gas deposits are estimated to be. But it is not just in Lancashire - according to Greenpeace shale gas deposits in several sites in Croydon and South London are being looked at.

Watterson, A. & Dinan, W. 2018.
"Unconventional oil and gas extraction (UOGE) including fracking for shale gas is underway in North America on a large scale, and in Australia and some other countries. It is viewed as a major source of global energy needs by proponents. Critics consider fracking and UOGE an immediate and long-term threat to global, national, and regional public health and climate. Rarely have governments brought together relatively detailed assessments of direct and indirect public health risks associated with fracking and weighed these against potential benefits to inform a national debate on whether to pursue this energy route. The Scottish government has now done so in a wide-ranging consultation underpinned by a variety of reports on unconventional gas extraction including fracking. This paper analyses the Scottish government approach from inception to conclusion, and from procedures to outcomes. The reports commissioned by the Scottish government include a comprehensive review dedicated specifically to public health as well as reports on climate change, economic impacts, transport, geology, and decommissioning. All these reports are relevant to public health, and taken together offer a comprehensive review of existing evidence. The approach is unique globally when compared with UOGE assessments conducted in the USA, Australia, Canada, and England. The review process builds a useful evidence base although it is not without flaws. The process approach, if not the content, offers a framework that may have merits globally."

Fracking in Europe
The most of Europe have, so far, said 'no' to fracking, with Poland being the exception. Big industrial countries like Germany and France have more or less ruled out fracking, with the French President Francois Hollande recently repeating his opposition to fracking, saying that it would not happen during his term. The people of Bulgaria gathered in mass to protest against fracking which prompted the government to cancel an exploration contract with ExonMobil. In Ireland five counties have passed motions for a ban on fracking.

Fracking in South Africa

South Africa lifted a ban on fracking in 2012, and further opened the door to exploitation of the resource by recently publishing regu-lations on the process, under which drillers will be required to meet American Petroleum Institute stan-dards regarding the type of equipment and chemicals they use.



[Picture Credit: Dry Gas Prospective]

It is said that the regulations include mea-sures to protect wildlife in the region as well as to safeguard water resources.

The accompanying map indicates the extent of the Karoo Basin and the identified shale gas prospective area.
(GEO Expro).

According to fin24 on 27 November 2016: If exploration for shale gas goes ahead in the Karoo, only 60 to 900 jobs will be created, and it is not going to add much value to the economy if government, as has become the “pattern” of late, simply keeps on spending the additional tax income on paying the salaries of additional government employees.

This is according to the final estimates from the CSIR research on shale gas exploration, which it carried out on the instruction of government.

Other information from the report:

- These are small numbers compared with the jobs that are currently created through agriculture and tourism in the area.
- Agriculture currently provides 38 000 jobs and contributes R5 billion a year to the economy.
- Tourism creates between 10 100 and 16 400 jobs annually and contributes R2.7 billion to the economy a year.

The report also confirms that there is not enough water in the area to extract shale gas using fracking. There is also a risk of water pollution, and it is recommended that hydraulic fracturing not be used in sensitive areas.

Added to this, the possibility of earthquakes “cannot be discounted”.

The area taken into account in the research is the part of the Karoo where there are currently five exploration applications pending – three by Shell, one by Falcon and one by Bundu.

Strategic Environmental Assessment for Shale Gas Development

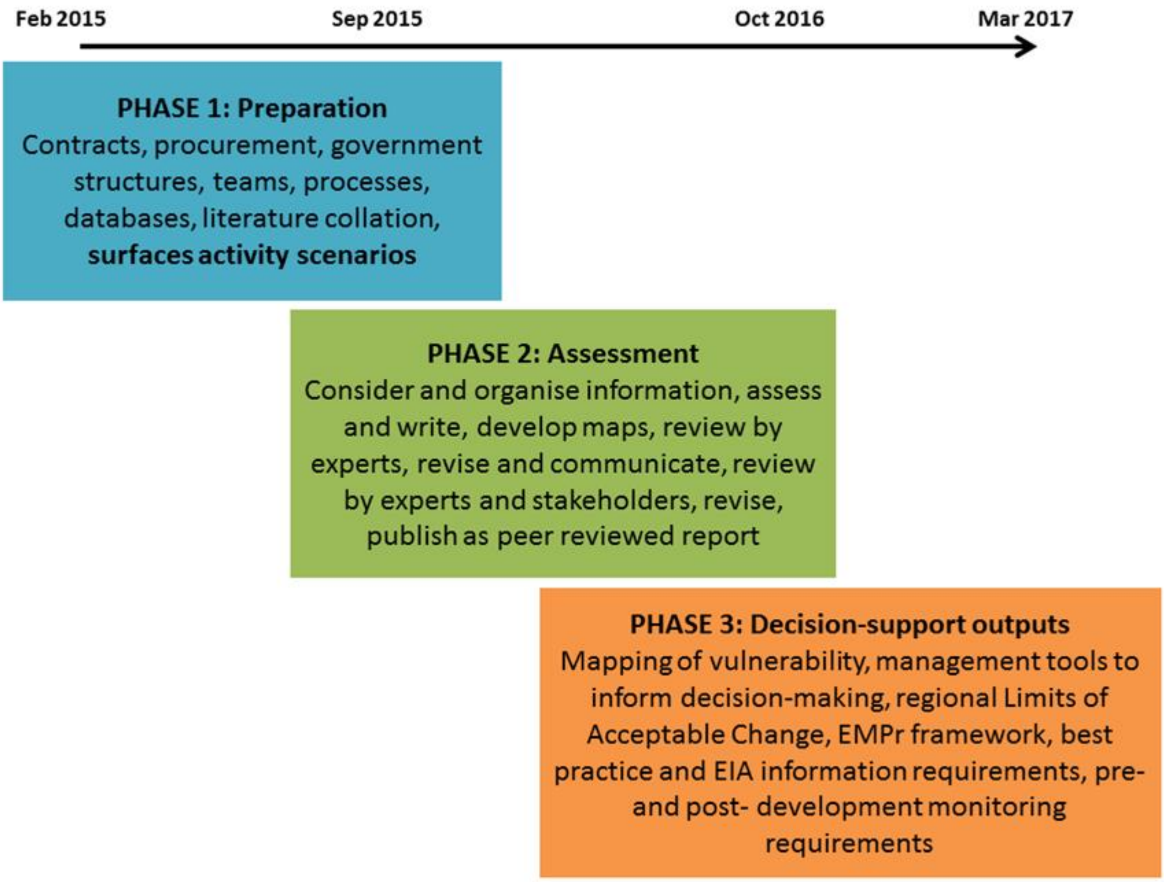
According to the Strategic Environmental Assessment (SEA) for Shale Gas Development in South Africa, the phases of the project are as follows:

Project duration:
24 Months

Project phases:
Phase 1: *The Conceptualisation and Methodology Phase*
The primary purpose of this phase of the assessment is to set-up and implement all project management structures, convene the project governance groups, recruit authors and experts to the Multi-Author Teams and release a Draft Approach Report at the end of Phase 1 for expert review. This document will also be available to the public on the website.

Phase 2: *The Scientific Assessment Phase*
This will be the component of the study where the actual scientific assessment by the Multi-Author teams for all Strategic Issues takes place. At the end of Phase 2 Draft and Final SEA reports will be released for expert and public review.

Phase 3: *The Decision-Making Framework Phase*
This phase will translate the outputs from Phase 2 into operational guidelines and decision making frameworks. It is undertaken by the Project Team (CSIR, SANBI and CGS) in close consultation with the various affected Departments. It commences with initial drafts after the delivery of the first draft of the Assessment report, and with final drafts after the delivery of the final Assessment report. The separation of the teams between phase 2 and 3 is to honour the assessment 'mantra' of being 'policy relevant, but not policy prescriptive'. The experts in Phase 2 are not being asked to make decisions about the development of shale gas. They are being asked to give an informed opinion on the consequences of different options. The decisions must be made by mandated authorities (i.e. government), who have contracted the science councils to help them in formulating the framework and content of such decisions



Water Baseline Testing

Reports of groundwater contamination have surfaced in several states across the United States of America in areas of oil and gas drilling. Unfortunately, in the absence of any pre-drilling characterisation of the drinking water, it is difficult, if not impossible, to prove that drilling operations have impacted on water quality. Baseline testing allows property owners to know exactly how clean the water is so that if water appears contaminated in the future, they can test it and compare the results to the baseline results.

Many of the compounds that are potential contaminants from the drilling process are naturally occurring in varying concentrations, and, as a result, their mere presence following oil or natural gas drilling is not proof of contamination. Without baseline testing there is no clear, scientific way to establish that the underground water was affected by the drilling and/or fracking activity.

The more one knows about the well and nearby surface water quality the better off a property owner will be at protecting his/her family and investment. Therefore, it is recommended to test a drinking well or surface waters before a natural gas or oil well is drilled in one's area.

The following guidelines may assist property owners with water baseline testing.

The key to water baseline testing is that it is conducted prior to any drilling or fracking activity so one is able to prove changes in water quality. It is essential to test for water quality prior to drilling activity to establish a water baseline quality, and at least once after drilling has been completed.

Botha, R., Lindsay, R., Newman, R.T., Maleka, P.P. & Chimba, G. 2019.
"The prospect of unconventional shale gas development in the semi-arid Karoo Basin (South Africa) has created the prerequisite to temporally characterise the natural radioactivity in associated groundwater which is solely depended on for drinking and agriculture purposes. Radon (^{222}Rn) was the primary natural radionuclide of interest in this study; however, supplementary radium (^{226}Ra and ^{228}Ra) in-water measurements were also conducted. A total of 53 aquifers spanning three provinces were studied during three separate measurement campaigns from 2014 to 2016. The Karoo Basin's natural radon-in-water levels can be characterised by a minimum of 1 ± 1 Bq/L (consistent with zero or below LLD), a maximum of 183 ± 18 Bq/L and mean of 41 ± 5 Bq/L. The mean radon-in-water levels for shallow aquifers were systematically higher (55 ± 10 Bq/L) compared to deep (14 ± 3 Bq/L) or mixed aquifers (20 ± 6 Bq/L). Radon-in-water activity concentration fluctuations were predominantly observed from shallow aquifers compared to the generally steady levels of deep aquifers. A collective seasonal mean radon-in-water levels increase from the winter of 2014 (44 ± 8 Bq/L) to winter of 2016 (61 ± 16 Bq/L) was noticed which could be related to the extreme national drought experienced in 2015. Radium-in-water (^{228}Ra and ^{226}Ra) levels ranged from below detection level to a maximum of 0.008 Bq/L (^{226}Ra) and 0.015 Bq/L (^{228}Ra). The $^{228}Ra/^{226}Ra$ ratio was characterised by a minimum of 0.93, a maximum of 6.5 and a mean value of 3.3 ± 1.3. Developing and improving baseline naturally occurring radionuclide groundwater databases is vital to study potential radiological environmental impacts attributed to industrial processes such as hydraulic fracturing or mining."

McGranahan, D.A. & Kirkman, K.P. 2019.
Applications for exploratory shale gas development via hydraulic fracturing (fracking) have raised concern about energy development impacts in South Africa. Initially, focus was on the arid Karoo, but interest now includes KwaZulu-Natal, a populous, agricultural province with high cultural, ecological, and economic diversity. We conducted focus groups and an online survey to determine how some South Africans perceive fracking. Focus group participants were unanimous in their opposition, primarily citing concerns over water quality and rural way-of-life. The survey confirmed broad consistency with focus group responses. When asked which provinces might be affected by fracking, KwaZulu-Natal ranked behind provinces in the Karoo, suggesting an awareness bias towards Karoo projects. Frequently-identified concerns regarding Agriculture and Natural Resources were Reduced quality of water, Negative impacts to ecosystems and natural biodiversity, Reduced quantity of water, and Pollution hazards. Frequent concerns regarding Social, Cultural, and Local Community issues were Impacts to human health, Visual/aesthetic degradation of tourism areas, Degradation of local infrastructure, and Physical degradation of tourism sites. Most survey respondents were pessimistic about potential benefits of fracking to South Africa's domestic energy supply, and did not agree fracking would reduce negative impacts of coal mining or create jobs. Survey respondents were pessimistic about government's preparedness for fracking and agreed fracking created opportunity for corruption. Many respondents agreed they would consider fracking when voting, and identified needs for more research on fracking in South Africa, which focused heavily on environmental impacts, especially water, in addition to the welfare of local citizens and their communities.

Before Drilling Activity:
The optimal time to conduct baseline sampling is before companies conduct seismic testing near one's property. Seismic testing involves the use of either trucks or explosives to create vibrations that are read with instruments to map underground rock formations. These vibrations could, in rare instances, mobilise and introduce sediment to a nearby water supply or change water flow.

Water baseline testing should also be conducted prior to commencement of drilling and/or hydraulic fracturing (fracking).

Post-drilling:
Post-drilling water quality testing should be done within 6 months of completion of drilling and hydraulic fracturing.

- Property owners may wish to conduct post drilling sampling annually after fracking of a well in the area.
- Subsequent screening using general parameters such as pH, specific conductance, total dissolved solids (TDS), or dissolved methane can be a less expensive way to monitor into the future to see if changes occur.

If a change in water quality is noted or a problem is suspected:

- If there is a change in concentration or occurrence of parameters tested, conduct further more sophisticated testing.
- If one notices changes in the water quality or quantity, the Department of Mineral Resources should be contacted immediately. The gas drilling company should also be informed immediately. Some obvious changes to the water supply include:
    - Changes in the appearance such as sediment, foaming, bubbling or spurting faucets
    - Changes in drinking water taste including salty or metallic tastes
    - Changes in water odour such as a rotten egg odour, fuel or oily smell
    - Reduction or loss of water quantity

It is important to note that water quality will vary naturally due in part to season, rainfall, and local geology. Multiple water tests, both before and after drilling and/or fracking, will help to clarify the difference between contamination events and natural variability.
(Watershed Council; ALS).

Regulations for Petroleum Exploration and Production
The Regulations for Petroleum Exploration and Production (hydraulic fracturing) was published in Government Gazette No 38855 of 3 June 2015.

DEPARTMENT OF MINERAL RESOURCES

No. R. 466 3 June 2015

MINERAL AND PETROLEUM RESOURCES DEVELOPENT ACDT, 2002 (ACT No 28 of 2002)

REGULATIONS FOR PETROLEUM EXPLORATION AND PRODUCTION

The Minister of Mineral Resources, under section 107 of the Mineral and Petroleum Resources Development Act, 2002, (Act No. 28 of 2002), read with the provisions of section 14 of the Interpretation Act, 1957 (Act No. 33 of 1957) made the regulations as arranged in the Schedule.

ADV. NGOAKO ABEL RAMATLHODI
MINISTER OF MINERAL RESOURCES

A copy of the applicable Government Gazette is available by visiting the following URL:

http://www.gov.za/sites/www.gov.za/files/38855_rg10444_gon466.pdf

CANSA's Position
CANSA firmly believes that:

- it (CANSA) cannot recommend and/or support the approval of hydraulic fracturing as a mining technology in South Africa before the safety, feasibility and acceptability of the technology to be used has been adequately determined under South African conditions.

- there is sufficient scientific evidence to indicate that fracking fluid contains carcinogens (cancer causing agents) like formaldehyde, benzene, Crystalline silica, diesel fuel, ethylbenzene, toluene, xylene, and possibly other carcinogens as well.

- the South African public and environment should be protected against any form of possible environmental pollution and contamination by carcinogens and/or any other harmful chemicals resulting from fracking to prevent any possible increase in the incidence of additional cases of cancer and/or other health rpblems resulting from hydraulic fracturing (fracking).

- because water quality may vary naturally due in part to season, rainfall, and local geology, multiple water sample tests, both before and after drilling, should be conducted to help to clarify the difference between contamination events and natural variability.

- costs towards water baseline testing as well as post-drilling testing of water should be for the account of the applicable licenced fracking company.

- fracking rules, similar to that of the state of Colorado in the United States, should be introduced in South Africa as a matter of urgency. These rules should include at least the following:

- filing before commencement of fracking, a list of all the chemicals and their concentrations that will be used in the fracking fluid
- the list is to be filed on a publicly accessible independent Internet database. The Cancer Association of South Africa (CANSA) has already made its website available for this purpose. The website can be sourced at www.cansa.org.za
- filing with the Department of Mineral Resources of any proprietary chemical a company does not want to disclose, claiming under penalty of perjury that the chemical is a trade secret that may have any harmful or damaging effect on the health of humans, animals and/or the environment
- filing the chemical family of any trade-secret chemical and its concentration as part of the disclosure
- sending background information on fracking to property owners near wells awarded drilling permits, including details on how to have a baseline well-water test done as well as post-drilling water testing

- underground and surface water should be tested before drilling and/or fracking takes place in order to establish a baseline. The following tests should ideally be included:

- Acidity, Alkalinity (Total as $CaCO_3$), Specific Conductance, pH, Hardness (Total as $CaCO_3$)

- Metals: Aluminium (classified as a Group I carcinogen by IARC), Arsenic (classified as a Group I carcinogen by IARC), Barium, Beryllium, Boron, Cadmium (classified as a Group I carcinogen by IARC), Calcium, Chromium (classified as a Group I carcinogen by IARC), Cobalt (classified as a Group 2A carcinogen by IARC), Copper, Iron – Dissolved & Total, Lead (classified as a Group 2A carcinogen by IARC), Lithium, Magnesium, Manganese, Mercury, Molybdenum, Nickel (classified as a Group I carcinogen by IARC), Selenium, Silver, Sodium, Strontium, Thorium, Uranium, Zinc
  - Acetic acids
  - Ammonia Nitrogen
  - Benzene (classified as a Group I carcinogen by IARC)
  - Biochemical Oxygen Demand, Chemical Oxygen Demand
  - Boric acids
  - Bromide
  - Chloride
  - Citric acids
  - Ethylene Glycol
  - Formaldehyde (classified as a Group I carcinogen by IARC)
  - Gross Alpha
  - Gross Beta
  - Methylene Blue Active Substances - MBAS (Surfactants)
  - Nitrite-Nitrate Nitrogen, and TKN
  - Oil & Grease
  - Phenolics (Total)
  - Radium 226 (classified as a Group I carcinogen by IARC)
  - Radium 228 (classified as a Group I carcinogen by IARC)
  - Sulphate
  - Toluene (classified as a Group 2B carcinogen by IARC)
  - Total Dissolved Solids
  - Total Suspended Solids

- underground and surface water should be tested following fracking (post-drilling) at least every two years for a period of at least 6 years. Post-drilling testing of water should ideally include testing for the same substances as described above.

CANSA further believes that:

- everyone has the right, as enshrined in the Constitution, to an environment that is not harmful to their health or well-being; and to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

- no amount of legislation, monitoring or enforcement will promote sustainable development if the development is at odds with the environment in which it is taking place (Constitution of the Republic of South Africa, 1996 (Section 24); ALS; Record On Line; Natural Society; Business Insider).

Medical Disclaimer

This Fact Sheet and Position Statement is intended to provide general information only and, as such, should not be considered as a substitute for advice, medically or otherwise, covering any specific situation. Users should seek appropriate advice before taking or refraining from taking any action in reliance on any information contained in this Fact Sheet and Position Statement. So far as permissible by law, the Cancer Association of South Africa (CANSA) does not accept any liability to any person (or his/her dependants/estate/heirs) relating to the use of any information contained in this Fact Sheet and Position Statement.

Whilst CANSA has taken every precaution in compiling this Fact Sheet and Position Statement, neither it, nor any contributor(s) to this Fact Sheet and Position Statement can be held responsible for any action (or the lack thereof) taken by any person or organisation wherever they shall be based, as a result, direct or otherwise, of information contained in, or accessed through, this Fact Sheet and Position Statement.

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