TENORM Associated with Shale Gas Operations

This information sheet will cover elementary aspects of the potential problems, regulatory issues, and ultimately prevention of exposure and environmental contamination by Technologically Enhanced, Naturally Occurring Radioactive Materials (TENORM) in shale gas operations. This document is strictly an information sheet produced by the ASTSWMO Radiation Focus Group and does not constitute any position on this issue.

Naturally occurring radioactive material (**NORM)**, such as uranium (U), radium (Ra), and thorium (Th), is present in the natural environment, including surface and subsurface soils, rock, and water. NORM does emit low levels of radiation and these naturally occurring materials may present health hazards. Natural gas development targets organic rich shale formations that contain NORM and activities such as shale fracturing may elevate NORM concentrations during gas extraction. The primary radionuclide of concern in the resulting wastes is Ra-226. It is important to note that chemical wastes are also associated with shale fracturing; however, chemical wastes will not be discussed in this document.

NORM in Shale Gas Extraction

Historically, large volumes of water have been used to develop oil and gas production wells. **Produced water** may include formation water, which exists naturally with oil and gas, and injected water, which is added to the well to stimulate production. Hydraulic fracturing may also produce **flowback water**, which includes a mixture of water, sand, and chemicals injected at very high pressure to create fractures. Produced water (with oil and gas) and flowback water return to the surface during oil and gas production and may require treatment and disposal (GAO, 2012).

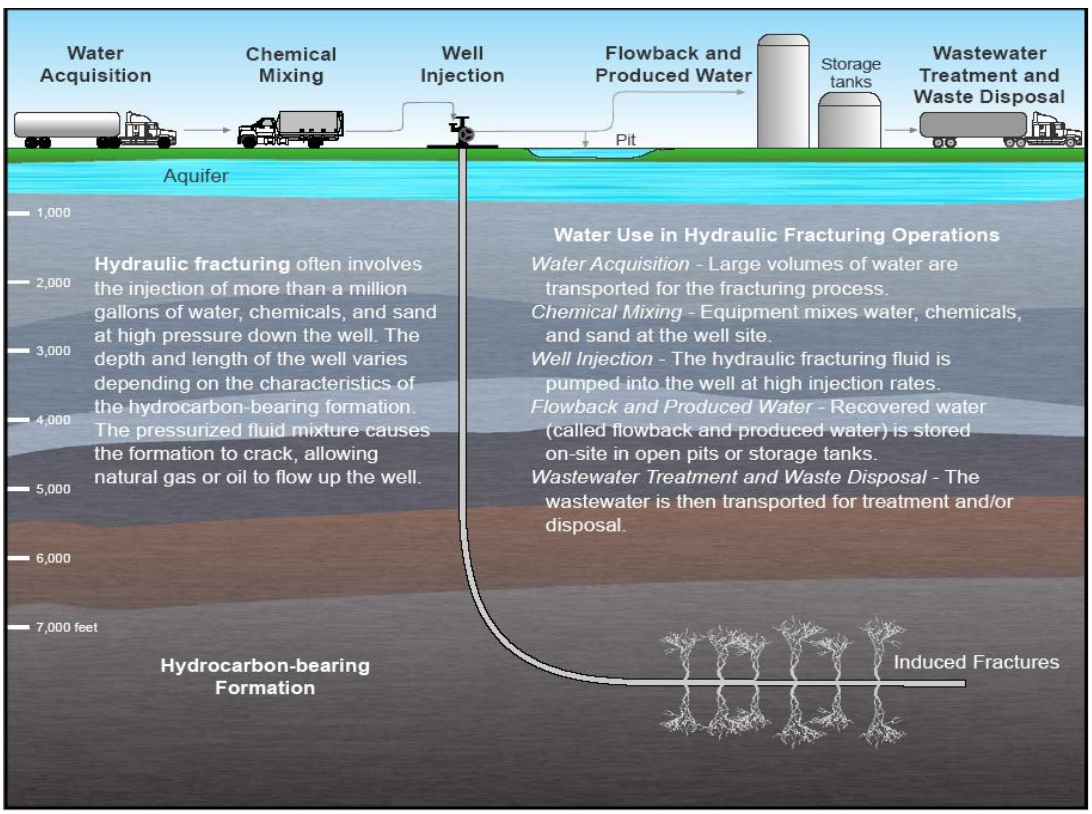


Illustration of a horizontal well showing the water life cycle of hydraulic fracturing (U.S. EPA, 2011)

Sometimes the traditional host rock formations may have high NORM levels, such as the Oriskany sandstone in the Eastern U.S. Over the past several years, hydraulic fracturing techniques have increased in oil and gas production, where high pressure water, chemicals and sand are injected into a shale rock formation to hydraulically fracture the rock. This process opens up pore space where natural methane gas has formed over the millennia and is trapped. Many of these “unconventional” shale formations have elevated levels of U and Th series NORM. Over the years the radioactive decay products in these U / Th decay chains have reached equilibrium. In particular, Ra-226 is present from the decay of U-238, and Ra-228 is present from the decay of Th-232. In fact, the gas well drillers often use a gamma ray well logging tool to determine where the highest level of radioactivity is in the shale, knowing that natural gas is likely there, too.

Radium, which is slightly soluble, can be mobilized in the liquid phases of a subsurface formation and transported to the surface in the produced water stream. As the produced water is brought to the surface, some of the dissolved radium precipitates out in solid form. Most commonly, the radium coprecipitates with barium sulfate, a hard and relatively insoluble scale deposit; however, it also can coprecipitate to form other complex sulfates and carbonates.

Managing Byproducts or Wastes

Radium that remains dissolved in solution is disposed of along with the produced water. Most produced water is disposed of by subsurface injection, and the radium content of reinjected water typically is not regulated. Radium-bearing scales and sludges, however, can pose a waste management issue if the radium content is sufficiently high. Similarly, pieces of equipment that contain residual quantities of NORM-bearing scales and sludges, as well as surface soils affected by these wastes, can present waste management issues. Because the extraction process concentrates the naturally occurring radionuclide in the form of scales and sludges, these wastes are classified as technologically enhanced naturally occurring radioactive material (TENORM).

Depending on local and State regulation, there are a number of options for disposal of solid or liquid waste containing NORM and/or TENORM. The primary factor in determining a disposal option is the concentration of radioactive materials in the waste. Depending on the concentration of TENORM, solid/sludge waste may be disposed of at municipal solid waste landfills, monofills, industrial landfills, hazardous waste landfills, uranium mill tailings impoundments, and commercial low-level radioactive waste disposal sites; however, each increasing level of protection comes with increased costs and regulatory oversight. Liquid wastes containing TENORM may be recycled through beneficial reuse or disposed of by underground injection with the appropriate permits or approvals. Other options may be available.

Always contact your local and State regulatory agency before choosing a disposal option, as additional requirements may apply depending on agency regulations, disposal facility restrictions and waste characteristics.

Health and Safety

It is important to look at environmental concerns when wastes containing NORM and TENORM are being disposed. Environmental monitoring may be necessary during the operational phase and in the post-closure phase of a facility where NORM and TENORM are disposed. When properly managed, NORM and TENORM do not pose any risk to the general public.

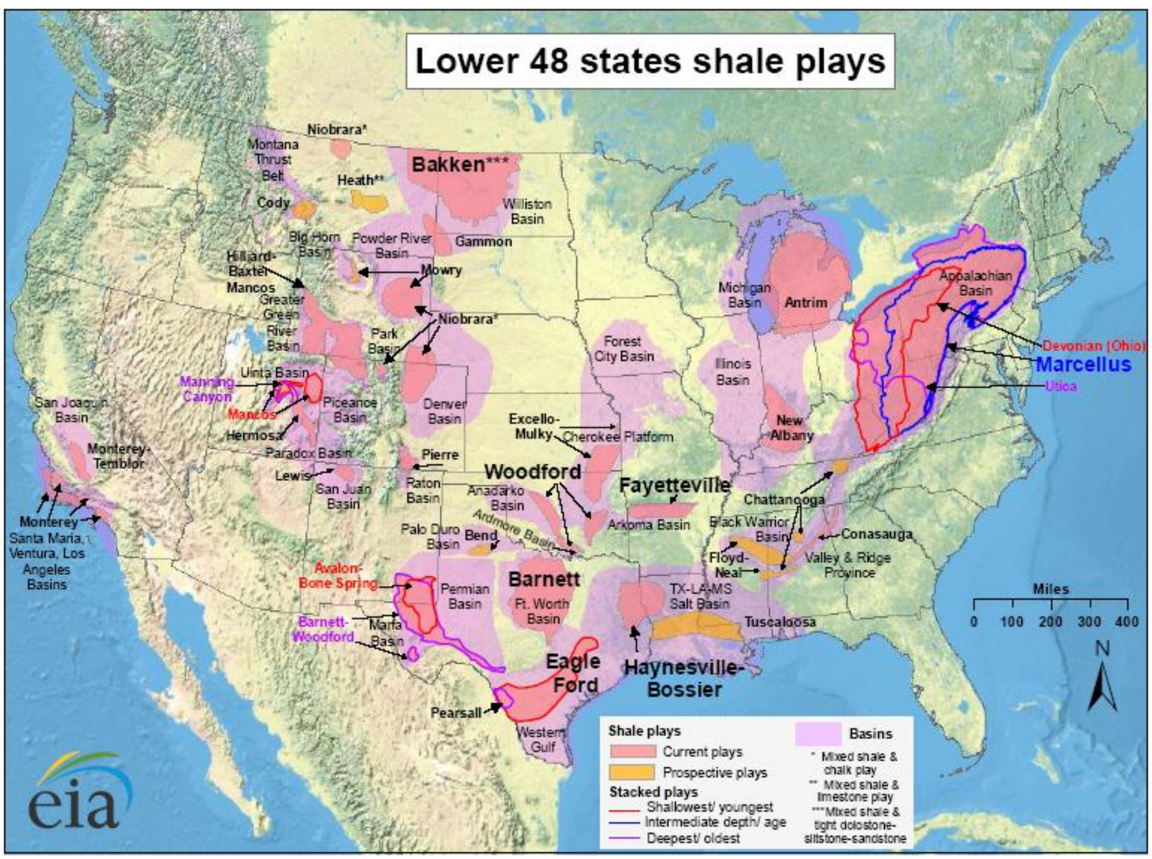
Facilities where NORM and TENORM are being generated should prepare a management plan to ensure that wastes are properly contained and a plan for cleanup in the event of any spills. If NORM and/or TENORM are properly contained within the facility, members of the public should not be exposed to radiation or come in contact with radioactivity.

The three basic pathways for exposure to workers are direct exposure from radiation, inhalation of radioactive materials, and ingestion of radioactive materials. A radiation exposure survey should be conducted to evaluate direct exposure to workers from radiation. Time, distance and shielding can be used to decrease worker exposure. Risk of inhalation or ingestion of NORM and TENORM can be reduced by using basic industrial hygiene practices to avoid contact with radioactivity. Radon measurements may also be warranted. Workers at shale gas operations where NORM and TENORM are being managed generally do not conduct activities that cause them to be exposed to radioactivity. Workers whose activities may bring them in contact with NORM and TENORM should be trained in basic radiation safety. A suggested training outline may be found in Appendix E of the Colorado Department of Public Health and Environment, TENORM Policy and Guidance.

Regulatory Framework

Shale gas exploration, hydraulic fracturing, and related operations are currently regulated by States under their respective oil and gas regulations. Management of wastes produced under these operations must also comply with State and federal waste regulations. State-specific regulatory updates concerning shale gas exploration and hydraulic fracturing are available on the Interstate Oil & Gas Compact Commission webpage at: http://groundwork.iogcc.org/topics-index/hydraulic-fracturing/state-progress.

There are no uniform national guidelines or regulations for management of TENORM. Management of TENORM falls under various regulatory authorities, including the U.S. Environmental Protection Agency (EPA), the U.S. Nuclear Regulatory Commission (NRC) and the authority of individual States. Additional information on the EPA regulations and guidance regarding TENORM can be found at http://www.epa.gov/rpdweb00/tenorm/regs.html. Additional information about the NRC's regulations can be found at http://www.nrc.gov/materials.html. Individual State regulatory guidelines can be obtained by contacting the State's radiation program. Contact information for each State's radiation program may be found at the website for The Conference of Radiation Control Program Directors (CRCPD) at http://www.crcpd.org.



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(U.S. Department of Energy, Energy Information Administration, 2012)

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