SOUTHWEST PENNSYLVANIA ENVIRONMENTAL HEALTH PROJECT

Illustrated Stages of Unconventional Oil and Gas Development (UOGD): Examining the potential for ground/surface water and air contamination

Unconventional oil and gas development (UOGD, commonly called "fracking") is the process of extracting oil and natural gas from shale deposits and delivering it to consumers. While companies have been extracting oil and gas for many years, today's process is called unconventional because methods like horizontal drilling and hydraulic fracturing are used to reach resources trapped in deep shale rock formations. The complex process used to reach this trapped oil and gas has many different stages that take place over a period of years.

When UOGD first comes to your community, you may be aware of new activities around you, but may not know exactly what is happening during each stage of development. This document explains some of the industrial activities you may see during each stage. The timeline for each stage varies greatly from site to site depending upon the amount of work required to extract the oil and gas.

TERMS TO REMEMBER:

Particulate Matter (PM): potentially dangerous mixture of small particles and liquid droplets found in the air.

Volatile Organic Compounds (VOCs): organic compounds that easily become vapors or gases. Many VOCs are also hazardous air pollutants (HAPs) such as benzene, formaldehyde, toluene and xylene.

INITIAL EXPLORATION

Energy companies search for underground reservoirs of oil or gas using mapping, geological clues, seismic testing, and other methods. Generally, this is done in an office setting, so you may not see this occurring in your community.

Bob Donnan. Seismic Testing. 2014.

Seismic testing

Seismic testing is used to help determine the geological characteristics below the surface of the ground before drilling starts. Marcellus Shale seismic testing usually uses 2D or 3D imaging. With this testing, seismic companies often bore holes where they can place dynamite charges for later detonation. Seismic equipment in the area monitors the shock waves after detonation. Trucks will stop at a set location, lower a large plate onto the highway that puts most of the weight of the truck on the surface, and then set off a series of vibrations into the ground. After a few minutes, they move forward and repeat the process. If trucks stop in front of your house, you are exposed to idling diesel emissions and ground vibrations.

LEASING AND PERMITTING

After an energy company determines that a place has enough resources to explore, leases are purchased from mineral rights owners, if necessary, and permits are requested and issued by the state.

WELL DEVELOPMENT

Once it is determined that an adequate amount of oil and/or gas deposits can probably be extracted, access roads are constructed and the well site is developed. The first step in development is building a well pad, a large 3-7 acre structural platform surrounding the drilling operations. The well pad holds the drilling rig, storage tanks, and other machinery and equipment.

Next, the energy company uses the drilling rig to drill the well(s). A typical well is drilled 5,000 to 9,000 feet vertically and up to 10,000 feet horizontally. Several wells may be drilled on one well pad.

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Judy Patrick Photography. 2016. Provided by Ahtna, Inc.

Casing – permanent infrastructure

After a well site is chosen and permitted, shallow test wells are drilled to varying depths, and casing (cement and/or steel) for the permanent well will be put in place. Pipes are installed to create a barrier between the flow of natural gas/fracking fluids and groundwater. Potential contamination of the groundwater may occur as the initial wellbore is drilled and cement is injected into the ground. If well casings fail, there may also be ground water contamination.

Ted Auch. Drilling rig in Washington County, Pennsylvania. 2016. Provided by FracTracker Alliance, www.fractracker.org/photos.

Drilling on well-pad

This is the drill you will see during the drilling stages. Issues at this point could include spills of drilling muds, fracking fluids, or other activities associated with clearing and use of the well pad itself. In addition, there may also be impacts from air contamination by PM, silica dust from the sand, VOCs, and diesel emissions.

PREPARATION FOR HYDRAULIC FRACTURING

After the well has been drilled, the drilling rig is removed and the well is ready for hydraulic fracturing.

Bob Donnan. Truck transport. 2014.

Truck transport of water, fluids, and sand

Each well fracked on a site requires significant amounts of water, along with sand to help prop open the cracks created by fracking. The exact amount of water and sand needed varies from well to well, but one well generally uses 2.4 to 7.8 million gallons of water. In this photo, three water-hauling trucks surround one truck hauling the fine silica sand used during hydraulic fracturing. Potential issues for water contamination include water withdrawals from local water sources using contaminated lines, spills of flowback water or chemicals taken on and off-site by the trucks, and leaks (either intentional or accidental) occurring during transport. To get water and sand to the wells, diesel engines are needed, which causes air emissions. These include increased PM and diesel emissions.

Bob Donnan. Freshwater impoundment. 2014.

Freshwater impoundment

Impoundments are used during hydraulic fracturing and for nearby or off-site well pads. While as residents we do not get this bird's eye view, the steep sides of the pit are noticeable from the ground. Contamination associated with a freshwater impoundment would most likely be associated with run-off of the soil used in construction. However, these impoundments may be re-purposed to become a flowback impoundment in which chemical contaminants are deposited. There may also be significant truck traffic associated with an impoundment, increasing PM and diesel emissions.

John B. McFarland. Fracking a well. 2015.

Hydraulic fracturing ("fracking")

Water use and disposal are important issues during the hydraulic fracturing stage. To "frack" a shale gas well, millions of gallons of fresh water are hauled in or withdrawn from local sources. Chemicals are added to the fluid to efficiently fracture the rock formation that traps the oil and gas. Sand is added to prop open fractures in the shale so the gas can escape from the shale rock. This mixture of water, chemicals, and sand is called "fracking fluid." There are potential impacts from air contamination by VOCs, HAPs, PM, diesel emissions, and silica dust from sand. Due to the volume of water being forced underground and mixing with hazardous materials, there is a potential for groundwater contamination.

PRODUCTION

The wastewater that returns to the surface during UOGD operations is a mixture of flowback and produced water. Flowback water contains the fracking fluid mentioned above. Produced water is water previously trapped in underground formations that is released with the gas and/or oil. Produced water can contain naturally occurring materials that are present in the shale layer, such as radioactive compounds, toxic organic and inorganic chemicals, and heavy metals such as arsenic. It also contains a significant amount of salt that was trapped in the shale, which is why it is often referred to as brine.

The wastewater is held in pits or tanks at the well site until it is treated, recycled, or disposed of in an underground injection well.


Bob Donnan. Flowback impoundment. 2014.

Flowback impoundment

These large ponds are used for storage of flowback fluids, drilling muds, and other chemicals and water used in the hydraulic fracturing process. Watch for torn impoundment pond liners, improper runoff management, leaks, and deposits from impoundment pond aeration. Accidents, leaks and spills can occur when the flowback water is trucked to and from the site. There may also be a cause for concern from VOCs, methane, and ethane emissions in the air coming off this impoundment.


Bob Donnan. Flaring. 2014.

Flaring

Flaring is used for burning off flammable gas when there is too much pressure in the pipelines. Flaring generates heat, noise, and light. There may be cause for concern from VOCs, methane, and ethane emitted into the air.


Bob Donnan. Condensate tanks. 2014.

Condensate tanks – permanent infrastructure

Areas with "wet" gas, such as in western PA, have gas which contains a mixture of natural gas and other commercially viable components such as ethane and propane, which are used as feedstocks for plastics and other industries. Methane is separated from these liquid components using a condensation process. Liquid contamination may leak from these condensate tanks into surface waters. Since many tanks are also designed to vent, there may also be VOCs, methane, and ethane emissions in the air.


Ramsey Martin. Glycol dehydrator.

Glycol dehydrators

Associated with the condensation process, glycol dehydration is used to separate wet oil or water out of the natural gas stream. Ethylene glycol, used in the dehydration process, binds readily to water, creating the potential for spills which may significantly contaminate nearby water sources. There may be leaks associated with these glycol dehydrators. In addition to leaks, there may be cause for concern from VOCs, methane, and ethane in the air.


Bob Donnan. Road application. 2014.

Road application of brine

Sometimes brine is sprayed to reduce dust on the roads or for de-icing in the winter. This fluid may contain high levels of barium, salts, and other naturally occurring substances including radioactive materials. The concentration of these compounds in the brine is usually unknown. Watch for any use of contaminated water on roadways, as run-off may contaminate nearby wells or surface/groundwater. In addition, there is an increase in PM and VOCs, as well as diesel emissions causing air pollution. Road application most often uses wastewater from conventional gas development, but some residents report that wastewater from unconventional activity has been used.


Bob Donnan. Christmas tree. 2014.

Christmas tree/wellhead – permanent infrastructure

This represents completion of drilling. A "Christmas tree" provides chemical injection points, pressure relief, and well monitoring points for pressure, temperature, corrosion, erosion, sand detection, and flow rate. Continue to watch for leaks, which could contaminate water supplies.

TRANSPORTATION AND PROCESSING

After the gas or oil is accessed, it is processed and transported to consumers. Work activity near well sites generally slows at this point, though some wells are re-fracked periodically in an attempt to boost gas production from a site.

Movement of unconventionally-produced oil and gas from producing regions to consumers requires an extensive and elaborate transportation system. In many instances, oil and gas have to travel a great distance to reach the point of use.

Bob Donnan. Gas pipelines. 2014.

Gas pipelines – permanent infrastructure

Once the gas wells are drilled and the natural gas begins to flow, the gas and gas liquids must get to market. Natural gas pipelines move gas to compressor stations and to end users. During pipeline construction, heavy diesel equipment is brought in to clear the land for the incoming pipelines. Watch for pipeline leaks, which could contaminate air and occasionally water. Toxins also accumulate on the interior lining of pipelines and must be regularly cleaned, via pig launchers.

Stevenson Gas Metering Station. Provided by Bridgeport Utilities.

Metering station – permanent infrastructure*

These stations are designed for simultaneous, continuous analysis of the quality and quantity of natural gas transferred via pipeline. Occasionally, gas, including VOCs, may be vented at these metering stations. Metering stations appear frequently along pipelines and can emit many of the same pollutants as compressor stations.

Ted Auch. Compressor station. 2016. Provided by FracTracker Alliance, www.fractracker.org/photos.

Compressor station – permanent infrastructure*

Compressor stations help move natural gas from one location to another. While being transported through a gas pipeline, natural gas needs to be constantly pressurized. Gas, including VOCs, may be vented at these stations on a sporadic basis, when pressure needs to be released and/or when pipes need to be cleaned. The frequency of these events is dependent on the volume of gas being transported via pipelines. Venting can cause an increase in VOCs, nitrogen oxides, and PM in the air.

Bob Donnan. Pig launcher. 2014.

Pig launcher – permanent infrastructure*

This structure is used in the process of maintaining pipelines. Devices known as "pigs" are used to perform various maintenance operations on a pipeline, such as cleaning and inspecting the pipes. This practice is accomplished by inserting the "pig" into an oversized section in the pipeline, reducing this section to the normal diameter. The launcher is then closed and the pressure-driven flow of the product in the pipeline is used to push the pig down the pipe, "cleaning" the interior of the pipe, until it reaches the receiving trap. Radioactive materials such as radon, as well as Polychlorinated Biphenyl (PCB) are among the contaminants that accumulate in pipelines. In addition to leaks, there may be VOCs, methane, and ethane released in the air.

Bob Donnan. Processing plant. 2014.

Processing plant – permanent infrastructure*

Processing plants purify natural gas by removing common contaminants. Emissions associated with processing facilities may include: emissions that contain VOCs; PM from generators and trucks; and spills/leaks.

**Not all metering stations, compressor stations, pig launchers, and processing plants will look the same; their size depends on the amount of gas flowing through them.*

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