SPRING 2015

ATLANTICA CENTRE FOR ENERGY

Wastewater from natural gas development - Treatment Options for New Brunswick and Nova Scotia

OVERVIEW

In 2012, the Nova Scotia government imposed a moratorium on all forms of hydraulic fracturing in the province and in 2014 passed legislation to ban the practice. In December 2014, the New Brunswick government followed suit with an open-ended moratorium. Both provinces note that the risks to human health and the environment are not understood well enough for hydraulic fracturing to occur.

"We have been clear from day one that we will impose a moratorium until risks to the environment, health and water are understood"

NEW BRUNSWICK PREMIER BRIAN GALLANT, 2014

Included within the New Brunswick moratorium are five conditions that must be met before the moratorium will be lifted, one of which is a plan to deal with wastewater created through the hydraulic fracturing process. This short document outlines what role water plays in hydraulic fracturing, and what New Brunswick and Nova Scotia natural gas wastewater will look like, how much there will be, and what we can do with it.

Regionally, nationally, and internationally, no two geologic formations are alike; they were formed under distinct circumstances and have been subjected to different conditions over time.

HIGHLIGHTS

1) Defining key terminology related to natural gas wastewater
2) Outlining the typical volume of wastewater for a natural gas well (*i.e.*, how much water?)
3) Identifying the composition of natural gas wastewater (*i.e.*, what is in the water?)
4) Outlining the regulatory standards (*i.e.*, what are the rules?)
5) Describing natural gas wastewater treatment options (*i.e.*, how can we treat the water?)
6) Identifying other common sources of wastewater and outlining how they are treated

What Role Does Water Play in Natural Gas Extraction?

What goes down the well? "Fracking Fluid"

Water

Water makes up approximately 90% of the fracking fluid. New Brunswick has guidelines on sourcing water for fracking within the *Rules for Industry*. The order of preference for sourcing fracking water is:

1) treated / recycled wastewater
2) seawater
3) non-potable groundwater
4) captured runoff or rainwater
5) lake or river water
6) potable groundwater

Proppant

A proppant, which is usually sand, makes up about 9.5% of the fracking fluid. When the fracking fluid is under high pressure at the end of the wellbore, the fluid fractures the formation. The sand within the the fracking fluid flows into the fractures. Once the pressure is released, the fractures are held open by the sand, allowing gas to flow into the pipe. If a proppant was not used, the fractures would close after the pressure was released, stopping the flow of gas into the pipe.

Fracking Chemicals

A small percentage of chemicals (about 0.5%) are mixed with the water and sand to create the fracking fluid. Those chemicals are chosen for their capability to improve the results of the fracking process and the well productivity.

The type and volume of chemicals used change based on the geology in the area and the type of water used (*i.e.*, fresh water versus seawater).

In New Brunswick, before fracking occurs, a full list of all chemicals used must be disclosed to the government.

What comes up the well?

Flowback Water

Once the hydraulic fracturing process is complete, the pressure is released from the well. This loss of pressure results in water flowing up the well, which is captured at the surface.

Initially, the water closely resembles the composition of the fracking fluid and is known as "flowback water". The flowback occurs within several weeks after the well is hydraulically fractured.

This is primarily "Fracking Fluid"

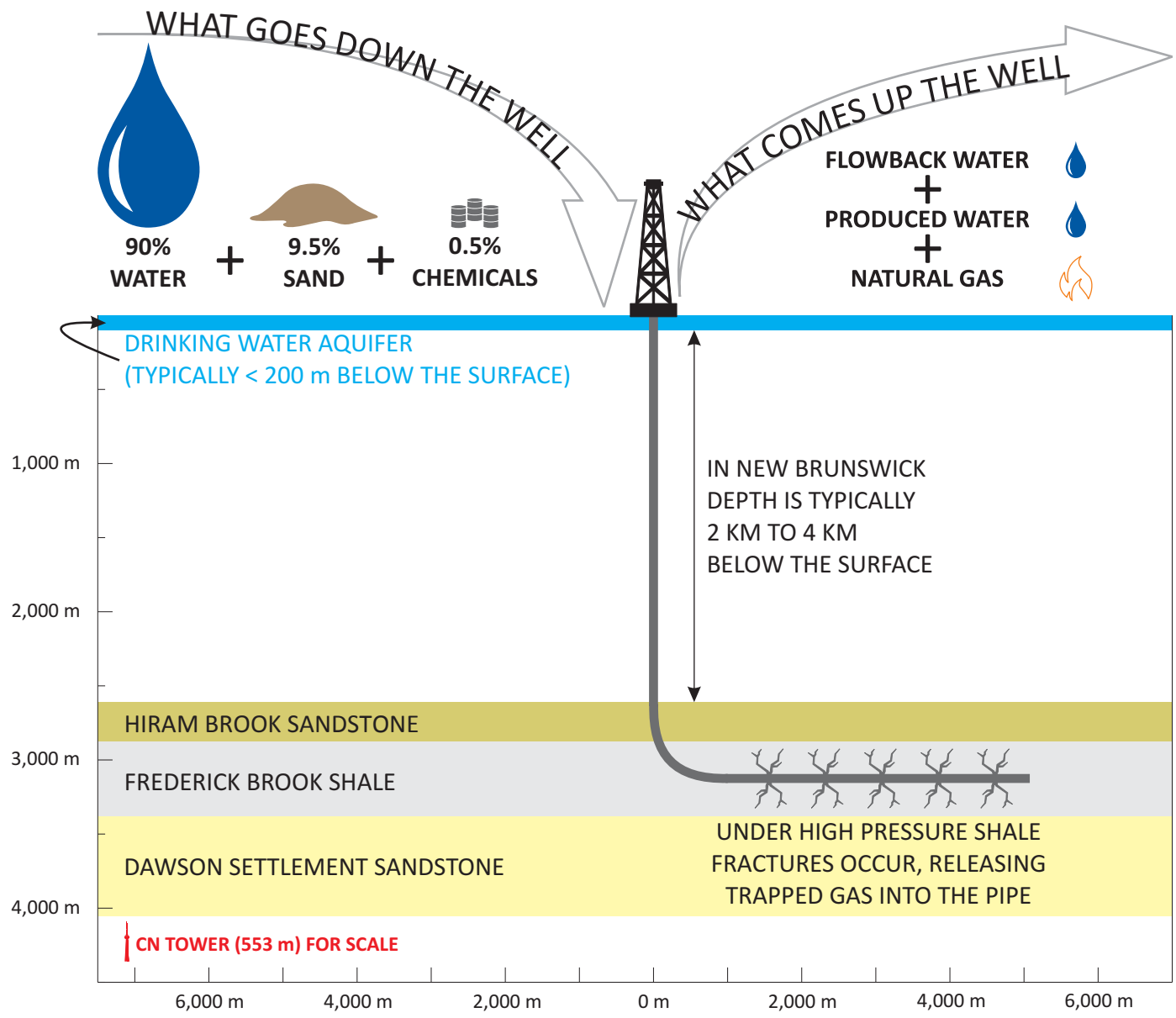
Produced Water

After several weeks, the composition of the water flowing up the well to the surface changes from resembling the fracking fluid to resembling the natural deep salty groundwater. The water is then known as "produced water" and will generally continue to flow up the well for as long as the well produces gas.

This is primarily formation water

Natural Gas

The natural gas, which is primarily methane, flows up the well to the surface along with the produced water over the life of the well. Over time, the amount of gas produced by the well decreases, but through further fracking events, the well can sometimes be re-stimulated to increase the volume of gas produced.



What type of chemicals are used in "Fracking Fluid"?

- sodium chloride is used to delay the breakdown of the fracking fluid
  - › we probably use sodium chloride every day because it is table salt
- ethylene glycol is used to prevent the build up of scale on the walls of the well
  - › many household cleaners contain ethylene glycol
- borate salts are used to slicken the fracking fluid
  - › many makeup products, like lipstick, contains borate salts
- sodium and potassium carbonate are used to maintain the effectiveness of the fracking fluid
  - › laundry detergents contain sodium and potassium carbonate
- guar gum is used to reduce the friction between the well and fracking fluid, helping it flow easier
  - › ice cream contains guar gum
- isopropanol is used to lower the freezing temperature of the fracking fluid
  - › deodorant contains isopropanol

New Brunswick Natural Gas Wastewater - What Does It Look Like?

New Brunswick Flowback Water

BASED UPON A FREDERICK BROOK SHALE PROGRAM, WHICH HAS BEEN IN PRODUCTION FOR 10 YEARS

How much will there be?

The volume of water that will require treatment and disposal from a well will depend on the number of fracture treatments completed, the volume of fracking fluid used for each fracture treatment, and the volume of flowback from the well (typically 15% to 30%).

THE VOLUME OF FLOWBACK WATER (WASTEWATER) GENERATED PER WELL COULD RANGE FROM 225 m^3 FOR A WELL WITH ONE FRACTURE TREATMENT TO 9,000 m^3 FOR A WELL WITH 10 FRACTURE TREATMENTS

What is in it?

The flowback water closely resembles the fracking fluid used for hydraulically fracturing the well.

TYPICAL FLOWBACK WATER COMPOSITION

WATER FROM PREFERRED SOURCE

1% TO 3% POTASSIUM CHLORIDE (AN ANTI-BACTERIAL AGENT)

1 LITRE/m^3 POLYACRYLAMIDE (A FRICTION REDUCER)

0.1 LITRE/m^3 BIOCIDE (TO KILL BACTERIA)

In addition, very salty deep formation water usually accompanies all flowback water in New Brunswick.

1 m^3 = 1,000 L

Bathtub = 0.2 m^3

Hot tub = 0.8 m^3

Tanker truck = 10 m^3 to 50 m^3

Olympic Swimming Pool = 2,500 m^3

New Brunswick Produced Water

BASED UPON THE MCCULLY GAS PLANT, WHICH HAS BEEN IN OPERATION FOR 10 YEARS

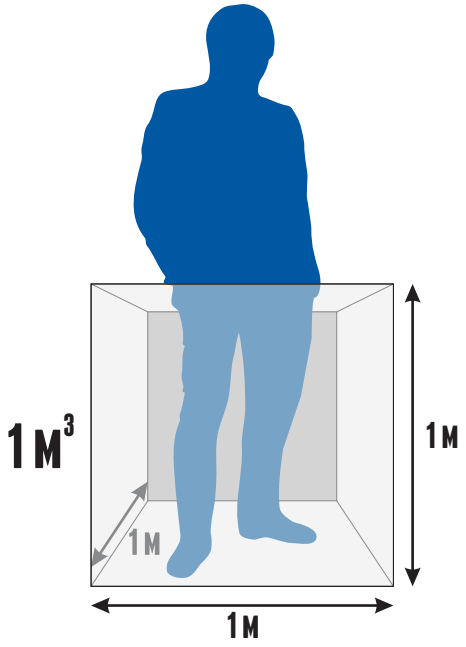
How much will there be?

Once a well is in production, the amount of produced water will vary based upon the well location and the number of fracture treatments completed.

TYPICAL WATER TO GAS RATIOS FOR A PRODUCING WELL CAN RANGE FROM 0 m^3 / 100 m^3 TO 0.25 m^3 / 100 m^3. THE CURRENT AVERAGE FOR NATURAL GAS WELLS IN THE MCCULLY FIELD IS 0.025 m^3 / 100 m^3, WHICH MEANS THAT IF A WELL PRODUCED 100,000 m^3 OF GAS PER DAY, 25 m^3 OF WATER WILL ALSO FLOW UP THE WELL

What is in it?

Produced water is collected from wells at a central processing plant where the water is processed to remove any components that have commercial value. The effluent from the central processing plant is composed of very salty water and trace amounts of carbonates and metals.



Natural Gas Wastewater - How Is It Stored Before Treatment?

In New Brunswick

As outlined in the New Brunswick *Rules for Industry*:

> "THE USE OF PITS FOR THE STORAGE OF FLOWBACK WATER OR PRODUCED WATER IS NOT PERMITTED. ALL FLOWBACK AND PRODUCED WATER RECOVERED FROM AN OIL OR GAS WELL MUST BE CONVEYED BY PIPING TO COVERED WATER-TIGHT TANKS EQUIPPED WITH SECONDARY CONTAINMENT"

also:

> "THE DURATION OF ON-SITE STORAGE OF FLOWBACK WATER IS LIMITED TO NO MORE THAN 90 DAYS FROM THE LAST DAY OF WELL COMPLETION OR SERVICING OPERATIONS UNLESS OTHERWISE PERMITTED BY THE REGULATOR (*E.G.*, IF THE OPERATOR INTENDS TO RECYCLE / REUSE THE WATER ON-SITE)"

In Nova Scotia

In Nova Scotia, there are no rules regarding the storage of natural gas wastewater. Previously, both flowback and produced waters were held in lined ponds, which were open to the environment.

Natural Gas Wastewater - What Are the Treatment Options?

Nova Scotia requires that discharges from wastewater treatment facilities, at a minimum, meet the Canadian Council of the Ministers of Environment (CCME) guidelines for the Protection of Freshwater Aquatic Life.

New Brunswick requires regulatory approval for discharge on a case-by-case basis. Because the untreated flowback and produced water resulting from the natural gas industry will not meet discharge guidelines in either province, a treatment process must be undertaken before disposal to the environment.

Outlined on the next page are some examples of commercially available treatment technologies, which are typically used in the natural gas industry.

The treatment process could involve the use of one of those treatment solutions or may require a combination of treatment solutions. The wastewater treatment will have to be tailored to the characteristics of the fracking fluid and formation waters in the area and the final fate of the water after treatment (*i.e.*, Re-use as fracking fluid or environmental disposal).

Although there are many treatment methods available worldwide, wastewater treatment is one of the most significant challenges for the natural gas industry.

Natural Gas Wastewater - The Treatment Options

Thermal Desalination

Desalination (*i.e.*, by boiling wastewater and producing clean water from the condensation of the steam), although highly energy intensive, begins with seawater or non-potable wastewater and produces demineralized potable water and a highly concentrated solute, which must be disposed of separately.

WORLDWIDE, THIS PROCESS IS COMMONLY USED TO GENERATE POTABLE WATER FROM SEAWATER.

Reverse Osmosis

Flowback and produced water can be treated using reverse osmosis whereby pressure is applied to force water through a semi-permeable membrane leaving behind a highly concentrated solution containing many types of molecules and ions.

GLOBALLY, THIS PROCESS IS COMMONLY USED TO GENERATE POTABLE WATER FROM SEAWATER.

Forward Osmosis

Flowback and produced water can be treated using forward osmosis whereby a highly concentrated solution is used to draw water through a semi-permeable membrane producing a highly concentrated solution containing many types of molecules and ions. Because water is drawn, rather than pushed, through the semi-permeable membrane, it is more energy efficient than reverse osmosis.

GLOBALLY, THIS PROCESS IS COMMONLY USED TO GENERATE POTABLE WATER FROM SEAWATER.

Solids Filtration

Generally, the first step in many water treatment systems is solids filtration. It involves using physical filters (*i.e.*, screens or sand filters) to remove the largest particles from wastewater. While they do not affect the overall water quality, physical filters allow the specialized treatment that follows (*e.g.*, reverse osmosis) to be more efficient because the specialized membranes will not clog as easily.

Electro-Coagulation

An electrical charge is used to cause suspended or dissolved contaminants (*i.e.*, salts, oil, grease, and metals) to clump together, which can then be removed more easily. Electro-coagulation successfully removes wastewater contaminants that are generally more difficult to remove by filtration and chemical treatment processes.

ELECTRO-COAGULATION IS A RAPIDLY GROWING AREA OF WASTEWATER TREATMENT.

Biological Treatment

Constructed wetlands are artificial wastewater treatment systems that utilize wetland vegetation to promote natural chemical and biological processes to achieve effective treatment of wastewater. Constructed wetland systems are very effective in removing nutrients, such as nitrogen and phosphorous. No such facilities currently exist in New Brunswick or Nova Scotia, yet it is a proven ecological method of wastewater treatment.

Activated Carbon

Carbon, which has been activated with oxygen to improve its porosity, is often used in conjunction with other filter media to remove pollutants from water (*e.g.*, Brita® filters use activated carbon to filter out chlorine from drinking water). The extremely high surface area of activated carbon has the ability to absorb large quantities of pollutants.

How Does Natural Gas Wastewater Compare To Other Wastewaters?

If not properly treated and disposed of, the potential constituents in flowback and produced natural gas wastewater could cause detrimental effects to human health and the environment. However, this is also true of various other types of wastewater comprised of similar constituents, including stormwater runoff, sanitary sewer effluent, landfill leachate, and industrial wastewater.

Stormwater Runoff

Stormwater, particularly in urban areas, collects pollutants as the runoff flows over various surfaces. Pollutant loading from urban runoff can be similar in some areas to the contaminants found in wastewater and industrial discharges. The degradation of water quality can occur due to increased concentrations of various contaminants, including but not limited to:

- nutrients (*i.e.*, nitrogen and phosphorous)
  - these nutrients can originate from fertilizers and animal waste (*i.e.*, manure)
- metals (*i.e.*, iron and zinc)
  - these metals can come from automobiles, corroding metal, and natural soil erosion
- hydrocarbons (*i.e.*, gasoline, oil, and lubricants)
  - these hydrocarbons can occur in parking lots, gas stations, garages, and illegal dump sites
- salt (*i.e.*, sodium and chloride)
  - these can be picked up from road de-icing
- organic materials
  - these can originate from lawns, gardens, and commercial landscaping

These contaminants can have detrimental effects to the receiving waterbody and human health. *The majority of stormwater runoff is untreated before it is reintroduced to the environment.*

Sanitary Sewer Effluent

In addition to stormwater runoff, sanitary sewer effluent is another municipal wastewater that contains various pollutants. Untreated sewage contains, in addition to human wastes, anything that is flushed down a toilet or put down a drain. Those substances can include dirt, food, oil and grease, soaps, pharmaceuticals, detergents, cleaning agents, and paints.

Wastewater treatment varies for each municipality. According to a Municipal Water Use survey, *nearly half of the population in Atlantic Canada that is serviced by municipal sewer systems release untreated wastewater directly into inland and coastal waters*. These releases rely on the dilution ability of the receiving water to reduce impacts. According to ACAP Saint John, prior to the Saint John Harbour cleanup initiative, the City of Saint John discharged 16 million litres per day of raw sewage into the harbour.

Even when municipal wastewater undergoes treatment, many pollutants still remain that can cause environmental damage, including suspended solids, nutrients, bio-degradeable oxygen-consuming organic matter, pharmaceuticals, micro-organisms, and sulphides.

Landfill Leachate

All solid waste landfills release leachate to the surrounding environment. That leachate often contains numerous pollutants, including nutrients, heavy metals, and hydrocarbons. Those compounds can cause major potential environmental impacts to groundwater and surface waters.

Leachate characteristics evolve over time, increasing to a peak value and then subsequently decreasing as the contaminants are either flushed from the system, broken down biologically, or settle out. Contents of the leachate dictate the potential environmental concern and generally include chloride, phenols, metals, and hydrocarbons.

Industrial Wastewater

Industrial wastewater also affects ecosystems and human health. *In the pulp and paper, mining, and petrochemical industries, effluent is discharged to various outlets, including lakes, rivers, and coastal environments.* Those discharges contribute various pollutants to the receiving systems, including nutrients.

Conclusion

Every day we produce wastewater as we go about our normal activities. Those wastewaters include waste from our bathrooms and kitchens, surface water runoff from driveways, parking lots, and road-ways, liquid discharges from industrial processes, and leachate produced from landfills. Although we may not realize it, we treat those wastewaters using a variety of conventional and modern methods.

Flowback water and produced water from natural gas wells may be new to us in New Brunswick, but its treatment is no different than for other types of wastewater we produce. Hydraulic fracturing wastewater can be cleaned up using commonly accepted treatment methods widely used throughout the world. By using those methods, the water can be treated to meet provincial and national guidelines so that it can be safely returned to the environment.