



Natural Gas Pipelines

Excerpt from Report 2 of the Pennsylvania Energy Impacts Assessment

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Natural Gas Pipelines

An extensive web of pipelines is needed to collect gas from well sites and transport it to storage areas and major markets. Even before Marcellus shale natural gas development started, Pennsylvania had over 8,600 miles of large diameter interstate and intrastate gas pipelines (8th highest in U.S.), due to the Commonwealth's long history of oil and gas production, its existing gas storage sites in depleted gas reservoirs, and its location between gas production areas and major northeastern markets (USDOE, 2011). Current and future Marcellus gas development will dramatically increase the miles of large diameter gas pipelines in the state. The two most important reasons for the pipeline expansion are the large number Marcellus well sites that are likely to be developed over the next two decades and the transport lines needed to get growing volumes of shale gas – from various formations – delivered to different parts of the country (INGAA, 2011). Although pipelines are buried, their construction, monitoring, and maintenance require clearing and maintaining open rights-of-way. While their widths vary, pipeline rights-of-way often create a significant and permanent fragmenting feature through natural habitats. Extensive soil disturbance during construction can also increase the risk of erosion and sedimentation if controls are not carefully designed and implemented. This assessment looks closely at pipeline development associated with Marcellus gas development in Bradford County, Pennsylvania, to better understand the potential scale and scope of statewide habitat impacts.

What Is Natural Gas Transmission?

The vast majority of natural gas gets to markets through pipelines, though some related products—including propane and butane—are transported in pressurized tanks via rail and trucks. Natural gas transportation infrastructure consists of **gathering lines** which take the gas from each well to a **transport line** which takes the gas either to another transport line (sometimes called “mid-stream” lines) or directly to markets (often referred to as “interstate” lines). This report does not address service lines that take gas from storage areas or transport lines directly to commercial, industrial, and residential consumers. In the Marcellus region, gathering lines may range from 6 to 24 inches in diameter and may clear rights-of-way (ROW) of 30 to 150 feet wide. These are much larger than gathering lines used in shallow gas fields, which generally range from 2 to 6 inches in diameter. Transport lines vary in size, generally ranging from 24 to 36 inches in diameter, and have right-of-way widths of up to 200 feet, depending on the size and number of lines. At various points along the pipeline, including at line junctions, compressor stations pressurize the natural gas to ensure a continuous and regulated flow. This report assesses the spatial footprint and scenarios for future expansion of gathering lines. Gathering lines are likely to comprise by far the greatest extent of new large diameter pipeline constructed in Pennsylvania during the next 20 years.



Gathering pipeline construction in Bradford County, PA © Nels Johnson /TNC

Current and Projected Natural Gas Pipeline Development

An estimated 8,600 miles of large diameter natural gas pipeline already crossed Pennsylvania before Marcellus development began (USDOE, 2008). This number is changing rapidly as pipelines are installed to move large volumes of Marcellus natural gas to markets. Unfortunately, there is no statewide source of data on new pipelines, including the expanding web of Marcellus gathering pipelines. Given the fast pace of Marcellus development and lack of a centralized regulatory framework for gathering pipelines, we recognize the many challenges associated with maintaining an accurate and updated pipeline dataset.

The Bradford County Office of Community Planning and Grants is tackling that challenge and maintains one of the best available datasets representing built and proposed gas pipelines. As of November 2011, Bradford County has Pennsylvania's highest number of permitted (almost 2,000) and drilled (781) Marcellus gas wells (DEP, 2011a) and has over 500 miles of built and proposed gas pipelines (Bradford County, 2011) (see Figure 1). Given the dearth of statewide datasets, we used gas pipeline data from Bradford County as a case study to develop statewide projections of gathering gas pipeline development.

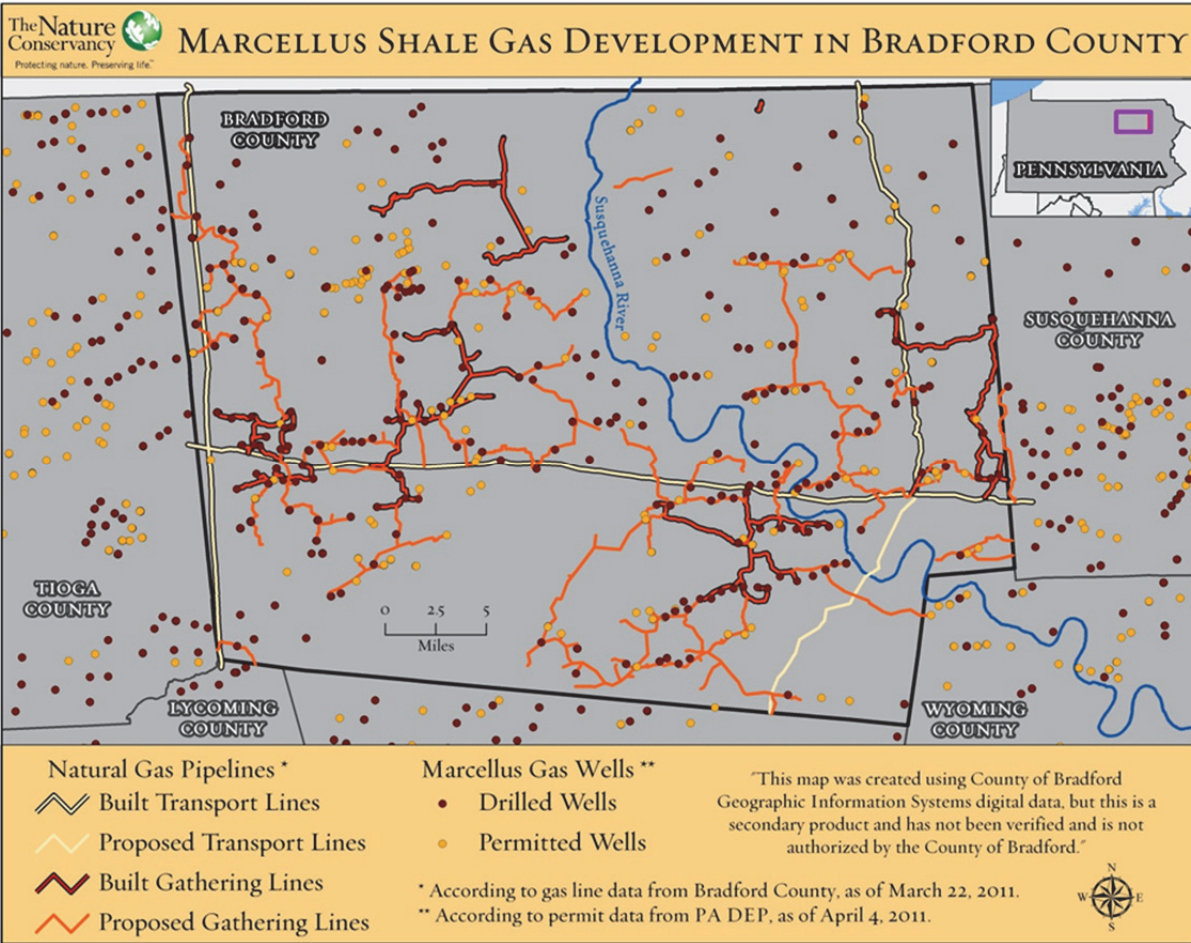


Figure 1. Marcellus gas development in Bradford County, PA, including wells and pipelines. Data sources are the Pennsylvania Department of Environmental Protection and Bradford County Geographic Information Systems.

Using Bradford County data, we estimated the average gathering pipeline length for each well pad by counting all well pads within one-half mile of an existing or proposed gathering pipeline (263 well pads) and dividing them by the total distance of existing and proposed gathering pipelines (434 miles). Well pads further than one-half mile were considered unlikely to be connected to existing and proposed pipelines and would likely connect through future proposed pipelines. The result is an average of 1.65 miles of gathering pipeline for each Marcellus well pad. Although the entire network of wells and gathering pipelines will take years to complete, the density of development in Bradford County is one of the highest in Pennsylvania. The ratio of pipelines to pads may be higher in other counties where gas development is more dispersed.

Based on an average of 1.65 miles of gathering pipeline per pad, we used Marcellus pad projections from Report 1 to estimate the length of new gathering pipelines that could be expected under each of

the development scenarios. Six thousand Marcellus pads are projected under the low development scenario, resulting in the construction of approximately **10,000 miles** (6,000 pads x 1.65 miles/pad) of new gathering pipeline by 2030 in Pennsylvania alone. The medium development scenario projects ten thousand new Marcellus pads, resulting in **16,500 miles** (10,000 pads x 1.65 miles/pad) of new gathering pipeline by 2030. Finally, under the high development scenario, fifteen thousand new pads are projected, which would mean approximately **25,000 miles** (15,000 pads x 1.65 miles/ pad) of new gathering pipeline would need to be added. Even the low scenario would more than double the miles of large diameter natural gas pipeline in Pennsylvania while the high scenario would nearly quadruple the mileage (see total projections of existing and new gathering pipelines in Figure 2, below).

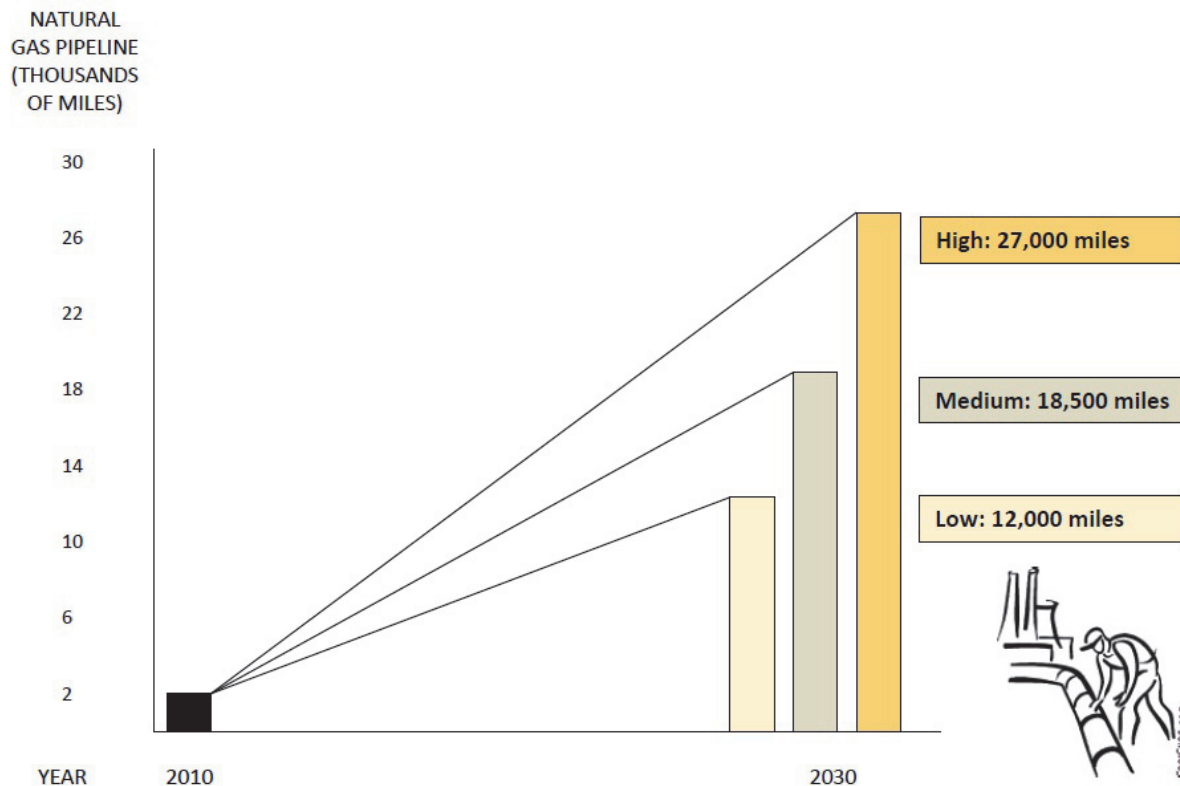


Figure 2. Projections for total miles of natural gas gathering pipelines under low, medium, and high development scenarios. As of the end of 2010, total gathering pipeline length was approximately 2,000 miles, based on the number of well pads at the time.

We assessed all existing gathering pipelines in Bradford County that were visible in 2010 aerial imagery (from the USDA National Agriculture Imagery Program; see Figure 3 below) and noted the following attributes: (a) the width of the cleared right-of-way, and (b) the land cover type through which the right-of-way passed (forested, agricultural, or existing cleared). We found that cleared rights-of-way were usually 100 feet wide but ranged between 30 to 150 feet. About one third of the mileage for built pipelines was in forest areas, with a somewhat higher portion (44%) for proposed pipelines. About one third of that length was in forest interior areas that were previously at least 300 feet from the edge of

the forest patch. In counties with more extensive forest cover and larger forest patches, we can anticipate a higher percentage of gas pipeline mileage will be cutting through forest interior areas.

Given that Bradford County is less forested than Pennsylvania's Marcellus region as a whole, we anticipate that the statewide percentage of pipelines built in forest areas will be higher. A conservative estimate would be that 50 percent of all future pipelines will be built in forest areas, or approximately 5,000 miles in the low Marcellus development scenario, 8,250 miles in the medium scenario, and 12,500 miles in the high scenario. Each mile of a 100-foot right-of-way directly disturbs 528,000 square feet or approximately 12 acres and creates an additional 72 acres of new forest edges.

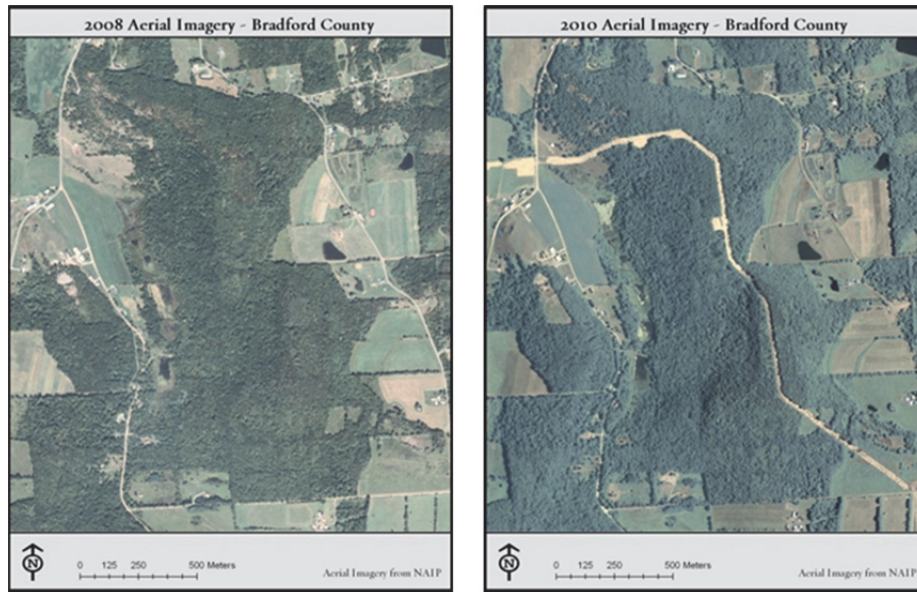


Figure 3. A right-of-way cleared for a gathering natural gas pipeline in Bradford County, PA. (Aerial imagery from USDA National Agriculture Imagery Program)

Therefore, we project that statewide forest area cleared from future pipeline development could be approximately 60,000 acres in the low scenario, 100,000 acres in the medium scenario, and 150,000 acres in the high scenario over the next two decades. In addition to these direct impacts, new gathering pipelines will create between 360,000 and 900,000 acres of new forest edges that deprive interior forest species, such as black-throated blue warblers, salamanders, and many woodland flowers, of the shade, humidity, and tree canopy protection that only deep forest environments can provide. We were unable to find any comprehensive plans for new transport lines in Pennsylvania. In general, however, we believe that the length of new gathering lines will dwarf mileage of new transport lines, perhaps by an order of magnitude.

Finally, compressor stations are an important part of natural gas transmission infrastructure. According to Bradford County data from March 2011, there are currently 14 built or proposed compressor stations in the county. Based on an aerial imagery assessment, these sites occupy an average area of slightly over 5 acres each (see Figure 4). Projecting how many compressor stations will be built in Pennsylvania is

difficult at this point in time, but the number is likely to be in the hundreds. Impacts from air emissions and noise pollution at compressor stations are likely to be more significant than land-use impacts.



Figure 4. Natural gas compressor station in Bradford County, PA. (Aerial imagery from USDA National Agriculture Imagery Program, 2010)

Conservation Impacts of Natural Gas Pipelines

Natural gas pipelines can impact the environment in several ways. This includes natural habitat loss and fragmentation, changes in species movement, sedimentation, and air emissions.

Rights-of-way for Marcellus gathering lines are generally cleared up to a width of 100 feet, but may be up to 150 or 200 feet if transport lines share the same corridor. After construction is completed, some portion of the right-of-way may be allowed to re-vegetate to trees and shrubs. At least 50 feet of the right-of-way, centered on the pipeline, is generally kept open, though vegetated with grass to minimize erosion and to facilitate monitoring, maintenance and repairs of the pipeline. This area represents a long-term loss of the cleared habitat. Even where forest remains, pipeline corridors can fragment large patches of forest into smaller ones (see Box 1, below). The new open corridor inhibits the movement of some species, such as forest interior nesting birds, which are reluctant to cross openings where they are more exposed to predators (Bennett, 2003). Pipelines, however, can also facilitate the movement of other species, both native and invasive (Transportation Research Board, 2004).

The large amount of soil disturbance involved in laying pipelines also poses erosion and sedimentation risks, particularly in steeper areas, near water bodies, and during heavy rain events. Heavy rains during two tropical storms in August and September 2011 caused extensive failures to erosion and sediment controls on pipelines under construction in north central Pennsylvania (Tanfani & McCoy, 2011). Stream and wetland crossings may create erosion and sedimentation problems, as well, especially with an “open cut” process, and there is a risk of stream bed collapse with “bore crossing” techniques if poorly designed or executed. The “open cut” process uses a trench dug across the stream channel with water temporarily diverted around the trench, while the “bore crossing” technique uses a drill or hydraulic ram to create a bore for the pipeline under the stream. Stream crossings require a permit from the PA Department of Environmental Protection with specific requirements to minimize erosion and sedimentation during and following construction.

Air emissions from pipelines and compressor stations are another concern, and may include methane, ethane, benzene, toluene, xylene, carbon monoxide, ozone and other pollutants (DEP, 2011b). High emission levels for some of these pollutants have been detected in the Barnett Shale region of Texas near pipelines and compressor stations and have exceeded human health standards at times (Armedariz, 2009). Short-term monitoring in north central Pennsylvania has detected some of the same pollutants but at lower levels not likely to trigger public health concerns, according to the Pennsylvania Department of Environmental Protection (DEP, 2011b). Air emissions – especially low level ozone – can also affect forest health. The focus of this assessment, however, is on habitat impacts from natural gas pipelines.

The Pennsylvania Marcellus Shale Advisory Commission (MSAC, 2011) recommended that pipeline impacts be reduced by identifying changes needed to:

- Share pipeline capacity and reduce surface disturbance and related environmental impacts;
- Encourage expansion of existing pipeline capacity and co-location of new capacity with other rights-of-way;
- Improve coordination and consistency of infrastructure planning and siting decisions by state, county and local governments, and;

Box 1. Large Forest Patches

Large contiguous forest patches are especially valuable because they sustain wide-ranging forest species, such as northern goshawk, and provide more habitat for “forest interior” species. Habitat fragmentation deprives “interior” forest species—such as black-throated blue warblers, salamanders, and many woodland flowers—of the shade, humidity, and tree canopy protection that only deep forest environments can provide. Large forest patches are also more resistant to the spread of invasive species, suffer less tree damage from wind and ice storms, and provide more ecosystem services—from carbon storage to water filtration—than small patches.

- Provide authority and resources for government agencies to ensure ecological and natural resource information is used to review siting of pipelines in order to avoid or minimize habitat impacts.

Key Findings

Key findings from the Pennsylvania Energy Impacts Assessment for natural gas pipelines include:

- Pennsylvania’s existing network of large diameter natural gas pipelines (including transport and gathering pipelines) will at least double, and possibly even quadruple, over the next two decades. This expansion will be largely due to a five- to twelve-fold increase in gathering pipeline mileage associated with Marcellus development.
- A low expansion scenario indicates 10,000 miles of new pipelines could be built (based on 6,000 new well pads), a medium scenario projects 16,500 miles (10,000 new well pads), and a high scenario shows up to 25,000 miles (15,000 well pads). Each new well pad on average requires 1.65 miles of gathering pipeline (based on data from Bradford County);
- Between 120,000 and 300,000 acres will be affected by natural gas pipeline construction, an area larger than the cumulative area affected by all other Marcellus gas infrastructure (e.g., well pads, roads, water containment, and staging/storage areas). Approximately half of this area is likely to be in forest areas.
- The expanding pipeline network could eliminate habitat conditions needed by “interior” forest species on between 360,000 and 900,000 acres as new forest edges are created by pipeline right-of-ways. This is substantially greater than the combined forest interior impacts from all other energy types examined in the *Pennsylvania Energy Impacts Assessment*.

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