# GATHERING PIPELINE DEVELOPMENT

Sullivan County, Pennsylvania

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# GATHERING PIPELINE DEVELOPMENT






## Pipeline Development & Marcellus Shale

In order to distribute the amount of natural gas and oil that our country currently consumes "it would take a constant line of 750 tanker trucks loading and rolling every two minutes, 24 hours a day, 7 days a week" (Chesapeake 3, 2012). Compared to truck trips, pipelines are much more efficient when transporting energy. Since they are also the safest way to transport this valuable resource, pipeline development is inevitable.

## Types of Pipelines

There are three types of pipelines: gathering, transmission, and distribution. Gathering lines usually are the smallest in diameter (6-24 inches) and transport oil or natural gas to production facilities or larger transmission lines. Transmission lines are larger in diameter (24-36 inches) and transfer the refined oil/natural gas to cities, countries or other continents. Distribution lines range from 2-24 inches in diameter and bring those products to homes and businesses within a city or town (TNC 1, 2011) (Chesapeake 1, 2012).

## MARC I Transmission Line

The Marc I, a 30 inch diameter, high pressure, steel transmission pipeline, extends for 39 miles and is currently under construction in three counties: Lycoming, Bradford, and Sullivan County. It will require “the clearing of approximately 326 acres of forest habitat and the permanent removal of approximately 170 acres of forested land” (Lapp, 2011). Not only will the transmission pipeline be ripping through these counties’ forested regions, but it will also “pose the threat of pollution to 111 sensitive streams” (Loewenstein, 2011). As wells begin to produce, gathering lines will need to connect each one to the MARC I line.

**Pictured Left:** Current construction on the Marc I Pipeline in Sullivan County

*Photo Source: Larch 414 Studio 2012

Sources:

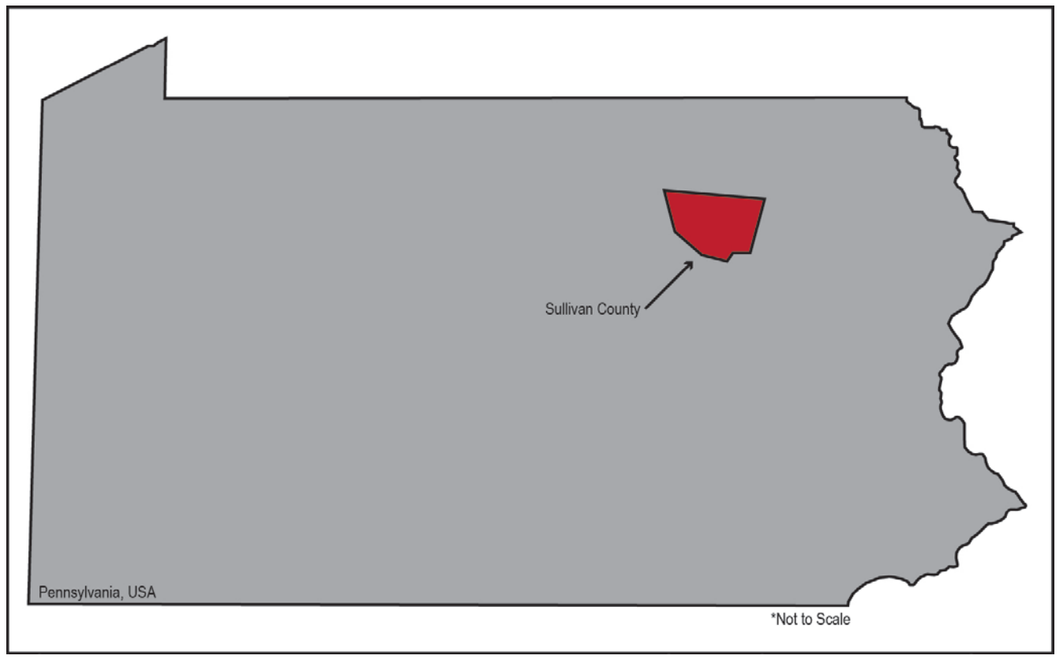
Chesapeake Energy. 2011. "Pipeline Transportation Fact Sheet." AskChesapeake.com. www.chk.com/Media/EducationalLibrary/FactSheets/Corporate/Pipeline_Transportation_Fact_Sheet.pdf (accessed September 16, 2012).

Lapp, Jeffrey D. 2011. "EPA Comments on MARC I Pipeline." State Impact. stateimpact.npr.org/pennsylvania/epa-comments-on-marc-1-pipeline/ (accessed September 27, 2012).

Loewenstein, James. 2011. "Pipeline approved for Bradford, Sullivan counties." The Daily Review.thedailyreview.com/news/pipeline-approved-for-bradford-sullivan-counties-1.1234415 (accessed September 28, 2012).

The Nature Conservancy. 2011."Natural Gas Pipelines." Excerpt from Report 2 of the Pennsylvania Energy Impacts Assessment. www.nature.org/ourinitiatives/regions/northamerica/unitedstates/pennsylvania/ng-pipelines.pdf

# OUR PROJECT




With the new and upcoming Marcellus Shale development in Sullivan County, planners will need to place all types of pipelines within the landscape. Without any concrete regulations the effects of these pipelines will impact daily life at the local level. Since the MARC I transmission line has already started construction, we formulated three different development scenarios for the placement of gathering lines that would service the Nature Conservancy's highest well projection prediction within Sullivan County.

The three scenarios are:

- Shortest Distance
- Market Based (following typical pipeline company practices)
- Conservation Based

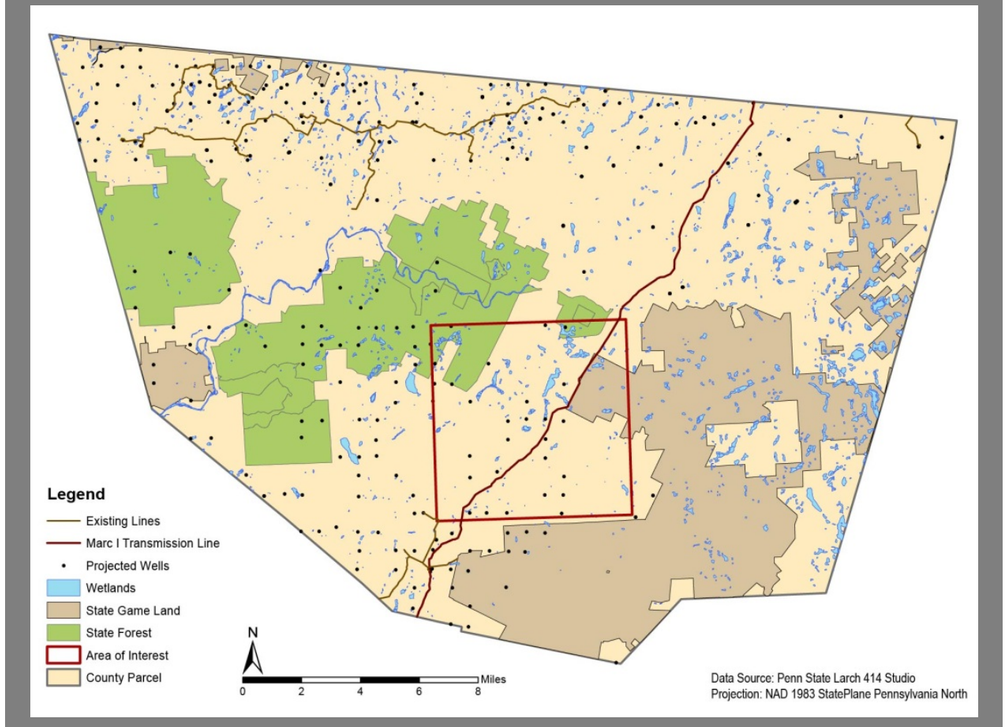
SHORTEST DISTANCE

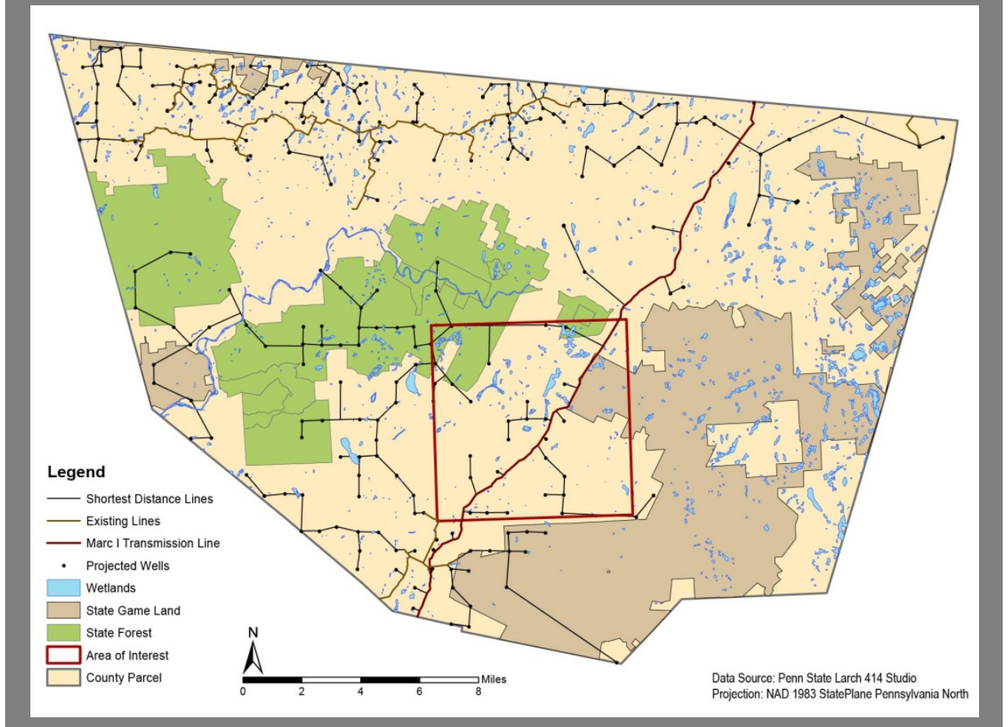
MARKET BASED

CONSERVATION BASED

# GATHERING PIPELINE DEVELOPMENT

## SULLIVAN COUNTY, PENNSYLVANIA




### Existing Pipelines

The above map conveys the existing gathering pipelines in Sullivan County, as well as the MARC I transmission pipeline. This map also shows the projected wells from the Nature Conservancy for Sullivan County.

### Shortest Distance Pipelines

The map above shows the network of pipelines formed from the shortest distance development approach, connecting all of the existing and proposed wells in Sullivan County to the MARC I Transmission Pipeline.

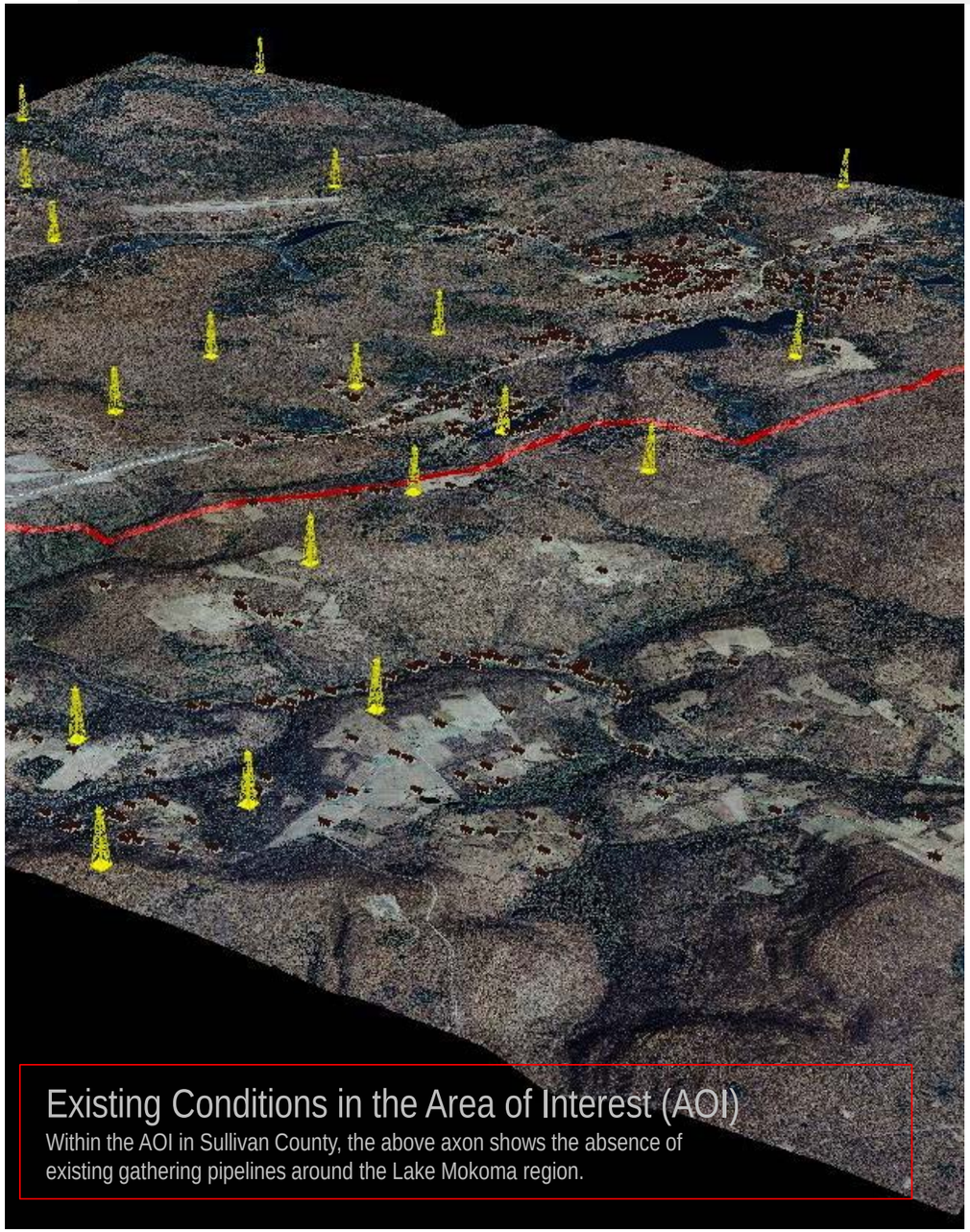
# GATHERING PIPELINE DEVELOPMENT

## SULLIVAN COUNTY, PENNSYLVANIA

SHORTEST DISTANCE

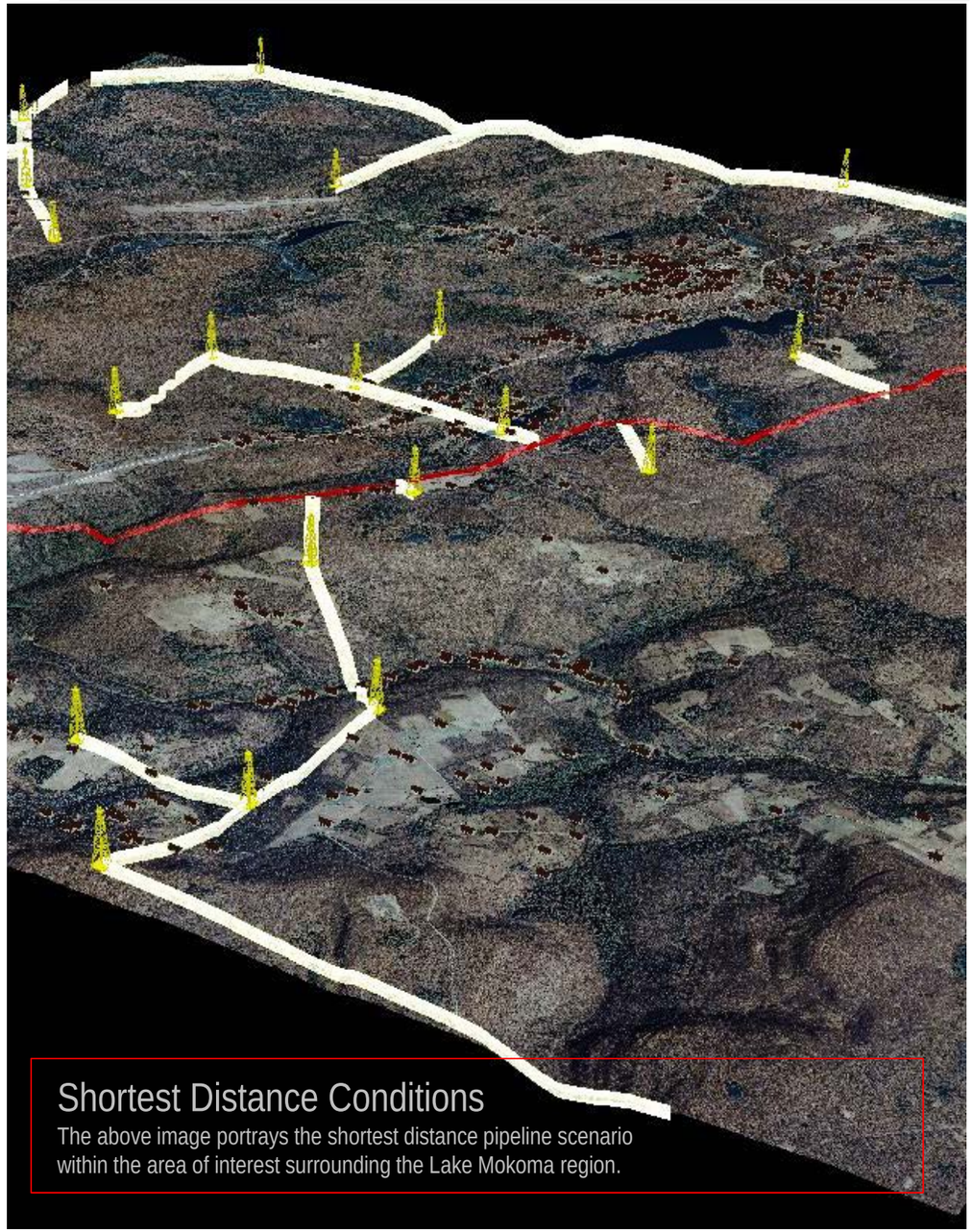
MARKET BASED

CONSERVATION BASED



### Existing Conditions in the Area of Interest (AOI)

Within the AOI in Sullivan County, the above axon shows the absence of existing gathering pipelines around the Lake Mokoma region.



### Shortest Distance Conditions

The above image portrays the shortest distance pipeline scenario within the area of interest surrounding the Lake Mokoma region.

# GATHERING PIPELINE DEVELOPMENT

# SULLIVAN COUNTY, PENNSYLVANIA

SHORTEST DISTANCE

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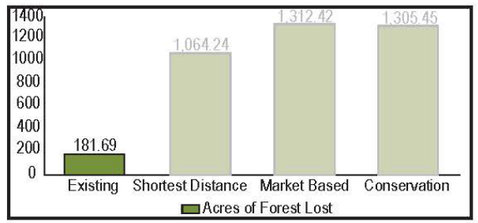
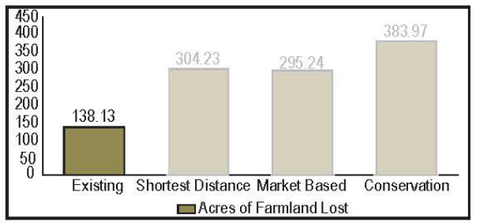
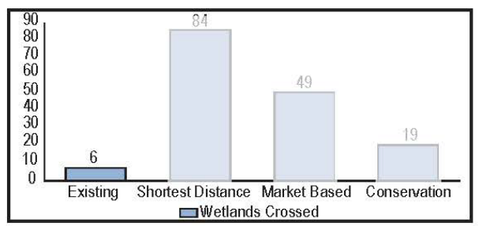
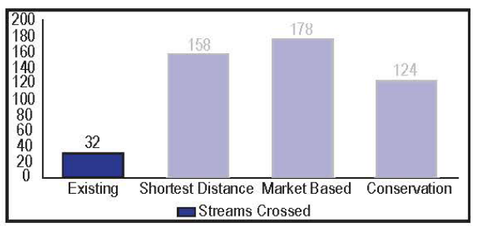
CONSERVATION BASED

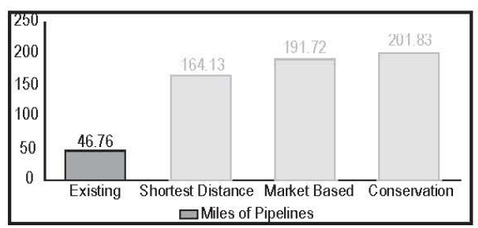


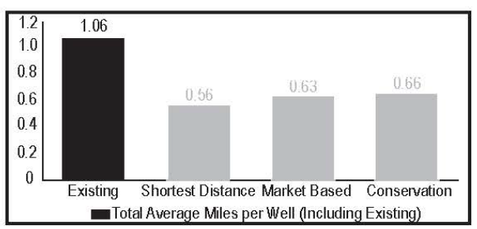



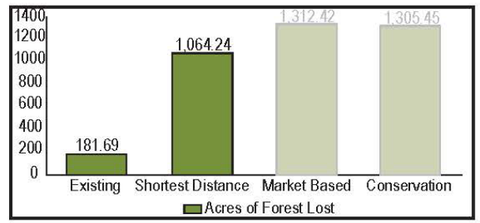


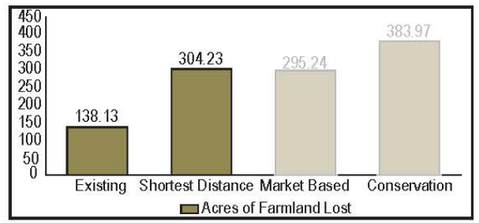



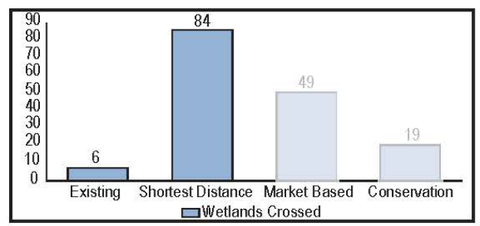



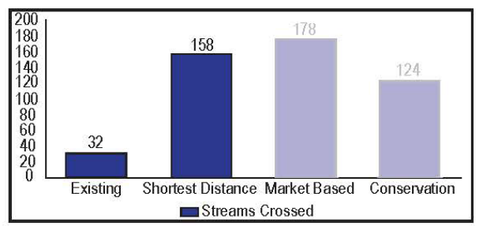

## Existing Pipeline Impacts

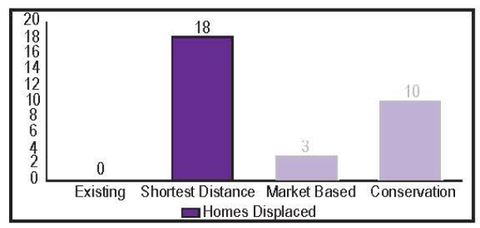
The charts above highlight the impacts that have already occurred from implementing the existing gathering lines in Sullivan County.



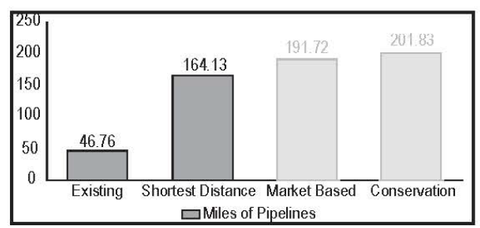



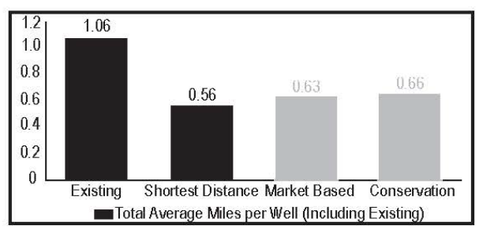








## Shortest Distance Pipeline Impacts

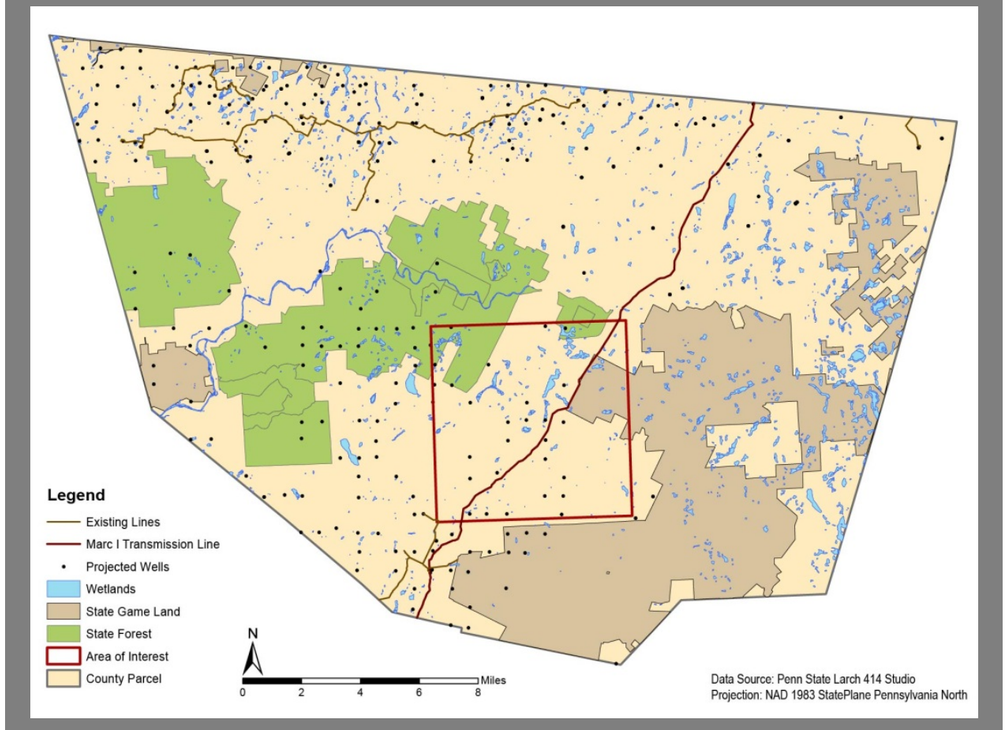
The charts above display the differences between the existing lines and the shortest distance lines. This scenario crosses the most wetlands, and displaces the most houses. It also requires the least amount of pipeline to connect the wells.

SHORTEST DISTANCE

MARKET BASED

CONSERVATION BASED

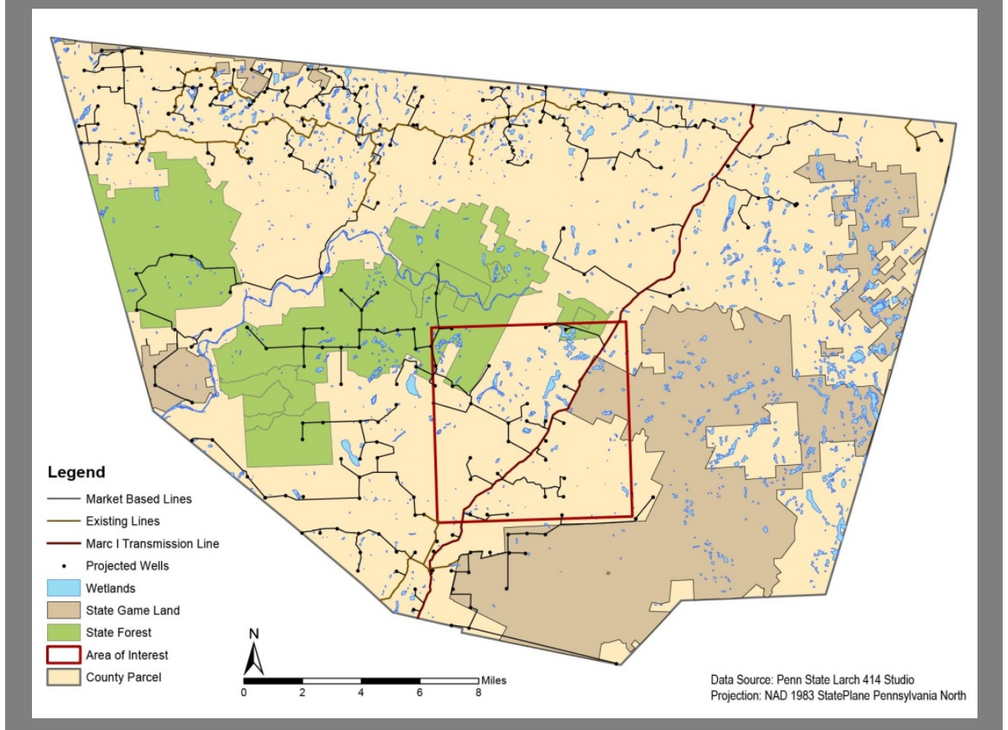
# PIPELINE DEVELOPMENT




## Existing Pipelines

The above map conveys the existing gathering pipelines in Sullivan County, as well as the MARC I transmission pipeline. This map also shows the projected wells from the Nature Conservancy for Sullivan County.

# SULLIVAN COUNTY, PENNSYLVANIA




## Market Based Pipelines

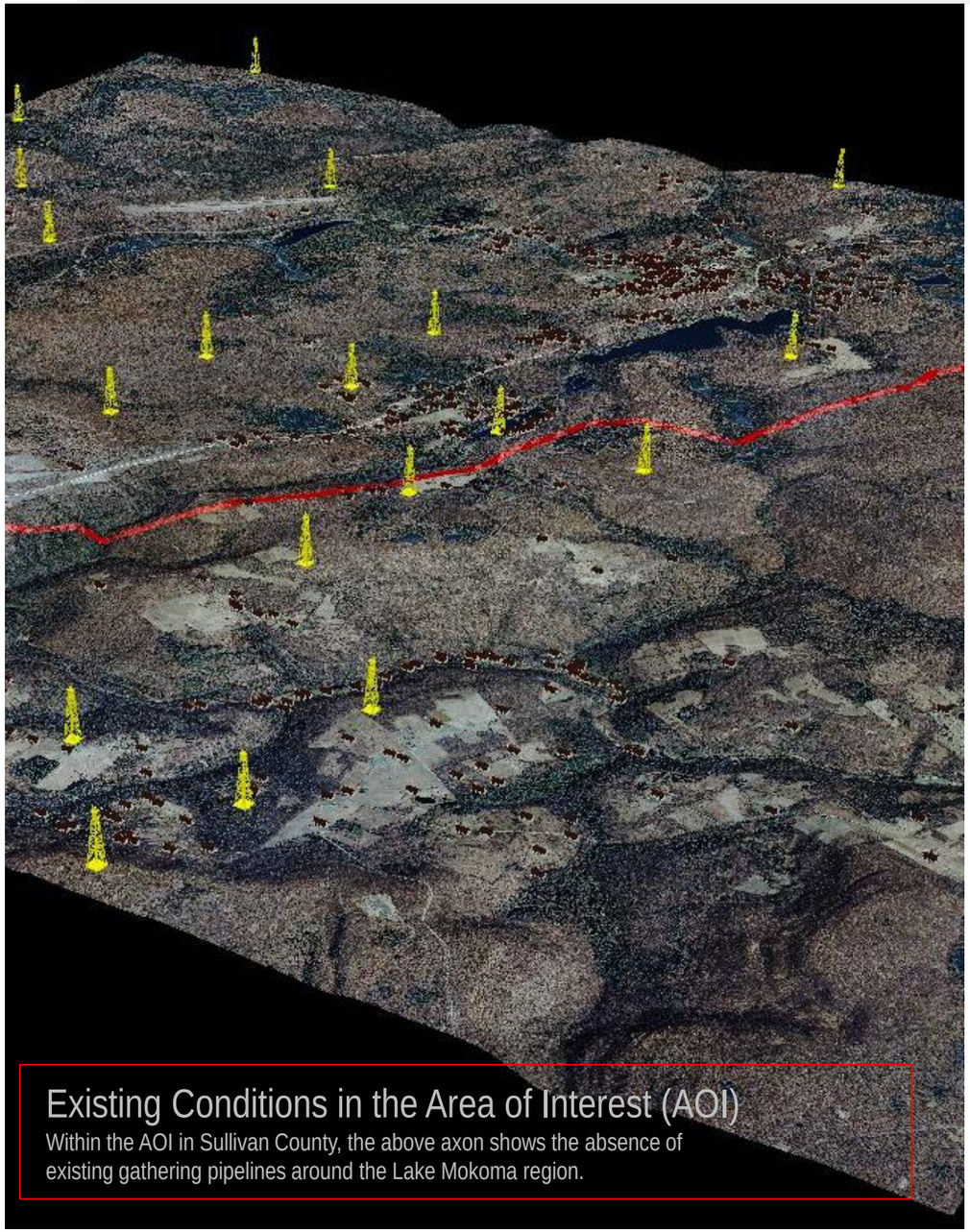
The map above shows the network of pipelines formed from market based development approach, connecting all of the existing and proposed wells in Sullivan County to the MARC I Transmission Pipeline.

# PIPELINE DEVELOPMENT

SHORTEST DISTANCE

MARKET BASED

CONSERVATION BASED



## Existing Conditions in the Area of Interest (AOI)

Within the AOI in Sullivan County, the above axon shows the absence of existing gathering pipelines around the Lake Mokoma region.

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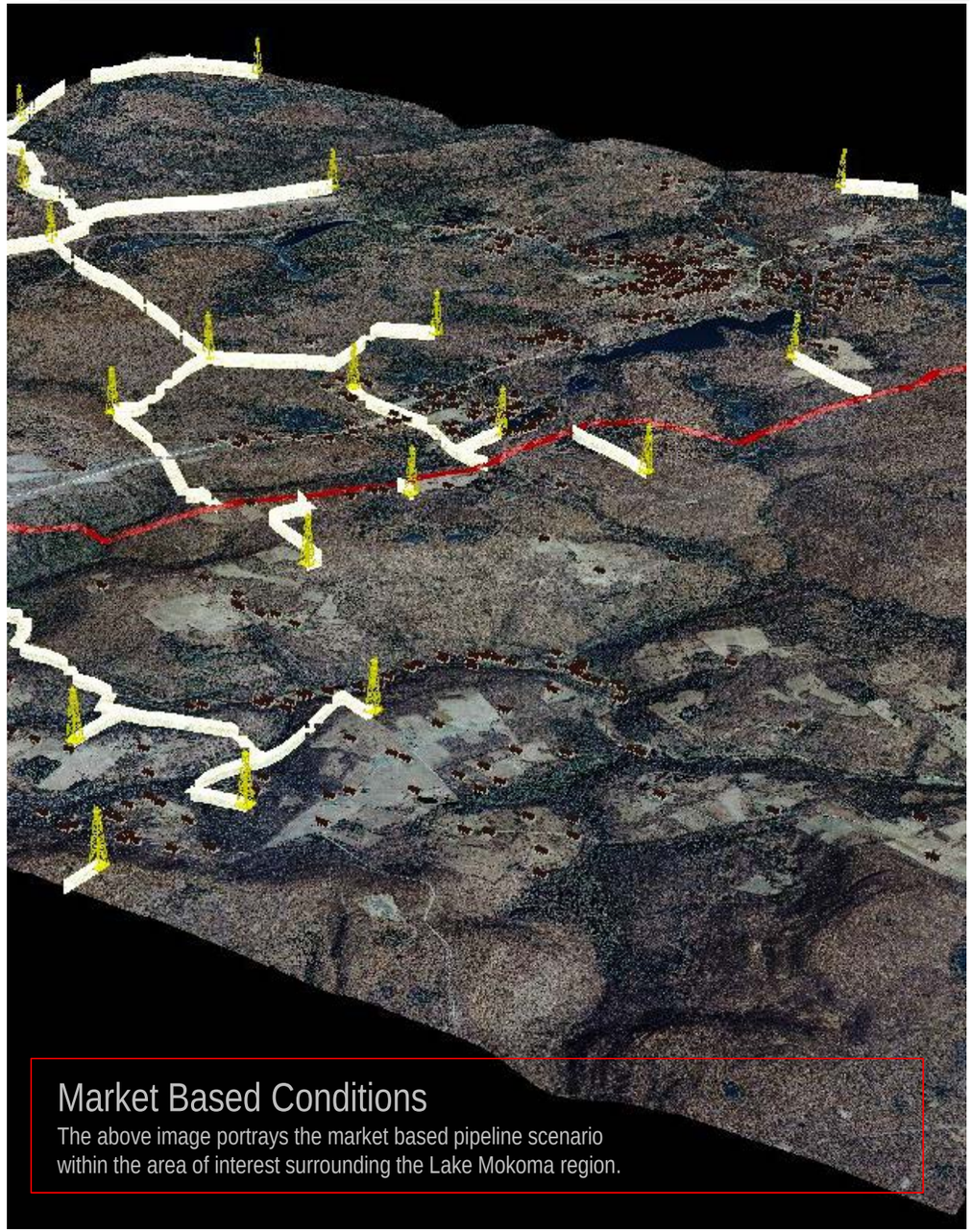

## Market Based Conditions

The above image portrays the market based pipeline scenario within the area of interest surrounding the Lake Mokoma region.

# PIPELINE DEVELOPMENT

SHORTEST DISTANCE

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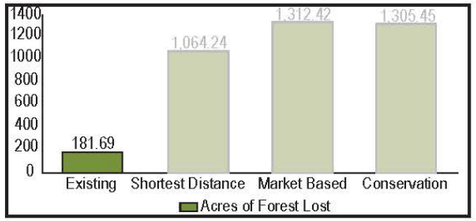


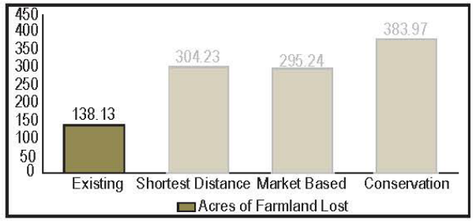


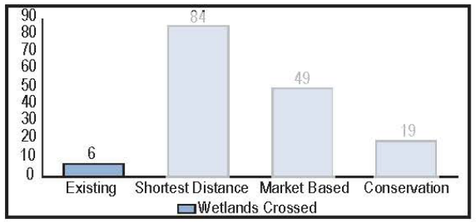


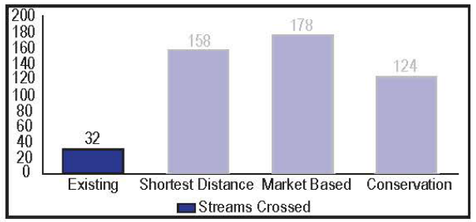


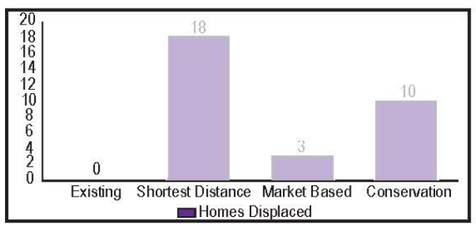



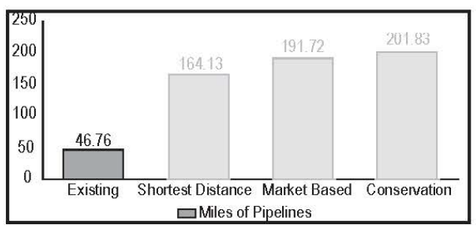


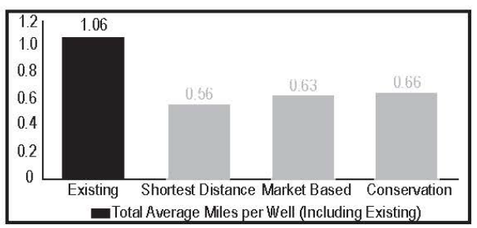


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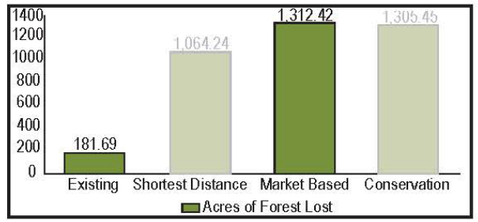
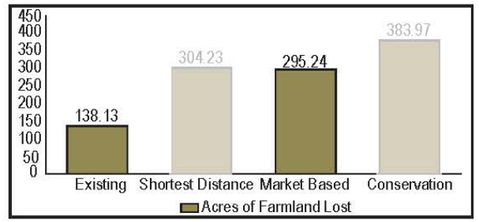
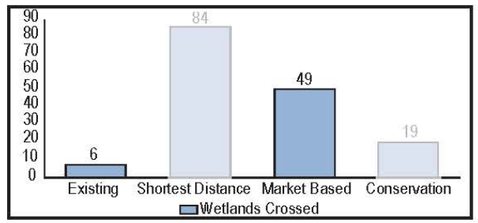
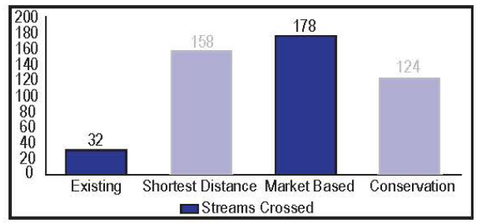
# SULLIVAN COUNTY, PENNSYLVANIA

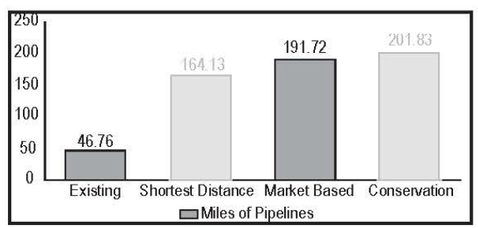


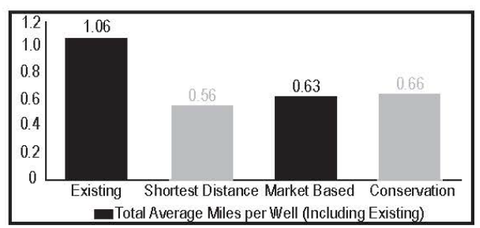






## Market Based Pipeline Impacts

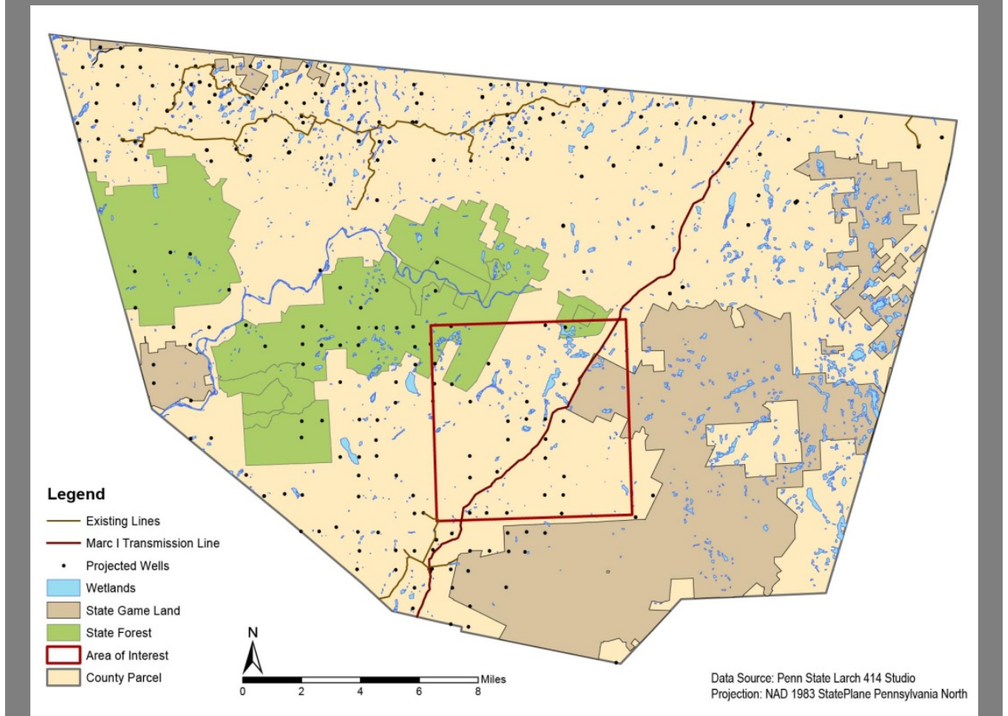
The charts above display the differences between the existing lines and the market based lines. This scenario fragments the most forest and crosses the most streams, but requires the least amount of individual property leases.

SHORTEST DISTANCE

MARKET BASED

CONSERVATION BASED

# PIPELINE DEVELOPMENT

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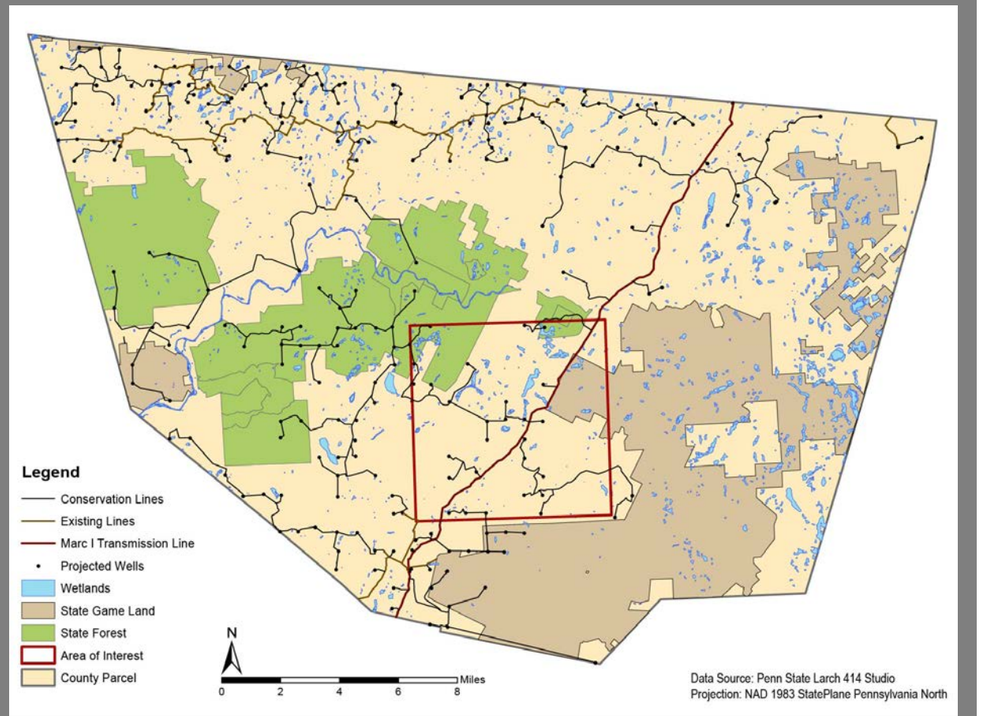


## Conservation Based Pipelines

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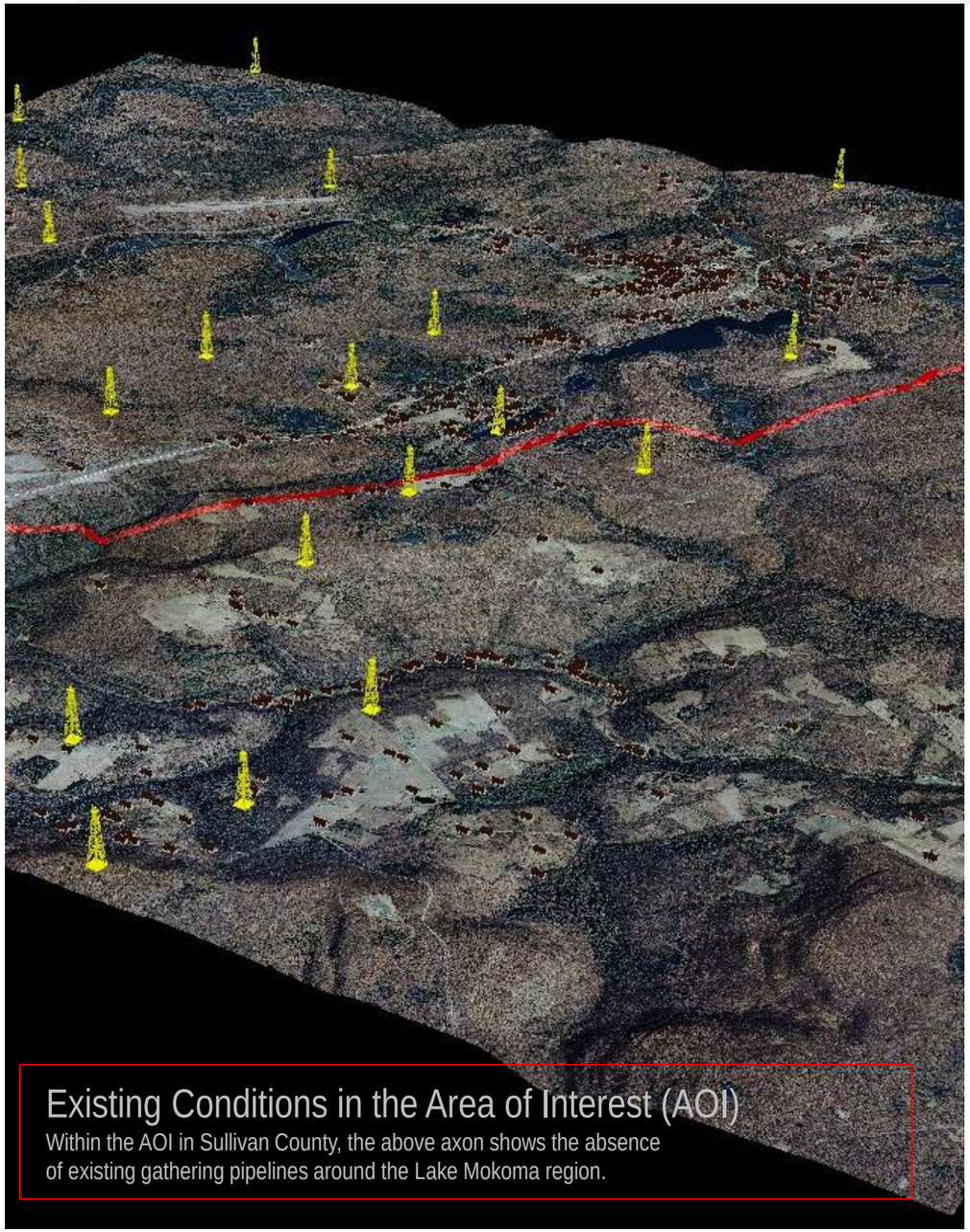
CONSERVATION BASED

# PIPELINE DEVELOPMENT

# SULLIVAN COUNTY, PENNSYLVANIA



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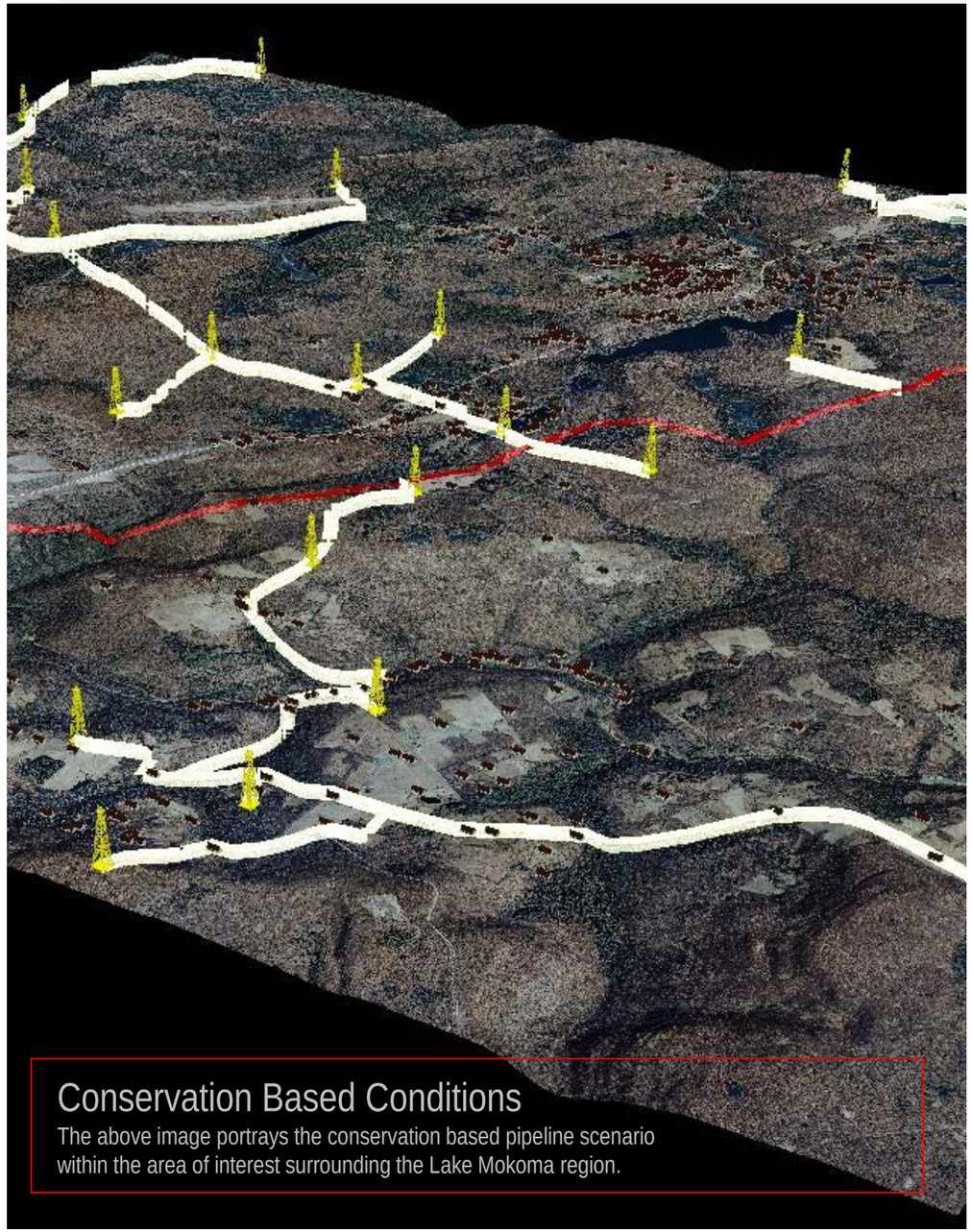

## Conservation Based Conditions

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# PIPELINE DEVELOPMENT

SHORTEST DISTANCE

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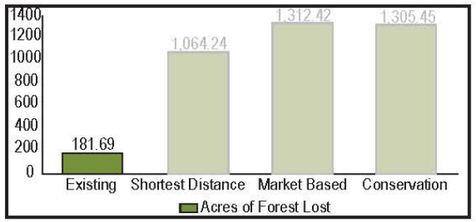


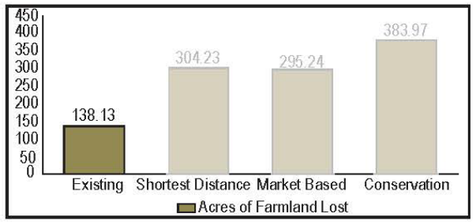


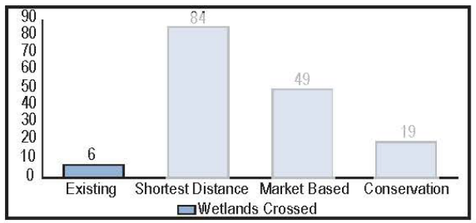


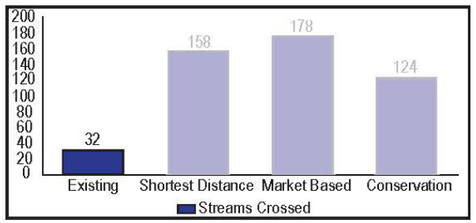




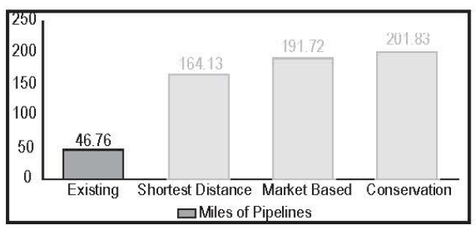


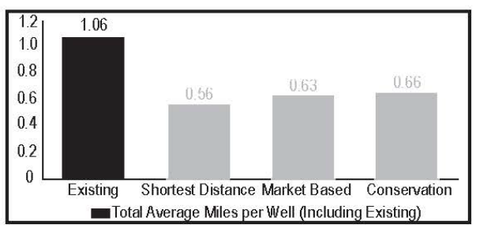


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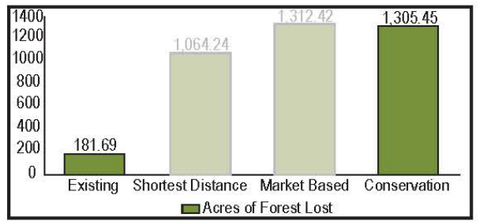
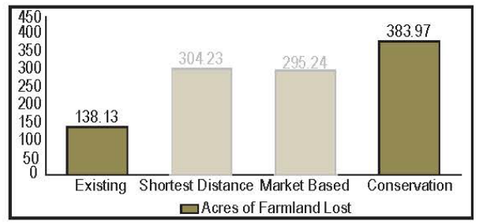
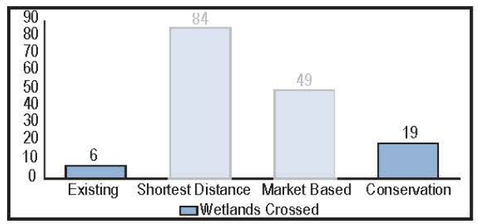
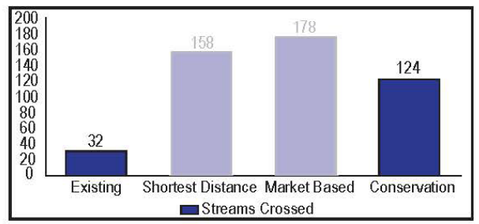
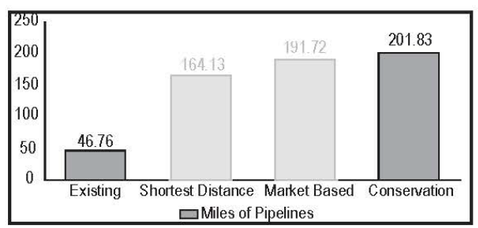


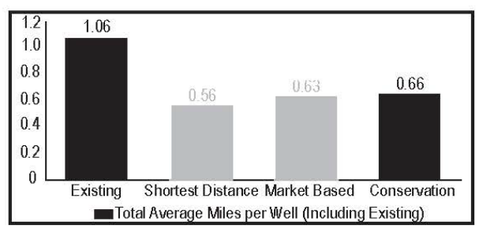





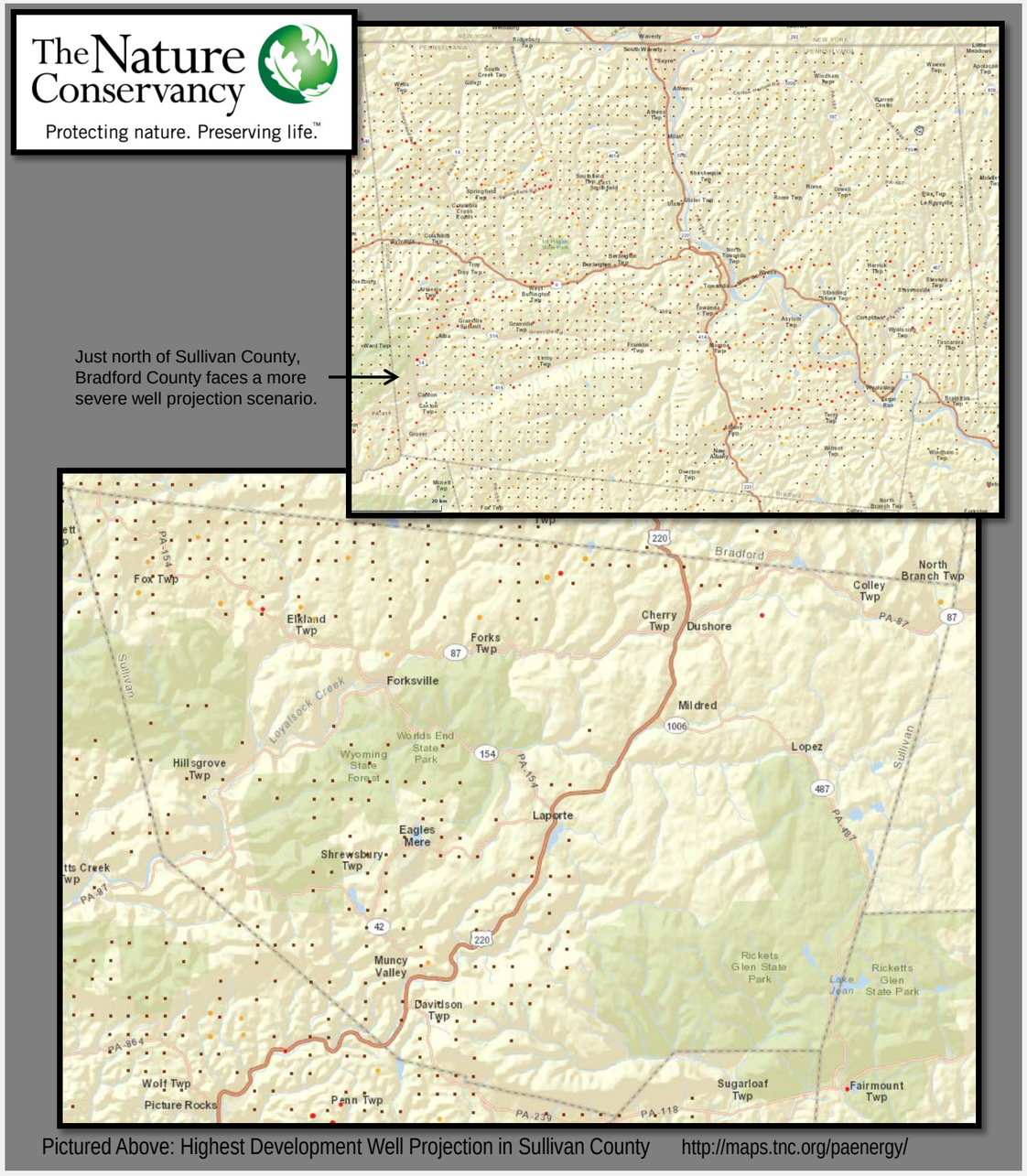




## Conservation Based Pipeline Impacts

The charts above display the differences between the existing lines and the conservation based lines. This scenario disrupts the most farmland, crosses the most property lines and requires the longest amount of pipeline to connect the wells.

# SUPPORTING MATERIAL: GATHERING PIPELINE DEVELOPMENT

# THE NATURE CONSERVANCY




Pictured Above: Highest Development Well Projection in Sullivan County http://maps.tnc.org/paenergy/

## Well Projections

The Nature Conservancy, a charitable organization, uses a scientific approach to define regions that need assistance for ecological preservation. With the large scale Marcellus Shale development sweeping across Pennsylvania, the Nature Conservancy analyzed drilling locations based on current trends within the state.

"Marcellus Shale is much larger and could reach 300 rigs in Pennsylvania alone. We chose a conservative estimate of 250 maximum horizontal drill rigs for each scale projection scenario. Assuming that each rig can drill one well per month, 3,000 wells are estimated to be drilled annually. At that rate, 60,000 new wells would be drilled by the year 2030" (TNC, 2010).

Based on current drilling patterns and the 60,000 wells predicted in Pennsylvania by 2030, the Nature Conservancy projected three different development scenarios – low, medium, and high – for the location of these wells. These projections range from 6,000 for the low scenario to 15,000 well pads in the high scenario and span over 30 counties in Pennsylvania. To formulate these projections, "a team of scientists spent nearly a year analyzing data from myriad public sources to model the location and intensity of likely future energy development in Pennsylvania" (TNC, 2010).

To decide which locations within Pennsylvania's Marcellus formation would be more suitable for development, the Nature Conservancy "used a machine-based learning modeling approach known as maximum entropy (Maxent 3.3.3a, Princeton University)" (TNC, 2010). Maximum entropy is an application that can analyze "real world problems in statistical estimation and pattern recognition" (Berger, 1996). "The model was found to be 80% accurate in predicting existing and permitted wells from randomly sampled undeveloped areas" (TNC, 2010). The regions incompatible for Marcellus Shale gas exploration were excluded from the designated development areas (TNC, 2010). These areas included: existing drilled Marcellus Shale wells, Wild and Natural Areas, and water bodies (TNC, 2010). To learn more about this process, please visit: http://www.shalegas.energy.gov/resources/tnc_energy_analysis.pdf.

The research and analysis we conducted on the following pages used the Nature Conservancy's highest well projection scenario in Sullivan County (pictured left) to formulate three separate gathering pipeline development situations.

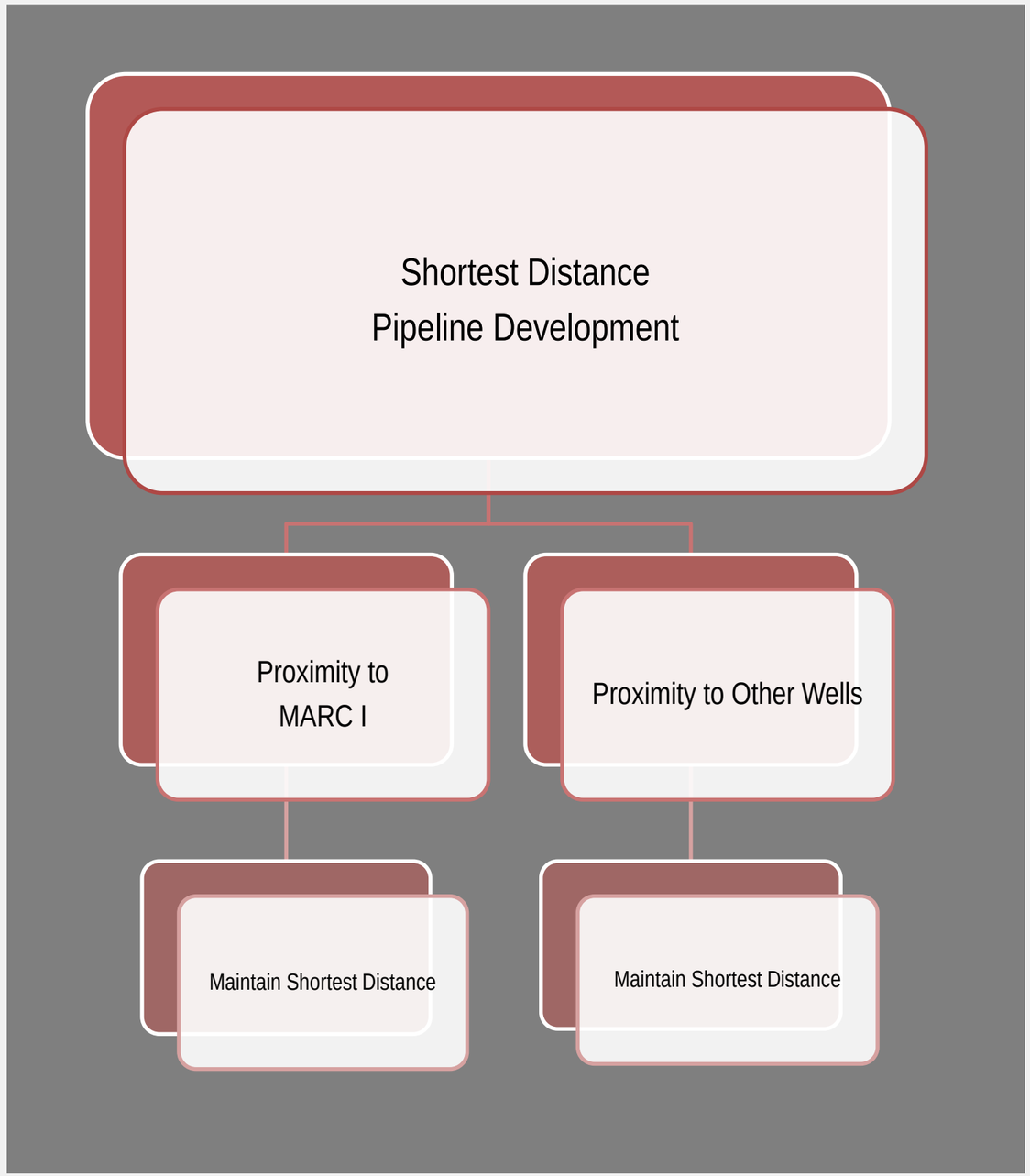

Sources:

Berger, Adam. 1996. "A Maximum Entropy Approach to Natural Language Processing." UPenn. acl.ldc.upenn.edu/J/J96/J96-1002.pdf (accessed December 12, 2010).

The Nature Conservancy. 2010. "Report 1: Marcellus Shale Natural Gas and Wind." Pennsylvania Energy Impacts Assessment. www.shalegas.energy.gov/resources/tnc_energy_analysis.pdf (accessed December 12, 2010).

The Nature Conservancy. 2010. "The Energy Equation." Marcellus Shale Gas. www.nature.org/photosmultimedia/marcellus-existing-projected1-1-1-1-1jpg.pdf (accessed December 12, 2010).

# SHORTEST DISTANCE PIPELINES




## Developing a Network

The chart to the left outlines the process taken to facilitate this development situation. To create a network of pipelines for this scenario, the only factors taken into account were the distance between the wells and the distance from the wells to the MARC I transmission pipeline. A suitability analysis was not needed, as this development scenario did not take the location of wetlands, streams, property lines, location of buildings, or forest, etc. into consideration.

Therefore, this development scenario managed to cross the largest number of wetlands and displace the most houses.

| Pros | Cons |
|---|---|
| + Uses the least amount of lines<br>+ Fragments the least amount of Forest | - Cuts through 158 streams<br>- Displaces 18 houses<br>- Crosses 84 wetlands<br>- Requires 1,648 individual property leases from private landowners |

By fragmenting the least amount of forest, the shortest distance pipelines will help to keep Sullivan County's forests intact

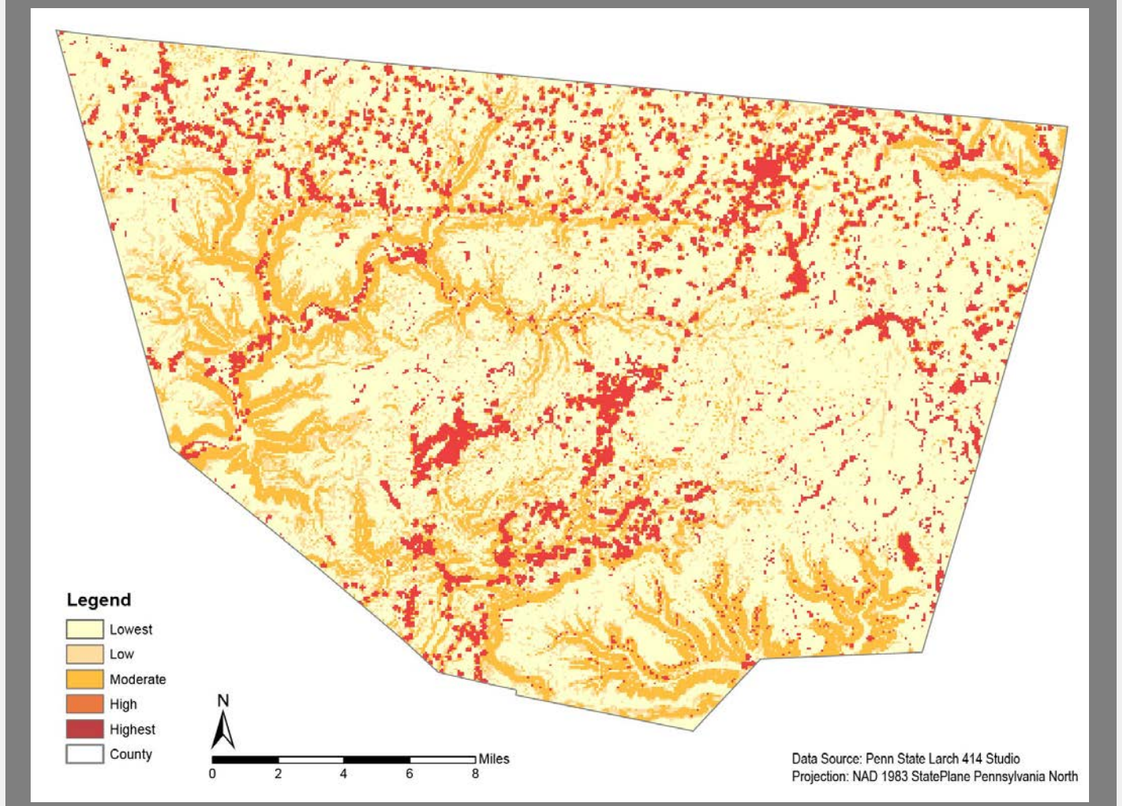
(Air Photo, 2007)

The shortest distance pipelines displace the highest amount of homes, causing interference with everyday residential life

(Larch 414 Studio, 2011)

Sources:
Air Photo. 2007. "Airphoto - Aerial Photo: Hardwood Forest, Potter County, Pennsylvania." Aerial Photography - Airphoto. http://www.airphotona.com/image.asp?imageid=10329 (accessed December 11, 2012).

# MARKET BASED PIPELINES




## Developing a Network – Suitability Analysis

The market based pipeline scenario was developed using the mind set of a pipeline planning company; ultimately driven by cost of materials, placement with regards to property lines and water bodies, and potential gains from clear cutting a forested area. The map to the left shows the suitability analysis derived by these input factors. The factors, seen below, were placed on a value system according to how pipeline companies rate suitable land for implementation of an actual pipeline.

Inputs for suitability analysis:

Distance from Homes

- 0-100 Feet : Highly Not Suitable
- 100-300 Feet : Not Suitable
- 300-500 Feet : Low Suitability
- Over 500 Feet : Suitable

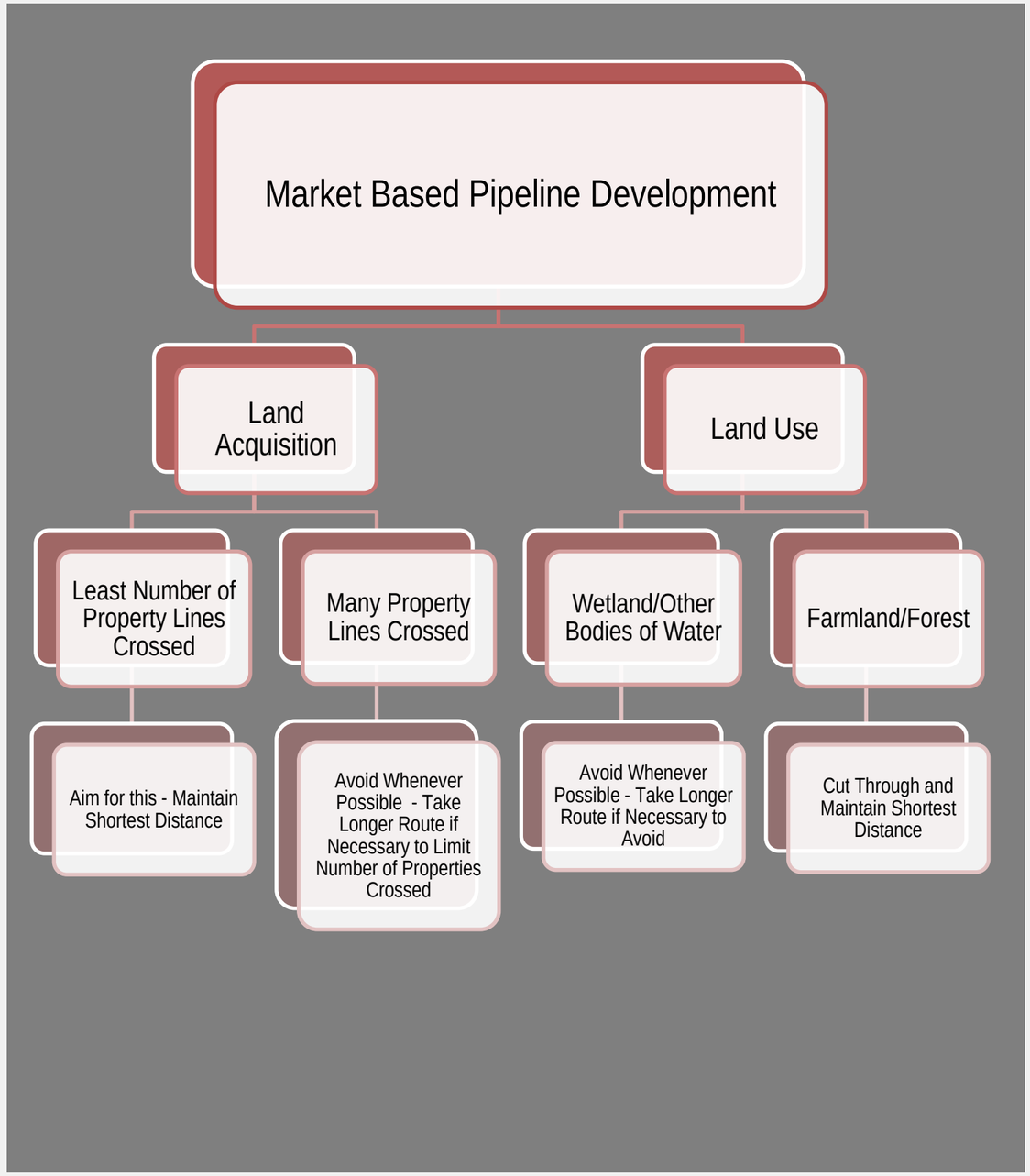
Slopes

- 0-10% : High Suitability
- 10-20% : Medium Suitability
- 20-30% : Low Suitability
- Over 30% : Not Suitable

Land Cover

- Forest : High Suitability
- Farmland : High Suitability
- Residential : Low Suitability
- Wetland : Not Suitable

# MARKET BASED PIPELINES




## Further Development of a Network

Upon completion of the suitability analysis, there were a few more factors which took prominence when developing the market based gathering pipelines, shown in the chart on the left. Appropriate areas for the pipelines, sought out by the suitability analysis, took precedence when evolving this pipeline situation. Once highly unsuitable areas were avoided, market based lines were placed according to the route that would cross the least amount of property lines. The less property lines that are crossed, the less money needed to settle contracts or leases with land owners. Shortest distance remained as the last factor taken into consideration for the market based pipelines.

| Pros | Cons |
|---|---|
| + Requires only 1,248 property leases<br>+ Displaces only 3 houses<br>+ Cuts through 1,312.42 acres of forest providing monetary gains from lumber sales | - Crosses 148 streams<br>- Cuts through 49 wetlands<br>- Fragments the most core forest habitat |

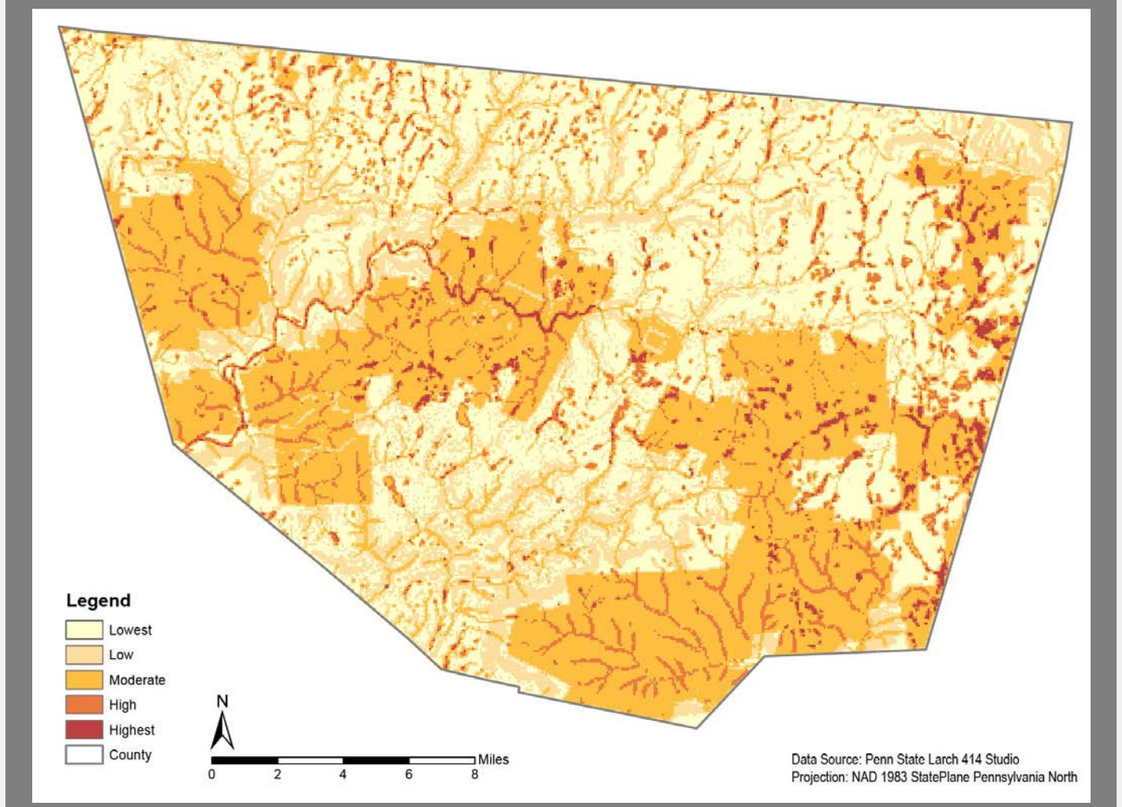

The market based pipelines tend to stay away from houses, avoiding the use of signage similar to what is seen above

(Larch 414 Studio, 2011)

The market based pipelines fragment the highest amount of forest acreage negatively impacting ecosystem health

(Larch 414 Studio, 2012)

# CONSERVATION BASED PIPELINES




## Developing a Network – Suitability Analysis

The conservation based pipeline scenario was developed using the mentality of an ecologically friendly conservation or advocacy group. Driven by core forest habitat acreage, locations of streams and other bodies of water, and steepness of the topography, the map to the left shows the suitability analysis derived from these considerations. Similar to the market based suitability analysis, the factors seen below had values placed on them to distinctively define the land which would be suitable for the pipelines in this situation.

Inputs for suitability analysis:

Core Forest Acreage
- 0-100 acres : Suitable
- 100-250 acres : Moderately Suitable
- 250-500 acres : Minimally Suitable
- Over 500 acres : Not Suitable

Streams
- 0-50 Feet : Highly Not Suitable
- 50-100 Feet : Moderately Not Suitable
- 100-200 Feet : Minimally Not Suitable
- 200-300 Feet : Not Suitable

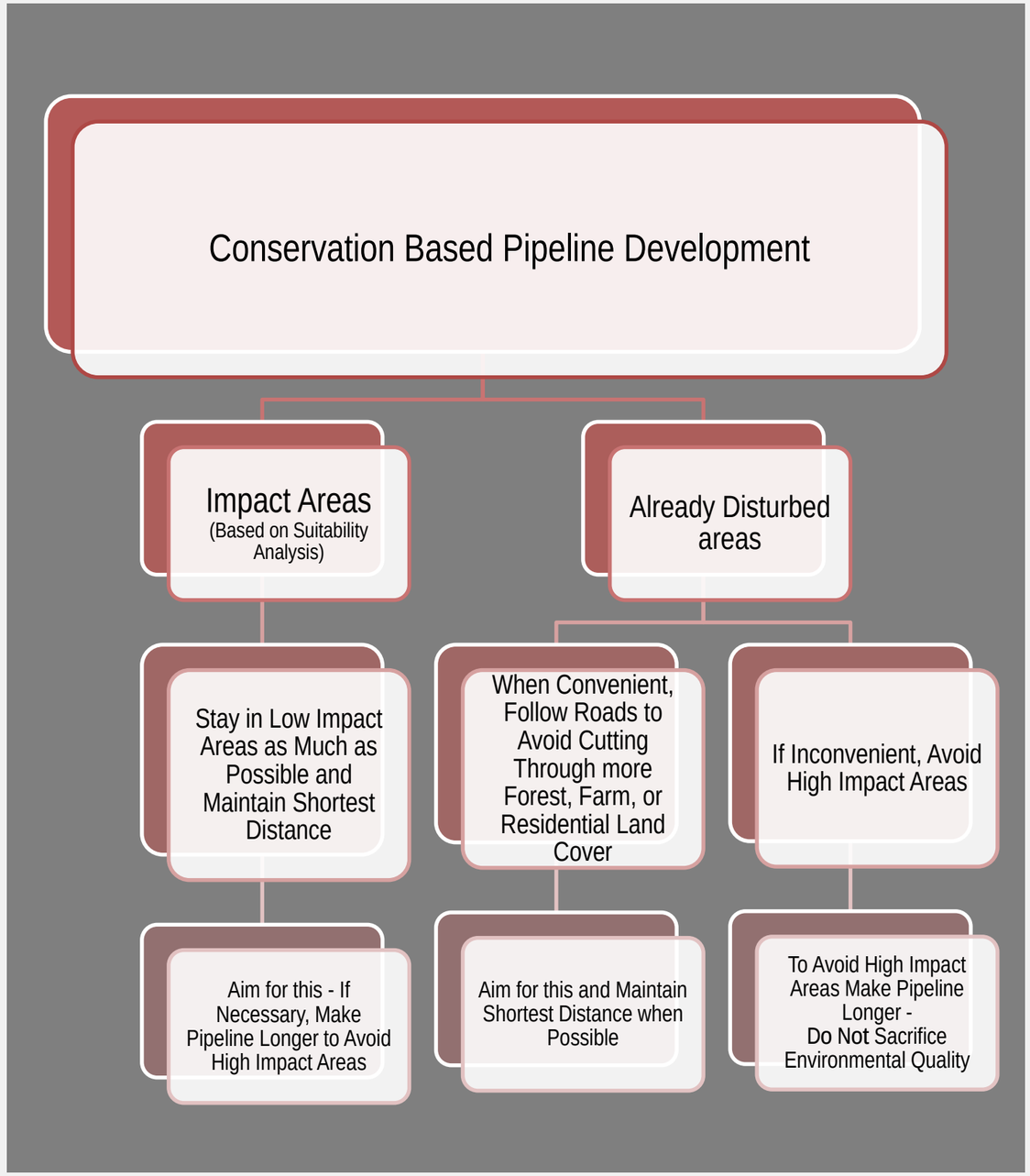
Wetland Locations
- Actual Wetland: Highly Not Suitable
- 0-50 Feet : Moderately Not Suitable
- 50-100 Feet : Minimally Not Suitable
- 100-200 Feet : Not Suitable
- 200-300 Feet : Barely Suitable

State Forest
- <100m Interior Buffer : Moderately Suitable
- Inside of 100m Interior Buffer : Not Suitable

Game Lands
- <100m Interior Buffer : Moderately Suitable
- Inside of 100m Interior Buffer : Not Suitable

Slopes
- 0-10% : High Suitability
- 10-20% : Medium Suitability
- 20-30% : Low Suitability
- Over 30% : Not Suitable

# CONSERVATION BASED PIPELINES




## Further Development of a Network

After completing the suitability analysis for the conservation based pipeline development scenario, a few other factors took precedence when laying out the network. Seen in the chart to the left, the most important factor was avoiding the areas which would be highly impacted by a pipeline cut. When possible, the pipeline development followed already impacted areas, such as roads. Overall, the network of conservation based gathering pipelines avoids high impacted areas at ALL costs, so as to not sacrifice the environmental quality of the county.

| Pros | Cons |
|---|---|
| + Follows existing disturbed areas (ex. roads)<br>+ Avoids Wetlands and Streams when possible<br>+ Minimally impacts state forest considering well projection | - Needs the most amount of line (201.83 miles)<br>- Requires 2,198 property leases<br>- Disrupts the most agriculture (383.97 acres) |

The conservation based pipelines follow roads and other disturbed areas where possible to minimize impacts on the environment

(Larch 414 Studio, 2012)

The conservation based pipelines fragment the most agricultural land, as seen cutting through a cattle grazing area above

(The Daily Review, 2010)

Sources:
The Daily Review. 2010. "Natural gas pipeline right-of-ways: Understanding landowner rights and options - News - Daily Review." Towanda, Pa. news, sports, obituaries, and shopping | thedailyreview.com | Daily Review. http://thedailyreview.com/news/natural-gas-pipeline-right-of-ways-understanding-landowner-rights-and-options-1.853683 (accessed December 11, 2012).

# BEST MANAGEMENT PRACTICES IN ROWS

## What is a ROW?

(Detroit HOUP, 2007)

A ROW, or Right Of Way, is “a strip of land over and around natural gas pipelines where some of the property owner's legal rights have been granted to a pipeline operator. A right-of-way agreement between the pipeline company and the property owner is also called an easement and is usually filed in the county Register & Recorders office with property deeds. Rights-of-ways and easements provide a permanent, limited interest in the land that enables the pipeline company to install, operate, test, inspect, repair, maintain, replace, and protect one or more pipelines within the designated easement” (Messersmith, 2012).

Gathering line ROWs in the Marcellus region range from **30-150 feet wide and 6-24 inches in diameter** (The Nature Conservancy, 2011). These ROWs "allow enough room for unobstructed aerial surveillance, inspection, maintenance and testing" (Chesapeake 1, 2011).

## Where are the Pipelines?

Natural gas pipelines are located by markers designated in the ROW. Tampering with, or intentional removal or destruction of these markers can result in “a **fine of up to $5,000 and/or a term of up to 1 year imprisonment**” (Texas Gas, 2012). The markers provide information including the approximate location of the pipeline, the material in transport, and the operator's name and emergency telephone number (Liberty Utilities, 2012).


(M3 Midstream LLC, 2012)

Sources:

Chesapeake Energy. 2011. "Pipeline Transportation Fact Sheet." AskChesapeake.com. www.chk.com/Media/Educational-Library/Fact Sheets/Corporate/Pipeline_Transportation_Fact_Sheet.pdf (accessed September 16, 2012).

Detroit HOUP. 2007. "Pipeline ROW & Construction." Detroit Heavy Oil Upgrade Project. www.detroithoup.com/FAQ-right-of-way.html (accessed November 12, 2012).

Liberty Utilities. 2012. "Natural Gas Pipeline Safety - What You Need to Know." Welcome to Liberty Utilities. http://libertyutilities.com/central/safety/need_to_know.html (accessed December 9, 2012).

M3 Midstream LLC. 2012. "Landowners | Momentum | M3 Midstream Energy Company." Momentum | M3 Midstream Energy Company. http://www.m3midstream.com/landowners/ (accessed December 9, 2012).

Messersmith, Dave. 2012. "Natural Gas Pipeline Right-of-Ways: Understanding Landowner Rights and Options — Natural Gas — Penn State Extension." Penn State Extension — Penn State College of Ag Sciences. http://extension.psu.edu/naturalgas/news/2010/04/pipelineinfo (accessed November 15, 2012).

Texas Gas. 2012. "Texas Gas - Frequently Asked Questions." Texas Gas - Welcome. http://www.txgt.com/Safety.aspx?id=1447 (accessed November 28, 2012).

The Nature Conservancy. 2011. "Pennsylvania Energy Impacts Assessment." Natural Gas Pipelines. www.nature.org/ourinitiatives/regions/northamerica/unitedstates/pennsylvania/ng-pipelines.pdf (accessed October 25, 2012).

# BEST MANAGEMENT PRACTICES IN ROWS

## Using the ROW

The uses of ROWs are regulated mainly for public safety. They are monitored "to ensure that ROW and pipelines are clearly defined, to prevent hindrance to routine inspections and maintenance, to enable crews to undertake emergency repairs quickly - thereby reducing exposure of the public to a potential hazard, and to ensure a possible location for a future pipeline" (NW Natural, 2012).

## Restricted Uses in the ROW

The minimum underground depth for a natural gas pipeline is 3 feet, which highly limits the opportunities of different uses in the ROW. ROWs must not contain: trees, deep rooted shrubs, structures (decks, patios, sheds, swimming pools, swing sets, tennis courts, walls etc.), septic tanks, drain fields, or wells. Trees are forbidden in the ROWs for safety reasons. "Roots follow the path of least resistance and grow easily in the less compact soils that typically surround a buried pipeline" (Questar Gas, 2009).Roots can manage to damage the protective coating designed to minimize pipe corrosion (Questar Gas, 2009).

Tree Roots Wrapped Around a Pipeline

"As the trees and roots grow larger the risk to the pipeline increases. If the tree is uprooted in a storm, it could rupture or severely damage the pipeline" (Questar Gas, 2009).

(U.S. Department of Transportation, 2005)

## Uses that Require Written Permission

Some uses in the ROW require written permission from a pipeline company. These uses include:

- Activities requiring excavation
- Underground utilities, roads/driveways, drainage ditches, fence, paving or parking crossings
- Changes to depth of soil over the pipeline, land development, and logging operations (NW Natural, 2012).

## Generally Accepted ROW Uses

Finally, there are a few generally acceptable uses of the ROW. These uses include:

- Planting crops, flower beds, vegetable gardens, lawns, low shrubbery
- Livestock grazing
- Hiking and horseback trails
- Sports fields and golf courses (subject to limits on re-grading, landscaping, or paving, and on installation of structures such as exercise equipment, goal posts and backstops) (NW Natural, 2012).

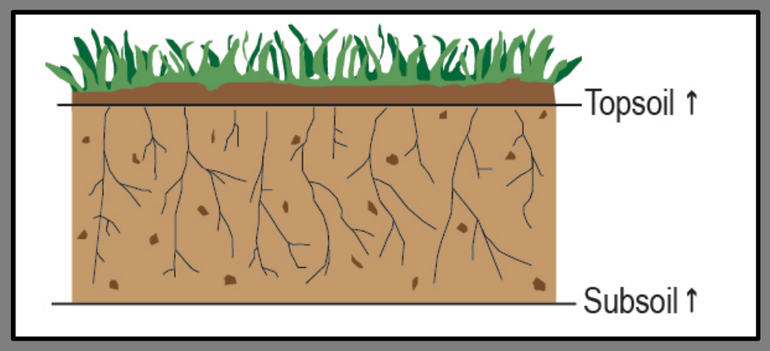

Sources:

NW Natural. 2012. "Pipeline Rights-Of-Way." NW Natural. https://www.nwnatural.com/Business/Safety/PipelineRightOfWay (accessed October 27, 2012).

Questar Gas. 2009. "Trees and Their Potential Damage to Pipelines." Questar Gas. www.questargas.com/brochures/59090.pdf (accessed November 27, 2012).

U.S. Department of Transportation. 2005. "PHMSA: Stakeholder Communications." Pipeline Risk Management Information System (PRIMIS). http://primis.phmsa.dot.gov/comm/pipa/pipa_examples.htm (accessed December 9, 2012).

# BEST MANAGEMENT PRACTICES IN ROWS




## Management in an Agricultural Area

In an agricultural setting, there are two options for managing a ROW:

1. Maintain agricultural cover (only shallow rooted crops may be planted)

As a general rule, “seasonal crops may be planted over the pipeline right-of-way so long as they do not interfere with or restrict the company’s ability to operate and maintain its pipeline and the right-of-way” (Texas Gas, 2012). If the company needs to access the pipeline for timely maintenance, which requires removal of crops, the company will pay the crop owner for the damages (Spectra Energy, 2012).

With reclaiming the ROW for crop production comes some complication. When gas companies implement a pipeline, the soil tends to heavily compact, causing the productivity of crops to decline. The magnitude and size of the heavy machinery used by the natural gas industry is responsible for this high soil compaction. Depending on the soil type and its associated drainage characteristics, as well as the volume of topsoil and subsoil, the soil may be prone to more or less compaction. When the topsoil becomes compacted, it is likely to “severely reduce plant productivity in the short term, whereas subsoil compaction is likely to modestly reduce productivity for decades in the future. Surface compaction is caused by the contact pressure (determined by tire pressure) while subsoil compaction is caused by axle load (very high in gas drilling operations) (Marcellus Education Team, 2009). Fortunately, topsoil is known to be susceptible to freeze-thaw conditions, wetting-drying cycles, and root growth associated with other macro and microbial activity which tends to alleviate soil compaction over time. Subsoils are not subject to these conditions, which “can lead to potential environmental degradation cause by decreased water percolation” (Marcellus Education Team, 2009), ultimately resulting in increased surface runoff conditions.

Opportunely, there are ways to mitigate soil compaction during negotiation in the lease agreement, prior to signing. One main way to improve severe soil compaction is through subsoiling. Subsoiling is an operation which involves fracturing and tilling methods down to the compaction layer. Reestablishing vegetation on disturbed and compacted sites is “critical for minimizing erosion, developing new macro channels resulting from roots and their decay, and rebuilding soil organic matter” (Marcellus Education Team, 2009). The results from subsoiling are temporary and pore space created will need to be occupied by living plant roots to keep macro channels open. “Cropland options will vary with the time of year; perennial forage vegetation is appropriate for spring and early summer. Forage radish also shows potential for establishing deep, short-lived taproots. Fall grains are best suited for autumn planting” (Marcellus Education Team, 2009). Of course, one other option remains. The land owner may choose that the affected areas are not worth the cost of re-cropping, and can be better utilized – whether the ROW turns into a temporary storage site for bales of hay, or left to revert back to wildlife habitat. Wildlife habitat is often the most economical land use of the site depending on the location and accessibility of the disturbed site (Marcellus Education Team, 2009).

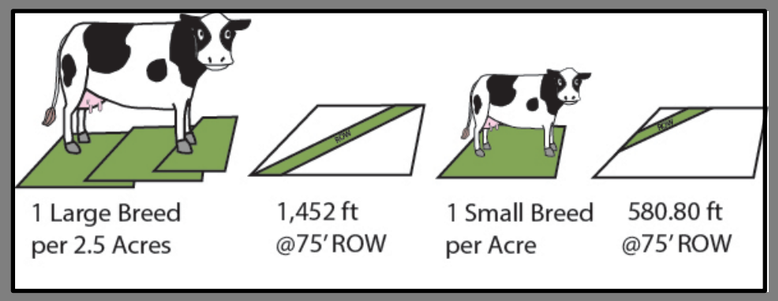
Sources:

Marcellus Education Team. 2009. "Avoiding and Mitigating Soil Compaction Associated with Natural Gas Development." Marcellus Education Fact Sheet. pubs.cas.psu.edu/FreePubs/pdfs/ua457.pdf (accessed December 12, 2007).

Spectra Energy. 2012. "Pipeline FAQs - Spectra Energy ." Home - Spectra Energy . http://www.spectraenergy.com/Operations/Pipeline-FAQs/ (accessed November 29, 2012).

Texas Gas. 2012. "Texas Gas - Frequently Asked Questions." Texas Gas - Welcome. http://www.txgt.com/Safety.aspx?id=1447 (accessed November 28, 2012).

# BEST MANAGEMENT PRACTICES IN ROWS




## Management in an Agricultural Area

2. Use ROW as a grazing area for livestock

The second option is keeping the ROW mowed grass and allowing livestock to graze in this area (in between the crop fields). A large breed of cow needs about 2.5 acres to graze on. Smaller breeds of cow only need about 1 acre to graze on (Local Harvest, 2012). With a ROW of 75 feet, to have 1 acre of ROW space, the pipeline would need to cut through at least 580.80 feet of cropland to have enough room for 1 small breed of cow to graze on. To have the minimum 2.5 acres for a larger breed of cow, the pipeline would need to cut through 1,452 feet of cropland. If a farmer has a very small herd of cattle, using the ROW as grazing space would be a viable option. But, if the farmer has a larger herd of cattle, the pipeline ROW could be used as an alternative, or secondary, grazing area. The ROW should not be used as the primary grazing area for cows.

If the pipeline is cutting through an area already designated for cattle grazing (not through cropland), keeping the ROW for grazing is an appropriate option. The ROW can remain as a low grass cover, continuous with the rest of the grazing area.

If necessary to have a fence around the grazing area, negotiating the terms of the pipeline lease with the gas company is required. Fences are generally permissible in the ROW, they just require written authorization from the company installing the pipeline.

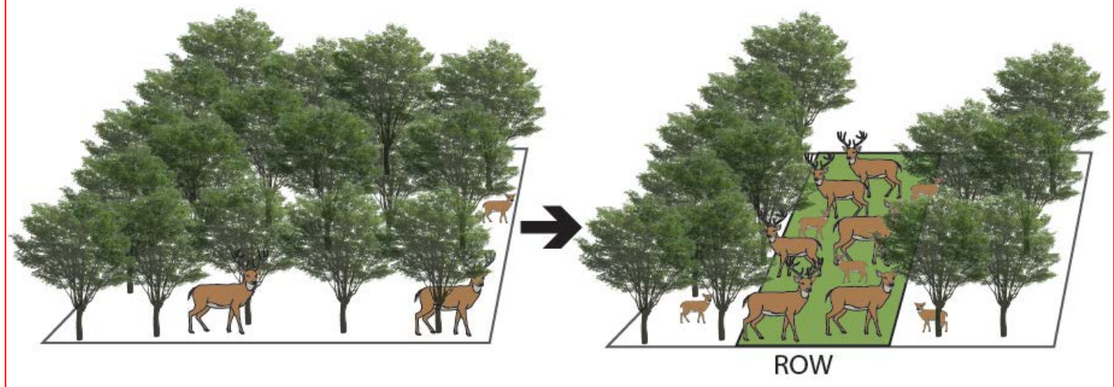
Sources:

Local Harvest. 2012. "How Much Pasture Land for How Many Cows." Local Harvest - Real Food, Real Farmers, Real Community. https://www.localharvest.org/forum/thread.jsp?forum=6&thread=461 (accessed November 28, 2012).

# BEST MANAGEMENT PRACTICES IN ROWS


## Management in a Forested Area

In a forested area, there is one main type of management that works best for ROWs, which is IVM. IVM, or integrated vegetative management, is a "process for managing plant communities that identifies compatible and incompatible vegetation, examines action thresholds, weighs control methods, and selects and implements controls to achieve specific objectives" (Environmental Consultants Inc., 2012). IVM is "based upon the anticipated effectiveness, environmental impact, site characteristics, safety, security, economics, and other factors. Pipeline ROW vegetation management can use IVM principles to create distinct zones of plant communities and serve as linear green ways connecting adjacent blocks of habitat" (Environmental Consultants Inc., 2012). Considering that fragmentation and habitat loss account for the two major issues involved in wildlife management, IVM could help to create increased linkages among habitat patches brought upon by the pipeline ROW cuts (not established with current practices).




Of course with an **increased edge habitat**, edge-loving animals are more likely to appear. The animal at the top of the list is the white-tailed deer. One adult white-tailed deer requires between 300 and 400 acres of rangeland with plenty of edge habitat (Whitetail Deer Hunting, 2010). Seeing as majority of Sullivan County is covered with forest, the pipeline ROW cuts in these areas will highly promote an increase in deer populations because of the enhanced edge habitat. The elevated deer population will support recreational hunting and increase tourism in the county during the hunting season.

Sources:
Environmental Consultants, Inc. 2012. "Integrated Vegetation Management on Pipeline Rights-of-Way." ECI-Consulting. www.eci-consulting.com/downloads/Pipeline%20IVM.pdf (accessed November 12, 2012).
Whitetail Deer Hunting. 2012. "Information About the Whitetail Deer." Comcast.net: Personal Web Pages. http://home.comcast.net/~gefferts/info.htm (accessed December 1, 2012).

# BEST MANAGEMENT PRACTICES IN ROWS

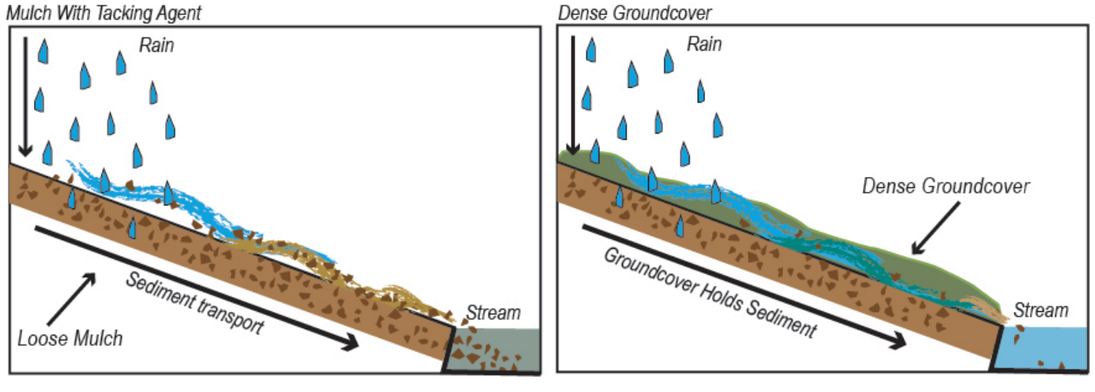
## Management on a Steep Slope

On steep slopes, roughly 30% or more, there are a few ways to manage the ROW, including:

1. A light application of mulch or hay with a tacking agent
2. Dense vegetated ground cover

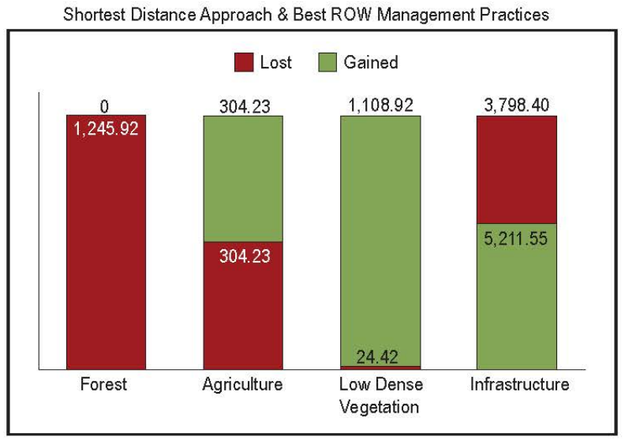
Mulch is a practical solution for the pipeline companies as it is affordable and easy to implement. Adding a tacking solution to the mulch will better ensure that it stays on the slope and protects the ground from erosion.

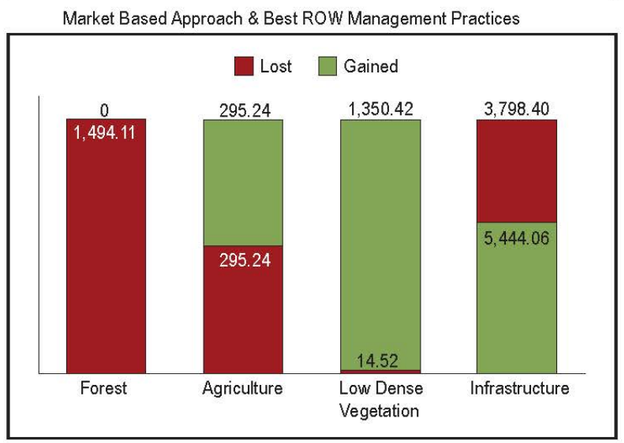
Implementing dense groundcover on the ROW is a better solution because unlike mulch, groundcover will not wash away in a storm. This is important when the steep slope is in the vicinity from a stream. Mulch is more likely to wash into the stream and decrease water quality – leaving the streams and other bodies of water full of sediments. A dense ground cover will secure the steep slope and  will help to link together the newly fragmented forest creating a green corridor. Plus, when looking at the landscape, seeing a dense groundcover is more visually and aesthetically pleasing than a strip of mulch.

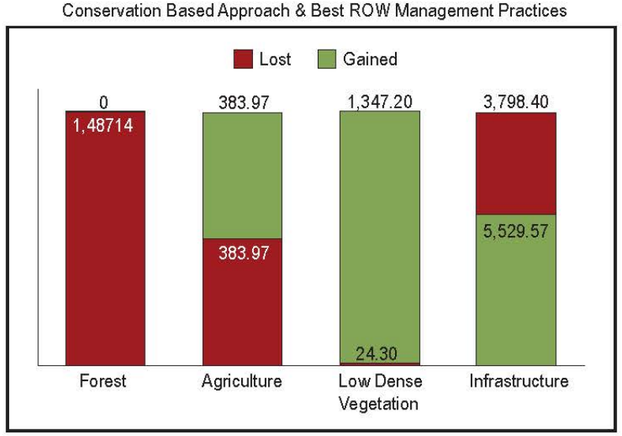



Sources:
Edgar, Dorland, and Stanley Zellmer. 1991. "Erosion Control on a Steeply Sloped Right-Of-Way in Southwesternn Pennsylvania." OSTI, Office of Scientific and Technical Information, USDOE | Speeding access to science information from DOE and Beyond. http://www.osti.gov/bridge/servlets/purl/6292712-1TBWgS/6292712.pdf (accessed November 18, 2012).

# EFFECTS OF ROW MANAGEMENT PRACTICES




## Effects on the Landscape

Unfortunately, all forest lost due to the pipeline ROW cuts will not be gained back, as trees are not allowed to be planted in the ROWs. Therefore, forested areas will gain back low dense vegetation. As for agriculture, all uprooted crops can be regrown. Infrastructure will be gained from installation of the pipelines, but will be lost as the ROWs are planted.

With many acres of forest lost comes probable gain for the forestry industry in Sullivan County. For every acre of clear cut forest, the timber is worth about $1,450.00. For the shortest distance pipeline scenario, cutting through 1,064.20 acres of forest would create $1,543,090. In the market based pipeline scenario, fragmenting 1,312.20 acres of forest cover would generate $1,902,690. Lastly, in the conservation based scenario, clear cutting 1,305.45 acres of forest would produce $1,892,902.50 in timber value.

Although this initial value seems tempting, the opportunity for continuing forestry practices on this land vanishes once the pipeline has been implemented. Over ten years this means a loss of $15,430,900 for the shortest distance pipelines, $19,026,900 for the market based pipelines, and $18,929,025 for the conservation pipelines in timber restocking value.

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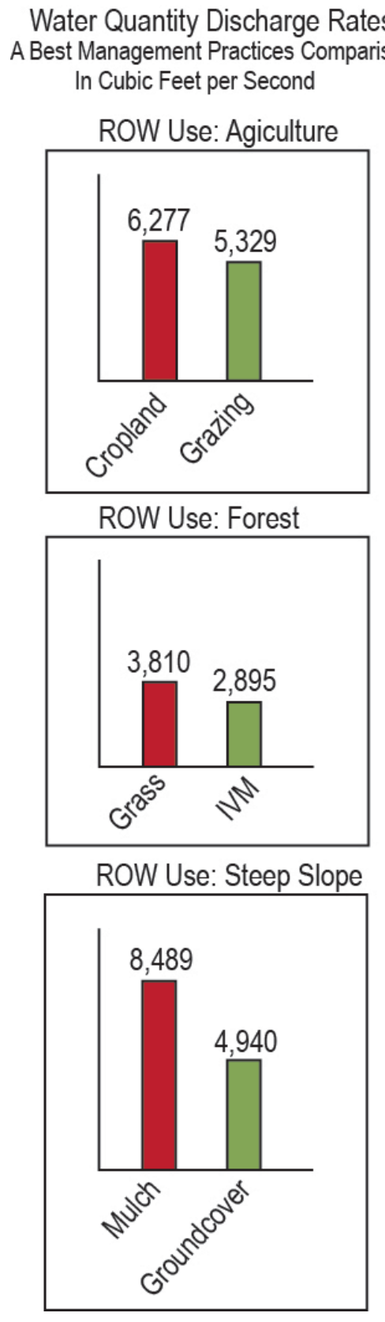



## Effects on Water Quantity

The implementation of best management practices can have a severe impact on water quantity in the watersheds located in Sullivan County. During a 100 year storm, the amount of cubic feet per second discharging into waterways ranges starkly between the variable best management practices in the ROWs. The lower the rate, the lower the potential for downstream flooding.

In an agricultural area, keeping crop cover in the ROW would generate a higher discharge rate of water than maintaining the ROW as a grazing area. In the forested regions, using integrated vegetative management (IVM) would decrease the water discharge rate as compared to current management practices (keeping the ROW mowed grass). And finally, on steep slopes, implementing dense ground cover would severely decrease the water quantity as compared to having a mulch with a tacking agent applied on the slope.

(Seen in the charts to the left)

Montoursville: Without Best Management Practices


Montoursville: With Best Management Practices

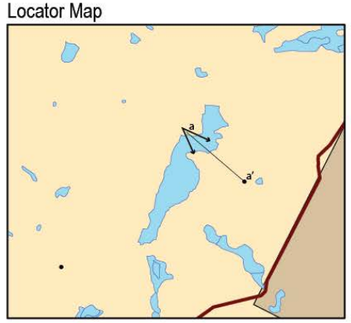

Montoursville, as shown above, is located southwest and down stream from Laporte, and Sullivan County. These visuals portray the benefits of best management practices within the ROWs. By implementing the best management practices, the town's chance of flooding decreases due to the lessened potential of stormwater runoff.

# LAKE MOKOMA: DRILLING VISIBILITY

According to the Nature Conservancy's well projection, the location of the well, seen in the images on the right, is the only well that would impact the Lake Mokoma region. In every scenario (shortest distance, market based, and conservation based) the gathering pipelines stretch away from Lake Mokoma to connect to the MARC I transmission line. Only forest located between the well pad and the transmission line would be fragmented from the pipeline ROW cuts. The ROW would not be visible from the beach of Lake Mokoma.

Therefore, the only visible impact upon Lake Mokoma's residents would occur during the drilling phase (approximately 2-6 weeks). During this period, residents will only be able to see the tip of the derrick due to its high elevation and placement behind forest cover. After the drilling is done, visual quality of the landscape will once again resume its original pristine state.

Locator Map

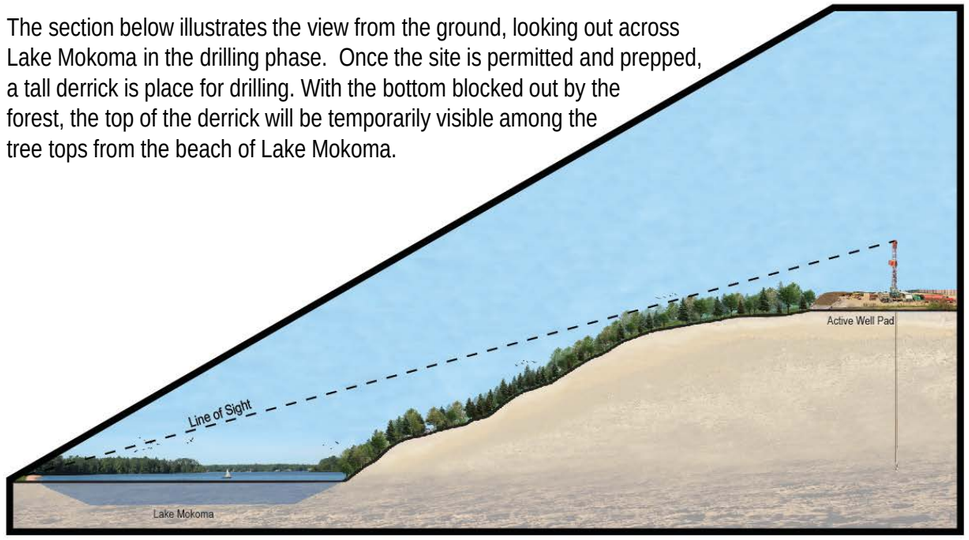



Shortest Distance

Market Based

Conservation Based

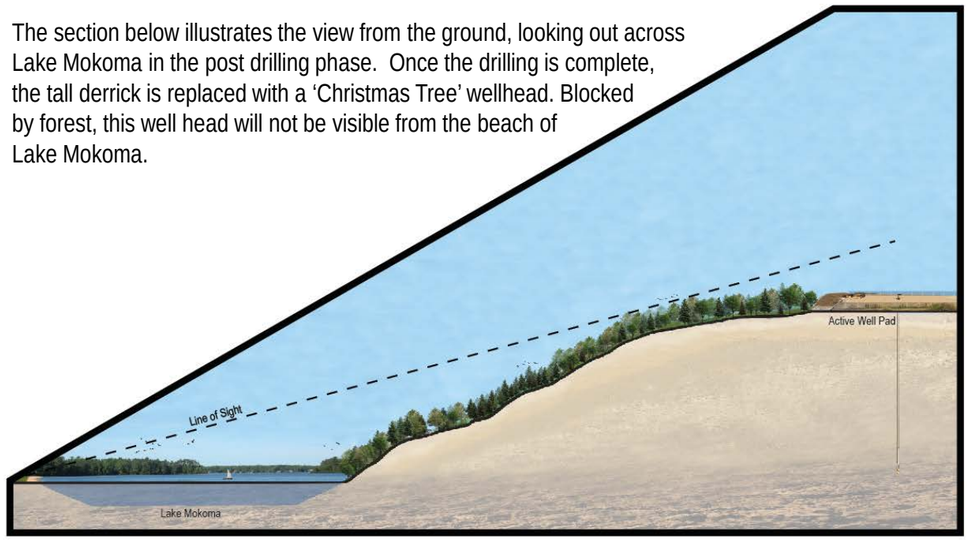
The section below illustrates the view from the ground, looking out across Lake Mokoma in the drilling phase. Once the site is permitted and prepped, a tall derrick is place for drilling. With the bottom blocked out by the forest, the top of the derrick will be temporarily visible among the tree tops from the beach of Lake Mokoma.




Section a-a'

0 150 300 600FT

The section below illustrates the view from the ground, looking out across Lake Mokoma in the post drilling phase. Once the drilling is complete, the tall derrick is replaced with a 'Christmas Tree' wellhead. Blocked by forest, this well head will not be visible from the beach of Lake Mokoma.




Section a-a'