Overview of Siting in WV

• Public opinion – nontechnical risk
• Terrain/Environment
• Regulatory
  – Wetlands
  – Streams
  – Endangered Species
• Ownership
Nontechnical risk

- Greater than risk associated with drilling and completion
- Must be cognizant of risk before siting
- Best companies understand concerns and work with local communities
Terrain

- Narrow ridges
- Steep slopes
- Soil prone to slipping
- Surface water
- Coal development
Regulatory

- Wetlands – must limit encroachment
- Can not impound streams, discharge into streams, fill or discharge into wetlands
- Jurisdiction of WV DEP and Federal EPA
- Must also follow erosion and sediment control regulations
Regulatory - spacing

- 30.5 meters to stream, natural or artificial lake, or wetland
- 91.4 meters to trout stream
- 304.8 meters from public water intake/supply
- 76.2 meters from water well
- 190.5 meters from pad to occupied dwelling or agricultural building
Endangered Species – Indiana Bat

• One factor of decline
  – loss of summer roosting
• Regulations on clearing
  – April through Nov
  – Nov through Mar
• Different regulations for each
Indiana Bat

• Summer clearing
  – Hire environmental firm
  – Develop/conduct mist net plan
  – Report to USFWS
  – If you catch bat – must use transmitter to determine if roosting location near
  – 2.5 mile buffer around if roost tree found, 5 mile if no roost tree found
  – No removal of trees in buffer during summer

• Winter clearing
  – Consult with USFWS
  – Locate any roosting trees
  – Submit report
  – Clear trees
  – Create artificial habitat
Other Regulatory

- Cultural Sites
- Coal
- Utilities
- Floodplain
- Trout stream
- Warm water stream
- Historic sites
- WVDEP 401 permit
11 streams, 6 wetlands
Landscape changes

• Analyzed >400 unconventional wells drilled between 2009-2012
• At each site – buffered well location by 15ha
• Within 15ha buffer, quantified total disturbed area
• Also quantified pad, water impound, road, and pipeline
Comparison – pre/post imagery
Comparison – Pre/Post imagery
Results II & III - Landscape changes

- Total of 421 unconventional wells were analyzed
- On average total disturbed area was 3.5 ha (8.8 acres)
### Results – Overall disturbance

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Disturbance (acres)</th>
<th>Disturbance (hectares)</th>
<th>Percent Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg.</td>
<td>8.8</td>
<td>3.6</td>
<td>43%</td>
</tr>
<tr>
<td>Min</td>
<td>1.2</td>
<td>0.49</td>
<td>0%</td>
</tr>
<tr>
<td>Max</td>
<td>25.2</td>
<td>10.2</td>
<td>100%</td>
</tr>
<tr>
<td>StDev</td>
<td>4.1</td>
<td>1.7</td>
<td>37.7%</td>
</tr>
</tbody>
</table>

- Higher than PA (Drohan et al. 2012) in size (2.7 hectares)
- Less forest disturbance than in PA (54% as opposed to 43% in this study)
Results – Pads, Pipelines, water, Roads

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Well Pad</th>
<th>Pipeline</th>
<th>Pond</th>
<th>Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg.</td>
<td>0.93</td>
<td>0.49</td>
<td>0.38</td>
<td>0.24</td>
</tr>
<tr>
<td>Min</td>
<td>0.05</td>
<td>0.05</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Max</td>
<td>4.90</td>
<td>1.86</td>
<td>2.11</td>
<td>0.97</td>
</tr>
<tr>
<td>StDev</td>
<td>0.49</td>
<td>0.36</td>
<td>0.28</td>
<td>0.16</td>
</tr>
</tbody>
</table>
## Resource Removals

<table>
<thead>
<tr>
<th>County</th>
<th>Total Private Acres</th>
<th>Total Forest Acres</th>
<th>Total Acres</th>
<th>Percent Forest</th>
<th>Board Feet /Acre</th>
<th>Total Tons/Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marshall</td>
<td>179,399</td>
<td>179,399</td>
<td>195,475</td>
<td>92%</td>
<td>7071</td>
<td>53.3</td>
</tr>
<tr>
<td>Doddridge</td>
<td>175,638</td>
<td>175,638</td>
<td>204,620</td>
<td>86%</td>
<td>9666</td>
<td>75.8</td>
</tr>
<tr>
<td>Wetzel</td>
<td>187,716</td>
<td>199,528</td>
<td>229,158</td>
<td>87%</td>
<td>6991</td>
<td>60.7</td>
</tr>
<tr>
<td>Harrison</td>
<td>158,303</td>
<td>164,387</td>
<td>266,246</td>
<td>62%</td>
<td>6801</td>
<td>64.6</td>
</tr>
<tr>
<td><strong>AVERAGE</strong></td>
<td><strong>175,264</strong></td>
<td><strong>179,738</strong></td>
<td><strong>223,875</strong></td>
<td><strong>82%</strong></td>
<td><strong>7632</strong></td>
<td><strong>64</strong></td>
</tr>
</tbody>
</table>

Total removals: 2421 total forested acres impacted: >150,000 tons of biomass
$7.2 million in stumpage

Total removals: 979 total forested hectares impacted: >130,000 metric tons of biomass
$7.2 million in stumpage
## Disturbance by well type (Ha)

<table>
<thead>
<tr>
<th>Well Type</th>
<th>Average Disturbance</th>
<th>Min Disturbance</th>
<th>Max Disturbance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>1.0</td>
<td>0.04</td>
<td>4.0</td>
</tr>
<tr>
<td>Unconventional</td>
<td>3.6</td>
<td>0.5</td>
<td>10.2</td>
</tr>
</tbody>
</table>
### Conventional Versus Unconventional

<table>
<thead>
<tr>
<th>Well Type</th>
<th>MMCF/month</th>
<th>MMCF/Acre</th>
<th>MMCF/m²/Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>896.9</td>
<td>12,055</td>
<td>0.8</td>
</tr>
<tr>
<td>UC</td>
<td>64,456</td>
<td>226,259</td>
<td>31.8</td>
</tr>
<tr>
<td>Change</td>
<td>↑18x</td>
<td>↑36x</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

- Many requirement must be met before D&C
- Shale related development increased substantially in WV over past 5 years
- Disturbs on average 3.6 ha per well PAD
- Individually, unconventional wells disturb more surface, however multiple wells on single pads decreases surface acreage required
Heading

• Bullets
  – State of West Virginia
Heading

• Bullets
  – State of West Virginia