Oil and Gas Potential in the Secretaries Potash Enclave*

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Abstract

Potash, oil and gas leases in the Secretary's Area are managed by the Bureau of Land Management (BLM) and oil and gas drilling is allowed by special permit. Since oil and gas wells must pass through potash, wells must be more than 1/4 mile from existing potash mines and, conversely, mining companies must allow 1/4 mile around existing oil wells. These limits are extended to 1/2 mile in formations below the Bone Spring where production has been from high pressure gas wells. Persistent conflict between the two industries has created management problems for the BLM and an understanding of the economic impact of potential resources within the area is important to making development decisions.

This study combines to-date geologic understanding of the area with historic production data to make per-acre estimates of underdeveloped oil and gas reserves within the geologic boundaries of the main body of the Oil Potash leasing Area, as defined by the New Mexico Oil Conservation Division Rule R-111-p. Production and development within that area was compared to production and development in a 1-township wide buffer zone immediately surrounding the R-111-p area (Figures 1-3, Tables 1-2).

The purposes were twofold: First to provide a database and Geographic Information System which illustrates development potential utilizing existing oil and gas plays; and second to provide economic estimates of the total values of those resources and as royalty and tax revenues to federal, state, and local governments. This study does not address the economic impact of the jobs that would be created to produce this oil and gas, or the economic impacts of mining operations.

Untapped oil and gas resources using only existing plays was estimated at 1.4 billion BOE (Barrels Oil Equivalent), or 468 million barrels of oil and 5.5 TCF of gas. Secondary recovery could add an additional 318 million barrels of oil.
valuations using oil prices of $50, $75, and $100 per barrel and gas values of prices of $3, $5 and $7 per MCF yielded a resource value between $40-$86 billion for primary recovery and an additional $16-$32 billion for secondary oil recovery. The majority of the R-111-p area (71%) is administered by the BLM and of the remainder, 19.4% are New Mexico State lands. Royalties and taxes for a fully developed R-111-p area represent $11.4-$24 billion in potential revenues for Federal, State and County governments (-20% of the total resource value) of which $7.5-$15.8 billion would go to the State of New Mexico in MMS royalty shares, state royalties, and various taxes. Ad valorum taxes would provide Lea and Eddy Counties a combined $1.4-$3.0 billion in revenue. The Federal MMS royalty share would provide $2.5-$5.2 billion at full estimated ultimate recovery.

Major existing plays that are under-developed in the Potash Enclave include the Brushy Canyon formation in the Delaware Mountain group, the Morrow, and the Bone Spring. Further, mature plays such as the Artesia group would likely have renewed interest within the currently restricted areas of the reserve both for primary production and for Residual Oil Zone (ROZ) Development. In recent years, the use of Drilling islands has already led to increased Brushy Canyon production within the enclave.

This study used only existing production data and represents a conservative estimate of available resources. It does not, at present, fully consider recent changes to technology and future plays that do not have extensive existing production data, such as the Siluro-Devonian carbonates, Woodford Shale, Bone Springs shale, and the Wolfcamp, which could significantly impact regional production as the lower Brushy Canyon play did in the late 1980s and early 1990s. Preliminary work on the Woodford Shale, Bone Spring/Avalon Shale, and ROZ potential in the Sand Andres and Grayburg strongly indicate significant additional potential reserves within the Potash Area.

Acknowledgement

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Selected References


Website

Oil and Gas Potential in the Secretaries Potash Enclave

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Martha Cather
Vidya Bammidi

AAPG SW Section Meeting, Ruidoso, NM - June 7, 2011
Overview

- Acknowledgements
- Introduction
  - Background, setting, significance
- Existing Production Analysis
  - Historic plays and production data
  - Under-drilling within the enclave
- Projected Resource Value
  - Value of Oil and Gas resources in the Potash Area
- That’s not all... There’s more
  - New Technologies/New Plays
    - Horizontals
    - Multi-stage fraccing
    - Secondary/tertiary recovery/ROZ’s?
    - Shale oil/gas
Acknowledgements

- Initial work requested by industry in late 2009
  - Existing data study ~2 months
- Refinements and continuing analyses funded as part of the BLM Pecos District RFD
  - PI- Tom Engler. Co-PI’s Martha Cather and Robert Balch
- Numerous students have worked on portions of this data
- Previous area studies by Ron Broadhead and Patrick Walsh provide a robust framework
Introduction

- ~777 sq miles of SE NM reserved for potash mining for over 70 years
  - Potash was a strategic mineral in World War II
- Underdevelopment of petroleum resources within the area
  - Significant reserves and development potential in the center of a mature basin
- History of conflicts between Oil/Gas and Mining stakeholders
  - Recently cooperation is becoming more common
    - Drilling Islands
    - Long horizontals
    - Solution Mining
Regional Geologic Setting

After Hills 1984
After Garber et al. [1989]
Stratigraphy

Modified from Broadhead et al. [1998]
Methods

1. Developed GIS database for production data, play boundaries (Walsh, 2005), cultural features
2. Established study area as the R-111p (567 mi$^2$) designation by the State of New Mexico
3. Defined a 1 township wide boundary around the study area for analysis of comparative development (926 mi$^2$)
4. Used Broadhead (1998) WIPP area study as a representative Township for production potential
5. Computed production totals within the area and in the buffer and made projections of potential future reserves
BLM Lands ~71%
State Lands ~19.4%

Defined Pools
First wells in 1920’s
- NW Shelf
- Some 1930’s wells still producing

Mostly shallow development until 1970’s
- Morrow, Atoka

Uptick in drilling in 1980’s-90’s
- Brushy Canyon Play
- Opening of parts of the reserve

In the Study area (r-111p + Buffer) 6257 wells drilled through 2009
- 1291 in the Reserve
- 4966 in Buffer
Completed Wells in or Near Potash Area

Wells Per Year

Wells Per Year Per Township

<table>
<thead>
<tr>
<th>Formation</th>
<th>In R-111-p</th>
<th>In Buffer</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delaware Mountain</td>
<td>182</td>
<td>231</td>
<td>413</td>
</tr>
<tr>
<td>Bone Spring</td>
<td>33</td>
<td>231</td>
<td>264</td>
</tr>
<tr>
<td>Morrow</td>
<td>31</td>
<td>198</td>
<td>229</td>
</tr>
<tr>
<td>Artesia Group</td>
<td>5</td>
<td>61</td>
<td>66</td>
</tr>
<tr>
<td>Atoka</td>
<td>6</td>
<td>35</td>
<td>41</td>
</tr>
<tr>
<td>Strawn</td>
<td>2</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Wolfcamp</td>
<td>8</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Pennsylvanian</td>
<td>8</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>278</strong></td>
<td><strong>798</strong></td>
<td><strong>1076</strong></td>
</tr>
</tbody>
</table>
Morrow Potential Area (Walsh 2005)

Morrow Pools
Atoka Potential Area (Walsh 2005)

Atoka Pools
Strawn Potential Area (Walsh 2005)

Strawn Pools
Bone Spring Pools
Artesia Group Pools
Wolfcamp Pools
Pennsylvanian, Devonian, and Other
## Summary of Statistics for Major Existing Plays in the Potash Area

<table>
<thead>
<tr>
<th>Formation</th>
<th>Oil</th>
<th>Gas</th>
<th>BOE</th>
<th>Area</th>
<th>Wells</th>
<th>Wells/mi²</th>
<th>BOE/Well</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delaware (Buffer)</td>
<td>86,337,549</td>
<td>201,258,127</td>
<td>119,880,570</td>
<td>306</td>
<td>1,446</td>
<td>4.7</td>
<td>82,905</td>
</tr>
<tr>
<td>Delaware (R-111-p)</td>
<td>53,315,796</td>
<td>129,750,008</td>
<td>74,940,797</td>
<td>351</td>
<td>703</td>
<td>2.0</td>
<td>106,601</td>
</tr>
<tr>
<td>Morrow (Buffer)</td>
<td>10,563,075</td>
<td>978,450,154</td>
<td>173,638,101</td>
<td>425</td>
<td>711</td>
<td>1.7</td>
<td>244,217</td>
</tr>
<tr>
<td>Morrow (R-111-p)</td>
<td>3,516,503</td>
<td>275,300,118</td>
<td>49,399,856</td>
<td>440</td>
<td>136</td>
<td>0.3</td>
<td>363,234</td>
</tr>
<tr>
<td>Atoka (Buffer)</td>
<td>1,380,074</td>
<td>271,412,977</td>
<td>46,615,570</td>
<td>331</td>
<td>229</td>
<td>0.7</td>
<td>203,561</td>
</tr>
<tr>
<td>Atoka (R-111-p)</td>
<td>465,665</td>
<td>99,406,351</td>
<td>17,033,390</td>
<td>159</td>
<td>52</td>
<td>0.3</td>
<td>327,565</td>
</tr>
<tr>
<td>Strawn (Buffer)</td>
<td>12,247,828</td>
<td>104,250,890</td>
<td>29,622,976</td>
<td>49</td>
<td>138</td>
<td>2.8</td>
<td>214,659</td>
</tr>
<tr>
<td>Strawn (R-111-p)</td>
<td>1,682,584</td>
<td>39,424,918</td>
<td>8,253,404</td>
<td>15</td>
<td>14</td>
<td>0.9</td>
<td>589,529</td>
</tr>
<tr>
<td>Artesia (Buffer)</td>
<td>65,139,168</td>
<td>44,455,127</td>
<td>72,548,356</td>
<td>N/A</td>
<td>1,481</td>
<td>N/A</td>
<td>48,986</td>
</tr>
<tr>
<td>Artesia (R-111-p)</td>
<td>19,160,356</td>
<td>4,895,241</td>
<td>19,976,230</td>
<td>N/A</td>
<td>209</td>
<td>N/A</td>
<td>95,580</td>
</tr>
<tr>
<td>Penn (Buffer)</td>
<td>1,121,309</td>
<td>45,609,348</td>
<td>8,722,867</td>
<td>N/A</td>
<td>44</td>
<td>N/A</td>
<td>198,247</td>
</tr>
<tr>
<td>Penn (R-111-p)</td>
<td>180,777</td>
<td>19,719,284</td>
<td>3,467,324</td>
<td>N/A</td>
<td>16</td>
<td>N/A</td>
<td>216,788</td>
</tr>
<tr>
<td>Bone Springs (Buffer)</td>
<td>34,612,267</td>
<td>141,882,018</td>
<td>58,259,270</td>
<td>N/A</td>
<td>820</td>
<td>N/A</td>
<td>71,048</td>
</tr>
<tr>
<td>Bone Springs (R-111-p)</td>
<td>7,427,454</td>
<td>31,282,322</td>
<td>12,641,174</td>
<td>N/A</td>
<td>142</td>
<td>N/A</td>
<td>89,022</td>
</tr>
<tr>
<td>Wolfcamp (Buffer)</td>
<td>8,072,109</td>
<td>78,333,623</td>
<td>21,127,713</td>
<td>N/A</td>
<td>121</td>
<td>N/A</td>
<td>174,609</td>
</tr>
<tr>
<td>Wolfcamp (R-111-p)</td>
<td>758,101</td>
<td>5,377,762</td>
<td>1,654,395</td>
<td>N/A</td>
<td>27</td>
<td>N/A</td>
<td>61,274</td>
</tr>
</tbody>
</table>
Method of Reserve Estimates

- Used EUR estimates from Broadhead (1998) for the WIPP area ~1 Township
  - Near geographic center of Potash Area
  - Detailed decline curve analysis by formation
  - Representative single Township area
- We consider these numbers to be conservative
  - New Plays not included
  - New technologies not addressed

<table>
<thead>
<tr>
<th>Production Type</th>
<th>per Township</th>
<th>per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil and Condensate</td>
<td>35,200,000.00 BBL</td>
<td>1,527.78 BBL</td>
</tr>
<tr>
<td>Oil Secondary</td>
<td>20,200,000.00 BBL</td>
<td>876.74 BBL</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>354,000,000.00 MCF</td>
<td>2,560.76 BOE</td>
</tr>
</tbody>
</table>
### R-111-p Production through August 2009

<table>
<thead>
<tr>
<th></th>
<th>Cum. Oil BBL</th>
<th>Cum. Gas MCF</th>
<th>CUM. BOE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Reserves</strong></td>
<td>86,579,566</td>
<td>605,492,694</td>
<td>187,495,015</td>
</tr>
<tr>
<td><strong>Secondary Reserves</strong></td>
<td>318,150,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Oil BBL</strong></td>
<td>467,820,434</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gas MCF</strong></td>
<td>5,575,500,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BOE</strong></td>
<td>1,397,070,434</td>
<td></td>
<td>318,150,000</td>
</tr>
</tbody>
</table>

### R-111-p Oil and Gas Resource Value

**Primary Oil**
- $50/BBL: $1,039,146,139
- $75/BBL: $1,558,719,209
- $100/BBL: $2,078,292,278

**Secondary Oil**
- $50/BBL: $706,690,688
- $75/BBL: $1,060,036,031
- $100/BBL: $1,413,381,375

**Natural Gas**
- $50/BBL: $474,074,763
- $75/BBL: $1,238,457,938
- $100/BBL: $1,733,841,113

### R-111-p Federal Royalty Values

**Primary Oil**
- $50/BBL: $23,391,021,700
- $75/BBL: $35,086,532,550
- $100/BBL: $46,782,043,400

**Secondary Oil**
- $50/BBL: $15,907,500,000
- $75/BBL: $23,861,250,000
- $100/BBL: $31,815,000,000

**Natural Gas**
- $50/BBL: $16,726,500,000
- $75/BBL: $27,877,500,000
- $100/BBL: $39,028,500,000
Valuation of Existing Reserves

- Over next 20-30 years if fully developed
  - 800 Million barrels oil
  - 5.5 TCF gas
- Resource Value at $100 per bbl and $4 per MCF
  - ~$101 Billion
- Royalty and Tax Value
  - ~20% of Resource Value
  - ~$20.5 Billion
    - State ~$13.5 Billion
    - Federal ~$4.5 Billion
    - Local ~$2.5 Billion
Reserves

- Largest Existing Reserves
  - Morrow
  - Brushy Canyon
  - Bone Spring Conventional

- Potential additional reserves
  - Avalon Shale
  - Woodford Shale
  - Wolfcamp
  - Wolfcamp Shale
  - Pennsylvanian
  - Siluro-Devonian
### Brushy Canyon Waterfloods

<table>
<thead>
<tr>
<th>Poolname</th>
<th>Yr of first production</th>
<th>Yr of first injection</th>
<th>S:P ratio</th>
<th>formation</th>
<th>comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avalon</td>
<td>1977</td>
<td>1996</td>
<td>0.44</td>
<td>Upper Cherry Canyon and Upper Brushy Canyon</td>
<td>good waterflood response</td>
</tr>
<tr>
<td>Brushy Draw</td>
<td>1959</td>
<td>1990</td>
<td>none</td>
<td>insufficient injection</td>
<td></td>
</tr>
<tr>
<td>El Mar</td>
<td>1959</td>
<td>1978*</td>
<td>none</td>
<td>Bell Canyon - Ramsey and Olds sands</td>
<td>Approved WF in 10/68, no waterflood response</td>
</tr>
<tr>
<td>Indian Draw</td>
<td>1973</td>
<td>1981</td>
<td>1.17</td>
<td>Bell Canyon - Ramsey and Olds sands</td>
<td>excellent waterflood response</td>
</tr>
<tr>
<td>Los Medanos</td>
<td>1990</td>
<td>2004</td>
<td>N/A</td>
<td>limited injection, response due to add dev</td>
<td></td>
</tr>
<tr>
<td>Lost Tank</td>
<td>1991</td>
<td>2004</td>
<td>N/A</td>
<td>limited injection, response due to add dev</td>
<td></td>
</tr>
<tr>
<td>Lusk, West</td>
<td>1987</td>
<td>1997</td>
<td>0.28</td>
<td>Bell Canyon - Ramsey and Olds sands</td>
<td>fair waterflood response</td>
</tr>
<tr>
<td>Paduca</td>
<td>1961</td>
<td>1978*</td>
<td>0.73</td>
<td>approved WF in 9/67, excellent waterflood response</td>
<td></td>
</tr>
<tr>
<td>Parkway</td>
<td>1987</td>
<td>1993</td>
<td>1.50</td>
<td>excellent waterflood response</td>
<td></td>
</tr>
<tr>
<td>Shugart, East</td>
<td>1985</td>
<td>2001</td>
<td>0.42</td>
<td>good waterflood response</td>
<td></td>
</tr>
</tbody>
</table>

* Earliest year Dwights reports injection data

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Conservative evaluation assumed a 0.6 S –P ratio, while 0.8 to 1.0 may be more likely. This would increase secondary Brushy Canyon potential:

**An additional 60-120 Million Barrels within the enclave?**
Bone Spring / Avalon Shale

Bone Spring/Avalon Potential

Avalon +300’ isopach
Some Avalon Potential

- 26 sections with > 300ft thickness if produced with 4000’ horizontals 4 to a section would yield 104 Avalon wells
  - At ~300,000 BOE recoverable in an average well reserves in the potash area could be 31 Million BOE
- The 300 ft thickness may be conservative and additional Avalon shale potential could exist in the enclave
Woodford Shale Regions Categorized based on Thermal Maturity (Ro%), Fracture Intensity (per 10ft) & TOC (wt%).

Woodford Potential Regions (Bammidi 2011)
Woodford Potential?

- Bammidi (2011) determined that:
  - High Oil ~4 million barrels oil remains per section
  - High Gas ~4.65 BCF gas remains per section
  - High Condensate ~ 0.94 million BOE remains per section
- The majority of the Potash reserve lies within the high oil and high gas potential regions
- If 4 initial horizontal wells per section were drilled and a recovery factor of 8% is assumed this yields
  - ~80,000 barrels per oil well or
    - Total additional potential reserves for potash area ~34 Million BBL
    - ~106 sections
  - ~372,000 MCF per gas well or
    - Total additional potential reserves for potash area ~536 BCF
    - ~360 sections
ROZ Potential?

- Limited ROZ potential in the San Andres Greyburg

Trends from Trentham (2011)
Technology Changes Everything

- Long horizontals and drilling islands could put the majority of the SPA into play
- Changes in completions, in particular multi-stage fraccing now being done in more than just shale has re-introduced life into old plays and in the underdeveloped Potash area could dramatically increase reserves from those projected by this study
Conclusions

- Significant under-development of oil and gas resources has occurred in the Potash Reserve compared to immediately adjacent locations.

- Using conservative estimates producible reserves are on the order of:
  - 800 Million BBLS oil
  - 5.5 TCF gas

- Technology and new plays will both allow development, and add to these resources.
Future Work

- As part of the BLM Pecos RFD we are generating pool scale analyses for all of SE New Mexico and this will allow direct calculation of resources in the enclave
  - Refined EUR estimates
  - Better estimates of the impacts of horizontal drilling fraccing and other technologies
  - Better estimates for emerging and potential plays

- GIS and full report available at
  - HTTP://ford.nmt.edu