WRAP/WEA Phase III Oil and Gas Emissions Inventory Development for the Intermountain West

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Overview

- Phase III project overview
- Williston Basin – geographic scope and background
- Williston Basin – 2009 baseline emissions results
- Williston Basin – midterm projections methodology
- Williston Basin – 2015 midterm emissions results
- Observations
Phase III – Overview of Inventory Effort

• Inventory is conducted on a basin-by-basin level

• Phase III has now completed most major oil and gas production basins in the Intermountain West

• Inventories include most major oil and gas sources including area sources and point sources – but does not include mobile sources (with the exception of drilling rigs)

• Temporal scope considers a 2009 baseline year, 2015 midterm projections for the Williston Basin

• Only criteria pollutants are covered: NOx, VOC, CO, SOx, PM
Williston Basin – Geographic Scope

- Large geographic area including North Dakota, Montana and small portion of South Dakota with oil and gas activity on both tribal and non-tribal land
- Basin boundaries re-defined to align with the county boundary to simplify reporting
- County-level emissions generated for all counties as well as separately for tribal and non-tribal land fractions
Williston Basin – Overview and Observations

• Williston Basin is the largest basin in the Phase III study by geographic area including major production areas in Montana and North Dakota and a small portion of northwest South Dakota, and significant activity on Fort Berthold Indian Reservation (FBIR)

• Largest oil production basin in the Phase III study, and one of the largest oil producing regions in the US; some gas production mainly associated gas from oil wells and some conventional gas – minimal CBM production

• Primary oil development in the Bakken Shale with additional production from the Cedar Creek Anticline

• Approximately 7% of primary oil production and 2% of gas production in the basin occurs on the FBIR

• Significant flaring of associated gas occurs in the Williston Basin
Williston Basin – Phase III inventory

- Phase III inventory for Williston Basin used the same methodology as developed for past basins that we have reported on; however survey data responses were extremely limited.

- Data sources included: detailed survey data sent to major oil and gas producers in the basin; permit data from MTDEQ and NDDOH primarily for midstream sources located on state-administered land; EPA permit data for major sources on tribal land; broader regional or national data to gap-fill missing information.

- Emissions inventory was developed for 2009 baseline year and 2015 midterm projections for all criteria pollutants (NOx, VOC, CO, SOx, PM).
Williston Basin 2009 Baseline Results
NOx Emissions By Source Category

Basin-wide NOx total:
14,387 (tpy)

- NOx emissions dominated by drilling rigs and compressor engines due to significant drilling activity in 2009
VOC emissions dominated by oil tank flashing, estimated to account for approximately 63% of basin-wide VOC emissions with additional emissions from casinghead gas flaring, and pneumatics.

Basin-wide VOC total: 357,798 (tpy)
Williston Basin 2009 Baseline Results
NOx Emissions by County

Basin-wide NOx total: 14,387 (tpy)

• Counties with less than 1% of basin-wide emissions are not shown
Williston Basin 2009 Baseline Results
NOx Emissions by Tribal and Non-Tribal Land

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Williston Basin 2009 Baseline Results
VOC Emissions by County

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VOC Emissions by Tribal and Non-Tribal Land

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Williston Basin 2009 Baseline Emissions - Observations

<table>
<thead>
<tr>
<th>Basin</th>
<th>Well Count</th>
<th>Oil Production (bbl)</th>
<th>Gas Production (MCF)</th>
<th>Spud Counts</th>
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<tbody>
<tr>
<td></td>
<td>Total</td>
<td>CONV</td>
<td>CBM</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Total</td>
<td>Oil Well Oil</td>
<td>Gas Well Condensate</td>
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<table>
<thead>
<tr>
<th>Basin</th>
<th>Emissions (tons/yr)</th>
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<tr>
<td></td>
<td>NOx</td>
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<tr>
<td>D-J Basin</td>
<td>20,783</td>
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<td>Wind River Basin</td>
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<td>Powder River Basin</td>
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<td>Southwest Wyoming Basin</td>
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<tr>
<td>Williston Basin*</td>
<td>14,387</td>
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</tbody>
</table>

*Williston Basin inventory is for 2009 base year

- NOx emissions in the Williston Basin are similar on a per-well basis to other basins;
- Williston Basin is the largest oil producing basin in the Phase III, significantly higher VOC emissions than any other basin; VOC emissions primarily from oil tank flashing and breathing losses;
Williston Basin Mid-Term Projections Methodology

- Mid-term projections are conducted for the scenario year of 2015 for the Williston Basin

- Projections were developed for three separate geographic groupings: (1) the Bakken Shale; (2) the Cedar Creek Anticline; and (3) all remaining counties;

- IHS database is used to identify 2009 production statistics in the basin and to compile all historical data on production, drilling and well counts for the basin

- Oil and gas well count projections made by extrapolating from historic growth rates in well counts; spud counts matched to the well count growth rate and corrected for drilling success rate

- Oil and gas production growth rates developed by extrapolating from historic growth rates and in conjunction with data from Bentek study

- Declining parameters (in the historic period reviewed) were conservatively assumed to remain at constant levels through 2015
Williston Basin Mid-Term Projections
Uncontrolled Scaling Factors

- Activity projections used to create scaling factors
- Scaling factors are ratio of value of activity parameter in 2015 to value in 2009
- Different source categories’ emissions are projected using different activity parameters and their scaling factors
- An additional parameter projected is the growth in gas gathering infrastructure – tracked using the fraction of gas produced that is not sold in the Bakken Shale area; projected that more than 80% of produced gas captured and processed by 2015

<table>
<thead>
<tr>
<th>Geographic Grouping</th>
<th>Total Well Count</th>
<th>Spud Count</th>
<th>Total Gas Production</th>
<th>Oil Production</th>
<th>Condensate Production</th>
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<td>4.30</td>
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<td>Cedar Creek Anticline</td>
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<td>1.53</td>
<td>0.86</td>
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<td>All Other Counties</td>
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<td>0.67</td>
<td>0.90</td>
<td>0.77</td>
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Williston Basin Mid-Term Projections
“On-the-Books” Regulations

- After uncontrolled scaling factors are applied, “on-the-books” regulations are considered which would impact 2015 emissions projections.

- Federal controls include Tier standards for non-road mobile sources (e.g. drilling rigs), fuel sulfur controls, New Source Performance Standards (NSPS) for stationary spark-ignited engines, and the recent NSPS Subpart OOOO for other oil and gas sources.

- State controls for tank flashing, tank loading, well completions and general VOC control requirements for well sites were applied.

- Where not specifically applicable to all sources, state controls were conservatively applied only to new sources brought on-line between the 2009 and 2015 years, leaving some existing sources uncontrolled.

- Changes in the regulatory requirements were tracked and the changes implemented in the specific years where a phase-in occurs (for example NSPS Subpart JJJJ and Subpart OOOO).
Williston Basin Mid-Term Projections
2015 NOx Emissions

- Comparison of Williston Basin baseline 2009 and mid-term 2015 NOx emissions
Williston Basin Mid-Term Projections
2012 VOC Emissions

- Comparison of Williston Basin baseline 2006 and mid-term 2012 VOC emissions
Williston Basin 2015 Midterm Results
NOx Emissions By Source Category

Basin-wide NOx total:
46,114 (tpy)

- NOx emissions still dominated by drilling rigs and compressor engines but lower contribution from drilling
Williston Basin 2015 Midterm Results
VOC Emissions By Source Category

- **VOC emissions from oil tank flashing significantly reduced, emissions from casinghead gas flaring and venting increase**

**Basin-wide VOC total: 454,443 (tpy)**
Observations

• NOx and VOC emission increases projected for 2015 due to high growth rate of activity in the Bakken Shale area
• Federal and state regulatory controls requirements for oil tanks significantly reduce the contribution of this category to VOC emissions
• Large growth in associated gas production and flaring/venting of this gas result in significant increase in VOC emissions despite projected growth in gas gathering infrastructure
• Emissions projections are sensitive to assumptions on growth in oil production and drilling activity – growth projections are consistent with Bentek report but additional data would improve these estimates