Chesapeake Modeling Tools for Integrating Air and Water Environmental Management

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Overview

• The U.S. Environmental Protection Agency has, for the first time in a TMDL, taken responsibility for a nitrogen atmospheric deposition load allocation of 15.7 million pounds.

• The allocation is for 15.7 million pounds of direct atmospheric deposition of nitrogen to the Chesapeake Bay’s tidal surface waters.

• The TMDL air allocation is quantified by the Chesapeake Bay Program partnerships’ airshed, watershed, and Bay water quality models which track national reductions in air emissions regulated under existing or planned federal Clean Air Act (CAA) authorized programs.
Reduce/Readjust Loads to Meet Standards

**Inputs**
- BMP Data
- LU Data
- Point Sources Data
- Septic Data
- U.S. Census Data
- Agricultural Census Data

**Model-Derived**
- Airshed Model
- Land Use Change Model
- Precipitation Data
- Meteorological Data
- Elevation Data
- Soil Data

**Scenario Builder**

**Watershed Model**

**Chesapeake Bay Model**

**Meet WQS?**
- No
- Yes

**Allocation Methodology**
Chesapeake Bay Airshed Models

Combining a regression model of wetfall deposition...

...with CMAQ estimates of dry deposition for the base...

...and using the power of the CMAQ model for scenarios.
The Community Multiscale Air Quality Model (CMAQ) has a domain that covers the North American continent at a 36 km x 36 km grid scale and is nested at a finer 12 km x 12 km grid scale over the Chesapeake watershed and Bay.
Atmospheric loads of NOx are decreasing

Estimated nationwide emissions of NOx and SO\textsubscript{2} from electric generating units (EGUs) since 1980 and estimated emissions to 2020.

CAIR has been recently replaced by the Cross-State Air Pollution Rule but the estimated load reductions are similar to CAIR.

Source: EPA
Nitrate and ammonia deposition concentration trends

Annual Concentrations in Atmospheric Deposition

\[ y = 2 \times 10^{-06}x + 0.1795 \]
\[ R^2 = 7 \times 10^{-07} \]

\[ y = -0.0053x + 10.971 \]
\[ R^2 = 0.5641 \]

\[ y = -0.0053x + 10.791 \]
\[ R^2 = 0.7061 \]
EPA Referenced Allocation of Deposition to the Watershed

Legend
- Phase 5 Study Area
- State Boundary

Phase 5 Land Use
- Water
- Urban
- Extractive
- Bare
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Agriculture
- Grass

EPA Allocation of Deposition to Tidal Waters
Boundaries of the coastal ocean region used to adjust the ocean boundary conditions in the Chesapeake Bay Water Quality Model.
### Key Scenarios Developed for the Chesapeake TMDL

Estimated Direct atmospheric deposition loads of nitrogen to the tidal Chesapeake Bay for key scenarios. Units in millions of pounds as N.

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>Wet NO\textsubscript{X} Deposition</th>
<th>Dry NO\textsubscript{X} Deposition</th>
<th>Wet NH\textsubscript{3} Deposition</th>
<th>Dry NH\textsubscript{3} Deposition</th>
<th>Total Inorganic Nitrogen Deposition</th>
<th>Wet Organic Nitrogen Deposition</th>
<th>Total Nitrogen Deposition</th>
<th>Wet PO\textsubscript{4} Deposition</th>
<th>Wet Organic Phosphorus Deposition</th>
<th>Total Phosphorus Deposition</th>
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<tr>
<td>1985 Scenario</td>
<td>6.57</td>
<td>13.15</td>
<td>3.34</td>
<td>1.97</td>
<td>25.03</td>
<td>1.05</td>
<td>26.08</td>
<td>0.33</td>
<td>0.98</td>
<td>1.30</td>
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<tr>
<td>2002 Scenario</td>
<td>4.81</td>
<td>10.04</td>
<td>3.57</td>
<td>2.12</td>
<td>20.54</td>
<td>1.05</td>
<td>21.60</td>
<td>0.33</td>
<td>0.98</td>
<td>1.30</td>
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<tr>
<td>2010 Scenario</td>
<td>3.27</td>
<td>6.85</td>
<td>3.49</td>
<td>2.76</td>
<td>16.36</td>
<td>1.05</td>
<td>17.42</td>
<td>0.33</td>
<td>0.98</td>
<td>1.30</td>
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<tr>
<td><strong>2020 Scenario</strong></td>
<td><strong>2.56</strong></td>
<td><strong>5.11</strong></td>
<td><strong>3.72</strong></td>
<td><strong>3.24</strong></td>
<td><strong>14.63</strong></td>
<td><strong>1.05</strong></td>
<td><strong>15.68</strong></td>
<td><strong>0.33</strong></td>
<td><strong>0.98</strong></td>
<td><strong>1.30</strong></td>
</tr>
<tr>
<td>2020 Maximum Feasible</td>
<td>2.30</td>
<td>4.48</td>
<td>3.64</td>
<td>3.41</td>
<td>13.84</td>
<td>1.05</td>
<td><strong>14.89</strong></td>
<td><strong>0.33</strong></td>
<td><strong>0.98</strong></td>
<td><strong>1.30</strong></td>
</tr>
<tr>
<td>2030 Scenario</td>
<td>2.22</td>
<td>4.30</td>
<td>3.96</td>
<td>4.08</td>
<td>14.56</td>
<td>1.05</td>
<td>15.61</td>
<td>0.33</td>
<td>0.98</td>
<td>1.30</td>
</tr>
</tbody>
</table>

- The 2020 Scenario is the Chesapeake Bay allocation scenario for air loads with an estimated load to the tidal Bay of 15.7 million pounds.
- This reflects 10.4 million pound reduction from the 1985 high load condition.
## Key Scenarios Developed for the Chesapeake TMDL

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<tbody>
<tr>
<td>Susquehanna</td>
<td>160.43</td>
<td>148.09</td>
<td>141.44</td>
<td>138.68</td>
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<td>139.28</td>
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<td>West Shore</td>
<td>15.72</td>
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<td>15.07</td>
<td>14.98</td>
<td>14.94</td>
<td>14.99</td>
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<tr>
<td>Potomac</td>
<td>77.00</td>
<td>72.15</td>
<td>69.41</td>
<td>68.34</td>
<td>67.87</td>
<td>68.58</td>
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<tr>
<td>Patuxent</td>
<td>4.82</td>
<td>4.54</td>
<td>4.38</td>
<td>4.32</td>
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<td>4.31</td>
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<tr>
<td>James</td>
<td>37.89</td>
<td>36.67</td>
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<td>35.15</td>
<td>35.01</td>
<td>35.11</td>
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<tr>
<td>York</td>
<td>9.33</td>
<td>8.88</td>
<td>8.55</td>
<td>8.41</td>
<td>8.36</td>
<td>8.39</td>
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<tr>
<td>East Shore MD-DE</td>
<td>31.57</td>
<td>29.77</td>
<td>29.19</td>
<td>29.18</td>
<td>29.06</td>
<td>29.69</td>
</tr>
<tr>
<td>East Shore VA</td>
<td>3.01</td>
<td>2.91</td>
<td>2.84</td>
<td>2.83</td>
<td>2.81</td>
<td>2.83</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>350.74</strong></td>
<td><strong>328.13</strong></td>
<td><strong>316.50</strong></td>
<td><strong>311.71</strong></td>
<td><strong>309.72</strong></td>
<td><strong>312.98</strong></td>
</tr>
</tbody>
</table>

Atmospheric Deposition Nitrogen Delivered to the Bay Under Key Scenarios Units in millions of pounds as N (Phase 5.2 - August 2009 Version).
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