Fugitive Dust from Coal Trains:
Factors Effecting Emissions
& Estimating PM$_{2.5}$

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NW-AIRQUEST 2013
Background

The main reason I looked into this topic was to address a public comment EPA received in relation to our federal register notice, which proposed approving WA Dept. of Ecology’s 2008 baseline emissions inventory (EI) for Tacoma.

The comment came from the Sierra Club and suggested the Tacoma 2008 EI was deficient for not discussing or accounting for fugitive dust from coal trains in the EI.

I was asked to see what could be estimated about coal train fugitive dust impacts in Tacoma.
Background

Based on US Coal export data*, coal exports from the ‘Seattle’ export district (includes Tacoma up through the Canadian border) were as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Coal Exported (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>30581</td>
</tr>
<tr>
<td>2009</td>
<td>365260</td>
</tr>
<tr>
<td>2010</td>
<td>3500204</td>
</tr>
<tr>
<td>2011</td>
<td>4854451</td>
</tr>
<tr>
<td>2012</td>
<td>4746960</td>
</tr>
</tbody>
</table>

So there was some level of coal transported in 2008 (and probably through Tacoma).

*http://www.eia.gov/coal/
Why is this an area of interest now generally?

- There is growing interest from Asian markets in U.S. export coal.
- Currently there are 7 proposed or existing coal export terminals along the west coast (4 U.S. & 3 Canadian).
- Coal transport could increase quickly.

### Existing and proposed coal export capacity. (in millions of tons)

<table>
<thead>
<tr>
<th>Location</th>
<th>2012</th>
<th>2017</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BC Canada</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prince Rupert</td>
<td>0.0</td>
<td>1.5</td>
<td>5.0</td>
</tr>
<tr>
<td>N. Vancouver</td>
<td>0.0</td>
<td>2.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Roberts Bank</td>
<td>5.0</td>
<td>8.0</td>
<td>15.0</td>
</tr>
<tr>
<td><strong>Washington</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cherry Point</td>
<td>0.0</td>
<td>27.5</td>
<td>52.5</td>
</tr>
<tr>
<td>Grays Harbor</td>
<td>0.0</td>
<td>0.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Longview</td>
<td>0.0</td>
<td>27.5</td>
<td>48.0</td>
</tr>
<tr>
<td><strong>Oregon</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>St. Helens</td>
<td>0.0</td>
<td>5.0</td>
<td>21.0</td>
</tr>
<tr>
<td>Boardman</td>
<td>0.0</td>
<td>3.5</td>
<td>8.5</td>
</tr>
<tr>
<td>Coos Bay</td>
<td>0.0</td>
<td>0.0</td>
<td>10.0</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>5.0</td>
<td>70.0</td>
<td>139.0</td>
</tr>
</tbody>
</table>

(Source: Whiteside et al., 2012)
Coal Transport and Source Location

- The majority of export coal would come from the Powder River Basin (PRB) in MT/WY.
- Based on current pricing, BNSF would be the primary U.S. rail carrier from PRB to PNW.

Rail routes from PRB to proposed U.S. Pacific Northwest Coal Terminals

Map showing rail routes from Powder River Basin to proposed U.S. Pacific Northwest Coal Terminals.
Coal Train Frequency Based on Projected Capacity

- The number of coal trains per day on rail routes would significantly increase if these terminals are built.

**Proposed coal export capacity and number of projected loaded coal trains per day.**

<table>
<thead>
<tr>
<th>Location</th>
<th>Capacity (10^6 tons)</th>
<th>Loaded trains per day*</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC Canada</td>
<td>2022</td>
<td></td>
</tr>
<tr>
<td>Prince Rupert</td>
<td>5.0</td>
<td>0.9</td>
</tr>
<tr>
<td>N. Vancouver</td>
<td>5.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Roberts Bank</td>
<td>15.0</td>
<td>2.8</td>
</tr>
<tr>
<td>Washington</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cherry Point</td>
<td>52.5</td>
<td>9.8</td>
</tr>
<tr>
<td>Grays Harbor</td>
<td>5.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Longview</td>
<td>48.0</td>
<td>8.9</td>
</tr>
<tr>
<td>Oregon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>St. Helens</td>
<td>21.0</td>
<td>3.9</td>
</tr>
<tr>
<td>Boardman</td>
<td>8.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Coos Bay</td>
<td>10.0</td>
<td>1.9</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>139.0</strong></td>
<td><strong>25.8</strong></td>
</tr>
</tbody>
</table>

(*assumes 14,750 tons per train, 125 cars per trains; there will be an equal number of empty trains returning to the PRB*)
Some Communities will be Impacted More than Others

- Some transit portions have multiple route options, some only one.
- *Every* BNSF coal train from the PRB to PNW would go through ‘the funnel’ (Sandpoint – Spokane)
- Three BNSF routes from Spokane to Pacific terminals (all would be utilized).

### BNSF – Pacific Northwest Rail Map

- **Three Routes from Spokane to coast**
  - Stevens Pass
  - Stampede Pass *(empty returns only)*
  - Columbia River Gorge

- **‘The funnel’**
  - Sandpoint, ID – Spokane, WA
Community Concerns

There are a range of community concerns related to increased coal train traffic, some of these are:

- Air quality impacts from fugitive coal dust & increased diesel emissions
- Ecological impacts of coal dust

- Derailments

- Longer rail crossing wait times
- Rail infrastructure improvement cost burden on local communities
- ‘Nuisance dusting‘ of coal dust on cars/homes

- Rail congestion adverse impacts on current rail customers (e.g., container ports, ag shipments)
- Long term climate impacts
Factors Effecting the Amount of Fugitive Coal Dust from Coal Trains.

**Car and load geometry**
- Rail car dimensions
- Coal load profile
- Total exposed surface area of coal

**Coal physical properties**
- Coal moisture content
- Coal size distribution

**Trip specifics**
- Train speeds throughout route
- Load jostling in route
- Total journey length
- Weather: wind, precipitation, temp

**Dust controls**
- Control measure effectiveness and percent remaining at end of journey
Dust control measures

Rail lines have an economic incentive to reduce fugitive coal dust ... coal dust in track ballast increases the frequency and cost of track maintenance and can lead to derailments.

In 2010 BNSF and Union Pacific conducted a field evaluation of coal dust suppressant technologies.

- Trackside and train-board aerosol monitors were used.
- 1633 coal trains treated with various dust suppressant technologies.

>85% dust suppression was achieved with:

Specific load profile guidelines

and

applying a topper agent to loaded coal

As of October 2011 BNSF’s Coal Loading Rule requires coal shippers to use measures achieving > 85% dust suppression.
Estimating Fugitive Coal Dust Emissions from Coal Trains.

No clear information about how much coal is lost through fugitive dust in transit.

Various sources give a range of 0.5% to 3% of total coal transported is lost through fugitive dust when there are no dust control measures.

Wind tunnel experiments (1983) have estimated losses on the order of 0.9 to 1.8% for a 1100 km journey.
Canadian EI Example

Canadians EI’s have been using a distance based equation based on a report titled “A Study of Fugitive Coal Dust Emissions in Canada” (Cope and Bhattacharyya, 2001).

The base equation is (for total suspended particulate, TSP):

Emissions Factor (kg/tonne) = 0.1\times(0.62\times D)^{0.6}

Where

D = total distance travelled by rail cars (km)

This equation gives 0.5% coal loss over a 1100 km transit, so on the low end of the 0.5 – 3.0% uncontrolled coal fugitive dust losses.

Their recommended equation for TSP estimates yearly emissions including terms for precipitation (P), emissions controls (CE), and estimating emissions for only a segment (SD) of the total rail trip.

Emissions Factor (kg/tonne) = 0.1\times(0.62\times D)^{0.6} \times (365-P)/365 \times (SD/D) \times (100-CE)/100

Where

D = total distance travelled by rail cars (km)
SD = rail segment estimation emissions for (km)
P = number of days in the year with measureable precipitation (rain and snow)
CE = Control efficiency of any applied dust control measures (%).
Example: Applying Canadian Method to Tacoma

WRAP and AP-42 recommended a PM2.5 / TSP ratio of 0.15 (Cope and Bhattacharyya used 0.2, from US EPA AP-42 c. 2000)

\[ PM_{2.5} \text{ Emissions Factor} = 0.15 \times \text{TSP Emissions Factor} \text{ (kg/tonne)} \]


\[
\text{(Emissions Factor (kg/tonne)} = 0.1 \times (0.62 \times D)^{0.6} \times (365 - P)/365 \times (SD/D) \times (100 - CE)/100
\]

Assumptions:
- SD = 40 km,
- D = 2414 km (1500 mi),
- PM2.5/TSP EF = 0.15
- all Seattle export district coal exported through Tacoma
- all projected Cherry Point coal exported through Tacoma

Tacoma nonattainment area estimated coal train fugitive PM2.5 (tons per year)

<table>
<thead>
<tr>
<th>Year</th>
<th>Control Efficiency (%)</th>
<th># Precipitation days</th>
<th>Coal Exported (tons)</th>
<th>Tacoma NAA PM2.5 (TPY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>0</td>
<td>161</td>
<td>30581</td>
<td>0.3</td>
</tr>
<tr>
<td>2009</td>
<td>0</td>
<td>146</td>
<td>365260</td>
<td>4.4</td>
</tr>
<tr>
<td>2010</td>
<td>0</td>
<td>190</td>
<td>3500204</td>
<td>33.5</td>
</tr>
<tr>
<td>2011</td>
<td>85 (3 months)</td>
<td>166</td>
<td>4854451</td>
<td>44.4</td>
</tr>
<tr>
<td>2012</td>
<td>85</td>
<td>177</td>
<td>4746960</td>
<td>7.3</td>
</tr>
<tr>
<td>2017*</td>
<td>85</td>
<td>168</td>
<td>27500000</td>
<td>44.5</td>
</tr>
<tr>
<td>2022*</td>
<td>85</td>
<td>168</td>
<td>52500000</td>
<td>84.9</td>
</tr>
</tbody>
</table>

*projected

For comparison, the Ecology Tacoma 2008 SIP EI lists yearly emissions of PM2.5 of:

1199 TPY for Residential wood combustion & 411 TPY for onroad sources
Uncertainties with Canadian method: *Many*, but it does give us an estimation method.

**Questions / unknowns / simplifications**

- Some evidence for nonlinear dust loss over journey (more earlier on), but this equation assumes linear.
- Majority of dust lost may be through ‘dusting events’. Some sections of track may be more prone to dusting events based on topography, typical winds, typical train speed, etc.
- Effectiveness of controls may wear off throughout journey, leading to more dust later in the journey.
- Does not account for emissions from ‘empty’ return trains (coal residue can emit fugitive dust).
- Fugitive dust is directly related to train speed, train speeds make be slower through cities(?)
- How variable is the coal size distribution?
- How variable is coal moisture content?
- How important are seasonal effects (winter/summer – temperature / humidity / winds )
- Effects of precipitation are simplified.

However, for estimating annual emissions the importance of some of the above variability may be reduced.
Other activity around coal train fugitive dust?

For the Gateway Pacific Terminal at Cherry Point WA

An environmental impact statement (EIS) is being developed under guidelines from the National Environmental Policy Act (NEPA) and the State Environmental Policy Act (SEPA).

Air quality is one of many environmental impacts under review. Uncertain if this will lead to measurements and/or improved fugitive dust estimates.

The agencies coordinating the EIS are
   U.S. Army Corps of Engineers,
   WA State Department of Ecology, and
   Whatcom County

EIS Timeline:
9/2012 – 1/2013 Public input on scope of EIS
3/2013 EIS scoping summary report issued (summary of comments)
~2014 Issue draft EIS
~2014/2015 Issue final EIS
Other activity around coal train fugitive dust?

Dan Jaffe (UW Prof.) will conduct a short trackside study based on ‘crowdsource’ funding.

Duration: 4-6 weeks
Location: North of Seattle (?)
Time: Summer/Fall 2013

Currently proposing to measure
PM1,
PM2.5,
PM10,
TSP, and
Met. variables
Selected References:


Thank you for your attention!