Fugitive Particulate Matter Emissions from Coal Train Staging at the Proposed Coyote Island Terminal

Oregon Department of Environmental Quality
Standard Air Contaminant Discharge Permit Review Report,
Coyote Island Terminal, LLC,
Permit No.: 25-0015-ST-01

Final Report

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I was asked to review the particulate matter emissions from wind erosion of uncovered railcars while the trains are staged, as estimated by Oregon Department of Environmental Quality ("ODEQ") in its Standard Air Contaminant Discharge Permit Review Report ("Review Report")[1] for the Coyote Island Terminal ("Terminal") and the resulting draft Permit No.: 25-0015-ST-01 ("Permit").[2]

The Coyote Island Terminal will receive 8.8 million tons per year of coal by rail at the Port of Morrow where it will then be loaded for export. Upon arrival, the coal will be uncovered from the point the train enters the Terminal until each car enters the unloading shed where the coal is transferred via rotary dump to a hopper and conveyor. ER,[3] pp. 2-12 to 2-18. Fugitive dust emissions will occur due to wind erosion of the coal in uncovered railcars while the trains are staged, prior to entering the unloading station. The unit trains will be split to avoid blocking Columbia Avenue, which will increase their original processing time of 4.8 hours to a much longer processing time of 12 hours. ER, p. 2-11.

The existing rail network at the Port of Morrow, totaling 18,000 feet, can handle two unit trains at once, each of which is about 5,800 feet long (or over 1 mile). ER, p. 2-6. The type of rail car that would be used is not disclosed, but gondola cars, commonly used for coal, typically have an inside width of about 9.5 feet.[4] Each unit train holds about 14,500 tons of coal, which will be exposed to ambient conditions for up to 12 hours at the terminal, the time required to unload a unit train. ER, p. 2-11. The ER indicates that up to 607 trains per year would import coal to the terminal at up to 12 hours per train to unload. ER, p. 3-139. Thus, coal trains will be present at least 83% of the time.[5]

The site will initially have only a single unloading shed that takes 12 hours to process a single unit train while the rail tracks can accommodate two unit trains simultaneously. ER, pp. 2-6. Thus, trains will be idle on the tracks, with exposed coal that is either dried out upon arrival or can continue to dry out while waiting to be loaded, degrading the coal surface and making it readily erodible by wind.

The draft Permit contains emission factors for PM, PM10, and PM2.5 expressed in pounds of pollutant per ton of coal (lb/ton) that will be used to determine compliance with emission limits in tons per year (ton/yr) in Permit Condition 4.1. Permit, Condition 12.0. These emission factors are underestimated, for the reasons set out below. Further, the draft Permit allows "alternative emission factors provided they are based on actual

[1] ODEQ, Standard Air Contaminant Discharge Permit Review Report, Coyote Island Terminal, LLC, Permit No.: 25-0015-ST-01, Application No.: 26945, Draft, May 28, 2013.

[2] ODEQ, Standard Air Contaminant Discharge Permit No.: 25-0015-ST-01, May 28, 2013.

[3] Anderson Perry & Associates, Inc., Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow, Prepared for Coyote Island Terminal, LLC and Ambre Energy North America, June 2012, Updated August 2012.

[4] CSX, Railroad Equipment, Plain Gondola, Available at: http://www.csx.com/index.cfm/customers/equipment/railroad-equipment/

[5] Percent of time trains present: 100(607x12/8760) = 83%.

test data or other documentation..." Permit, Condition 5.6. Any modification to these emission factors should be submitted for public review due to the complex issues involved in their calculation.

Wind blown dust from loaded uncovered railcars, waiting to be unloaded, is a major source of particulate matter emissions. The ODEQ estimated the emissions from and emission factors for loaded uncovered railcars at the site using an equation from AP-42, Section 13.2.5, for wind erosion from flat areas covered with coal dust. Review Report, p. 9. I reviewed the ODEQ's application of this equation and related permit conditions. In my opinion, ODEQ did not use accurate input variables and thus underestimated particulate matter emissions from loaded uncovered railcars. The particulate matter emissions from staging coal cars are much higher than estimated in the Review Report, high enough to classify the terminal as a major source.

I. The ODEQ's Application of the Wind Erosion Equation Underestimates Particulate Matter Emissions From Loaded Uncovered Trains During Staging

The Review Report estimated emissions from wind erosion of staging coal cars using AP-42 Section 13.2.5.3, equations for wind erosion from flat areas covered with coal dust. Review Report, p. 9. The subject equations are:

$$P_i = 58(u^* - u_t^*)^2 + 25(u^* - u_t^*) \qquad (1)$$

where

P_i = the erosion potential corresponding to the observed (or probable) fastest mile of wind for the ith period between disturbances in grams per meter squared (g/m^2)

u^* = friction velocity in m/s (0.599 m/s) = $0.053u^+_{10}$

u_t^* = threshold friction velocity in m/s (0.54 m/s).

The total wind erosion in a year is the sum of the number of disturbances per year or

$$EF = k\sum_{i=1}^{N} P_i \qquad (2)$$

where

k = particle size multiplier

N = number of disturbances per year.

A. Input Assumptions Underestimate Emissions

The ODEQ's use of these equations underestimates particulate matter emissions from the subject rail cars for the reasons set out below.

First, the wind speed in the AP-42 equation (p. 13.2.5-5, Eqn (4)) that ODEQ used to estimate friction velocity (u^*) or $0.053u^+_{10}$, is estimated as 0.053 times the fastest mile of the reference anemometer for the period between disturbances in m/s. ODEQ did not use the fastest mile,[6] but rather the "24-hr highest annual 24-hour average wind speed" (sic). Review Report, p. 9. This underestimates the fastest mile wind speed as it does not include peak wind gusts of short duration (over a few seconds instead of the 24-hour average used by ODEQ). These short gusts are responsible for wind erosion. For the equations that ODEQ used, AP-42 notes that "estimated emissions should be related to the gusts of highest magnitude." AP-42, p. 13.2.5-1. The ODEQ instead used a 24-hr average that does not include peak wind gusts of short duration, thus substantially underestimating wind erosion.

Second, the equation that ODEQ used only applies to flat piles with little penetration into the surface wind layer. Rail cars are not flat piles. The coal surface is located 10 feet or more above ground level, with significant penetration into the surface wind layer. Thus, the friction velocity estimated by this equation is underestimated and with it, wind erosion emissions.

Third, the threshold friction velocity is best estimated from a simple hand sieving test of the material to be disturbed as material characteristics determine erosion potential. AP-42, pp. 13.2.5-3/4. In the absence of test data, AP-42 provides a table of estimates for six materials. AP-42, Table 13.2.5-2. This table was used by ODEQ, who selected the entry called "fine coal dust on concrete pad." Clearly, the surface of a loaded rail car is nothing like fine coal dust on a concrete pad. Footnotes to this table indicate the coal included in this test was at an eastern power plant in 1985 and thus unlikely to be PRB coal. PRB coal is very different from eastern bituminous coals that were likely used in this test. PRB coals are extremely friable and easily degrade into smaller particles, regardless of how they are transported or handled, thus causing fugitive dust emissions.[7] Thus, a much lower threshold friction velocity likely applies.

Fourth, the equations ODEQ used were developed for stationary aggregate storage piles whose surfaces are characterized by finite availability of erodible material (mass/area) referred to as the "erosion potential" or "P". AP-42, p. 13.2.5-1. Erosion is assumed to occur only when there is a disturbance, as when new aggregate is either added to or removed from the old surface. Further, they implicitly assume the exposed material

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[6] The fastest-mile wind speed is the wind speed obtained from wind velocity maps prepared by the National Oceanographic and Atmospheric Administration. It is the highest sustained average wind speed based on the time required for a mile-long sample of air to pass a fixed point.

[7] Roderick J. Hossfeld and Rod Hatt, PRB Coal Degradation -- Causes and Cures, PRB Coal Users Group Annual Meeting, April 5-7, 2005. Available at: http://www.prbcoals.com/pdf/paper_archives/56538.pdf

has limited erosion potential. AP-42, p. 13.2.5-3. However, the availability of erodible material for the railcars is unlimited. A total of 607 unit trains will visit the site every year, each staying about 12 hours. The arrival of each train presents fresh erodible material. Further, rail transport of coal continuously jostles the coal en route, exposing new coal for erosion as the trains move along the tracks. Train vibration during transport causes coal particles to break, producing finer material that will be lifted more readily from the coal surface. One study, for example, measured coal losses of 0.2 to 0.4 tons or 400 to 800 pounds per individual rail car during a 500 mile long trip.[8] Others have estimated that 0.5% to 3% of the total coal transported is lost through fugitive dust when no dust control is used.[9] This would amount to 73 to 435 tons for a unit train serving the Terminal, amounting to a substantial amount of "jostling."

Thus, rail cars will arrive with freshly exposed coal, ready to be further eroded at the site. Two unit trains, each about a mile long and 9.5 feet wide, will be present at the site for 12 hours each up to 83% of the time. Thus, about 2.4 acres[10] or about two football fields[11] of fresh exposed coal will be available for wind erosion 83% of the time. The PRB coal that will be imported is known to be highly friable and thus would be expected to have a much greater "erosion potential" than aggregate "with limited erosion potential" as assumed in these equations. Thus, the concept of "erosion potential" as presented in this section of AP-42 underestimates emissions from an unlimited source of erodible material such as PRB coal in newly arrived railcars.

Fifth, the principal equation (AP-42, p. 13.2.5-3, Eqn (3) or Eqn. 1 above) assumes a flat surface. The coal is generally not present as a flat surface in the rail cars, but rather presents as trapezoidal or rounded profiles that extend above the walls of the rail car.[12] This increases the available surface area, increasing emissions.

Finally, ODEQ applied a control efficiency of 85% to the calculated erosion emissions to account for the control of fugitive dust by dust control agents know as "topping agents" in the industry, that are applied at the mine. As discussed below, these topping agents would have worn off by the time the trains reach the Terminal.

As discussed in the next section, when just the correct wind speed and control efficiency are used, the particulate matter emissions from wind erosion of uncovered railcars exceeds the major source threshold of 250 ton/yr.

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[8] Edward M. Calvin and others, A Rail Emission Study: Fugitive Coal Dust Assessment and Mitigations, Available at: http://www.powerpastcoal.org/wp-content/uploads/2011/08/A-RAIL-EMISSION-STUDY-FUGITIVE-COAL-DUST-ASSESSMENT-AND-MITIGATION.pdf

[9] Robert Kotchenruther, EPA Region 10, Fugitive Dust from Coal Trains: Factors Effecting Emissions & Estimating PM2.5, 2013, Available at: http://lar.wsu.edu/nw-airquest/docs/201306_meeting/20130606_Kotchenruther_coal_trains.pdf

[10] Exposed coal area in rail cars = 2 x 5800 ft x 9 ft x 2.2957E-5 ac/ft^2 = 2.4 acres.

[11] An official NFL football field measures 360 ft long by 160 ft wide. Thus, one football field occupies 360 ft x 160 ft x 2.2957E-5 ac/ft^2 = 1.32 acres.

[12] See, e.g., Calvin et al. and photographs of loaded trains in Kotchenruther 2013.

B. ODEQ Emission Estimates Are Unsupported

The ODEQ used the AP-42 equations, which yield erosion potential in grams per square meter of surface area per event, to estimate PM, PM10, and PM2.5 emissions in pounds per ton of coal as follows (Review Report, p. 17):

- PM: 2.00E-04 lb/ton
- PM10: 1.00E-04 lb/ton
- PM2.5: 1.5E-5 lb/ton

These coal train erosion emission factors are then summed with emission factors for other coal handling operations to yield combined emission factors that are set as permit conditions. Permit, Sec. 12.0. The combined emission factors are proposed to determine compliance. The Permit does not require any demonstration that these assumed emission factors accurately represent actual emissions from the subject railcars. Review Report, pp. 17-18.

The Review Report does not explain how ODEQ converted erosion potential in grams per square meter per event into pounds per ton of coal and then into tons per year. I attempted to reproduce ODEQ's calculations, as set out below. I used the equations and input variables from the Review Report (Review Report, p. 9) and information from the ER to estimate erosion potential. My calculations indicate the uncontrolled erosion potential using ODEQ's input assumptions is 1.68 g/m^2.[13]

It is unclear how ODEQ used this erosion potential to estimate an emission factor in lb/ton and annual particulate matter emissions in ton/yr. The responses to comments should disclose all of the calculations and underlying assumptions to convert erosion potential into pounds of particulate matter per ton of coal as reported in the Review Report at 17 and recirculate the Review Report and draft Permit for public review.

Using the description of the proposed operations, as set out above, the uncontrolled PM emissions from a single erosion event would be 37.9 lbs of particulate matter per event.[14] Assuming the surface of staged unit trains is disturbed only daily and unit trains are present 83% of the time, the annual uncontrolled PM emissions would be 5.7 ton/yr.[15] Assuming 85% control as assumed by ODEQ yields 0.86 ton/yr of PM,

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[13] Following the procedures in the Review Report, p. 9, the friction velocity u^* is given by $0.053u^+_{10}$ = 0.053 x 25.3 mph x 0.44705 m/s per mph = **0.599 m/s**. The threshold velocity (u_t^*) is taken from AP-42 Table 13.2.5-2 for "fine coal dust on concrete pad" and is **0.54 m/s**. Thus, $P= 58(0.599 - 0.54)^2 + 25(0.599 - 0.54) =$ **1.68 g/m^2.**

[14] PM emissions from one wind erosion event = $[(1.68\ g/m^2)(0.00220462\ lb/g)/10.7639\ ft^2/m^2)]$(2 unit trains x 5800 ft long x 9.5 ft wide) = **37.9 lbs of PM per event**.

[15] Annual PM emissions = (37.9 lb/event)(365 day/yr)(0.83)/2000 lb/ton = **5.7 ton/yr**.

which is very close to the value of 0.88 ton/yr estimated in the Review Report, page 17. However, this underestimates potential emissions as demonstrated below.

C. ODEQ Underestimated Emissions

The PM/PM10/PM2.5 emission factors in lb/ton and total emissions in tons/yr estimated using the above-described procedures are underestimated, assuming ODEQ's undisclosed calculations are similar to mine, as laid out above for three reasons: (1) wrong wind speed (24-hour average instead of fastest mile); (2) low disturbance frequency (one per day instead of multiple); (3) high dust control efficiency (85% instead of 0%). These issues are discussed below.

When the friction velocity is increased to 64 mph and the topping agent control efficiency set to zero, but otherwise using ODEQ's input assumptions (some of which further underestimate PM emissions), PM emissions from uncovered railcars increases from 5.7 ton/yr to at least 270 ton/yr. These revised PM emissions for just train staging exceed the major source threshold for particulate matter of 250 ton/yr. Actual train staging emissions could be even larger under the AP-42 Section 13.2.5 emission model that ODEQ used due to the other errors and omissions in ODEQ's calculations as discussed further below.

1. Fastest Mile

First, the ODEQ calculations are based on a 24-hour average wind speed, rather than the fastest mile, as explicitly required by the AP-42 equation. The fastest mile is no longer reported in the local climatological data, but a good indicator is the maximum 3-second wind. For 2012, the maximum 3-second wind for Astoria was 76 mph and for Portland, it was 48 mph. Historic tabulations yield a range for the fastest mile of 55 mph to 88 mph at Oregon stations with an average of 67 mph for the five available stations.[16] There is no local climatological data for Hermiston. However, in previous work, I used an estimate of 64 mph to account for wind gusts, calculated as two times the highest daily wind speed of 32 mph, averaged over daytime hours at Hermiston during 2007-2011.[17] As this value falls squarely within the range of historic fastest mile wind speeds for Oregon stations, I used it here for the fastest mile to revise ODEQ's train staging particulate matter emission estimates.

2. Disturbance Frequency

Second, the ODEQ calculations appear to assume (based on my reconstruction) one disturbance event per day, where a disturbance event is the arrival of two new unit trains, one every 12 hours. However, it is possible that the staged trains could move

[16] Richard A. Wood (Ed.), Weather of U.S. Cities, Fifth Ed., 1996, pp. 760-783 (Astoria - 55 mph; Medford - 55 mph; Pendelton - 77 mph; Portland - 88 mph; Salem - 58 mph).

[17] Khanh T. Tran, AMI Environmental, AERMOD Modeling of Air Quality Impacts of the Proposed Morrow Pacific Project, Final Report, p. 5, October 2012.

around the site, jostling their contents multiple times, creating additional disturbance events. If each unit train, for example, were disturbed twice per day, once on arrival, and once during transit across the site to the unloading shed, the emissions estimated above would double to 540 ton/yr. Even more disturbances are plausible.

3. Topping Agent Control Efficiency

Third, the calculations in the Review Report assume that the coal arrives treated with a topping agent that controls 85% of the fugitive emissions. Review Report, p. 9. This is the assumed control efficiency at the mine, where topping agent is applied. The control efficiency at the Terminal is likely to be zero due to coal and topper degradation during transit, among other reasons further described below. Additionally, the 85% control assumption for topping agents (or surfactants) even at the mine is questionable and has been criticized as being based on "junk science".[18] There is some evidence that indicates that surfactants/topping agents may even increase coal loss due to "saltation". A declaration by Dr. Mark Viz in a case before the Surface Transportation Board (STB) noted as follows: [19]

[18] Before the Surface Transportation Board, Reasonableness of BNSF Railway Company Coal Dust Mitigation Tariff Provisions, Finance Docket No. 35557, Opening Evidence and Argument of Western Coal Traffic League, American Public Power Association, Edison Electric Institute and National Rural Electric Cooperative Association, October 1, 2012 ("STB Brief"), pdf 18 ("Coal Shippers demonstrated in Dust I that the coal dust mitigation standards in the Original Coal Dust Tariff [the 85% relied on by ODEQ] were predicated on junk science..."). See also Arkansas Electric Cooperative Corporation's Reply Evidence and Argument, pdf 3 ("BNSF created the appearance that toppers are highly effective by simply excluding from testing the real world conditions where they are not effective."), 4 ("BNSF's claim that toppers remain intact until they reach their final destination is refuted by [REDACTED] toppers cannot achieve the promised reductions in fugitive coal deposition between the mine and the power plants."), 9 ("..the profile established at the mine and the coating of the topper on the coal are likely to degrade during the course of the rail journey from the mine. This is particularly true where excessive stresses are placed on the coal load as a result of the railroad's operations (e.g., excessive speed, slack action, etc.,) and/or the state and condition of the track (e.g., modulus changes, worn switches, etc.). Shippers have no control over these factors, which may materially alter the load profile and/or the integrity of the topper that have been applied."), 14 ("The safe harbor toppers put a thin chemical coating over the top of the coal, which is supposed to "keep [] the wind from blowing coal dust out of a coal car or off the top of a coal stockpile."[] that may work well enough on a stationary pile of coal, but coal cars move. Coal leaves a rail car not only because of wind, but also because of vibrations, impacts, and other forces caused by the movement of the train over the track...Moreover, these same forces can cause the thin chemical coating on top of the coal in the car to break apart so that it is no longer effective even to prevent wind-blown coal dust."), 15 ("BNSF's claim that chemical toppers are a silver bullet to prevent deposition of fugitive coal is a fantasy.").

[19] Verified Statement of Mark J. Viz, Ph.D., P.E., on behalf of Western Coal Traffic League, American Public Power Association, Edison Electric Institute and National Rural Electric Cooperative Association, in support of Opening Brief Dust II, Surface Transportation Board, Docket. No. 35557, October 1, 2012, p. 3.

e. **I also note at the outset that many if not all of the dust suppressants were designed for use in dust mitigation from static coal stockpiles at coal-burning power plants or similar facilities. In this regard these products are generally recognized to work when applied to a large pile of coal *that is stationary*, but there are still many aspects of their performance *in moving railcars* that have not yet been verified. I have observed from my own field work that crusting agents and other topper sprays essentially break apart when a railcar gets shaken or bumped going over the track. Frequently other events can also occur to either upset the efficacy of the topper agent or in certain cases to make the fugitive loss even worse by a process known as "saltation," i.e., the greater entrainment of particles in a moving air stream as a result of released particles impacting the surface and therefore releasing yet greater amounts of dust. The performance of suppressants during precipitation events and long exposure to wind and solar radiation are also not that well-understood.**

Topping agents have a limited useful lifetime as they breakdown by ultraviolet radiation and microbes; abrasion and loss from wind erosion and motion of the train; washout by rain, and degradation of the PRB coal itself.[20] One proposed topping agent, for example, DustBind, is mostly alcohol, which is highly volatile. As noted by Dr. Viz, topping agents have been mainly studied only on stationary coal piles, not on moving trains.[21] Finally, as the topping agent would be applied at the mines, out of sight and control of both the applicant and ODEQ, it is possible that the rail cars would arrive without any topping agent at all, exposing degraded[22] coal that can be eroded by the wind or dislodged during staging. Further, evidence presented in proceedings before the Surface Transportation Board suggests that all or most of the topping agent or surfactant is lost during transit.[23] Thus, any topping agent applied at the mine would not necessarily control wind-blown dust on the trains sitting at the Terminal.

Further, the Review Report and draft Permit do not support 85% dust control. The draft Permit only requires that the "facility must only accept and transfer coal that has had a topping agent applied to all railcars prior to shipping." Permit, Conditions 6.1(d). This is a desirable condition but it is not sufficient to assure that railcar staging

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[20] See, e.g., Kotchenruther 2013 ("Effectiveness of controls may wear off throughout journey, leading to more dust later in the journey.").

[21] See Western Coal Transportation League brief, at 19. Viz verified statement at 3. .

[22] See discussion of PRB coal degradation in Hossfeld and Hatt.

[23] Verified statement of Michael Nelson, a coal transportation analyst provided in support of *Arkansas Electric Cooperative Ass'n* reply brief, Dust II proceeding, Surface Transportation Board, Docket. No. FD 35557 *,* November 15, 2012. "Ultimately, the evidence shows that BNSF's claim that the toppers normally are intact at the destination point is unsupported, incorrect, and entitled to no weight." Further, utilities have noticed that topping agents do not make it through the trip. "Corroboration of the seriousness of enroute topper failure has been provided by coal users who have movements currently receiving treatment with safe harbor toppers. Such users have noticed that the toppers they pay for frequently don't make it all the way to the plant." Nelson, *id.* at 7.

fugitive dust is controlled by 85% at the Terminal. The draft Permit does not explain how this condition will be enforced, i.e., will a traceable loading certificate be required? Will monitoring at the site be conducted and if so, will it be able to ensure that the 85% control is being met continuously? The draft Permit also does not require any specific control efficiency anywhere, including on arrival at the Terminal nor any demonstration of 85% control. How can one judge the control efficiency at the Terminal of an agent applied at the mine? Thus, a specific control efficiency is not enforceable at the Terminal. For purposes of calculating emissions and ambient impacts, a control efficiency of zero should be assumed in calculations, as for example, to determine compliance with Condition 12.0.

The draft Permit implies that ODEQ "may" require addition of topping agent at the Terminal. However this is only optional, subject to determination by undisclosed methods in the future, if at all. Permit, Condition 6.1(h). The draft Permit, for example, requires installation of a system to apply topping agent to railcars as they enter the Terminal or covering each railcar until it enters the Unloading Building if ODEQ determines one is required based on visible emissions monitoring data and information from complaints. Permit, Condition 6.1(h). However, the draft Permit language is not practically enforceable as it leaves undefined the amount and type of visible monitoring and the number and nature of the complaints that will be required to trigger this condition.