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RE: Ecological Impacts of Proposed Coal Shipping on the Columbia River Port of Morrow and Port Westward, Oregon

Mr. Winter:

This technical memorandum provides Leyda Consulting, Inc.'s (LCI) expert ecological review of the proposed Coyote Island Terminal Dock and associated coal shipping operation involving rail and water routes (the Morrow Pacific Project or MPP). The location of the investigation is the Port of Morrow near Boardman, OR, in Morrow County (T4N, R25E W.M.), with proposed barges shipping coal to Port Westward near Clatskanie, OR in Columbia County (T8N, R4W W.M.).

The current proposal is to construct facilities to ship up to 8 million metric tons (8,760,000 short tons) of low-sulfur intermountain US coal to Asia.[1] The applicant will then hire a barging company to move the coal along the Columbia River to Port Westward, and then the coal will be transloaded over the water by Pacific Transloading from enclosed river barges to ocean-going vessels operated by shipping companies commissioned by the buyer of the coal.[2]

The analysis in the Environmental Review Document (ERD) depends upon certain assumptions that, based on my opinion, are not certain enough to constrain a proper analysis of potential ecological impacts. If the export terminal is constructed, there appears to be no enforceable condition that the coal shipped would be exclusively low-sulfur coal from the intermountain west, or that enclosed river barges and storage facilities would be used in perpetuity. There also appears to be no limitations on the design of the coal export terminal, which could be amended in the future or changed subsequent to construction in the event of repair or other alternations. There is no apparent information in the ERD that these assumptions would be imposed as enforceable conditions on the operation of the MPP by either state or federal regulatory agencies.

The applicant states that there is a demand for shipping intermountain west coal through US west coast ports to Asia, and that this proposal fills that demand.[3] In Appendix J of the

[1] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. Executive Summary, p. 1
[2] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. Executive Summary, p. 1, 2.
[3] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 1-3.

Environmental Review, a map of US coal producing regions is shown.[4] The map clearly shows the presence of bituminous coal in the Uinta Basin of Utah and Colorado, and in central Montana, which is mapped as the same type of coal found in the Appalachian Mountains that may contain higher amounts of sulfur. The Utah Department of Natural Resources estimates that the existing coal fields in Utah contain almost 15,000,000,000 short tons of recoverable resource[5], and a large majority of that coal is moved by rail.[6] Given the proximity and demand, it is reasonable to assume for this ecological review that any type of coal may be shipped from the proposed terminal, including the higher sulfur, higher mercury bituminous coal. Studies pertaining to pollution stemming from sulfidic impurities in coal, such as acid drainage and dissolved metals, are therefore relevant to considering the potential impacts of MPP.

Based on the proposed location of the MPP, primary considerations for assessing impacts to ecological receptors includes the proximity of the Port of Morrow to the Umatilla National Wildlife Refuge and the presence of sensitive and/or protected areas at the Port of Morrow, Port of Westward and along the Columbia River shipping route. Fish listed under the Endangered Species Act include steelhead (*Oncorhynchus mykiss*) (threatened), Chinook salmon (*O. tshawytscha*) (endangered and threatened), chum salmon (*O. keta*) (threatened), coho salmon (*O. kisutch*) (threatened), sockeye salmon (*O. nerka*) (endangered), bull trout (*Salvelinus confluentus*) (threatened), green sturgeon (*Acipenser medirostris*) (threatened), eulachon (*Thaleichthys pacificus*) (threatened). Critical habitat for salmon species occurs in the area.

I. Fugitive Coal Dust Impacts

A. Dust Impacts from Rail Transportation of Coal

This review of the available literature demonstrates the potential for coal dust to cause adverse impacts to a wide range of ecological receptors, including mammals, fish and benthic communities. The ERD assumes that the operations at the MPP will not result in substantial emissions of coal dust, however those assumptions have not been supported by adequate information.

The proposed shipping operation will generate coal dust at various points and the potential exists for a discharge of the coal dust to land and water along the rail and river routes. According to the ERD, the coal trains will require 4.8 hours to unload, but will likely be split to avoid blocking traffic and then require 12 hours to unload.[7] The applicant also mentions that

[4] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. Appendix J - Coal Toxicology Report, p. 6.
[5] Utah Department of Natural Resources, Utah Coal Reserves by Coal Field, 2011 (October 3, 2012) (available at http://geology.utah.gov/emp/energydata/statistics/coal2.0/pdf/T2.3%20&%20T2.1.pdf).
[6] Utah Department of Natural Resources, Distribution of Utah Coal be Method of Transportation, 1970-2010 (December 14, 2011) (available at http://geology.utah.gov/emp/energydata/statistics/coal2.0/pdf/T2.14%20&%20F2.5.pdf).
[7] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 2-11.

"prior to shipping, the coal will be coated with an approved surfactant to reduce transit coal dust losses by 85%."[8]

In Appendix U of the ERD, the applicant states that the rail cars may be treated with a product that reduces coal dust discharge during transit.[9] The shipper is responsible for treating the loaded cars to reduce dust 85% compared to untreated cars. According to this UP [Union Pacific] loading tariff, the topper application applies only to Powder River Basin mines, not to all coal shipments bound for the proposed terminal, nor to any other coal mined in the "intermountain west," and only those "for subsequent movement on UP." So, there is the potential for any coal mined anywhere else besides the Powder River Basin to escape treatment of any kind, as well as coal shipped on any other line aside from UP.

The same document also says there are alternatives to using the topper agent: "shipper or shipper's loading operator may adopt an alternative coal dust mitigation plan involving other measures (e.g. compaction or other technology)" and that BNSF will review test results for those measures, and be satisfied that "any product involving topper agents, devices or appurtenances utilized to control the release of coal dust will not adversely impact railroad employees, property, locomotives, or owned cars."

The original statement in the Environmental Review that "prior to shipping, the coal will be coated with an approved surfactant to reduce transit coal dust losses by 85%,"[10] is not accurate. Other measures approved by BNSF may be used, such as "compaction or other technology." Additionally, no oversight by any government agency or independent authority will monitor any dust control measures or alternatives. The dust control measures are merely voluntary and nothing in this application indicates any dust control measures during rail transport beyond this treatment, so there is no guarantee of any dust control measure being applied. Prevention of harm to the ecosystem is not a criterion of coal dust release. Essentially, UP or BNSF makes the final decision as to whether coal dust reduction is adequate, which does not contain any measures guaranteeing compliance, and could likely result in excessive coal dust discharge into the ecosystem. The assumption that these control measures will be effective is therefore unsupported because there is not a clear plan for how coal will be handled and managed.

Most importantly, the Appendix U document, titled "Item 216," essentially states that no coal dust mitigation measures are required at all: "in order to comply with the BNSF Operating Rule, regarding coal dust mitigation measures, Shippers must adopt measures to comply with this Item as soon as practicable." That means that if implementing measures are not "practicable," they don't have to occur. It could be decades before the companies making this agreement decide it is "practicable." Based on the applicant's coal dust mitigation agreement, it is clear that the rail cars do not have to be treated to begin shipping coal, and there is no clear indication of how much time may pass after the proposed shipments begin before they are treated. Therefore,

[8] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 3-4.
[9] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. Appendix U - Required Loading Measures, UP6603-C, Item 216 Required Loading Measures to Mitigate Coal Dust.
[10] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 3-4.

ecological impacts from coal dust should be considered as if no topping agent or mitigation measures will occur.

The following photographs[11] show how Powder River Basin coal fragments in just a few days under normal indoor conditions:

Results of Test Program 1

The first test simply allowed large PRB coal particles to sit at ambient conditions (inside a building) for 6 days while photos were taken. Figures 4a–4f show a series of photos of one particle over time.

Figure 4a. PRB coal at start of test.

Figure 4b. PRB coal after 5 hours.

Figure 4c. PRB coal after 2 days.

Figure 4d. PRB coal after 4 days.

Figure 4e. PRB coal after 6 days.

Figure 4f. PRB coal after 6 days.

PRB coal is highly friable, that is, prone to breaking apart.[12] It is likely that coal will crack apart during transport from the mine to the proposed shipping terminal, and thus produce more

[11] Hossfeld, R.J. and R. Hatt. PRB Coal Degradation - Causes and Cures. Private company research accessed online at http://www.prbcoals.com/pdf/paper_archives/56538.pdf on 10/18/12.
[12] Hossfeld, R.J. and R. Hatt. PRB Coal Degradation - Causes and Cures. Private company research accessed online at http://www.prbcoals.com/pdf/paper_archives/56538.pdf on 10/18/12.

coal dust in transport than the intact chunks. If the topping agent treatment actually occurs, and if it covers the top part of the coal in the rail car, then if/when the coal cracks during transport, the new surfaces will not be treated and could produce large amounts of coal dust along the way. The photographs above show PRB coal in an indoor setting - outdoor transportation through dry, windy corridors could accelerate the dusting process. At the Port of Morrow, 29,000 tons of dusty, cracked coal would be sitting in rail cars waiting for transfer to barges at the proposed export terminal.

The air quality application shows that particulate matter will be released from the Engart dust extractors at the rail car unloading station.[13] Appendix E - Vendor Information - Scrubbers page 2 of 3, Table 1 states, "Particulate Matter Emissions - lbs/hr - 0.13." Form AQ230, page 2 of the application says the operation schedule is year-round, projected for 8,760 hours per year. That means the Engart dust extractor will release approximately 1,139 pounds of coal dust per year.

In an expert report authored by Dr. Phyllis Fox, revised fugitive dust particulate matter emissions are presented. Dr. Fox calculates emissions from transfers to be approximately 139 tons/year at the Port of Morrow, which is likely to significantly underestimate the total emissions. Moreover, Dr. Fox finds the emission estimates at Port Westward to be wholly unsupportable. These coal dust emissions, and other emissions from moving the coal, need to be closely examined for ecological effects.

B. Harmful Pollutants in Coal and Coal Dust

The applicant states that coal dust is a non-carcinogen, and that "coal dust itself does not require any special consideration in the air quality assessment other than it is a source of particulate matter."[14] Fugitive coal dust air emissions of antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, selenium, and uranium combined are estimated by the applicant at 0.00000666 tons per year (0.01332 pounds = 0.213 oz. = 6.04g).[15] Coal contains elements mentioned by the applicant, and also tin (Sn), boron (B), vanadium (Va), copper (Cu), molybdenum (Mo), and zinc (Zn),[16] among others.

The actual emissions of trace elements could be much greater than 6.04g given the estimated 163 tons of coal dust emissions per year. Table 1 presents the potential contents of some trace elements in three types of US coals.[17] An estimate of the potential weight of the trace elements in 163 tons of coal dust is included in the far right column, based on the Powder River column. The Wasatch Formation is part of the Powder River Basin. The contents of trace elements can vary among different types of coal.

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[13] Air Contaminant Discharge Permit Application. Coyote Island Terminal, LLC. Received August 3, 2012. Golder & Associates, July 26, 2012.

[14] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 3-130.

[15] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 3-141.

[16] Lucas, S.A, and J. Planner. Grounded or submerged bulk carrier: The potential for leaching of coal trace elements to seawater. *Marine Pollution Bulletin* 64 (2012) 1012-1017.

[17] Lindahl, P.C. and R.B. Finkelman. Factors Influencing Trace Element Variations in US Coals *in* Overview of Mineral Matter in US Coals. Argonne National Laboratory. Accessed online at http://web.anl.gov/PCS/acsfuel/preprint%20archive/Files/Volumes/Vol29-4.pdf

Table 1. Concentrations of Selected Elements in Coal Samples from Black Mesa, Powder River, and San Juan Regions.[18]

Component	Black Mesa	Powder River	San Juan		~Amount in 163 tons PRB
	Percent	Percent	Percent		Tons (pounds)
Ash	8.0	9.9	21.1		16
Silicon, Si	1.1	1.5	5.4		2.4
Aluminum, Al	0.69	0.78	2.7		1.3
Calcium, Ca	0.78	1.1	0.67		1.8
Magnesium, Mg	0.1	0.2	0.1		0.3 (600)
Sodium, Na	0.09	0.1	0.2		0.2 (400)
Potassium, K	0.04	0.05	0.16		0.08 (160)
Iron, Fe	0.31	0.54	0.54		0.9 (1,800)
Titanium, Ti	0.05	0.047	0.11		0.08 (160)
	ppm	ppm	ppm		
Copper, Cu	5.5	11.2	13.3		0.0018 (3.6)
Thorium, Th	2.2	4.3	5.9		0.0007 (1.4)
Zinc, Zn	5.6	20	15.1		0.0033 (6.5)
Chromium, Cr	3	7	5		0.0011 (2.3)
Nickel, Ni	2	5	3		0.0008 (1.6)
Vanadium, V	7	15	20		0.0024 (4.9)
Manganese, Mn	9.7	51	29		0.0083 (16.6)
Lithium, Li	3.9	5.9	19.7		0.001 (1.9)
Lead, Pb	2.7	5.6	19.7		0.0009 (1.8)
Selenium, Se	1.6	1.7	2		0.0003 (0.6)
Boron, B	300	300	300		0.049 (97.8)
Strontium, Sr	150	200	100		0.033 (65.2)
Niobium, Nb	1.5	1.5	3		0.0002 (0.5)
Zirconium, Zr	15	15	50		0.002 (4.9)
		PRB Wasatch Formation			
Cadmium, Cd		0.06			0.00001 (0.02)
Uranium, U		1.2			0.0002 (0.4)
Arsenic, As		0.8			0.0001 (0.3)
Fluorine, F		67			0.011 (21.8)
Barium, Ba		70			0.011 (22.8)
Cobalt, Co		1.5			0.0002 (0.5)
Molybdenum, Mo		0.7			0.0001 (0.2)
Scandium, Sc		3			0.0005 (1.0)
Yttrium, Y		7			0.0011 (2.3)

[18] Lindahl, P.C. and R.B. Finkelman. Factors Influencing Trace Element Variations in US Coals *in* Overview of Mineral Matter in US Coals. Argonne National Laboratory. Accessed online at http://web.anl.gov/PCS/acsfuel/preprint%20archive/Files/Volumes/Vol29-4.pdf on 10/12/12.

Coal dust is implicated in causing health problems in humans because of its unique properties, which suggests that it may also harm other organisms in the ecosystem. In humans, "recent investigation of coal workers' pneumoconiosis (also known as black lung disease) suggests that finely disseminated pyrite grains within coal dust may be responsible for the inflammation of lung tissue that leads to development of lung fibrosis (Finkelman *et al.* 2006). Possible human health issues may also arise from inhalation of airborne "environmental" particulate coal owing to the fact that: (1) it can occur in size fractions (e.g., PM2.5; <2.5 μm) that are potentially hazardous (Zheng *et al*. 1999); and (2) because it may be enriched in pyrite and/or toxic trace elements such as As, Hg, Se, Cd, and Cr (Eskenazy 1995; Smith *et al*. 1998; Querol *et al*. 1999; Finkelman *et al*. 2006)."[19] [author cites Finkelman *et al*. 2006, *Geotimes*, 51, 24–28; Zheng *et al*. 1999, *International Journal of Coal Geology*, 40, 119–132; Eskenazy 1995, *Chemical Geology*, 119, 239–254; Smith *et al*. 1998, *Advances in Agronomy*, 64, 149–195; Querol *et al*. 1999, *International Journal of Coal Geology*, 40, 175–188].

In addition, "many of the coal components are mutagenic and carcinogenic (da Silva et al., 2000a); for instance, quartz could be a prominent risk factor for lung cancer in coal miners (Borm and Tran, 2002), and the International Agency for Research on Cancer (IARC) classified it into IARC's Group 1 (carcinogenic to humans), due to sufficient evidence for carcinogenicity in experimental animals and in humans (IARC, 2010). Heavy metals such as arsenic, cadmium, as well as polycyclic aromatic hydrocarbons (PAHs), present in coal, are also well recognized carcinogens (da Silva *et al*., 2000a, 2000b). Coal dust extracts have also been reported to be cytotoxic and mutagenic in mammalian systems (Ulker *et al*., 2008). Oxidative DNA damage was observed to be significantly higher in lymphocytes of retired coal miners than in controls (Shins *et al.*, 1995). There was an increase in the frequencies of sister chromatid exchanges, chromosomal aberrations, and micronucleus in underground coal miners, indicating the genetic damage due to coal dust exposure (Donbak *et al*., 2005)."[20] [author cites Borm and Tran, 2002, *Ann Occup Hyg*, 46:25–32; IARC, A review of human carcinogens. *Monographs on the evaluation of the carcinogenic risk of chemicals to humans* Genova: IARC Pres, 2010; da Silva *et al*., 2000a, *Mutat Res* 470:39–51; da Silva *et al*., 2000b, *Environ Mol Mutagen* 35:270–8; Ulker *et al*., 2008, *Environ Mol Mutagen* 2008;49:232–7; Shins *et al.*, 1995, *Int Arch Occup Environ Health* 67:153–7; Donbak *et al*., 2005, *Mutat Res* 2005;588:82–7].

"Moreover, airborne coal particles as well as coal tailings are rich in potentially toxic hydrocarbons and genotoxic metals, among other contaminants (Celik *et al*., 2007), that ultimately may lead to profound changes in cells, tissues, populations, and ecosystems (Leffa *et al*., 2010)."[21] [author cites Celik *et al*., 2007, *Mutat Res* 627:158–63; Leffa *et al*., 2010, *Environ Contam Toxicol* 59:614–21]. Moving coal results in discharges of these contaminants in

[19] Bounds, W.J. and K.H. Johannesson. Arsenic Addition to Soils from Airborne Coal Dust Originating at a Major Coal Shipping Terminal. *Water Air Soil Pollut*. (2007) 185:195–207.
[20] Cabarcas-Montalvo, M. *et al.* Genotoxic effects in blood cells of Mus musculus and Iguana iguana living near coal mining areas in Colombia. *Science of the Total Environment* 416 (2012) 208–214.
[21] Cabarcas-Montalvo, M. *et al.* Genotoxic effects in blood cells of Mus musculus and Iguana iguana living near coal mining areas in Colombia. *Science of the Total Environment* 416 (2012) 208–214.

particulate matter along transport routes such as roadways, and "elevated levels of particulate matter have been associated with significant negative effects on human health."[22]

Arsenic in coal is an element of "major concern."[23] Coal dust was studied at a coal shipping terminal in Norfolk, Virginia to assess potential ecological effects of the 35 tons of particulate coal released into the air during the year 2000.[24] "Black, gritty veneers of what appears to be particulate coal coating objects (e.g., automobiles, window sills, plants, etc.) are common in both Norfolk and Portsmouth, Virginia, and anecdotal accounts suggest that such veneers are more prevalent in the West Ghent neighborhood of Norfolk, proximal to the Lambert's Point Docks. These thin coatings of probable coal dust suggest that airborne transport of coal dust from the Lambert's Point Docks is prevalent in the region."[25]

The researchers in the Norfolk study sampled soil 4 cm below the soil down to 32 cm.[26] They found particulate coal in the samples varying from 1 - 20% of the sample by weight; the highest sample was found less than one kilometer away, and a sample 5.5 km away had a value of 3.4% coal by weight. The Great Dismal Swamp, approximately 25 miles away, was also sampled in two places, and coal dust was found at all depths from 4 - 32 cm, ranging from 1.0 - 2.02% by weight. In the Norfolk soil samples, arsenic (As) concentrations from sand-sized coal particles were as high as 17.4 mg/kg, with an average of 7.3 mg/kg. In the whole soil sample, "arsenic concentrations for the total (i.e., bulk) soil digests (silicate minerals, metal oxides, amorphous phases, organic matter, and particulate coal), performed on aliquots from 8 cm depth for each soil core, ranged from a high of 30.5 mg/kg to a low of 3.0 mg/kg, with a mean As value of 13.3 mg/kg."[27]

In Colombia, mice and iguanas captured near coal mines had significantly more DNA damage than control organisms far from coal mines.[28] The coal dust from the mines may have been instrumental in damaging the organisms, and the author remarked, "water droplets can capture coal dust, and this is an efficient method to decrease respirable coal dust." "Given the strong rainy season that took place in late 2010 and early 2011 in Colombia, the concentrations of genotoxic compounds could have decreased as a result of heavy precipitations."[29] Given the ability of coal dust to migrate from coal shipping terminals as demonstrated in the Norfolk study,

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[22] Aneja, V, *et al.* Characterization of particulate matter (PM10) related to surface coal mining operations in Appalachia. *Atmospheric Environment* 54 (2012) 496-501.
[23] Lucas, S.A, and J. Planner. Grounded or submerged bulk carrier: The potential for leaching of coal trace elements to seawater. *Marine Pollution Bulletin* 64 (2012) 1012-1017.
[24] Bounds, W.J. and K.H. Johannesson. Arsenic Addition to Soils from Airborne Coal Dust Originating at a Major Coal Shipping Terminal. *Water Air Soil Pollut*. (2007) 185:195–207.
[25] Bounds, W.J. and K.H. Johannesson. Arsenic Addition to Soils from Airborne Coal Dust Originating at a Major Coal Shipping Terminal. *Water Air Soil Pollut*. (2007) 185:195–207.
[26] Bounds, W.J. and K.H. Johannesson. Arsenic Addition to Soils from Airborne Coal Dust Originating at a Major Coal Shipping Terminal. *Water Air Soil Pollut*. (2007) 185:195–207.
[27] Bounds, W.J. and K.H. Johannesson. Arsenic Addition to Soils from Airborne Coal Dust Originating at a Major Coal Shipping Terminal. *Water Air Soil Pollut*. (2007) 185:195–207.
[28] Cabarcas-Montalvo, M. *et al.* Genotoxic effects in blood cells of Mus musculus and Iguana iguana living near coal mining areas in Colombia. *Science of the Total Environment* 416 (2012) 208–214.
[29] Cabarcas-Montalvo, M. *et al.* Genotoxic effects in blood cells of Mus musculus and Iguana iguana living near coal mining areas in Colombia. *Science of the Total Environment* 416 (2012) 208–214.

the genotoxic effects of coal can be a serious threat to mammals and reptiles on a landscape scale, as the Colombian study demonstrates.

A study of wild rats (*Rattus rattus*) and mice (*Mus musculus*) found DNA damage in the specimens trapped near a coal mine and processing plant that prepares coal for transport by crushing it. Coal dust was implicated as the likely cause of this damage: "the rodent species investigated in the mining area are subject to exposure due to different mining activities, specifically, stripping and crushing of coal. The first activity includes the extraction of rocks and transportation to the crushing machines. During the crushing procedure, coal is processed into small particles in order to enable transportation. These activities are liberating great quantities of fugitive particles into the environment which contain ashes including PAHs and toxic gases [4]. During the crushing process of the coal large quantities of coal dust particles can be spread into the surrounding environment and they are deposited on the surfaces of the plants or in river beds. Results similar to ours were obtained in a biomonitoring study conducted in a carboniferous areas using wild rodent species *Ctenomys torquatus* [12]."[30] [author cites (4) Carbones del Caribe S.A., Plan de Manejo Ambiental, Flanco Occidental del Sinclinal del R´ıo San Pedro M´odulo D (Wenceslao), Departamento de Planeaci´on, 1996; (12) Da Silva, J, *et al*. *Environ. Mol. Mutagen.* 35 (2000) 270–278].

Coal, when deposited in water, can be harmful to aquatic organisms, as one study at the Roberts Bank, BC, Canada coal terminal addresses. "The benthos, composed of organisms dwelling on the sea bottom and in sediments are the most greatly affected due to the disturbance of the bottom caused by deposition of coal particles. Anoxic conditions, evident from the presence of hydrogen sulphide, in the sediments receiving very high levels of organic input (including coal), caused by the consumption of oxygen during the degradation (oxidation) of organic matter, would likely have the most detrimental impact on the benthic florae and faunae. The ecological contribution of bottom microinvertebrates is very significant, as larvae from clams, mussels, barnacles, and crabs drift out to sea and constitute a substantial proportion of the seasonal food for juvenile salmonids and herring. Damage to the benthos therefore has serious implications for both the mature invertebrate populations as well as those creatures that predate upon the benthic larvae."[31] A similar effect could occur at the proposed Columbia River terminals if coal dust settles on the river bottom, and could potentially affect juvenile salmonid benthic food sources in the Umatilla National Wildlife Refuge, which extends into the Columbia River near the proposed Port of Morrow terminal.

Coal can accumulate in sediments around coal terminals over time, even in moving water such as an estuary with river and tidal currents. Shown below is a map of soil percent coal dust concentrations, which accrued from 1977-1999 at the Roberts Bank coal terminal. "NHS" in the map caption stands for "non-hydrolysable solids," a part of the coal that can be measured in the

[30] Leon, G, et al. Genotoxic effects in wild rodents (Rattus rattus and Mus musculus) in an open coal mining area. *Mutation Research* 630 (2007) 42-49.
[31] Johnson, R. and R.M. Bustin. Coal dust dispersal around a marine coal terminal (1977-1999), British Columbia: The fate of coal dust in the marine environment. *International Journal of Coal Geology* 68 (2006) 57–69.

lab. NHS values, which give an indication of the coal content in marine sediments, are less than the total coal, which includes hydrolysable solids (organic content).[32]

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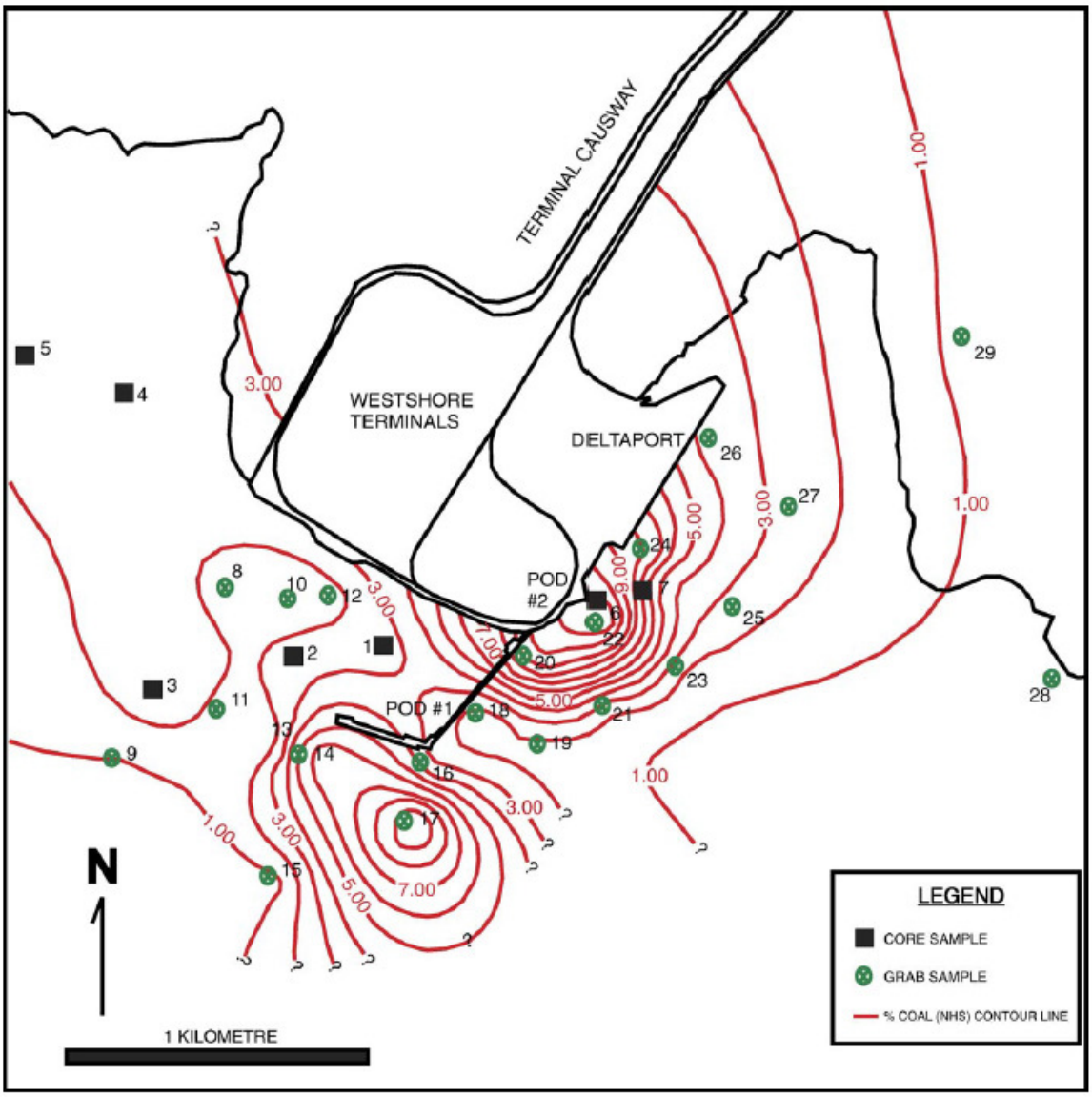

Fig. 2. Sample location and coal dust distribution in surface sediment as measured in weight percent NHS.

Coal dust from shipping terminals in other countries also raise environmental concerns. In South Africa, "despite the adoption of several dust abatement mechanisms such as water sprays and wind breaks, the coal operations, which involve shunting, stockpiles, conveyer belts and ship loading, create dust which is a problem in the harbour and surrounding areas, not only on wetland species, but also on other plant communities in the vicinity, as well as on human

[32] Johnson, R. and R.M. Bustin. Coal dust dispersal around a marine coal terminal (1977-1999), British Columbia: The fate of coal dust in the marine environment. *International Journal of Coal Geology* 68 (2006) 57–69.

health."[33] Wetland trees contaminated with coal dust 3 km from the coal terminal were found to have reduced CO_2 exchange (32-39%), transpiration (28% less), and photosynthetic activity.[34]

Conclusions. The Environmental Review Document does not adequately address the potential for fugitive dust from coal cars, emissions from dust control systems, and covered conveyor systems, or the estimated mass of coal dust that will be emitted each year. The effects of the discharge of 163 tons of coal dust annually as identified in the Fox report should be addressed. The Norfolk study found coal dust and arsenic in soils many kilometers away, stemming from a coal terminal authorized to release 35 tons of coal dust per year. The Roberts Bank study shows up to 10% coal particles in the aquatic sediment near the terminal. These impacts should be addressed for the Columbia River and Umatilla National Wildlife Refuge.

The cracking of coal and the effect of the topper agent should be discussed and the wind emissions from the rail cars estimated. Long-term deposition of coal dust has been documented at other coal shipping terminals, and an estimate should be included in the ERD. An analysis of trace elements, such as arsenic and heavy metals, should be multiplied by the mass of coal discharged and presented for review. The potential effects of coal dust on wildlife should also be discussed for the long-term.

Emissions from an accidental explosion should also be presented. The ERD should include a discussion of dust emissions in transit when no topper is applied, and provide more durable and government enforceable assurances that 1) only Powder River Basin coal will ever be shipped through the terminal for the life of the terminal, and 2) that all shipments will receive dust mitigation measures absolutely. A coal dust monitoring plan should also be presented for all phases of the shipping operation, and local vegetation should also be monitored for coal dust. Any contingency plans should include shutting down the terminal to prevent environmental contamination.

II. Process Water Impacts

Industrial water will be recycled through concrete sump basins, clarifiers with flocculants, and to a filter press that will separate the coal from the water, deposit the coal on to the conveyor, and send the water back through the sprayer system. The system is intended to deliver a 21,000 gallon wash-down of the coal buildings once per week. The water is to be contained in sumps, and is proposed for re-use after treatment with the clarifier. [35]

Despite the assurance of a self-contained system with no leaching, the applicant says that an Oregon DEQ Water Pollution Control Facility Permit for an "industrial wastewater discharge (coal dust abatement)" "pertains to the MPP," as does an Oregon 1200-Z stormwater permit, and

[33] Naidoo, G. and Y. Naidoo. Coal dust pollution effects on wetland tree species in Richards Bay, South Africa. *Wetlands Ecology and Management* (2005) 13: 509–515.
[34] Naidoo, G. and Y. Naidoo. Coal dust pollution effects on wetland tree species in Richards Bay, South Africa. *Wetlands Ecology and Management* (2005) 13: 509–515.
[35] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 3-193-194.

a Removal/Fill permit.[36] Because the applicant intends to apply for a permit to discharge coal dust abatement water, it is clear that the system will not be self-contained, and that the risk of a discharge exists. In other words, if there was no discharge, they would not need a permit. So it makes sense to examine the potential ecological impacts of coal dust wash water to the environment.

Considering that the applicant considers emitting approximately 1,139 pounds of coal dust from the rail car unloader portion of the dust control system alone to be "less than significant air quality impacts,"[37] and did not mention the dust system discharge, and that the applicant underestimated emitting approximately 163 tons of coal dust annually, it is possible that the actual discharges of process water requiring this industrial wastewater discharge permit are similarly understated. In stormwater systems there are generally emergency overflows built in, and it is possible that the actual process water system will have some emergency overflow, or that it will leach into the ground via the sumps (hence the permit requirement).

More details about the locations and management of the 21,000 gallons of wash water should be examined as well. Failsafe mechanisms such as freezing protection, breakdown and repair protocols, and routine maintenance shut-downs should be evaluated, because if the system is not operating then process water could be released.

If a discharge of the coal-laden process water occurred, the effects could be similar to the effects of the stormwater drainages expected from the runoff produced from the 29,000 tons[38] of coal exposed to the elements in the rail cars. Some potential effects of coal-affected water infiltrating are discussed in the Stormwater section elsewhere in this document.

Conclusions. The specifics of how the facility will handle process water to avoid discharge should be presented, and any potential discharges should be assessed for contribution of coal dust slurry to the environment. Contingency plans for system breakdowns or regular maintenance should also be assessed. Effects of discharge to groundwater should be discussed, including likely movement through soils and soil composition and risk assessment.

III. Impacts to Fisheries

The proposed Port of Morrow terminal dock is adjacent to the Umatilla National Wildlife Refuge, which extends into the Columbia River.[39] The 4-5 tugs required for the operation will consume 2,500 - 4,000 gallons of diesel fuel per day, and will be re-fueled every five to seven

[36] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 3-187-188.
[37] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 3-147.
[38] The tracks can accommodate up to two unit trains; each train will carry approximately 14,500 short tons (1 short ton = 2,000 lbs.) of coal, for a maximum total of 29,000 tons in two trains. Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 2-11.
[39] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. Port of Morrow Zoning Map, Fig. 3.3-2.

days, and operate 24 hours per day.[40] The ocean-going vessels (OGVs) will consume 50 tons of fuel per day at sea and 5 - 7 tons while in port.[41] The transloader at Port Westward may incorporate diesel storage tanks and a vacuum system for collection of spilled coal.[42] The presence and operation of vehicles requiring liquid petroleum in such large quantities presents a chance that fuel could be spilled into the water, or that residual fuel from routine operations could be discharged into the river. Such a discharge could adversely affect the aquatic ecosystem. In addition, exhaust fumes may also produce polycyclic aromatic hydrocarbons (PAHs) that could harm aquatic life if sufficient quantities are generated.

Nitrogen and sulfur inputs to the environment are also a concern. In a report by AMI Environmental titled AERMOD Modeling of Air Quality Impacts of the Proposed Morrow Pacific Project (October 2012), estimated emissions are presented for the Port of Morrow and Port Westward:

Pollutant Emissions for Modeled Sources at Port of Morrow

Emission Sources	NO_x (tpy)	1-hr NO_x (lb/hr)	SO_2 (tpy)	1-hr SO_2 (lb/hr)	$PM_{2.5}$ (tpy)	24-hr $PM_{2.5}$ (lb/hr)
Train unloading	492	135.09	0.3	0.824	12.8	3.51
Tug boat	39	13.76	0.0088	0.0031	0.92	0.32
Storage facility	--	--	--	--	0.012	0.0027
Open barge	--	--	--	--	--	4.341
Open train	--	--	--	--	--	4.35

Pollutant Emissions for Modeled Sources at Port Westward

Emission Sources	NO_x (tpy)	1-hr NO_x (lb/hr)	SO_2 (tpy)	1-hr SO_2 (lb/hr)
Panamax	81.5	18.61	14.7	3.36
Transloader (emergency power)	281	64.16	0.048	0.011
Transloader (shore power)	0.33	0.0753	7.9e-5	1.80e-5
Tug boat	32	7.31	0.0042	0.00096

These emissions could change the water quality in the Columbia River over time, depending on the amount deposited and area affected. The potential effects of these emissions on salmonid life cycle, habitat, and food supply should be addressed.

[40] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 2-13.
[41] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 2-13.
[42] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 2-16.

Fuel Discharges. A large number of studies focus on the effects of polycyclic aromatic hydrocarbons (PAHs), chemicals that are found in petroleum, and are often found in areas where petroleum is spilled, transported, and combusted.[43] Diesel contains PAHs, as does other forms of petroleum (p. 2657).[44] "The percentage of PAHs in crude oil, Bunker C oil, and No. 2 diesel oil are about 1%, 4%, and 9% by weight, respectively" (p. 104).[45]

Oil and/or diesel sheen on the water surface is harmful to fish. "Fish mortality following spills has often been attributed to the formation of a layer of oil (sheen) on the water. Sheen limits the oxygen exchange between air and water, and both sheen and dissolved constituents may coat the gills of fish causing lesions on respiratory surfaces affecting respiration (p. 2657) [author cites Green, J.; Trett, M. W. Fate and Effects of Oil in Freshwater; Elsevier: London, 1989]."[46] The sheen itself represents pure product floating on the water surface; the concentration there would be much higher than a grab sample several inches below the water surface.

Diesel is harmful to salmonids, and one study determined the mortality rates for rainbow trout (*Oncorhynchus mykiss),* as well as the genetic toxicity. A steelhead is an ocean-run rainbow trout, so studies on rainbow trout are relevant to salmonids living in the Columbia River. "Diesel [No. 2] doses of 40 mg/L were associated with a gradual increase in mortality over the duration of the test, and a sharp increase in the number of genes and functional groups of genes with altered expression. Exposures ≥200 mg/L of diesel resulted in 100% mortality of rainbow trout fry. Based upon dose–response curves interpolated from data for individual end points, toxicity reference values of 4-45 mg/L were determined" (p. 2658). The data trends show that gene expression begins to be affected in a smaller percentage of fish at levels as low as 4.1 mg/L (Table 2).[47]

Salmon that are exposed to pollution (such as oil and diesel fuel that may be spilled from vessels) could be at risk for pigmented salmon syndrome (PSS) and tainting. This syndrome's symptoms include discoloration from silver to yellow or red, significant gill and kidney damage, anemia, and kill the fish (p. 505-506).[48] Studies have found that fish living in water with 2 mg/L

[43] Meador, J. P., Sommers, F. C., Ylitalo, G. M., & Sloan, C. A. (2006, October). Altered growth and related physiological responses in juvenile Chinook salmon (Oncorynchus tshawytscha) from dietary exposure to polycyclic aromatic hydrocarbons (PAHs). *Canadian Journal of Fisheries and Aquatic Sciences,* 63: 2364-2376.
[44] Mos, L., Cooper, G., *et al*. (2008). Effects of Diesel on Survival, Growth, and Gene Expression in Rainbow Trout (Oncorhynchus mykiss) Fry. *Environmental Science & Technology,* Vol. 42, No. 7.
[45] Huntley, S. L., Bonnevie, N. L., & Wenning, R. J. (1995). Polycyclic Aromatic Hydrocarbon and Petroleum Hydrocarbon Contamination in Sediment from the Newark Bay Estuary, New Jersey (pp. 93-107). *Arch. Environ. Contam. Toxicol.* 28.
[46] Mos, Lizzy, Glenna Cooper, *et al*. (2008). Effects of Diesel on Survival, Growth, and Gene Expression in Rainbow Trout (Oncorhynchus mykiss) Fry. *Environmental Science & Technology*, Vol. 42, No. 7.
[47] Mos, Lizzy, Glenna Cooper, et al. (2008). Effects of Diesel on Survival, Growth, and Gene Expression in Rainbow Trout (Oncorhynchus mykiss) Fry. *Environmental Science & Technology*, Vol. 42, No. 7.
[48] Croce, B., Stagg, R. M., et al. (1997, December). Ecotoxicological Determination of Pigmented Salmon Syndrome: A Pathological Condition of Atlantic Salmon Associated with River Pollution (pp. 505-510). *Ambio*, Vol. 26, No. 8.

of diesel can develop PSS if also exposed to certain other chemicals (p. 509).[49] In addition, salmon that are exposed to 0.224 mg/L of diesel or 0.076 mg/L of crude oil become tainted (p. 260).[50] Tainted fish do not taste as good as un-tainted fish, and tainting can threaten the economic livelihood of those people in the supply chain (p. 258)[51] because customers do not wish to buy tainted fish.

The PAHs in oil and diesel are bioavailable and harmful to salmonids.[52] Other sources of PAHs besides boats and trains are "creosote wood preserving facilities, petroleum storage and refinery facilities, paint and chemical manufacturers, combined sewer overflows, and sewage treatment facilities" (p. 93).[53] The dominant PAHs found in diesel and oil are naphthalenes (p. 260).[54] PAHs that are larger than naphthalenes are less soluble in water, and can move more rapidly into some aquatic organisms. These PAHs "partition directly from crude oil to lipid rich tissues coming into contact with oil droplets."[55] Salmonids have lipid rich tissues, and are at immediate risk when in contact with undissolved oil, which could be discharged from tugs or Panamax vessels, or from locomotives via the stormwater system.

PAHs can also be absorbed through digestion, and poses a risk to juvenile Chinook salmon (and others) moving through urbanized areas when migrating to the marine waters from fresh water spawning grounds. At ingestion levels of 18 – 22 µg/day for 58 days in the lab, comparable to field measurements of in Puget Sound, another area of heavy ship traffic, juvenile Chinook salmon show signs of starvation and reduced body mass.[56] The daily dose that would starve a wild juvenile fish living in a polluted Puget Sound estuary, which may be similar to the Columbia River estuary, is estimated at 3.8 µg PAH/gram of fish/day; wild salmon in Puget

[49] Croce, B., Stagg, R. M., et al. (1997, December). Ecotoxicological Determination of Pigmented Salmon Syndrome: A Pathological Condition of Atlantic Salmon Associated with River Pollution (pp. 505-510). *Ambio*, Vol. 26, No. 8.
[50] DAVIS, H. K., MOFFAT, C. F., et al. (2002). Experimental Tainting of Marine Fish by Three Chemically Dispersed Petroleum Products, with Comparisons to the Braer Oil Spill (pp. 257–278). *Spill Science & Technology Bulletin*, Vol. 7, Nos. 5–6.
[51] DAVIS, H. K., MOFFAT, C. F., et al. (2002). Experimental Tainting of Marine Fish by Three Chemically Dispersed Petroleum Products, with Comparisons to the Braer Oil Spill (pp. 257–278). *Spill Science & Technology Bulletin*, Vol. 7, Nos. 5-6.
[52] Meador, J. P.; Sommers, F. C.; Ylitalo, G. M. & Sloan, C. A. (2006, October). Altered growth and related physiological responses in juvenile Chinook salmon (Oncorynchus tshawytscha) from dietary exposure to polycyclic aromatic hydrocarbons (PAHs). *Canadian Journal of Fisheries and Aquatic Sciences,* 63: 2364-2376.
[53] Huntley 1, S. L., Bonnevie, N. L., & Wenning, R. J. (1995). Polycyclic Aromatic Hydrocarbon and Petroleum Hydrocarbon Contamination in Sediment from the Newark Bay Estuary, New Jersey (pp. 93-107). *Arch. Environ. Contam. Toxicol.*, 28.
[54] Davis, H. K., Moffat, C. F., et al. (2002). Experimental Tainting of Marine Fish by Three Chemically Dispersed Petroleum Products, with Comparisons to the Braer Oil Spill (pp. 257-278). *Spill Science & Technology Bulletin*, Vol. 7, Nos. 5-6.
[55] Shukla, P., M. Gopalani, et al. Influence of Salinity on PAH Uptake from Water Soluble Fraction of Crude Oil in Tilapia mossambica. *Bulletin of Environmental Contamination & Toxicology* (2007) 79: 601-605.
[56] Meador, J. P.; Sommers, F. C.; Ylitalo, G. M. & Sloan, C. A. (2006, October). Altered growth and related physiological responses in juvenile Chinook salmon (Oncorynchus tshawytscha) from dietary exposure to polycyclic aromatic hydrocarbons (PAHs). *Canadian Journal of Fisheries and Aquatic Sciences,* 63: 2364-2376.

Sound have been found with about 23 µg PAH/ gram of fish/day for a 7g fish (roughly equivalent).[57]

Descriptions of diesel effects on the environment and organisms should be assumed to include a certain fraction of PAH effects as well. For example, since diesel has a density of about 900 kilograms per cubic meter, and 1,000 gallon = 3.785 cubic meters, then 1,000 gallons of diesel fuel would weigh about 3,406 kilograms. Since diesel is 9% PAH by weight, then 306 kilograms (675 pounds) of PAH (mostly naphthalene) per 1,000 gallons spilled is a reasonable estimate.

PAH absorption through direct contact with oil continues for the duration of exposure, depending on the circumstances. "This is of concern since these contaminants can bioconcentrate in tissues of organisms to factors 10–1000 times greater than in water. Fluorescing oil droplets were observed under microscope to adhere to the gills of rainbow trout (*Oncorhynchus mykiss*)… Rainbow trout was chosen [for the study] to enable comparisons with freshwater data from previous experiments across salinities within their zone of tolerance (0–15‰)."[58]

High-energy ultraviolet light (UVB) reacts with PAHs in water. Compounds such as naphthalene were found to become more toxic when exposed to UVB light (p. 983).[59] "PAHs and solar radiation can therefore interact to induce a broad range of effects in aquatic animals and plants. After co-exposure to adequate amounts of solar radiation and PAH the lethal effects are likely due to massive cellular and tissue damage that cannot be repaired at an adequate rate" (p. 984).[60]

The applicant states that 8,585 gallons of hazardous material will be theoretically spilled into the Columbia River by the operation, and that the estimate in gallons is for liquid petroleum products.[61] If 8,585 gallons of liquid fuel, such as diesel fuel, were spilled it could affect the aquatic life as a source of bioavailable PAHs and heavy metals, as well as having direct effects as sheen on the water, as described above (also see Stormwater section for potential effects of heavy metals).

If the 8,585 gallons per year of theoretically spilled material were coal (the hazardous material being transported), other effects to the aquatic ecosystem could occur. Coal has an estimated density of 1.9 g/cm^3,[62] which would equal 136,126 pounds spilled per year,

[57] Meador, J. P.; Sommers, F. C.; Ylitalo, G. M. & Sloan, C. A. (2006, October). Altered growth and related physiological responses in juvenile Chinook salmon (Oncorynchus tshawytscha) from dietary exposure to polycyclic aromatic hydrocarbons (PAHs). *Canadian Journal of Fisheries and Aquatic Sciences,* 63: 2364-2376.
[58] Ramachandran, Shahunthala D., Michael J. Sweezey, et al. Influence of salinity and fish species on PAH uptake from dispersed crude oil. *Marine Pollution Bulletin* 52 (2006) 1182–1189.
[59] Pelletier, É., Sargian, P., et al. (2006). Ecotoxicological Effects of Combined UVB and Organic Contaminants in Coastal Waters: A Review. *Photochemistry and Photobiology*, 82(4):981-993.
[60] Pelletier, É., Sargian, P., et al. (2006). Ecotoxicological Effects of Combined UVB and Organic Contaminants in Coastal Waters: A Review. *Photochemistry and Photobiology*, 82(4):981-993.
[61] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 3-194.
[62] Luppens, J.A., 2011, A critical review of published coal quality data from the southwestern part of the Powder River Basin, Wyoming: U.S. Geological Survey Open-File Report 2011–1148, 23 p. P. 19.

corresponding to 42.5 cubic yards of material per year (8,585 gal. = 32,498 L = 32,498,000 cm^3 x 1.9 g/cm^3 = 61,746,200 g = 61,746 kg = 136,126 pounds = 68 tons of coal; 32,498 L = 42.5 cubic yards).

Coal spillage, such as the theoretical spillage mentioned by the applicant, has been studied and determined to affect freshwater invertebrates, including invertebrates that provide food for salmonids such as those present in the Columbia River.[63] A railway accident in New York caused the discharge of several rail cars of coal to Cayuga Inlet, which remained in the water for 2-3 weeks before total removal. Cayuga Inlet is a third-order stream approximately 20-45 feet wide as it appears on air photos. The invertebrate inventory included oligochaete worms, gastropods (snails), isopods (crustaceans), insect orders Ephemoptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies) ("EPT," all three sensitive to pollution), Megaloptera (dobsonflies), Coleoptera (beetles), and Diptera (chironomidae). "Immediately following the coal spill (1999) there were significantly lower total invertebrate abundance and taxon richness at the site downstream than upstream of the impoundment and the coal spill (Fig. 1a and b). Abundance of total invertebrate grazers was also significantly reduced at the site downstream of the coal spill in 1999... Abundance of invertebrates in the orders especially vulnerable to turbidity (Trichoptera, Megaloptera, Ephemeroptera, and Isopoda) was also significantly reduced at the site downstream of the coal spill."[64]

The investigators proposed two possible reasons for the invertebrate decline. "The significant decline in total invertebrates and taxa richness following the coal spill with no significant effects on EPT demonstrated that the negative effects of the coal spill were not limited to the most sensitive invertebrates of the community. These effects could be attributed to two different mechanisms. First, a change in water chemistry could have caused invertebrate mortality, due to increased levels of Fe(OH)x and a decline in pH that occur when coal is added to water (Vinikour, 1979; Cherry *et al.*, 1979b; Scullion & Edwards, 1980). Second, Cherry *et al.* (1979a) reported that in some cases the physical effects of increased turbidity and smothering by the coal particles are more deleterious than the toxicity created by the coal/water mixture."[65] [author cites Vinikour, W.S., 1979, *Entomology News* 90: 203-204; Cherry, D.S., *et al* 1979b. *Journal of Fisheries Research Board Canada* 36: 1089–1096; Scullion, J. & R. W. Edwards, 1980. *Freshwater Biology* 10: 141–162; Cherry, D.S., *et al* 1979a *Hydrobiologia* 62: 257–267].

Selenium (Se) is an element that is found in coal, ranges between 0.1 - 5.3 mg/kg in coal worldwide,[66] and is toxic to fish, including bull trout (*Salvelinus confluentus*) and other salmonids.[67] One watershed level study in Canada examined Se in creeks downstream from coal

[63] Harper, M.P. and B.L. Peckarsky. Effects of pulsed and pressed disturbances on the benthic invertebrate community following a coal spill in a small stream in northeastern USA. *Hydrobiologia* (2005) 544:241-247.
[64] Harper, M.P. and B.L. Peckarsky. Effects of pulsed and pressed disturbances on the benthic invertebrate community following a coal spill in a small stream in northeastern USA. *Hydrobiologia* (2005) 544:241-247, p. 243.
[65] Harper, M.P. and B.L. Peckarsky. Effects of pulsed and pressed disturbances on the benthic invertebrate community following a coal spill in a small stream in northeastern USA. *Hydrobiologia* (2005) 544:241-247, pp. 243-4.
[66] Lucas, S.A, and J. Planner. Grounded or submerged bulk carrier: The potential for leaching of coal trace elements to seawater. *Marine Pollution Bulletin* 64 (2012) 1012-1017.
[67] Palace, V.P., C. Baron, et al. An assessment of the potential for selenium to impair reproduction in bull trout, *Salvelinus confluentus*, from an area of active coal mining. *Environmental Biology of Fishes* 70: 169-174, 2004.

mines, which likely provides a dilution effect from the mine drainage sites upstream. This study is important to consider because of the potential for coal or coal leachate discharges to the Columbia River which may be initially diluted but still accumulate to harmful levels in places.

Selenium bioconcentrates (enters from water) and bioaccumulates (enters from sediment) in aquatic primary producers (such as phytoplankton) and consumers, as well as fish,[68] and so represents a toxic threat to the entire food web. Se accumulation in wild fish is thought to occur both from dietary ingestion and direct uptake from the water, beginning in the egg stage.[69] Bull trout muscle tissue in watersheds with coal mines had Se concentrations from 0.6 - 9.4 μg/g on a wet mass basis, with 2 μg/g representing the toxicity threshold.[70]

Teratogenesis is the development of malformed organisms or growths, especially in the embryo. "A hallmark of Se toxicity is the appearance of teratogenic deformities in the progeny of exposed females that result from the deposition of Se to their eggs. Teratogenesis is restricted to the egg–larval stage of development when the larvae utilize yolks contaminated with Se (Lemly 1997a). The most common types of terata include spinal curvatures (lordosis, scoliosis, or kyphosis), missing or deformed fins, gills, opercula and eyes, as well as abnormally shaped heads and mouths (Lemly 1993b, 1997a). Other symptoms of Se poisoning include pericardial and abdominal edema, exopthalmus (bulging or protrusion of eyes), and cataracts (Lemly 1996)."[71] [author cites Lemly, A.D. 1997a, *Ecotoxicol. Environ. Safety* 37: 259–266; Lemly, A.D. 1993b, *Environ. Monitor. Assess.* 28: 83–100; Lemly, A.D. 1996, "Selenium in aquatic organisms." pp. 427–445. In: W.N. Beyer, G.H. Heinz & A.W. Redmon-Norwood (ed.) *Environmental Contaminants in Wildlife*. CRC Press, Boca Raton, FL, U.S.A.].

Marine Environment. Discharges of coal and coal dust to the Columbia River have the chance to either become deposited in the freshwater portions of the river or in the estuarine and marine areas near the mouth of the river when the Panamax ships leave the river. Some potential impacts to the downstream marine environment from the proposed project are discussed here.

The shipping of coal in Panamax ocean going vessels invites consideration of potential impacts to marine fisheries as well. Should a vessel full of coal sink in salt water, trace elements from the coal can leach into the marine environment, as a study commissioned by Xstrata Coal of Australia found.[72] Coal contains elements including selenium (Se), chromium (Cr), tin (Sn), mercury (Hg), arsenic (As), boron (B), vanadium (Va), cadmium (Cd), copper (Cu), lead (Pb), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn), which were tested for leaching. Of those elements, cadmium, copper, lead, manganese, molybdenum, nickel, and zinc leached from the coal into seawater, and copper and manganese exceeded the water quality guidelines for

[68] Palace, V.P., C. Baron, et al. An assessment of the potential for selenium to impair reproduction in bull trout, *Salvelinus confluentus*, from an area of active coal mining. *Environmental Biology of Fishes* 70: 169-174, 2004.
[69] Palace, V.P., C. Baron, et al. An assessment of the potential for selenium to impair reproduction in bull trout, *Salvelinus confluentus*, from an area of active coal mining. *Environmental Biology of Fishes* 70: 169-174, 2004.
[70] Palace, V.P., C. Baron, et al. An assessment of the potential for selenium to impair reproduction in bull trout, *Salvelinus confluentus*, from an area of active coal mining. *Environmental Biology of Fishes* 70: 169-174, 2004.
[71] Palace, V.P., C. Baron, et al. An assessment of the potential for selenium to impair reproduction in bull trout, *Salvelinus confluentus*, from an area of active coal mining. *Environmental Biology of Fishes* 70: 169-174, 2004.
[72] Lucas, S.A, and J. Planner. Grounded or submerged bulk carrier: The potential for leaching of coal trace elements to seawater. *Marine Pollution Bulletin* 64 (2012) 1012-1017.

Queensland, Australia, with final concentrations of 11 µg/L of Cu (seawater had 3 µg/L to begin) and 37 µg/L of Mn (seawater had 1.8 µg/L).[73] These levels could potentially harm listed salmonids with sufficient exposure, or be transported into sediments where they could build up over time.

Salt water may attenuate the absorption and effects of dissolved metals such as copper to some degree. According to the NOAA, regarding dissolved copper (dCu), "estuarine and nearshore salt water environments, despite their higher salinity (in part due to increased cation concentrations) and hardness may or may not confer protection against dCu-induced olfactory toxicity."[74] Impacts to salmonids in salt water environments from metals such as copper can still occur, and until more is known about the risks, it makes sense to use the same regulatory thresholds for salt water as the more sensitive fresh water, especially to protect listed species such as Chinook salmon.

The effect of coal dust from a shipping terminal has been shown to produce behavioral changes in crabs in laboratory experiments, as a Canadian government study revealed.[75] Coal dust was gathered from beneath a conveyor belt at Westshore Terminals, Roberts Bank, Canada, and mixed with sand to form an experimental substrate in tanks. After 15-31 days, Dungeness crabs were added and observed. "The burrowing reaction of the crabs differed with the four substrates. Crabs in sand (substrate D) never completely burrowed, but remained completely exposed, or with only a fraction of the rear portion of their carapace buried. The proportion of carapace buried increased with increasing amounts of coal in the substrate, so the in substrate (C) the crabs burrowed completely under the surface, with only eyes and antennae remaining visible."[76]

Dungeness crab megalopae (immatures) are prey for Chinook salmon (*Oncorhynchus tshawytscha*) in marine coastal areas. Although no Dungeness crabs can live in the freshwater ecosystem near the Port of Morrow, the change in burrowing behavior of other arthropods, such as isopods, if similarly affected by coal dust in the water, could reduce their availability as prey, and potentially affect trophic interactions in the Columbia River food web. Burrowing provides protection and likely reduces the opportunity for detection by predators. If coal dust entered the substrate of the salt and brackish portions of the Columbia River estuary where it meets the ocean, it could produce this effect on resident crabs there. Local fishermen who take Dungeness crabs near the Roberts Bank coal terminal report a darker coal-coloration of some crabs, and they find these crabs more difficult to market.[77]

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[73] Lucas, S.A, and J. Planner. Grounded or submerged bulk carrier: The potential for leaching of coal trace elements to seawater. *Marine Pollution Bulletin* 64 (2012) 1012-1017.
[74] Hecht, S.A., D.H. Baldwin, C.A. Mebane, T. Hawkes, S.J. Gross, and N.L. Scholz. 2007. An overview of sensory effects on juvenile salmonids exposed to dissolved copper: Applying a benchmark concentration approach to evaluate sublethal neurobehavioral toxicity. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-83, 39 p.
[75] Hillaby, B.A. 1981. The effects of coal dust on ventilation and oxygen consumption in the Dungeness crab, *Cancer magister. Can. Tech. Rep. Fish. Aquat. Sci.* 1033: vi + 18 p.
[76] Hillaby, B.A. 1981. The effects of coal dust on ventilation and oxygen consumption in the Dungeness crab, *Cancer magister. Can. Tech. Rep. Fish. Aquat. Sci.* 1033: vi + 18 p.; p. 12.
[77] Johnson, R. and R.M. Bustin. Coal dust dispersal around a marine coal terminal (1977-1999), British Columbia: The fate of coal dust in the marine environment. *International Journal of Coal Geology* 68 (2006) 57–69.

Conclusions. The ERD does not adequately address potential impacts from continued discharges of liquid fuels from shipping operations. The amount of fuel released annually should be estimated and reviewed for effects to aquatic life. The theoretical spillage of hazardous material should be discussed in detail, and the effects of the spillage estimated. Discharges from accidents have the potential to impact aquatic invertebrates that are part of the salmonid life cycle. Selenium pollution causes deformities in fish, and could threaten bull trout and other salmonids over time as coal dust deposits increase. Coal has been shown to leach elements into seawater, and could produce pollution harmful to aquatic life if a Panamax OCV became grounded or wrecked and allowed sea water to mix with the coal. Dungeness crab behavior and appearance could be affected by coal pollution entering marine waters. The effects of salinity may or may not confer protection to fish from dissolved copper from coal leaching.

IV. Stormwater Plan Review

The applicant states that the Port of Morrow facility will be designed with full on-site containment with no discharge anticipated, with bioswales to 25-year storm intensity standards.[78] "All stormwater and process water will be handled on site, with no discharge to the Columbia River."[79] Most stormwater designs include an overflow outlet for storms of greater intensity than the design. For example, the proposed 25-year storm system will not contain a 100-year storm event, and the excess water must go somewhere if it does not infiltrate. Generally overflows are directed to a receiving body, such as a wetland, river or stream, or to a low point in the uplands. The proposal does not include a preliminary drainage report, so the location of the overflow outlet and sub-basin sizes are unknown. LCI recommends reviewing a preliminary drainage report to better assess the potential impacts to nearby wetlands or waters that may receive stormwater from events larger than the 25-year storm.

The proposed coal storage area and conveyor system will be covered in some way, and may reduce the likelihood of stormwater interacting with the main coal stockpile. However, there will still be substantial contact of stormwater with coal before reaching the covered stockpile, which could become polluted and drain into nearby wetlands or waters.

Pollution of stormwater with coal compounds could occur while the rail cars are waiting to be unloaded. The tracks can accommodate up to two unit trains, each approximately 5,800 feet long.[80] The coal trains will require 4.8 hours to unload, but will likely be split to avoid blocking traffic and then require 12 hours to unload; each train will carry approximately 14,500 short tons (1 short ton = 2,000 lbs.) of coal,[81] for a maximum total of 29,000 tons in two trains.

[78] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 3-193.
[79] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 2-8.
[80] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 2-6.
[81] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. P. 2-11.

Since the terminal will be in operation for 24 hours per day, it is reasonable to assume that there will be a constant presence of coal-filled rail cars at the site. Those rail cars are uncovered, and precipitation will fall on the coal, drain to the bottom of the rail cars, and out of any drains or gaps in the car bottom. The large number of rail cars at the proposed terminal will likely provide an opportunity for polluted runoff to form similar to a 29,000 ton stockpile of coal.

When coal is transported, the vibrations may cause the coal chunks to break up to some degree. Coal is generally broken up mechanically at the mine, crushing larger pieces into smaller chunks prior to shipment. Coal chunks may also crack over time, as shown in the photos elsewhere in this document.[82] This cracking and breakdown exposes fresh coal surfaces to the air and increases the surface to volume ratio for a give amount of coal. When mined minerals are exposed to the air, they produce weathering effects at an accelerated rate, which may cause acid drainage and heavy metal release that impairs water quality.[83] When the coal arrives at the proposed terminal, it may have fractured during transport, and fresh surfaces may then be exposed to the air, which could pollute any precipitation draining through the rail cars. The polluted runoff could enter surface waters, or infiltrate to the groundwater table.

The Phase I Environmental Site Assessment Report states that the site has a high soil infiltration rate.[84] The stormwater design for the outdoor portion of the rail yard involves some infiltration of water to the soil via the bioswales.[85] Through infiltration via the bioswales, there is a high potential for groundwater contamination, depending on the soil properties.[86]

Coal piles are known to produce acids and dissolved metals which can run off into nearby wetlands or waters, even away from mine sites: "Analogous to mining operations, the storage of coal can also generate highly acidic, metal-rich leachate resulting from the oxidation of sulfidic ores present in coal as impurities (1, 2). Additional water quality concerns with regard to coal storage include that coal stockpiles are relatively abundant, not restricted to areas associated with mining operations, and often uncontrolled."[87] [author cites (1) Davis, E. C.; Boegly, W. J. *J. Environ. Qual.* 1981, 10, 12-133; (2) Swift, M. C. *Water Resour. Bull.* 1985, 21, 449-457].

Pollution from coal storage piles, and potentially from rail car on-site storage, can contain toxic metals that have been shown to pollute groundwater. Coal in the Powder River Basin can have the same amount of sulfur as the coal used in one water runoff study. The Wasatch coal

[82] Hossfeld, R.J. and R. Hatt. PRB Coal Degradation - Causes and Cures. Private company research accessed online at http://www.prbcoals.com/pdf/paper_archives/56538.pdf on 10/18/12.
[83] Sheldon, D., T. Hruby, P. Johnson, K. Harper, A. McMillan, T. Granger, S. Stanley, and E. Stockdale. March 2005. *Wetlands in Washington State - Volume 1: A Synthesis of the Science.* Washington State Department of Ecology. Publication #05-06-006. Olympia, WA. P. 3-33.
[84] Baird, Brad. Phase I Environmental Site Assessment Report Port of Morrow - Morrow Pacific Project Site. Anderson Perry & Associates, Inc. 2/27/2012, p. 11.
[85] Environmental Review for the Coyote Island Terminal Dock at the Port of Morrow. Anderson Perry & Associates, Inc. Updated August 2012. Figure 3.10-4, Conceptual Bioswale Design.
[86] Anderson, M.A., P.M. Bertsch, *et al*. Interactions of Acidic Metal-Rich Coal Pile Runoff with a Subsoil. *Environ. Sci. Technol.* 1991, 25, 2038-2046.
[87] Anderson, M.A., P.M. Bertsch, et al. Interactions of Acidic Metal-Rich Coal Pile Runoff with a Subsoil. *Environ. Sci. Technol.* 1991, 25, 2038-2046.

formation in the Powder River Basin contains up to 1.5% sulfur.[88] A study at the US Department of Energy's Savannah River Site near Aiken, SC examined the soils that received runoff from a stockpile of low-sulfur (1-2%) coal,[89] similar to some of the Wasatch formation coal. The study analyzed the soils at the far end of the 1.5 hectare (3.7 acre) coal pile drainage basin by lab extraction through a column:

Table 2. Composition of the Coal Pile Runoff Used in Column Experiments[90]

Component	Conc., mg/L (except pH)		Component	Conc., mg/L
pH	2.13			
Al^{3+}	101.0		Li^{+}	0.232
Be^{2+}	0.055		Mg^{2+}	62.17
Ca^{2+}	83.62		Mn^{2+}	7.302
Co^{2+}	0.461		Na^{+}	11.52
Cr^{3+}	0.010		NI^{2+}	0.878
Cu^{2+}	0.262		H_4SiO_4	69.4
Fe^{2+}	4.70		$SO4^{2-}$	2,024
Fe^{3+}	119.5		Sr^{2+}	0.791
K^{+}	1.668		Zn^{2+}	2.392

The metals from the coal can move into and pollute the groundwater: "naturally acidic, noncarbonatic soils offer little resistance to subsurface migration of acidic, metal-rich runoff. As a result, coal stockpiles situated on such materials pose a serious threat to underlying groundwater systems."[91] If the soils on the proposed terminal site are similar to these soils, substantial pollution could occur. If other soil characteristics are present, the effects could vary from those described in this study.

The study found that the pollutants moved through the soil in different ways, and concentrated the pollution: "The development of concentration waves attendant with infiltration and migration of runoff within subsurface materials further exacerbates potential water quality problems. That is, chromatographic and precipitation-dissolution reactions result in the development and movement of metals in waves of concentrations potentially greatly exceeding initial source concentrations. Discharge of effluent meeting appropriate water quality criteria may thus produce downgradient concentrations exceeding standards and source concentrations. This phenomenon also emphasizes the need for continued research evaluating multicomponent transport processes."[92]

[88] Luppens, J.A., 2011, A critical review of published coal quality data from the southwestern part of the Powder River Basin, Wyoming: U.S. Geological Survey Open-File Report 2011–1148, p. 18.
[89] Anderson, M.A., P.M. Bertsch, et al. Interactions of Acidic Metal-Rich Coal Pile Runoff with a Subsoil. *Environ. Sci. Technol.* 1991, 25, 2038-2046.
[90] Anderson, M.A., P.M. Bertsch, et al. Interactions of Acidic Metal-Rich Coal Pile Runoff with a Subsoil. *Environ. Sci. Technol.* 1991, 25, 2038-2046.
[91] Anderson, M.A., P.M. Bertsch, et al. Interactions of Acidic Metal-Rich Coal Pile Runoff with a Subsoil. *Environ. Sci. Technol.* 1991, 25, 2038-2046.
[92] Anderson, M.A., P.M. Bertsch, et al. Interactions of Acidic Metal-Rich Coal Pile Runoff with a Subsoil. *Environ. Sci. Technol.* 1991, 25, 2038-2046.

The constant presence of coal in rail cars on the site has the potential to pollute the groundwater in high concentrations over time via the stormwater bioswale system if soil conditions allow. It is possible that the Columbia River could be contaminated with metals through a groundwater connection. A hydrogeologic investigation would show the groundwater movement patterns, and where such potentially polluted groundwater would travel, and a soil analysis would show if the conditions are similar to the concentration wave study.

Another study examined the sediment collected near a coal storage pile in detention ponds for metals, and featured a short-term storage pile of low-sulfur coal. The sediment contained 167 -233 ppm (parts per million; 1 ppm = 1 μg/g or 1 mg/kg) of lead (Pb), well above the average soil background level of 17 ppm.[93] Since the bioswales will catch stormwater that could contain similar sediments, similar pollution could build up in the bioswales over time. This study also reported lead groundwater concentrations of 62 ppb (parts per billion; 62 ppb = 62 μg/kg = 62 μg/L of water = 0.062 mg/L) in a well under the low-sulfur coal short-term storage pile, which exceeded Indiana's maximum contaminant level of 15 ppb.[94] If soil properties allow the concentration wave effect described in the previous study, then this level could become higher over time.

Metals in sediments, such as those that could collect in stormwater control systems contaminated with coal and acid drainage, are bioavailable (able to move into or onto an organism), can show bioaccumulation (concentration in organism/concentration in sediment), and bioconcentration (concentration in organism/concentration in pore water) in aquatic organisms.[95]

Freshwater macroinvertebrates such as the insect *Chironomus sp.* (Order Diptera, family Chironomidae), and worms *Branchiura sowerbyi* and *Limnodrilus claparedeianus* (Order Oligochaeta, family Tubificidae), were found to bioconcentrate aluminum, lead, chromium, manganese, iron, cobalt, nickel, copper, and zinc from coal contaminated water.[96] The chironomid bioaccumulated via ingestion[97] copper, zinc, and cadmium to levels greater than found in the sediment in which they lived, and to a lesser degree aluminum, lead, chromium, manganese, iron, cobalt, and nickel; the oligochaete bioaccumulated aluminum, lead, chromium, manganese, iron, cobalt, nickel, copper, zinc, and cadmium at levels lower than surrounding sediments.[98]

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[93] Cook, A.M, and S.J. Fritz. Environmental Impacts of Acid Leachate Derived from Coal-Storage Piles upon Groundwater. *Water, Air, and Soil Pollution* 135: 371–388, 2002, p. 383.
[94] Cook, A.M, and S.J. Fritz. Environmental Impacts of Acid Leachate Derived from Coal-Storage Piles upon Groundwater. *Water, Air, and Soil Pollution* 135: 371–388, 2002, p. 382.
[95] Lopez, D.L., E. Gierlowski-Kordesch, et al. Geochemical Mobility and Bioavailability of Heavy Metals in a Lake Affected by Acid Mine Drainage: Lake Hope, Vinton County, Ohio. *Water Air Soil Pollution* (2010) 213: 27-45.
[96] Lopez, D.L., E. Gierlowski-Kordesch, et al. Geochemical Mobility and Bioavailability of Heavy Metals in a Lake Affected by Acid Mine Drainage: Lake Hope, Vinton County, Ohio. *Water Air Soil Pollution* (2010) 213: 27-45, p. 37.
[97] Lopez, D.L., E. Gierlowski-Kordesch, et al. Geochemical Mobility and Bioavailability of Heavy Metals in a Lake Affected by Acid Mine Drainage: Lake Hope, Vinton County, Ohio. *Water Air Soil Pollution* (2010) 213: 27-45, p. 42.
[98] Lopez, D.L., E. Gierlowski-Kordesch, et al. Geochemical Mobility and Bioavailability of Heavy Metals in a Lake Affected by Acid Mine Drainage: Lake Hope, Vinton County, Ohio. *Water Air Soil Pollution* (2010) 213: 27-45, p. 37.

Stormwater and Rail Use. Another concern is the constant presence of locomotives and rail cars on the site. Rail yards can produce toxic pollution from certain activities. For example, re-fueling locomotives can result in spilled diesel fuel, rail car hookups and movement can contribute to heavy metal inputs, and maintenance activities all have the potential for creating polluted stormwater. A BNSF Railway Company rail yard in Seattle, WA contributed to stormwater pollution in this manner. That rail yard is approximately 8,000 feet long with multiple tracks, so it could conceivably contain 12,000 feet of rail cars or more.

Because of the intended heavy rail use of up to 12,000 feet of rail cars at one time at the proposed terminal, it makes sense to look at other rail operations in the Pacific Northwest to see what types and levels of pollution could be generated. In the recent past at the Balmer Railyard in Seattle, metals such as copper, zinc, and lead, as well as polycyclic aromatic hydrocarbons (PAHs) from spills and fuel residue drained into the stormwater system.

Some of the concentrations for pollutants are expressed in micrograms per liter (µg/L). One milligram per liter is equal to 1,000 micrograms per liter (1,000 µg/L = 1.0 mg/L).

BNSF submitted the following stormwater monitoring data to the Washington Department of Ecology between 2003 and 2009: zinc ranged from 125 - 1,950 µg/L (=0.125 - 1.950 mg/L), copper 81 - 522 µg/L (=0.081 - 0.522 mg/L), lead from 44.6 - 1,980 µg/L (=0.047 - 1.980 mg/L), and oil and grease as high as 38 mg/L.[99] One catch basin in an area dominated by tracks and rail car storage showed zinc levels at 1,180 µg/L (1.18 mg/L). If similar rail car storage functions occur at the proposed coal terminal, then it is possible that similar metal pollution will follow.

The combined presence of rail operations along with coal storage in open rail cars presents a potential and opportunity for pollution to surface and/or groundwater, as explained previously. Potential effects from bioavailable PAHs, zinc, copper, and lead pollution that may result from rail activities and coal are detailed below. Diesel contains PAHs, as does other forms of petroleum.[100] "The percentage of PAHs in crude oil, Bunker C oil, and No. 2 diesel oil are about 1%, 4%, and 9% by weight, respectively."[101] These diesel and oil based PAHs are bioavailable and potentially toxic to aquatic organisms.

Heavy metals include elements such as copper (Cu), zinc (Zn), and lead (Pb). The first two elements are needed in trace amounts by many organisms; lead has no biological role. Heavy metals accumulate in all levels of the food chain, and enter fish through the gills, tissue, or by ingestion. In the marine environment, where salinity has a negative association on metal uptake, animals that may be harmed by heavy metals are oysters, polychaete worms, shrimp, prawns,

[99] DMR Data for BNSF (Balmer Yard). (2003-2009). WA Department of Ecology Industrial Stormwater General Permit Discharge Monitoring Reports.
[100] Mos, L., Cooper, G., et al. (2008). Effects of Diesel on Survival, Growth, and Gene Expression in Rainbow Trout (Oncorhynchus mykiss) Fry. *Environmental Science & Technology,* Vol. 42, No. 7, p. 2657.
[101] Huntley, S. L., Bonnevie, N. L., & Wenning, R. J. (1995). Polycyclic Aromatic Hydrocarbon and Petroleum Hydrocarbon Contamination in Sediment from the Newark Bay Estuary, New Jersey (pp. 93-107). *Arch. Environ. Contam. Toxicol.* 28, p. 104.

marine snails, various crustaceans, and saline-tolerant bacteria.[102, 103] Effects of metals may be even more pronounced in freshwater environments such as the Columbia River, which lacks the protective effect of salinity.

The entire aquatic ecosystem can be affected when copper pollution harms microscopic aquatic organisms, the basis of the food chain. Copper inhibits photosynthesis in phytoplankton, and the presence of UVB light compounds the effect.[104] Copper and lead uptake in blue-green algae (cyanobacteria) also increases with exposure to UVB light, and limits the organism's ability to synthesize nitrogen.[105] This has major implications to the ecosystem, since blue-green algae are one of the few organisms that can convert airborne nitrogen (N_2) into biologically usable nitrate forms (NO_3). "Therefore, any threat to their existence will bring about an imbalance in the nitrogen status of entire ecosystems."[106]

Copper is toxic to salmonids and even amounts of copper as low as 2-3 µg/L can change a fish's smell and behavior.[107] "It is well established that waterborne Cu concentrations above 80 nmol/L (~5 µg/ L) can be toxic to the olfactory system of fishes causing reduced olfactory sensitivity and impaired behavioral responses."[108] One study found that exposure to 80 µg/L of copper for five days can kill salmonids.[109] Copper levels of 105 µg/L can reduce the critical swimming speed of salmonids,[110] and make them more vulnerable to predators. Copper can also bind to certain forms of hemoglobin in fish blood, and can destroy the red blood cell membranes.[111]

According to the NOAA, "adverse effects of dissolved copper and zinc on listed salmon occur at very low levels (values ranging from 0.18 to 2.1 µg/L in freshwater for copper [Hecht et al., 2007] and at 5.6 µg/L in freshwater for zinc [Sprague, 1968]). Adverse effects of copper

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[102] Wright, David A. Trace Metal and Major Ion Interactions in Aquatic Animals. *Marine Pollution Bulletin*, Vol. 31, Nos 1-3, pp. 8-18, 1995.
[103] Amoozegar, M.A., J. Hamedi1, et al. Effect of salinity on the tolerance to toxic metals and oxyanions in native moderately halophilic spore-forming bacilli. *World Journal of Microbiology & Biotechnology* (2005) 21: 1237–1243.
[104] Rai, Pramoda Kumar, and Lal Chand Rai. Interactive effects of UV-B and Cu on photosynthesis, uptake and metabolism of nutrients in a green alga *Chlorella vulgaris* under simulated ozone column. *J. Gen. Appl. Microbiol.*, 43, 281-288 (1997). P. 283.
[105] L.C. Rai *et al*. Interactive effects of UV-B and heavy metals (Cu and Pb) on nitrogen and phosphorus metabolism of a N2-fixing cyanobacterium *Anabaena doliolum*. *Environmental and Experimental Botany* 39 (1998) 221–231. P. 229.
[106] L.C. Rai *et al*. Interactive effects of UV-B and heavy metals (Cu and Pb) on nitrogen and phosphorus metabolism of a N2-fixing cyanobacterium *Anabaena doliolum*. *Environmental and Experimental Botany* 39 (1998) 221–231. P. 222.
[107] Green, Warren W., Reehans Mirza, *et al*. Copper Binding Dynamics and Olfactory Impairment in Fathead Minnows (*Pimephales promelas*). *Environ. Sci. Technol.* 2010, 44, 1431–1437. P. 1434.
[108] Green, Warren W., Reehans Mirza, *et al*. Copper Binding Dynamics and Olfactory Impairment in Fathead Minnows (*Pimephales promelas*). *Environ. Sci. Technol.* 2010, 44, 1431–1437. P. 1434.
[109] A. Gagnon *et al*. Effects of Cu on plasma cortisol and cortisol secretion by adrenocortical cells of rainbow trout (*Oncorhynchus mykiss*). *Aquatic Toxicology* 78 (2006) 59–65. P. 61.
[110] Waser, Wolfgang, Olga Bausheva, *et al*. The copper-induced reduction of critical swimming speed in rainbow trout (*Oncorhynchus mykiss*) is not caused by changes in gill structure. *Aquatic Toxicology* 94 (2009) 77–79. P. 78.
[111] Fedeli, Donatella, Manuel Carloni, *et al*. Oxidative damage in trout erythrocyte in response to ''in vitro" copper exposure. *Marine Environmental Research* 69 (2010) 172–177. P. 176.

include interference with fish sensory systems and important behaviors that underlie predator avoidance, juvenile growth and migratory success…adverse effects of zinc include altered behavior, blood and serum chemistry, impaired reproduction, and reduced growth" (p. 39).[112]

Zinc is absorbed by rainbow trout through the water (at 150-600 µg/L) and dietary intake (at 45 µg/gram food/fish/day).[113] "Zinc is easily bioaccumulated in stream invertebrates – an important food source for juvenile salmonids while rearing in freshwater systems. Recent studies demonstrate that fish fed diets contaminated with zinc exhibited reduced survival, growth, and increased incidence of disease (Farag et al., 1994, Balasubramanian et al., 1995)."[114]

Lead is a toxic element and bioaccumulates in aquatic species. "Apart from the natural weathering processes, Pb contamination in the environment has resulted from mining and smelting activities, Pb-containing paints, gasoline, and explosives, as well as from the disposal of municipal sewage sludges rich in Pb (Chaney and Ryan 1994). Despite measures adopted in many countries to limit Pb input to the environment, it continues to be one of the most serious global environmental biohazards."[115]

"Pb is assumed to be toxic for aquatic organisms at concentrations above 100 mg/kg of dry sediment (Environment Canada 1998). However, at a level of 30 mg/kg adverse biological effects have occasionally been observed."[116] Lead has been found in the liver and muscle of Alaskan Pacific Cod, which is caused by close proximity to ports and human activity.[117]

Lead has the potential to affect the aquatic food chain by harming a type of phytoplankton, blue-green algae, or cyanobacteria (an ancient bacterium found on land and in water). These organisms provide much of the oxygen on earth, and convert inert atmospheric nitrogen into forms usable by other organisms (nitrate, ammonia, etc.).

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[112] NOAA. (2009, July 15). Letter from Steven W. Landino to Mike Gearheard of US EPA. p. 2.
cites Hecht, S. A., Baldwin, D. H., Mebane, C. A., Hawkes, T., Gross, S. J., & Scholz, N. L. (2007). *An Overview of sensory effects on juvenile salmonids exposed to dissolved copper: Applying a benchmark concentration approach to evaluate sublethal neuro behavioral toxicity*. U.S. Department of Commer., NOAA Technical Memorandum NMFS-NWFSC-83.
cites Sprague, J. B. (1968). *Avoidance reactions of rainbow trout to zinc sulphate solutions*, Vol. 2:367-372. Water Research Pergamon Press.
[113] Sappal, Ravinder, and Collins Kamunde. Internal bioavailability of waterborne and dietary zinc in rainbow trout, Oncorhynchus mykiss: Preferential detoxification of dietary zinc. *Aquatic Toxicology* 93 (2009) 166–176. P. 167.
[114] Bowen, Lizabeth, Inge Werner, et al. Physiological and behavioral effects of zinc and temperature on coho salmon (*Oncorhynchus kisutch*). *Hydrobiologia* (2006) 559:161–168.
[115] Zutshi, Sunaina, Meenakshi Choudhary, et al. Evaluation of antioxidant defense responses to lead stress in *Hapalosiphon fontinalis-339*. *Journal of Phycology* 44, 889-896 (2008).
[116] Venturini, N., P. Muniz, et al. Macrobenthic subtidal communities in relation to sediment pollution: the phylum-level meta-analysis approach in a south-eastern coastal region of South America. *Marine Biology* (2004) 144:119-126.
[117] Burger, Joanna, Michael Gochfeld, et al. Heavy Metals in Pacific Cod (Gadus macrocephalus) from the Aleutians: Location, Age, Size, and Risk. *Journal of Toxicology and Environmental Health, Part A,* 70: 1897–1911, 2007.

When the cyanobacteria are in the presence of lead, they do not absorb nitrogen as easily; the effect is vastly compounded when ultraviolet light (UVB) is also present.[118] Since zooplankton eat phytoplankton like the cyanobacteria, the lead can move up the food chain, eventually reaching fish, birds, and marine mammals. Lead also creates a stress response in cyanobacteria, and de-activates the beneficial anti-oxidants inside the cells.[119] Another species of phytoplankton, a green algae, is harmed by lead concentrations of only 250 μg/L.[120]

Urban stormwater runoff (similar to the proposed terminal area), is known in general to have adverse effects on waters.[121] For example, much of the pollution that degrades the Puget Sound and threatens fish in that Pacific Northwest ecosystem is contained in stormwater.[122] Even the newest stormwater runoff models produce treatment systems that harm aquatic environments, especially those vegetated with a wide variety of sensitive native plants.[123, 124, 125] The extra coal-associated pollutants picked up in the proposed rail yard and terminal area makes this typically bad urban runoff even worse, and potentially toxic to fish.

Conclusions. A preliminary drainage report should be reviewed to determine the risk of discharging pollution to the environment via the stormwater system. The amount of carbonate in the soils should be determined to assess the ability of the soil to attenuate toxic leachates from the coal dust entering the infiltrating stormwater system. More detail should be given about the rail operations to estimate the pollution from the rail yard portion of the development, given the amount of pollution generated at similar sites in the Pacific Northwest. Liquid fuel runoff from storage tanks should be evaluated for environmental harm. The effects of potential pollution on the food web should be examined more closely to determine if harm to salmonids may occur.

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[118] L.C. Rai et al. Interactive effects of UV-B and heavy metals (Cu and Pb) on nitrogen and phosphorus metabolism of a N2-fixing cyanobacterium *Anabaena doliolum*. *Environmental and Experimental Botany* 39 (1998) 221–231.

[119] Zutshi, Sunaina, Meenakshi Choudhary, et al. Evaluation of antioxidant defense responses to lead stress in *Hapalosiphon fontinalis-339*. *Journal of Phycology* 44, 889-896 (2008).

[120] Pinto, Ernani, Teresa C. S. Sigaud-Kutner, et al. Heavy metal-induced oxidative stress in algae. *Journal of Phycology* 39, 1008-1018 (2003).

[121] Azous, Amanda L. and Richard G. Horner, Ed. *Wetlands and Urbanization: Implications for the Future. Final Report of the Puget Sound Wetlands and Stormwater Management Research Program.* Published by Washington State Department of Ecology, Olympia, WA; King County Water and Land Resources Division; the University of Washington, Seattle, WA. 1997.

[122] Cornwall, Warren. "The Painful Cost of Booming Growth." *The Seattle Times.* May 11, 2008. Accessed online on 02/21/11 at http://seattletimes.nwsource.com/html/localnews/2004405985_growth_stormwater20m0.html.

[123] Cornwall, Warren. "The Painful Cost of Booming Growth." *The Seattle Times.* May 11, 2008. Accessed online on 11/23/10 at http://seattletimes.nwsource.com/html/localnews/2004405985_growth_stormwater20m0.html.

[124] Azous, Amanda L. and Richard G. Horner, Ed. *Wetlands and Urbanization: Implications for the Future. Final Report of the Puget Sound Wetlands and Stormwater Management Research Program.* Published by Washington State Department of Ecology, Olympia, WA; King County Water and Land Resources Division; the University of Washington, Seattle, WA. 1997.

[125] Concerned Scientists and Engineers. Letter to Puget Sound Partnership, "Partnership Recommendations To: Improve Water Quality and Habitat by Managing Stormwater Runoff; Protect Ecosystem Biodiversity and Recover Imperiled Species; Provide Water for People, Fish and Wildlife, and the Environment." October 26, 2006. Accessed online on 02/02/10 at http://seattletimes.nwsource.com/ABPub/2008/05/10/2004406008.pdf.

V. Toxicology Report

The Environmental Review, Appendix J presents a toxicology report by Golder Associates, Inc. in the form of a literature review. In this section a closer look at the works cited reveals additional information that should be considered in determining the effects of the coal shipping operation.

The report says, "Ibeanusi et al (2003) observed metals (iron, aluminum, zinc, arsenic, cadmium, lead, and selenium) in eastern US coal storage pile runoff at concentrations above drinking water standards. The measurements were based on total metal concentrations; thus the biological availability and potential toxicity of these contaminants was not assessed" (p. 2). The Ibeanusi article mentioned is a study about how bacteria can absorb metals from coal runoff and be used to process acid mine drainage water. The Ibeanusi article says,

> "Wastewater effluents from coal pile run off are of major concern because of the acidity and presence of several dissolved metals in the waste stream. Similar to acid mine drainage (AMD), the chemical and biological reactions of pyrite in coal pile run off generate acidic minerals, which can oxidize to form sulfuric acid, ferrous sulfate and associated toxic metals... Unlike a typical AMD, in which the major metal ions are Fe^{2+} and Fe^{3+}, the coal pile runoff used in this study presented unique and complex chemical dynamics due to the prevalence of several dissolved toxic metals (Al, As, Be, Cd, Cr, Cu, Fe, Ni, Pb, Se and Zn) in the wastewater." (p. 35, 36) [126]
>
> "In Figure 1, results of the transmission electron microscopy indicated various stages of intracellular complexation of metal precipitates within the cytoplasm and cell membranes of the bacterial cells. Ultimately, the metal ions were sequestered outside the cells as metal precipitates (Figure 1e). The x-ray microanalysis of precipitates revealed the presence of most of the metals (As, Al, Cu, Cr, Fe, Pb and Zn) originally present in the wastewater (Figure 2). The presence of Ca, P, and S in Figure 2 suggested that most of the metals could possibly precipitate as metal carbonates, phosphates and sulfides." (p. 38)[127]

In the excerpts above, Ibeanusi says the metals are dissolved, in ionic form, are toxic, and that the bacteria can absorb the metals into the cell walls and cytoplasm, and that eventually the metals can be deposited outside the cells as metal precipitates. Counter to the Golder Associates report statement, the author addressed the toxic nature of the compounds, and showed that they are bioavailable to bacteria, which transform them inside the cells and deposit them outside the cells as precipitates.

Another author comments that metal ions are widely accepted to be bioavailable: "the most broadly accepted paradigm explaining the negative effect of salinity on trace metal uptake

[126] Ibeanusi, V.M., et al. Removal and Recovery of Metals from a Coal Pile Runoff. *Environmental Monitoring and Assessment* 84: 35–44, 2003.
[127] Ibeanusi, V.M., *et al.* Removal and Recovery of Metals from a Coal Pile Runoff. *Environmental Monitoring and Assessment* 84: 35–44, 2003.

assumes that the most bioavailable metal form is the free metal ion (Sunda et al., 1978; Engel & Fowler, 1979)."[128] [author cites Sunda et al., 1978, *Environ. Sci. Technol.* 12, 409-413; Engel & Fowler, 1979, *Environ. Health Perspect.* 28, 81-88]. So it seems that the dissolved metal ions found in acid mine drainage, such as in the Ibeanusi study quoted by Golder Associates, are bioavailable.

Metal leaching from coal is discussed in the Golder Associates report, which begins with a citation of a study by Cabon, *et al*, 2007[129] (p. 2), which is a study on leaching of metals from coal into seawater. Another author criticized Cabon's study, and largely dismissed the relevancy of his findings to coal transport: "Cabon *et al*. (2007) explained the leaching dynamics (for Mn in particular) as a function of the bicarbonate (HCO_3^-) system present in seawater. However the leach tests used a few grams of milled (<212 µm) coal samples in 20 mL of seawater and this is not typically representative of the top-size of exported coal in a bulk carrier."[130]

A study by Cook and Fritz (2002) that examined leaching from coal piles and the fate of the leachate is presented (p. 2), and the Golder Associates report highlights the effects of the surroundings on the chemicals emanating from the pile. The cited study concluded by saying,

> "data obtained from groundwater monitoring at Wade Utility Plant reflect a site in which the impacts of coal-pile leachate are largely ameliorated by carbonate mineral dissolution and by dilution. This is supported by near-neutral groundwater pH, minimal concentrations of metals, and limited geographic extent of sulfate contamination. However, a significant accumulation of trace metals in recharge pond sediments indicates that the site is not completely immune to the negative impacts of coal-pile leachate. Without the ameliorating effects of carbonate minerals to neutralize acid leachate and immobilize trace elements, above-ground storage of coal piles in non-carbonate terrain may be compromising the water quality of underlying aquifers."[131]

The soil and groundwater properties are important to consider, because in the absence of carbonate material, it is more likely that coal dust leachates could degrade the groundwater. It is unknown if similar soils exist at the Port of Morrow, and whether they are similar enough to ameliorate the leachate. If there is a groundwater table that absorbs polluted leachate, it will likely be transmitted to the adjacent Columbia River, where ESA-listed fish live.

Nitrogen pollution from coal in the form of ammonium (inorganic nitrogen, the NH_4+ ion, formed from ammonia, NH_3) is discussed. The Golder Associates report states, "dissolved inorganic nitrogen species can be removed from the water through a variety of processes, such as exposure to sediments and plant communities (Smith et al. 2009)" (p. 2). The study by Smith, et al. is an examination of polluted water produced from coal bed natural gas (CBNG) extraction in

[128] Wright, D.A. Trace Metal and Major Ion Interactions in Aquatic Animals. *Marine Pollution Bulletin*, Vol. 31, Nos l-3, pp. 8-18, 1995.
[129] Cabon, J.Y., *et al*. Study of trace metal leaching from coals into seawater. *Chemosphere* 69 (2007) 1100–1110.
[130] Lucas, S.A, and J. Planner. Grounded or submerged bulk carrier: The potential for leaching of coal trace elements to seawater. *Marine Pollution Bulletin* 64 (2012) 1012-1017.
[131] Cook, A.M, and S.J. Fritz. Environmental Impacts of Acid Leachate Derived from Coal-Storage Piles upon Groundwater. *Water, Air, and Soil Pollution* 135: 371–388, 2002.

the Powder River Basin of Wyoming. It describes the dynamics of dissolved inorganic nitrogen (DIN) over time and the differences in the form of nitrogen detected in tributaries to the Powder River. The study found by chance that one tributary, "trib B," showed a net removal of nitrogen:

> "The load calculations further emphasize that a substantial amount of the source ammonium N was removed during transport through the trib B channel but virtually none was removed in the longer trib C channel. This difference is attributed primarily to the presence of dense stands of grasses in the trib B channel. Nitrification, ammonium assimilation, and nitrate reduction all appear to be more active in the trib B channel."[132]

The effect described by the author is similar to nitrogen uptake in wetlands used for wastewater treatment. The study also said, "overall, it appears that the Burger Draw daily summertime contribution to the Powder River was about 23 kg of DIN in 2003 (Table 3). This load is a substantial contribution to the entire Powder River DIN load at Burger Draw."[133] "Management strategies for disposal of CBNG-produced water rarely consider downstream nitrogen effects. The results of this study clearly indicate that CBNG-associated DIN was being delivered from Burger Draw to the Powder River. The net result is an increased potential for eutrophication, though relatively little is specifically known about in-stream nitrogen cycling in this semiarid region."[134]

It is important to note that the mining water came into contact with coal, became rich in ammonium, and presents the ecological threat of eutrophication (excess nutrients) to downstream aquatic communities. If the runoff from the 29,000 tons of coal being stored in the rail cars produces the same effect, it is possible that portions of the Columbia River or other receiving bodies could experience eutrophication.

The Golder Associates report further discusses CBNG water use: "relatively low-flow (ephemeral stream) surface waters that receive coal bed-impacted water have been proposed for use as agricultural and livestock or wildlife drinking water (Jackson and Reddy 2007), suggesting negligible risk from a discrete nitrogen loading incident on a large river system" (p. 2). In other words, because the water is proposed for animal and crop use, it must be okay to dump into the Columbia River. That implication begs the question, if the coal-affected water was not safe for drinking, would it still be okay to dump it into the Columbia River?

Most of the water from the cited study is not safe for human drinking, or for aquatic life, and may become unsafe for animal and agricultural use, as the author of the study points out:

> "The most restrictive use, based solely on trace metal concentrations, is aquatic life. Most CBNG produced water samples exceeded the aquatic life criteria for Al

[132] Smith, R.L., et al. Geochemistry of Inorganic Nitrogen in Waters Released from Coal-Bed Natural Gas Production Wells in the Powder River Basin, Wyoming. *Environ. Sci. Technol.* 2009, 43, 2348–2354.
[133] Smith, R.L., et al. Geochemistry of Inorganic Nitrogen in Waters Released from Coal-Bed Natural Gas Production Wells in the Powder River Basin, Wyoming. *Environ. Sci. Technol.* 2009, 43, 2348–2354.
[134] Smith, R.L., et al. Geochemistry of Inorganic Nitrogen in Waters Released from Coal-Bed Natural Gas Production Wells in the Powder River Basin, Wyoming. *Environ. Sci. Technol.* 2009, 43, 2348–2354.

> and Cu. Based on secondary water quality standards, many CBNG outfall water samples are not suitable for human drinking water due to high Fe and Al concentrations. These results suggest that many of the CBNG produced waters across the PRB can be used for agriculture and livestock/wildlife drinking water."[135]
>
> "Mean concentrations of Al and Cu decreased over time in disposal ponds, whereas Ba, As, and B concentrations increased over time. Molybdenum concentrations remained the same in most watersheds. Most CBNG-produced waters examined were unsuitable for human drinking water and aquatic life, but were suitable for agricultural uses and livestock and wildlife drinking water. If the trace elements continue to increase and accumulate in CBNG disposal ponds, there may be a point in time when the concentrations of these trace elements could exceed standards for agricultural uses and livestock and wildlife drinking water."[136]

The Golder Associates report mentions coal dust as a source of total suspended solids (TSS), and says,

> "Fine particulates of coal dust in water could increase the general turbidity (as measured by suspended solids, or TSS), based on TSS data for runoff from coal storage areas (Tan and Coler 1986, Campbell and Devlin 1997, Curran *et al.* 2000). Clarity of water decreases with increased TSS, and elevated levels of TSS have been linked to toxic effects on aquatic organisms (depending on duration and concentration of exposure), but given the precautions proposed to minimize coal dust entering water bodies from the proposed operations, such elevated levels of TSS are not expected to occur" (p. 2-3).

The Fugitive Coal Dust Impacts section of this document addresses the coal dust risks for the proposed Port of Morrow project. The cited study by Campbell and Devlin 1997 states:

> "Coal dust can enter the marine environment around coal ports through storm water discharge, coal pile drainage run-off, and when coal dust from storage piles, transfer conveyer belts and rail cars becomes airborne and is deposited in the surrounding environment (i.e. fugitive coal dust)(Xuan and Robins, 1994). The practice of using additives, such as surfactants, in the water being used for surface wetting of coal piles can increase the solubility of hydrophobic compounds and thus their mobility in the aquatic environment (Enzminger and Ahlert, 1987). Coal dust contamination of estuarine habitat can occur around coal loading and storage terminals and hence may impinge on vital habitat for juvenile chinook salmon (*Oncorhynchus tshawytscha*)(Levings and Riddell, 1992; Macdonald *et al.*, 1988). Previous studies have shown that low tide use of habitats immediately

[135] Jackson, R.E. and K.J. Reddy. Trace Element Chemistry of Coal Bed Natural Gas Produced Water in the Powder River Basin, Wyoming. *Environ Sci Technol* Vol. 41, No. 17, 2007, 5953-5959.
[136] Jackson, R.E. and K.J. Reddy. Trace Element Chemistry of Coal Bed Natural Gas Produced Water in the Powder River Basin, Wyoming. *Environ Sci Technol* Vol. 41, No. 17, 2007, 5953-5959.

> surrounding coal ports on the British Columbia coast by juvenile Pacific salmon is extensive (Levings, 1985). Chinook salmon may be exposed to coal-dust-derived PAHs through contaminated water and via their food since chironomid larvae, a significant food source for juvenile salmon, have been shown to bioaccumulate PAHs in estuaries contaminated with coal byproducts (Dickmann *et al*., 1992). The construction and expansion of coal terminals has already exerted some pressure on the survival of some stocks of Pacific salmon since this activity has reduced the amount of suitable estuarine habitat available for juvenile salmonids (Levings, 1985 ; Levings and Riddell, 1992). The exposure of Pacific salmon to pollution is of some concern since it is one of the contributing factors implicated in the depletion of some chinook salmon stocks on the West Coast of Canada over the past decade (Rogers *et al*., 1988 and Rogers *et al*., 1989; Birtwell and Kruzynski, 1989; Servizi *et al*., 1993; Kruzynski *et al*., 1994)."[137]

The study tested juvenile Chinook salmon for genetic responses to the PAHs in coal dust:

> "It is clear that coal dust has effects on the expression of several genes in juvenile chinook salmon. It is also possible that these sublethal effects may become manifest at higher levels of biological organization. Coal byproducts and specific components found in coal dust leachate have been shown to reduce the growth rate of trout (Herbert and Richards, 1963), cause oocyte atresia and reduced ovarian growth in crayfish (Sarojini *et al*., 1995) and to promote DNA adduct formation and hepatocellular carcinoma in fish (Hendricks *et al*., 1985; Varanasi *et al*., 1986; Stein *et al*., 1990). It is known that CYP1A1 plays a role in the activation of procarcinogens and the formation of DNA adducts (Varanasi *et al*., 1986, 1989; Okey, 1990)."[138]

Campbell *et al.* also found that the fish were affected by the coal dust, and that expression of a particular gene, L5, can potentially be used as a biomarker test for PAH exposure:

> "Since L5 plays such a crucial role in ribosome biogenesis and cellular metabolism it is certainly plausible that the altered expression of this gene by contaminant exposure may ultimately have physiological consequences. The results of this study also indicate that alterations in the expression of L5 may potentially be used as a biomarker of specific PAH exposure in teleosts."[139]

The levels of coal dust TSS tested by Campbell et al. were of regulatory significance, and may apply to future conditions at the proposed Port of Morrow coal terminal:

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[137] Campbell, P. M., R. H. Devlin. Increased CYP1A1 and ribosomal protein L5 gene expression in a teleost: The response of juvenile chinook salmon to coal dust exposure. *Aquatic Toxicology* 38 (1997) 1-15.
[138] Campbell, P. M., R. H. Devlin. Increased CYP1A1 and ribosomal protein L5 gene expression in a teleost: The response of juvenile chinook salmon to coal dust exposure. *Aquatic Toxicology* 38 (1997) 1-15.
[139] Campbell, P. M., R. H. Devlin. Increased CYP1A1 and ribosomal protein L5 gene expression in a teleost: The response of juvenile chinook salmon to coal dust exposure. *Aquatic Toxicology* 38 (1997) 1-15.

> "For the 8 day exposure period a static system was utilized: the tanks were filled with sea water only or sea water containing either 60 mg L^{-1}, 200 mg L^{-1} or 500 mg L^{-1} coal dust. These concentrations were chosen since present regulations in British Columbia (Environment Canada) limit levels of suspended solids in coal terminal effluent to 60 mg L^{-1} however, consideration is presently being given to a request that allowable levels of suspended solids in coal terminal effluent be raised to 200 mg L^{-1}."[140]

The Golder Associates report later discusses the risk of PAH poisoning via coal dust, saying, "Chapman et al (1996) reviewed the available literature and found no evidence of toxicity from PAH or other constituents of coal leachate to crabs or fish" (p. 4).

However, Golder Associates cites the 1997 study by Campbell *et al*. that states an effect of PAH from coal dust leachate on gene expression in juvenile Chinook salmon, as quoted above. Campbell *et al'*s lab study showed one element of how PAH from coal dust can affect salmon without causing death. In nature, there is a lot more going on than in the lab, and sub-lethal effects can certainly compromise survival in many situations (such as copper affecting smell, but not killing the fish). Just because a fish doesn't die from an exposure in a lab, doesn't mean its survival is not adversely affected by it in the wild.

The Golder Associates report also mentions that PAHs from coal are not biologically available, as found by Deepthike *et al* (2009) (p. 4). The study by Deepthike *et al*. uses a PAH-sensitive bacterial biosensor to assess the bioavailability of PAHs in the Kulthieth Formation coal along the Alaska coast.

> "The bioreporter used here employs sensor and regulator proteins of a metabolic pathway (i.e., not an intracellular pathway for toxicity response) and exhibits increasing response with increasing analyte concentration, characteristic of chemical approaches, while reflecting the biological system dynamics, characteristic of ecotoxicological approaches." "When PAHs bind to a repressor protein, it activates transcription of the reporter gene to produce a reporter mRNA, which undergoes translation to produce EGFP, a stable variant of green fluorescent protein GFP (vide infra). Naphthalene was used for calibration, since the organism is most sensitive to naphthalene, although it also reacts to phenanthrene and some other PAHs." [141]

The authors mixed kaolinite, a solid from which naphthalene is completely bioavailable, with varying concentrations of naphthalene as a control, and then prepared test samples with Exxon Valdez crude oil (EVCO) and kaolinite, and samples with coal dust. The EVCO sample was obtained from another researcher who had collected it from the ship after it was stranded. The coal samples were collected from the field, "along a vertical section from dipping beds exposed

[140] Campbell, P. M., R. H. Devlin. Increased CYP1A1 and ribosomal protein L5 gene expression in a teleost: The response of juvenile chinook salmon to coal dust exposure. *Aquatic Toxicology* 38 (1997) 1-15.
[141] Deepthike, H.U. et al. Unlike PAHs from Exxon Valdez Crude Oil, PAHs from Gulf of Alaska Coals are not Readily Bioavailable. *Environ. Sci. Technol.* 2009, 43, 5864–5870. Supporting information on methods and results at http://pubs.acs.org/doi/suppl/10.1021/es900734k.

on the east side of upper Tyndall Arm and from riverine coal floats (Figure 1). Exposed coal seams range from 6 cm to 1.5 m thick. Coal samples with a large PAH content range were chosen for this study."[142] The samples were analyzed for PAH levels, and reported completely in the supporting information available on the internet.

> "Naphthalene-amended kaolinite samples were prepared by spiking 1 g of kaolinite with 20 µL methanolic solutions of naphthalene at various concentrations and thoroughly mixing. Kaolinite samples amended with various concentrations of EVCO were prepared likewise by adding a weight-range of small portions of the crude oil. Coal samples were prepared by grinding and sieving (100 µm metal sieve). For coal, varying PAH concentrations were obtained by using samples having different natural PAH contents."[143]

The preparations were combined with the bioreporter bacteria, incubated, and examined for fluorescence. In conclusion, the authors found that "biological results indicate that PAHs in Icy Bay coals are unavailable (Figure 4B), and geological results support this."

There are several questions about this study that are not addressed by the authors. One is that the concentrations of PAHs found in the EVCO sample are generally one or more orders of magnitude higher than the coal samples. For example, the EVCO sample was assayed to contain 7.24×10^5 ng naphthalene /g of sample (nanograms per gram; 1 ng = 0.000000001g), but coal sample PKC-G had only 1.33×10^3 ng/g. In the few cases where the EVCO and coal samples are the same order of magnitude, the EVCO samples are several times stronger the coal samples. No details about the actual mixtures of the samples or levels of treatment are given; would the results have been different with a more concentrated form of coal-derived PAH?

Another question is whether the study is representative of realistic conditions in nature. The samples were prepared using a minimal medium (MM) with a pH of 6.8 so that the bacteria would be able to live. In nature, organisms may subject coal particles to varying pHs, for example in the gut, which in humans has a pH of 2. Organisms may also combine enzymes with the coal particles during digestion, which could differ among species. It is possible that a bacterium at room temperature in near-neutral pH media might absorb and transform compounds differently than a vertebrate with a body temperature four times higher and a pH much lower.

The authors do address the fact that PAHs may be slow to become available and not able to be detected by their study, and that those are beyond the scope of their work:

> "Due to the high chemical resistance to mass transport (release) of PAHs from the coal samples used here, the corresponding dominant desorption kinetics will be very slow, obviously much slower than the time scale of measurement employed

[142] Deepthike, H.U. et al. Unlike PAHs from Exxon Valdez Crude Oil, PAHs from Gulf of Alaska Coals are not Readily Bioavailable. *Environ. Sci. Technol.* 2009, 43, 5864–5870. Supporting information on methods and results at http://pubs.acs.org/doi/suppl/10.1021/es900734k.
[143] Deepthike, H.U. et al. Unlike PAHs from Exxon Valdez Crude Oil, PAHs from Gulf of Alaska Coals are not Readily Bioavailable. *Environ. Sci. Technol.* 2009, 43, 5864–5870. Supporting information on methods and results at http://pubs.acs.org/doi/suppl/10.1021/es900734k.

> here. We and other authors have addressed this point from many perspectives, full consideration of which is beyond the scope of the present manuscript. In brief, it is difficult to extend bioreporter studies past the time periods used here. However, most measurements of bioavailability are similarly restricted to measurement periods of a few hours or even weeks, i.e., periods equally inadequate to slow desorption (many months to years; with reference to the Valdez spill, some studies address this point of very slow desorption (13), others overlook it). One highly cited work on chemical extraction demonstrated that the bioremediable (i.e., perforce ad hoc bioaccessible) fraction of desorbing PAHs over two years is captured in the amount desorbed to Tenax over the same time frame as used in the present experiments (44)."[144]

A peer-review scientist's opinion of Deepthike *et al*'s research article is mentioned in the published version of the article: "one reviewer of this manuscript mandated mention of another possibility for the role of these coals in the environment: because of their capacity to sorb PAHs, rates of other processes of natural attenuation (photooxidation, biodegradation) could be diminished, diminishing the immediate PAH burden, but enhancing the persistence of toxic PAHs."[145] This comment illustrates that the coal can take up other PAHs from surroundings, which may be changed by radiation or biological activity, thereby potentially protecting the native coal PAH.

Finally, the authors reiterate their main point of finding, which is very specific: "bioavailable PAHs do not originate from organic-rich source rock associated with the Poul Creek and Kulthieth Formations east of Prince William Sound. EVCO represents the primary known source of bioavailable PAHs in the region."[146]

In no way do Deepthike *et al*. state or imply that all PAHs from all coal are biologically unavailable, as the Golder Associates report asserts: "therefore while coal PAH may be ingested by oysters (Bender et al 1987) or even bioaccumulated by aquatic insect larvae (Campbell and Delvin 1997), the PAH do not pose a toxicological risk to those animals, or others higher in the food chain" (p. 4). The Deepthike *et al* study was designed to answer a question about a local condition, not a world-wide chemical behavior.

A scientific article completed just prior to the Deepthike *et al* study reviewed unburnt coal PAH studies, and is also cited by Golder Associates. The authors write,

> "Coal-bound native PAH in soils and sediments have been studied to a minor extent, despite 30 years of research on PAH in the environment. Their impact on

[144] Deepthike, H.U. et al. Unlike PAHs from Exxon Valdez Crude Oil, PAHs from Gulf of Alaska Coals are not Readily Bioavailable. *Environ. Sci. Technol.* 2009, 43, 5864–5870. Supporting information on methods and results at http://pubs.acs.org/doi/suppl/10.1021/es900734k.
[145] Deepthike, H.U. et al. Unlike PAHs from Exxon Valdez Crude Oil, PAHs from Gulf of Alaska Coals are not Readily Bioavailable. *Environ. Sci. Technol.* 2009, 43, 5864–5870. Supporting information on methods and results at http://pubs.acs.org/doi/suppl/10.1021/es900734k.
[146] Deepthike, H.U. et al. Unlike PAHs from Exxon Valdez Crude Oil, PAHs from Gulf of Alaska Coals are not Readily Bioavailable. *Environ. Sci. Technol.* 2009, 43, 5864–5870. Supporting information on methods and results at http://pubs.acs.org/doi/suppl/10.1021/es900734k.

> the environment is not well understood. Unburnt hard / bituminous coal emissions from mining activity particularly impact those countries holding large coal basins... Hard coal consists of a macromolecular network phase and a mobile phase, and PAH are part of both. However, the latter phase is of special environmental interest because it is more mobile and is expected to have higher bioavailability. Aromatization of coals increases with increasing rank from sub-bituminous coal to anthracite. In coals, oil (mobile phase, including 2–6 ring PAH) is generated at low to medium hard coal rank from 0.5–1.3% Ro. In this range also maximum PAH concentrations may occur but they also depend on origin (e. g. maceral composition). naphthalene, phenanthrene, chrysene and alkylated derivatives are characteristic petrogenic PAH. To date, it is hardly possible to distinguish PAH derived from oil vs. PAH from coal. If other geosorbents such as black carbon are not present at higher levels, limited evaporation of naphthalenes compared to the greater losses in other samples may be a helpful indicator of the presence of coal... The data is presently insufficient for us to ascertain if native PAH derived from unburnt hard coal particles pose a severe risk for humans or organisms of the benthos and soil."[147]

Based on this review, the effects of unburnt coal PAHs are yet to be determined, and may or may not have negative effects on portions of the ecosystem. In such cases, especially when threatened or endangered species may be exposed to coal PAH (which some studies show has a physiological effect), it is best to err on the side of caution and prevent such exposures.

Conclusions. It is important to take a close look at toxicological research literature to assess the risks of discharging coal into the environment. The literature presented by Golder Associates shows that:

1) dissolved toxic metal ions from coal are bioavailable and transformable by bacteria;
2) carbonate-poor soils present a risk of groundwater contamination from metals leached from coal;
3) nitrogen pollution of water in contact with coal can occur, and pose a threat to water quality;
4) water in contact with coal can contain levels of aluminum, copper, and iron that are unsafe for human consumption and harmful to aquatic life;
5) surfactants used to control coal dust can increase the mobility of coal compounds into the aquatic environment;
6) coal dust contamination around coal loading terminals may impinge on vital habitat for juvenile Chinook salmon;
7) chironomid flies bioaccumulate PAHs which may become available to juvenile Chinook salmon via digestion;
8) coal terminal construction has exerted pressure on Pacific salmon by polluting estuaries;
9) pollution is implicated in depletion of some Chinook salmon stocks in Canada over the past decade;
10) PAHs in coal effect the expression of several genes in juvenile Chinook salmon;
11) coal dust leachate has been shown to reduce the growth rate of trout;

[147] Achten, C and T. Hofmann. Native polycyclic aromatic hydrocarbons (PAH) in coals - A hardly recognized source of environmental contamination. *Science of the Total Environment* 407 (2009) 2461-2473.

12) expression of gene L5 in teleost fish may potentially be used as a biomarker of PAH exposure;
13) sub-lethal effects may occur from exposure to coal constituents;
14) coal in the environment may sorb PAHs from the surroundings, which may prevent the native coal PAHs from reacting;
15) bioavailable PAHs from coal may be limited;
16) more research is needed to fully understand the biological risks of PAHs in coal.

A more detailed toxicological review should be performed, and should address the forms and reactivity of pollutants in the environment. Compounds can change in form from largely inert to bioavailable when subjected to different conditions, and if those conditions occur in the ecosystem near the proposed coal terminal, then they present a risk to organisms. When information on the effects of pollutants are lacking or imprecise, the activities producing those pollutants should be prevented because of the potential to directly or indirectly harm listed species such as Chinook salmon.

IV. Conclusions

The proposed coal terminal has the potential to release harmful substances into the environment. The coal dust generated by the operations may be much greater than discussed in the application. Impacts to fish could occur as a result of physical and chemical discharges from the proposed shipping terminal. Process water could also pose a risk, but more information is required to assess the potential for ecological harm. Stormwater could become polluted from coal in rail cars, and/or from the rail operations at the proposed terminal. The applicant's toxicology report contains information on scientific studies that has higher value when explained in greater detail.

Sincerely,

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Professional Wetland Scientist
Certified Ecologist