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Re: Environmental Impact Statement Scoping Comment for Proposed Millennium Bulk Terminals at Longview, WA

I. Introductory Note: We are deeply concerned about the potential impact on public health and the environment from the proposed coal export terminal at Longview, WA and the transport of coal by rail from Wyoming's Powder River Basin across the United States and along the Columbia River.

In this comment we draw particular attention to one aspect of the potential impact of the proposed project: the effects of cadmium toxicity from coal and coal dust on aquatic life in general and on shellfish in particular. The dangers from some of the other heavy metals in coal and coal dust, such as lead, mercury, and arsenic are more widely known. Cadmium is found in coal and coal dust in smaller quantities than lead and mercury, but its toxicity is such that it may actually pose an even greater danger. Similarly, public attention might more easily focus on larger animals, such as salmon and marine mammals. But oysters, crabs, clams, and other shellfish have significant commercial and recreational value in Washington and Oregon, in addition to their intrinsic value as part of the Columbia River estuary's unique marine environment. This focus should not diminish concern for all potentially affected species, aquatic and terrestrial, since the ecosystems involved must be considered as integrated systems and shellfish comprise an important part of the food chain. Nor should it diminish concern for public health, since this too depends in myriad ways on environmental factors.

The "Scientific Background" section (below) is crafted to be accessible to non-experts, but we are asking for analysis in the environmental impact statement that meets the highest standard of professional, scientific investigation. We have included excerpts from scientific publications in the "Numbered References" section; these are noted in the text of the background statement and provide examples of research that the EIS should take into account. Along with other references in the "Bibliography" section, they are intended to help show the extent and quality of current research world wide on the problem of cadmium toxicity. They should serve as a point of departure for the research that should be included in the EIS, rather than the sole base for it.

II. Scientific Background – Coal and Cadmium: Coal in general, and Powder River Basin coal in particular, contains numerous heavy metals that are toxic to humans and other creatures. These include, among others, lead, mercury, nickel, cadmium, selenium, manganese, antimony, and arsenic. Coal also contains the radioactive elements thorium and strontium.

Transporting coal by train or truck and creating stockpiles for shipping sends coal dust into the air, which diminishes air quality and subjects nearby populations to dust inhalation. Health effects from exposure to coal dust include increased asthma, wheezing and cough, especially in children and the elderly. A wide range of serious health problems accompanies exposure to the heavy metals present in coal dust. Coal dust may also be carcinogenic due to the presence of polycyclic aromatic hydrocarbons (PAH).

Each of these metals as well as the spectrum of carcinogenic polycyclic hydrocarbons presents hazards to many species including humans. As may be expected, there is more scientific literature on the effects of these contaminants on humans than on other species; however, by the precautionary principle, it is reasonable to extrapolate data from other organisms to humans and vice versa.

Based upon a literature examination, we believe we must be wary of additional cadmium introduction to natural ecosystems because of established adverse effects on both humans and wildlife. That is not to imply that the other metals and chemicals should not be matters of concern. For example, mercury is certainly a huge hazard also.

Several facts provide a platform for understanding the hazards of cadmium contamination of the environment. First, cadmium occurs in many soils and rocks. It is easily mobilized by various anthropogenic activities such as agriculture, forestry operations and mining. There can, therefore, be levels of cadmium present in soils, waters and sediments that provide a "background" of cadmium that may allow little leeway for added accumulation before toxic concentrations result. (E.g., Numbered Reference 1).

Second, certain organisms, such as shellfish, are able to actively sequester cadmium in their bodies due to the presence of a metal-binding protein. This "bioaccumulation" can greatly magnify the concentrations of cadmium in the environment by astounding factors as high as 40,000-fold. As a result, any organism that consumes these shellfish will obtain a dose of cadmium that is much greater than ambient environment levels. (E.g., Numbered References 2, 3, 4, 5, 6, 7, 8, 9, & 10).

Third, the human kidney also accumulates cadmium, leading to renal toxicity and, if not controlled, kidney failure. Women, especially those with low iron levels, as well as smokers of both sexes, are particularly at risk from cadmium toxicity. This has become a serious issue in European countries. Cadmium burdens have also been linked to osteoporosis and breast cancer. (E.g., Numbered References 11, 12, 13, 14, & 15).

Fourth, cadmium is toxic at part-per-billion concentrations to shellfish and is even more toxic to their juvenile forms. . (E.g., Numbered References 7 & 17).

Fifth, organisms at higher trophic levels that consume shellfish (as an example) can suffer adverse consequences from consumption of cadmium-containing tissues. This has been well documented for avian species. . (E.g., Numbered References 16 & 18).

Based on these facts from the scientific literature, we can predict that increased environmental cadmium burdens may cause: 1) increase in shellfish mortality; 2) decrease in shellfish reproduction and population levels; 3) increased cadmium burdens in shellfish tissue with resultant accumulation in wildlife with consequent adverse effects on terrestrial, freshwater, and marine wildlife populations; 4) increased cadmium burdens in shellfish with the potential of shutdown of recreational and commercial harvests and/or increased human body burdens with resultant kidney damage and other pathogenic effects.

Thus the externalized cost of coal has to include (among a panoply of other costs) the negative economic, ecological and human health effects (including healthcare costs) of cadmium toxicities.

III. Partial List of Specific Concerns to Be Addressed in the EIS: The scope of the EIS for the Millennium Bulk Terminals at Longview should address the concerns associated with cadmium contamination outlined above. It should also address the implications for specific species, sites, and environmental systems that can logically be drawn from the concerns outlined. The following list is not exhaustive; like the Scientific Background sketch, the excerpts in the Numbered References, and the Bibliography, it implies many additional, specific questions that should be addressed. Responsible assessment of the concerns articulated here, and the additional concerns implied by them, should draw on all relevant scientific research worldwide. It will almost certainly require new, site-specific research as well.

The EIS should, among many other things, do the following:

1. Determine existing background cadmium levels in all areas that will be subject to coal dust accumulation both in the vicinity of the proposed terminals at Longview, WA and along the rail route(s) from the Powder River Basin. This should include, though not be limited to, estuaries and watershed areas along the Columbia River, riparian areas, and land and marine areas vulnerable to wind-borne coal dust in the vicinity of the proposed terminal and along the rail route(s) from the Powder River Basin.

2. Determine future "background" accumulations of cadmium in all these areas that can be expected from current and planned and proposed future activities, including rail transport of coal along the route(s) to destinations other than the proposed terminal at Longview.
3. Determine existing and expected future background accumulations of cadmium in watersheds of river systems where migratory fish, including salmon and steelhead, will travel upriver from areas with cadmium accumulation, spawn, and die, thereby transporting cadmium contamination upriver into the watershed.
4. Determine existing and expected future background levels of cadmium in humans who will be exposed either directly or indirectly to cadmium accumulation due to the proposed project.
5. Determine existing and expected future background levels of cadmium in all aquatic and terrestrial species that will be subject to direct absorption from coal and coal dust from contaminated land or water, and/or absorption through consumption of cadmium bearing animal or plant organisms.
6. Determine rates of bioaccumulation of cadmium in both aquatic and terrestrial species that will consume and be consumed by other organisms as part of the food chain and the ecosystem.
7. Determine vulnerabilities to cadmium toxicity of all threatened and endangered species, both aquatic and terrestrial, that may be subjected to increased cadmium levels from coal and coal dust generated by the proposed project. Again, we refer to all aspects of the transport, storage, and handling of coal from the Powder River Basin to the proposed terminal at Longview, as well as its transport by sea from the proposed terminal.
8. Determine the economic impact of increased shellfish mortality resulting from increased cadmium levels in all areas affected by the transport, storage, and handling of coal and coal dust from the proposed project.
9. Include in calculations of the quantity and range of coal dust dispersal and accumulation the prevailing wind patterns along the rail routes and in the vicinity of Longview. This must include the seasonal strong winds from the east along the Columbia River Gorge, as well as the frequent, strong southwest winds common to the region.
10. Include in the calculation of the accumulations of cadmium the amount that will be carried back in the atmosphere from the sites where the coal will be burned.
11. Determine vulnerability to cadmium toxicity and rates of bioaccumulation in salmon that consume aquatic species that will be subject to increased cadmium levels in all areas affected by transport, storage, and handling of coal.
12. Determine capacity for bioaccumulation of cadmium in salmon that will be subjected to increased levels due to the transport, storage, and handling of coal and the impact on upriver species both aquatic and terrestrial that will consume these salmon after they have migrated upriver, spawned, and died. Since salmon provide the principal source of nutrition for plants and wildlife in Pacific Northwest watersheds, this implies virtually all wildlife in watersheds with runs of salmon and steelhead that may be subjected to cadmium toxicity from the proposed project.
13. Determine public health impacts resulting from human consumption of shellfish with increased cadmium levels.
14. Determine economic impact of increased cadmium levels for commercial, recreational, cultural, and tourism activities associated with oysters, crabs, and other shellfish. Evaluate this impact in the light of current and expected levels of bacteria contamination

and ocean acidification, factors already recognized as threatening shellfish populations and thus impacting the human activities associated with them.

15. Base calculations of cadmium accumulations on expected rates of coal and coal-dust dispersal from transport by train, storage and handling at the proposed terminal, and subsequent transport from the terminal by ship.
16. Base additional calculations on the amounts of coal and coal dust that will predictably escape due to mishaps caused by acts of nature and human error. These include, among other things, floods, earthquakes, train derailments and accidents, and shipping accidents. (We note there have been several train derailments with spilled coal in the national news in the time since the application for the terminals at Longview was submitted. There was also a major collision of a coal transport ship with the loading dock at the coal terminal in Vancouver, BC, with major damage to the dock and coal spilled into the water [cf. The Vancouver Sun 12/8/12]).
17. Determine public health impacts of increased cadmium levels in shellfish, salmon, and other fish among human populations that by individual choice or in keeping with cultural tradition depend more on these food sources than the average population. This may include some Native American tribes and communities.
18. Determine public health impacts from direct contact with coal dust and also from the introduction of cadmium and other heavy metals into the food chain, including fish and shellfish to be consumed by humans as well as agricultural products potentially contaminated by coal dust.
19. Determine public health impacts from direct contact with wind-borne coal dust, exposure through the food chain, and also the return of cadmium in the air from coal we export being burned in Asia. This analysis should include cadmium introduced into water supplies.
20. Include in the analysis cadmium and other heavy metals introduced into the environment by escapement of water used to cool coal piles and lessen the amount of dust picked up by wind.
21. Include in the analysis the coal dust blown off train cars by wind as they wait on sidings, especially in populated areas and also along shorelines. Based on siding locations and wind patterns, certain areas and communities could thus experience heavier than average exposure and accumulation. Returning train cars must also be counted, since they do not empty completely. This is true particularly in winter when the coal arriving from Wyoming is still frozen and tends to remain on the inside surfaces of the car when emptied.
22. Among potential health impacts, consider that cadmium has been associated with learning disabilities in children.
23. Measure the effects of cadmium accumulation on oyster farming in the context of increasing ocean acidification and bacterial contamination.
24. Analyze the above effects in the context of cumulative effects based upon total emissions of heavy metals not only from domestic emissions associated with this proposal but also with the atmospheric deposition burden of transport back to the U.S. from end use sites, and that also in terms of the cumulative deposition via atmospheric transport from increase in worldwide coal use.
25. The analysis must incorporate the project-specific and also cumulative effects on carbon dioxide emissions, not only on global warming-climate change, but also on OCEAN

ACIDITY increases. Increases in ocean acidity will not only adversely affect all shellfish and calcium-dependent species, but may well lead to increased release of toxic heavy metals from ocean sediments and bedrock.

26. A similar analysis must be undertaken with regard to near-shore and deep oceanic sediment absorbed anthropogenic pollutants that may be increasingly released as ocean acidity changes.
27. The *in toto* effect of all the above must be related to the survival and fecundity of all threatened and endangered species, state or federal that occur in the affected ecosystems which of course are worldwide. That analysis must also be extended to all species of commercial interest.
28. Assess the above impacts of cadmium toxicity associated with coal transport, storage, and handling in a comprehensive, programmatic environmental impact statement that includes all coal terminals proposed in the Pacific Northwest.

IV. Analysis: The EIS should draw on research already carried out by scientists in the US and abroad. The bibliography (below) offers examples of available studies that can serve as points of departure. The analysis should also initiate new research to fill gaps in current knowledge and to extend it. The potential impacts of cadmium toxicity are too serious, too far-reaching, and too long lasting for anything but a complete and honest, scientific analysis.

V. Mitigation: We believe the concept of "mitigation" for these impacts is misguided. Many potentially affected species are already under stress and suffering declining populations due to various forms of toxic pollution and environmental degradation. These include species familiar to people who live near the Pacific Coast -- oysters, orca whales, salmon (Chinook, chum, sockeye, and coho in different locations), as well dozens more on the state and federal threatened and endangered species lists: American white pelicans, brown pelicans, bull trout, steelhead (various locations), rockfish (several varieties), fishers, sea turtles (green, leatherback, loggerhead), whales (blue, fin, humpback, orca, North Pacific right, sei, and sperm), sandhill cranes, and sea otters, to name some. To risk further declines and potential extinction of these species by allowing a project which will surely result in increased introduction of toxic substances into the environment is simply unacceptable. The same applies to negative impacts on human health. The only reasonable approach is to speak of *guaranteed prevention*. Given the current, available means of transport, storage, and handling of coal and the established record of this activity, we believe that guaranteed prevention is not honestly possible. Any company or its representative that would offer such a guarantee could not possibly be doing so in good faith. The true costs involved in transporting, storing, handling, and using coal *safely and cleanly*, if this were even possible, would be simply too great for there to be any profit in it. We include in the true cost the so-called "external costs," which typically are borne by communities, the general public, and the environment rather than the coal industry. The potential cost to human health and the environment from the accumulation and toxicity of cadmium, along with that of other heavy metals, must be included in the assessment. If it is, we believe it will be obvious there is no satisfactory way the effects can be "mitigated."

VI. Alternatives: There are many alternatives to building a coal-export terminal at Longview, WA that will work much better to help the local and regional economies, create good jobs, protect public health, and preserve the unique environment along the Columbia River, and along the rail route from Wyoming to Washington state. Longview, Cowlitz County, and the state of Washington should stay on course with existing initiatives to lessen rather than increase pollution in the Columbia River, protect existing jobs associated with shellfish harvesting and fishing, stop our use of coal for generating electrical power, and support research and development of wind and solar energy.

VII. Numbered References: These excerpts from scientific research publications illustrate the sorts of available data that should be considered in the EIS. Along with the resources noted in the Bibliography, they should serve as points of departure for a complete study.

Reference 1. "Critical Soil Concentrations of Cadmium, Lead, and Mercury in View of Health Effects on Humans and Animals," deVries, et. al.: "Assessment of the risk of elevated soil metal concentrations requires appropriate critical limits for metal concentrations in soil in view of ecological and human toxicological risks. This chapter presents an overview of methodologies to derive critical total metal concentrations in soils for Cd, Pb, and Hg as relevant to health effects on animals and humans, taking into account the effect of soil properties. The approach is based on the use of nonlinear relationships for metals in soil, soil solution, plants, and soil invertebrates, including soil properties that affect metal availability in soil. Results indicate that the impact of soil properties on critical soil metal concentrations is mainly relevant for Cd because of significant soil-plant, soil-solution, and soil-worm relationships. Critical Cd levels in soil thus derived are sometimes lower than those related to ecotoxicological impacts on soil organisms/processes and plants, which is especially true for critical soil Cd concentrations in view of food quality criteria for wheat, drinking water quality, and acceptable daily intakes of worm-eating birds and mammals."

Reference 2. "**Exploring Spatial and Temporal Variations of Cadmium Concentrations in Pacific Oysters from British Columbia," Feng, CX., et. al. (Abstract):** "Oysters from the Pacific Northwest coast of British Columbia, Canada, contain high levels of cadmium, in some cases exceeding some international food safety guidelines."

Reference 3. "Cadmium in Shellfish: The British Columbia, Canada Experience…," Bendell LI. (Abstract): "Over 10 years ago, research scientists in the federal department of Fisheries and Oceans Canada (DFO) were alerted to the presence of high levels of cadmium, a toxic metal, in the Pacific oyster (Crassostrea gigas) cultured in British Columbia (BC), Canada waters. This mini-review summarizes the most recent published studies on levels of cadmium in shellfish from the Pacific Northwest (BC and Washington State)."

Reference 4. "Geochemical Survey and Metal Bioaccumulation of Three Bivalve Species," Baudrimont, M. et. al. (Abstract): "A 15-month experiment combining a geochemical survey of Cd, Cu, Zn and Hg with a bioaccumulation study for three filter-feeding bivalve species (oysters, Crassostrea gigas; cockles, Cerastoderma edule; and clams, Ruditapes philippinarum) was conducted in a breeding basin of the Nord Medoc salt marshes connected to the Gironde estuary, which is affected by historic polymetallic pollution.… Although Cd bioaccumulation of oysters was lower in the basin than in the estuary during the same period (27,000 ng g(-1), dry weight and 40,000 ng g(-1), respectively) these values are largely above the new human consumption safety level (5000 ng g(-1), dw; European Community, 2002)."

Reference 5. "Cadmium Toxicity Among Wildlife in the Colorado Rocky Mountains," Larison, James R., et. al. (Abstract): "Our results suggest that cadmium toxicity may be more common among natural populations of vertebrates than has been appreciated to date and that cadmium toxicity may often go undetected or unrecognized. In addition, our research shows that ingestion of even trace quantities of cadmium can influence not only the physiology and health of individual organisms, but also the demographics and the distribution of species."

Reference 6. "Cadmium Toxicity to Three Species of Estuarine Invertebrates," Pesch, Gerald and Nelson E. Stwart (Abstract): "Three species of estuarine invertebrates, *Palaemonetes pugio* (grass shrimp), *Pagurus longicarpus* (hermit crab) and *Argopecten irradians* (bay scallop), were exposed to Cd in flowing seawater at concentrations of 0·06, 0·12, 0·25, 0·5 and 1·0 mg/litre. Incipient LC_{50} values of 0·53 and 0·07 mg/litre were estimated for bay scallop and hermit crab, respectively. The toxicity curve for grass shrimp had not stabilised, but the incipient LC_{50} value was estimated to fall within a range of 0·2 to 0·3 mg/litre. Short-term response, as measured by time to 50% mortality at the highest Cd concentration, was 10, 21 and 23 days for the bay scallop, hermit crab and grass shrimp, respectively. Scallop growth was inhibited at all exposure concentrations with a measured 42-day EC_{50} value of 0·078 mg/litre Cd. Byssal thread detachment precedes death in bay scallops. An EC_{50} value of 0·54 mg/litre Cd for byssal detachment was measured on day 8 of the bioassay before appreciable mortality. This compared favourably with the incipient LC_{50} value of 0·53 mg/litre Cd. Cadmium accumulation occurred at all concentrations in bay scallop and grass shrimp."

Reference 7. "**Acute Toxicity of Copper, Cadmium, and Zinc to Larvae of the Crab *Paragrapus quadridentatus* (H. Milne Edwards), and Implications for Water Quality Criteria," M Ahsanullah and GH Arnott** (Abstract): Acute toxicity tests were carried out on the larvae of *P. quadridentatus* and 96-h LC50 values of 0.17, 0.49, and 1.23 mg/l were determined for copper, cadmium, and zinc respectively. Potency ratios of the three metals were as follows: Cu/Cd 3.1, Cu/Zn 7.2, and Cd/Zn 2.4. Larvae were found to be nine times more sensitive to zinc and at least 29 times more sensitive to cadmium than were adults. The larval 96-h LC_{50} values multiplied by an application factor of 0.01 (as recommended in Victorian water quality criteria) results in derived 'safe' concentrations, which in the case of copper and zinc are below the stated 'minimal risk concentrations' of 10 and 20 μg/I respectively. In view of the known greater sensitivity of larvae of many taxa to heavy metal toxicity, the validity of using the same application factor for both adult and larval stages is questioned."

Reference 8. "Bioaccumulation of Cadmium in Marine Organisms," Frazier, JM. (Abstract): "A general review of cadmium concentrations in marine organisms and studies of cadmium bioaccumulation is presented. Factors which influence cadmium concentrations, such as regional differences, seasonal fluctuations and salinity, are discussed and species which are likely to accumulate cadmium identified. Experimental studies designed to investigate the influence of some of these factors on cadmium bioaccumulation in a filter feeding bivalve mollusk, the American oyster (Crassostrea virginica), are presented. Field studies of seasonal dynamics of cadmium in oysters indicate patterns which may be correlated with seasonal physiological activity. The bioaccumulation of cadmium following input to estuarine systems by natural phenomena is observed. Cadmium concentrations in oysters collected from regions of different salinity suggest an inverse relationship between cadmium concentration and salinity. Laboratory experiments designed to investigate mechanisms of cadmium accumulation demonstrate that an inducible cadmium binding protein, similar to metallothiomein, is present in the American oyster."

Reference 9: "Bioaccumulation of Cadmium in Marine Organisms," Ray, S. (Abstract): "It has been established that, although Cd occurs in the marine environment in only trace concentrations, most marine organisms, especially molluscs and crustaceans, can accumulate it rapidly. Cadmium is not uniformly distributed in the body and selectively accumulates in specific organs like liver, kidney, gills, and exoskeleton. The concentrations in muscle tissues are several orders of magnitude lower. The disposition of Cd in the organisms in the laboratory studies generally parallels those in nature. A number of biotic factors like body size, maturity, sex, etc. influence bioaccumulation but extensive studies are still lacking. The chemical form of Cd in the environment is of prime importance in bioaccumulation by marine organisms. Salinity can affect the speciation of Cd, and bioaccumulation is affected by both temperature and salinity. The ultimate level of Cd in the organisms will depend not only on the biotic and abiotic factors but also on metabolism of the metal by the organisms.... Much of what is known about Cd bioaccumulation by marine organisms has come from laboratory studies and there are inherent dangers in trying to extrapolate the results to field situations. In spite of tremendous progress made over the years, the basic understanding of the bioaccumulation process is still very nebulous and will remain so until the uptake, storage, and elimination processes are fully understood."

Reference 10. "The Comparison of Heavy Metal Accumulation Ratios of Some Fish Species in Enne Dame Lake (Kütahya/Turkey)." Uysal, K., et. al. (Abstract): "The metal accumulation levels for muscle, skin, gill, liver and intestine tissues of some Cyprinidae species (Carassius carassius, Condrostoma nasus, Leuciscus cephalus and Alburnus alburnus) in Enne Dame Lake (Kütahya/Turkey), which is mostly fed by hot spring waters, were investigated.... . In all tissues and the species, while the bioaccumulation factors (BAFs) of Mn, Zn, Fe and Cu were remarkably high, the BAFs of Mg, Cr, Co, and B were also fairly low or none. Although the heavy metal accumulation levels for the muscle were generally lower than other tissues, there were some exceptions. Cd level in the muscle of C. carassius was higher than the permissible limit stated by Turkish legislation, FAO and WHO."

Reference 11. "Health Effects of Cadmium Exposure…," Järup, L. et. al. (Abstract): "The diet is the main source of cadmium exposure in the Swedish nonsmoking general population. … It has been shown that a high fiber diet and a diet rich in shellfish increase the dietary cadmium intake substantially. Cadmium concentrations in agricultural soil and wheat have increased continuously during the last century. At present, soil cadmium concentrations increase by about 0.2% per year. Cadmium accumulates in the kidneys. Human kidney concentrations of cadmium have increased several fold during the last century…. In general, women have higher concentrations of cadmium in blood, urine, and kidney than men. The population groups at highest risk are probably smokers, women with low body iron stores, and people habitually eating a diet rich in cadmium. According to current knowledge, renal tubular damage is probably the critical health effect of cadmium exposure, both in the general population and in occupationally exposed workers. Tubular damage may develop at much lower levels than previously estimated, as shown in this report…. Even if the population average kidney concentration is relatively low for the general population, a certain proportion will have values exceeding the concentration where renal tubular damage can occur. It can be estimated that, at the present average daily intake of cadmium in Sweden, about 1% of women with low body iron stores and smokers may experience adverse renal effects related to cadmium. If the average daily intake of cadmium would increase to 30 micrograms/day, about 1% of the entire population would have cadmium-induced tubular damage. In risk groups, for example, women with low iron stores, the percentage would be higher, up to 5%. Both human and animal studies indicate that skeletal damage (osteoporosis) may be a critical effect of cadmium exposure."

Reference 12. "Current Status of Cadmium as an Environmental Health Problem," Järup, L., & A. Akesson. (Abstract). "Cadmium is a toxic metal occurring in the environment naturally and as a pollutant emanating from industrial and agricultural sources. Food is the main source of cadmium intake in the non-smoking population. The bioavailability, retention and toxicity are affected by several factors including nutritional status such as low iron status. Cadmium is efficiently retained in the kidney (half-time 10-30 years) and the concentration is proportional to that in urine (U-Cd). Cadmium is nephrotoxic, initially causing kidney tubular damage. Cadmium can also cause bone damage, either via a direct effect on bone tissue or indirectly as a result of renal dysfunction. After prolonged and/or high exposure the tubular injury may progress to glomerular damage with decreased glomerular filtration rate, and eventually to renal failure. Furthermore, recent data also suggest increased cancer risks and increased mortality in environmentally exposed populations. Dose-response assessment using a variety of early markers of kidney damage has identified U-Cd points of departure for early kidney effects between 0.5 and 3 microg Cd/g creatinine, similar to the points of departure for effects on bone. It can be anticipated that a considerable proportion of the non-smoking adult population has urinary cadmium concentrations of 0.5 microg/g creatinine or higher in non-exposed areas. For smokers this proportion is considerably higher. This implies no margin of safety between the point of departure and the exposure levels in the general population. Therefore, measures should be put in place to reduce exposure to a minimum, and the tolerably daily intake should be set in accordance with recent findings."

Reference 13. "Cadmium Exposure in the Population: From Health Risks to Strategies of Prevention," Nawrot, TS., et. al. (Abstract): "We focus on the recent evidence that elucidates our understanding about the effects of cadmium (Cd) on human health and their prevention. Recently, there has been substantial progress in the exploration of the shape of the Cd concentration-response function on osteoporosis and mortality. Environmental exposure to Cd increases total mortality in a continuous fashion without evidence of a threshold, independently of kidney function and other classical factors associated with mortality including age, gender, smoking and social economic status. Pooled hazard rates of two recent environmental population based cohort studies revealed that for each doubling of urinary Cd concentration, the relative risk for mortality increases with 17% (95% CI 4.2-33.1%; $P < 0.0001$). Tubular kidney damage starts at urinary Cd concentrations ranging between 0.5 and 2 µg urinary Cd/g creatinine, and recent studies focusing on bone effects show increased risk of osteoporosis even at urinary Cd below 1 µg Cd/g creatinine. The non-smoking adult population has urinary Cd concentrations close to or higher than 0.5 µg Cd/g creatinine. To diminish the transfer of Cd from soil to plants for human consumption, the bioavailability of soil Cd for the plants should be reduced (external bioavailability) by maintaining agricultural and garden soils pH close to neutral (pH-H(2)O of 7.5; pH-KCL of 6.5). Reducing the systemic bioavailability of intestinal Cd can be best achieved by preserving a balanced iron status. The latter might especially be relevant in groups with a lower intake of iron, such as vegetarians, and women in reproductive phase of life. In exposed populations, house dust loaded with Cd is an additional relevant exposure route. In view of the insidious etiology of health effects associated with low dose exposure to Cd and the current European Cd intake which is close to the tolerable weekly intake, one should not underestimate the importance of the recent epidemiological evidence on Cd toxicity as to its medical and public health implications."

Reference 14. "Cadmium Linked to Breast Cancer, " Brown, Anthony": "Women with the highest levels of cadmium in their urine have more than a two-fold higher risk of breast cancer than women with the lowest levels, according to a new study. However, further studies are needed to determine if these elevated levels are a cause or effect of breast cancer. Although cadmium, a heavy metal, has been classified as a probable cancer-causing substance by the US Environmental Protection Agency, until now no human studies have investigated its link with breast cancer."

Reference 15. "Health Concerns of Consuming Cockles (Cerastoderma edule L.) from a Low Contaminated Coastal System," Figuera E., et. al. (Abstract): "Commercial and recreational harvesting of shellfish within the coastal systems is usually very extensive. Since these ecosystems are frequently subjected to contamination, namely from agricultural, urban and industrial activities, and shellfish generally display a high capacity to bioaccumulate metals, populations may be at risk in terms of toxic metal exposure as a consequence of the harvesting and ingestion of near shore coastal marine organisms."

Reference 16. "Sea Ducks and Aquaculture: the Cadmium Connection," Bendell LI. (Abstract): "Elevated concentrations of cadmium have been reported in the kidneys of sea ducks that forage along the Pacific Northwest, and cadmium has been postulated as a possible cause of population declines. The blue mussel (Mytilus spp.) which occurs in dense numbers on aquaculture structures and are a primary prey item for sea ducks also contain elevated cadmium concentrations. To determine if foraging on mussels associated with aquaculture structures could pose a toxicological risk to sea ducks, amounts of cadmium ingested per body weight per day by a representative sea duck species, the surf scoter (Melanitta perspicillata), were estimated and compared to the reported avian cadmium NOAEL (no observable adverse effect level) and LOAEL (lowest observable adverse effect level). Results indicate that in some locations within the Pacific Northwest, sea ducks could be exposed to toxicologically significant levels of cadmium associated with mussels foraged from aquaculture structures. This raises the possibility that such exposure could be contributing to observed population declines in these species."

Reference 17: "Toxicity of Cadmium to Six Species in Two Genera of Crayfish and the Effect of Cadmium on Molting Success," Wigginton, AJ, and Birge W J. (Abstract): "Nine acute (96-h) toxicity tests were conducted on six species of crayfish (Cambaridae). Six tests focused on adults, and three tests examined juveniles.... Crayfish sensitivity to Cd varied by a factor of nine among species tested as adults and by a factor of 17 among species tested as juveniles. Molting was a sensitive life stage for crayfish. Most individuals that molted shortly before or during exposure to Cd died, whereas all controls that molted in the adult assays survived. Because molting is a sensitive, recurring life-cycle event, molting individuals should be included in toxicological analysis despite some contrary recommendations."

Reference 18: "Cadmium Hazards to Fish, Wildlife, and Invertebrates...," Eisler, Ronald (Summary): "Cadmiuim contamination of the environment is especially severe in the vicinity of smelters and urban industrialized areas. There is no evidence that cadmium, a relatively rare heavy metal, is biologically essential or beneficial; on the contrary cadmium is a known teratogen and carcinogen, a probable mutagen, and has been implicated as the cause of severe deleterious effects on fish and wildlife. The freshwater biota is the most sensitive group; concentrations of 0.8 to 9.9 ug Cd/L (ppb) in water were lethal to several species of aquatic insects, crustaceans, and teleosts, and concentrations of 0.7 to 570 ppb were associated with sublethal effects such as decreased growth, inhibited reproduction, and population alterations.... Freshwater and marine aquatic organisms accumulated measurable amounts of cadmium from water containing Cd concentrations not previously considered hazardous to public health or to many species of aquatic life; i.e., 0.02 to 10 ppb. ... It is now conservatively estimated that adverse effects on fish or wildlife are either pronounced or probable when cadmium concentrations exceed 3 ppb in fresh water, 4.5 ppb in saltwater, 100 ppb in the diet, or 100 g Cd/m^3 in air."

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(Note: The Scientific Background, the Numbered References, and the Bibliography for this scoping comment were contributed by Paul F. Torrence, Professor of Chemistry Emeritus, Northern Arizona Universitiy, and formerly Chief of Biomedial Chemistry, National Institutes of Health (retired).)