Response to *Review: Summary of the Existing Science Regarding Public Health Effects from the Spreading of Dairy Manure, With an Emphasis on Effects in Eastern Washington and the Yakima Basin*

This is a rebuttal and critique of a *literature review* that was submitted by Dr. Nichole Embertson of the Whatcom County Conservation District and the Washington Dairy Federation to the Yakima Regional Clean Air Agency in August of 2013. Her *literature review* was in response to a petition from fifty citizens to ban the land and aerial application of manure during inversions that trigger a burn ban. You will see that the *literature review* is a biased presentation with the intent to deceive the Yakima Regional Clean Air Agency and the people who live in the Yakima Valley.

Research Misconduct

"Some researchers are so at odds with the core principles of science that they are treated very harshly by the scientific community and by institutions that oversee research. Anyone who engages in these behaviors is putting his or her scientific career at risk and is threatening the overall reputation of science and the health and welfare of the intended beneficiaries of research.

Collectively these actions have come to be known as scientific misconduct. A statement developed by the U.S. Office of Science and Technology Policy, which has been adopted by most research funding agencies, defines misconduct as 'fabrication, falsification or plagiarism in proposing, performing or reviewing research or in reporting research results.' According to the statement, the three elements of misconduct are defined as follows:

- *Fabrication is 'making up data or results'*
- *Falsification is 'manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research record.'*
- *Plagiarism is 'the appropriation of another person's ideas, processes, results, or words without giving appropriate credit.'*

In addition, the federal statement says that to be considered research misconduct actions must represent a 'significant departure from accepted practices,' must have been committed intentionally or knowingly, or recklessly' and must be 'proven by a preponderance of evidence.' According to the statement, 'research misconduct does not include differences of opinion.'"

(Statement from the National Academy of Sciences, 2009)

What is a Literature Review?

"Definition: A literature review is an assessment of a body of research that addresses a research question. Purpose: A literature review identifies what is already known about an area of study. It may also identify questions a body of research does not answer and make a case for why further study of research questions is important to a field." (Harvard Graduate School of Education, n.d.)

Response to *Review: Summary of the Existing Science Regarding Public Health Effects from the Spreading of Dairy Manure, With an Emphasis on Effects in Eastern Washington and the Yakima Basin* paragraph by paragraph

Purpose & Scope

The author states, "It is postulated that the community members believe that there is a link between burn bans, manure application, and community health. The purpose of this review and professional assessment is to examine this postulation and assess its validity." The community members believe that there is a relationship between feces and infectious disease. That is why we teach children to wash their hands after using the bathroom. The community members believe that there is a relationship between particles in the air and respiratory disease. The community members believe that the purpose of burn bans is to protect human health, especially during air inversions.

The author states, "The scope of this review focuses only on dairy and dairy manure. Additionally, this review only looks at the emissions from the application of dairy manure to crop land, not emissions form the dairy operations themselves (i.e. housing, manure storage, etc.)". Much of the literature in this review describes animal waste in general and is not specific to the dairy industry. Some of the studies address waste from hog operations. Much of the literature in this review looks at all aspects of animal agriculture and dairy operations, not just manure application. It would be difficult to find sufficient relevant studies restricted to application of dairy manure to the land. The inclusion of health problems and complaints due to hog operations and other sources of air pollution is understandable and acceptable.

Summary Opinion

The author states, "Furthermore, the literature does not support the conclusion that dairy manure applied at agronomic rates to farm fields is a significant hazard to community health in the Yakima region. With the use of best management practices, any potential concerns with air pollutants from manure application can be actively mitigated to avoid potential transport to neighboring areas."

Thirteen of the forty references in the *literature review* address community health. Twelve of these references document elevated health risks related to concentrated animal feeding operations and/or air pollution. Only one agrees with Dr. Embertson's statement.

Donham et al (2007) state, with respect to poultry workers, "Significant dose-response relationships were observed between exposures and pulmonary function decrements over a work shift."

Heedrick et al (2007) state, "This working group, which was part of the *Conference on Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards—Searching for Solutions*, concluded that there is a great need to evaluate health effects from exposures to the toxic gases, vapors, and particles emitted into the general environment by CAFOs."

Merchant et al (2003) contributed 25 pages to the *Iowa Concentrated Animal Feeding Operation Air Quality Study* in which they documented the significant health problems related to CAFOs. They cited four studies on community health, all of which showed adverse health effects from CAFOs:

Merchant et al (2004) state, "The high prevalence of asthma health outcomes among farm children living on farms that raise swine (44.1%, $p = 0.01$) and raise swine and add antibiotics to feed (55.8%, $p = 0.013$), despite lower rates of atopy and personal histories of allergy, suggests the need for awareness and prevention measures and more population-based studies to further assess environmental and genetic determinants of asthma among farm children."

Mirabelli et al (2006) state, "Estimated exposure to airborne pollution from confined swine feeding operations is associated with adolescents' wheezing symptoms."

Ngo et al (2010) state, "We have observed seasonal variability in particle mass and composition along with small, significant changes in some markers of inflammation and cell viability. This type of field study, which characterizes ambient particulate-matter mixtures found in agricultural regions and determines health outcomes in animal inhalation models, helps provide new insights into how particulate matter affects agricultural workers and residents living in the San Joaquin Valley."

O'Conner et al (2010) performed a literature review for the United Soybean Board and the National Pork Board looking for an association between animal feeding operations (AFOs) and health effects in neighbors. The found 4,908 pieces of research and rejected 4,899 before completing their analysis. Based on only nine studies they concluded, "There was inconsistent evidence of a weak association between self-reported disease in people with allergies or familial history of allergies. No consistent dose response relationship between exposure and disease was observable."

Osornio-Vargas et al (2010) state, "Compelling evidence indicates that exposure to urban airborne particulate matter (PM) affects health. However, how PM components interact with PM-size to cause adverse health effects needs elucidation, especially when considering soil and anthropogenic sources. We studied PM from Mexicali, Mexico, where soil particles contribute importantly to air pollution, expecting to differentiate in vitro effects related to PM-size and composition. . . . We conclude that PM-size and PM-related soil or anthropogenic elements trigger specific biological-response patterns."

Schiffman (1998) performed a literature review that found over a hundred studies showing adverse health effects related to odor.

Schiffman and Williams (2005) cited over a hundred studies showing adverse health effects related to air pollution from confined animal feeding operations and proposed that technological solutions will be needed to protect neighbors.

Schiffman et al (2000) state, "Complaints of health symptoms from ambient odors have become more frequent in communities with confined animal facilities, wastewater treatment plants, and biosolids recycling operations. The most frequently reported health complaints include eye, nose, and throat irritation, headache, nausea, diarrhea, hoarseness, sore throat, cough, chest tightness, nasal congestion, palpitations, shortness of breath, stress, drowsiness, and alterations in mood. Typically, these symptoms occur at the time of exposure and remit after a short period of time. However, for sensitive individuals such as asthmatic patients, exposure to odors may induce health symptoms that persist for longer periods of time as well as aggravate existing medical conditions."

Schmalzreid and Fallon (2007) surveyed people living near two new 700 cow dairies. 87% felt that their property values were affected and 83% felt that these values had decreased. 47% feared that their drinking water would be affected and 69% felt that the quality of life was reduced. 92% had concerns about the smell of manure and 81% found the smell unpleasant. 70% felt that flies were a nuisance and 64% felt that the fly problem was bad. The authors argued that the neighbor's perceptions were not based on reality.

Williams et al studied bovine allergens and particulate matter in homes near Yakima County dairies. They state, "These findings demonstrate that dairy operations increase community exposures to agents with known human health effects. This study also provides evidence that airborne biological contaminants (i.e. cow allergen) associated with airborne particulate matter are statistically elevated at distances up to three miles (4.8 km) from dairy operations."

Overview of Yakima Dairy Manure Application Practices

Dr. Embertson states, "Following best practices, the majority of manure is applied to crops at agronomic rates using crop appropriate technologies." According to the Washington State Dept. of Agriculture 11% of the fields owned by dairy operations have soil nitrate levels greater than 45 parts per million, a sign of manure/fertilizer over application. In a county with 120,000 milk cows plus calves, replacement heifer's, and cattle for slaughter 11% is significant. This means that one out of ten dairies endangers public and environmental health by not following agronomic application guidelines.

Dr. Embertson details how and when manure is applied to the fields in Yakima County but she does not live here. Our observations differ. We know that manure is applied to bare fields during the months November, December, January and February. And these are the times when hospital admission rates for asthma are highest.

Can Dr. Embertson support the statement "A small percentage (<5%) of other crops and less desirable application technologies such as honey wagons (tanks) and Big Gun sprinklers are used for application, but the land acreage applying these technologies is small (<3%)." It is our observation that this type of application is very common in the lower Yakima Valley. If she cannot provide supporting references, then she is fabricating data.

Dr. Embertson states, “All dairy operations must apply nutrients (i.e. manure) according to their Dairy Nutrient Management Plan which outlines agronomic guidance and application restrictions. Restrictions include when not to apply (i.e. wind > 10 mph, inversions, high temperatures, etc.) what local criteria (i.e. schools, neighbors, wells, etc.) and setbacks need to be taken into consideration when applying and best methods for reducing nutrient losses via volatilization.”

The *Dairy Nutrient Management Act* applies to water pollution, not air pollution. There is a small paragraph in the 2012 NRCS *Conservation Practice Standard for Nutrient Management* that addresses air pollution. It simply says "Do not apply poultry litter, manure, or organic by-products of similar dryness/density when there is a high probability that wind will blow the material offsite."

We find no restrictions for applying manure during inversions, high temperatures or winds > 10 mph in the WA State NMP requirements. Although these recommendations are found in recommendations from Purdue University and Michigan State University they are not part of the YRCAA *Air Quality Management Policy for Dairies and Best Management Practices*. The closest that this document comes to regulating manure application is a vague “Apply during cool weather and on still rather than windy days.” It is a fact that neighbors have complained to YRCAA when one of the authors of the YRCAA *Air Quality Management Policy and Best Management Practices for Dairies* sprayed manure into the air during 40 mph winds.

Dr. Embertson states, “In general, the technologies, timing, and application restriction guidance followed by the majority of dairy operations in Yakima meet the best management practice guidelines encouraged by University guidance and research for maximum reduction of emissions during application for ammonia, dust and odor (Smith et al, 2009; Webb et al, 2010; Rotz et al, 2011; Brandt et al, 2011).” None of the references cited examines best management practices in the Yakima Valley. They only define dairy best management practices and manure application in general. They <u>do not</u> state that dairy operations in the Yakima Valley follow BMP guidelines.

Smith et al (2009) used a simulation model to analyze various types of manure spreading with respect to ammonia losses. They found that putting lime on the soil to raise the pH increases NH3 emissions. Delaying manure spreading till later in the day reduces NH3 losses. Rainfall and incorporating manure into the soil immediately reduce NH3 emissions. It is our observation that farmers in the Yakima Valley apply manure to the fields at all hours of the day and do not routinely incorporate manure into the soil after application. There is little rain in the Yakima Valley with annual precipitation of around 8 inches per year.

Webb et al (2010) reviewed the literature to determine the “impacts of manure application methods on emissions of ammonia, nitrous oxide and crop response.” They recommend open slot injection or trailing shoe application methods and note that incorporation into the soil is the most effective way to reduce ammonia emissions. We are unaware of any studies that detail how many operations in the Yakima Valley utilize these methods of application. Sufficient to say, we see frequent aerial applications of manure and flooding of fields with manure.

Rotz et al (2011) created and tested a dairy farm model to determine optimal feeds to meet fiber, energy and protein needs for six sub groups of dairy animals. We do not see how this relates to ammonia, dust and odor during manure application.

Brandt et al (2008) measured odor in the ambient air after different types of manure application to the land. They did not assess the "Big Gun" approach and did not assess human health or agronomic rates. They found differences in effect ranging from worst to best: surface broadcast > aeration infiltration > surface + chisel incorporation > direct ground injection = shallow disk injection > control (no application).

Burn Bans and Manure Application

Wood stoves may be the number one contributor to excess PM 2.5 in most areas of Washington State and in the Rocky Mountains. This does not mean that agricultural activities do not exacerbate the situation. Neither YRCAA nor the dairy industry has done the research needed to quantify the contribution of animal agriculture to PM 2.5 in the Lower Yakima Valley. The situation here is quite different from most parts of the state. The fact that smoke from wood stoves is the major contributor to PM 2.5 in Ellensburg, for example, does not mean that this is the major contributor in Sunnyside. The research by Ward and Lange (2009) is not from "a similar region". The northern Rocky Mountains of Montana do not have high concentrations of dairy cows.

The statement, ". . emissions from manure and nitrogen-based chemical fertilizers are considered a precursor to PM 2.5 when ammonia from applied nitrogen volatilizes and comes in contact with available nitrous and sulfuric acid gases that are released into the atmosphere from vehicles and combustion processes (NOx and SOx) to form fine particulates through chemical reaction." is incorrect. Ammonia reacts with nitric acid, not nitrous acid to form particulate matter.

Dr. Embertson states, "Depending on atmospheric conditions and geographic location, this pathway contributes less than 10% of the total secondary PM 2.5 production in the atmosphere (Hristov, 2011). She omits Hristov's ensuing comments, "In certain areas and in cool weather, farm animal contribution to atmospheric PM 2.5 concentration may be as much as 20%." His graphics show that this scenario is especially true in the Pacific Northwest. (Please see pp. 3130 and 3133 of Hristov's Technical Notes)

Dr. Embertson states, ". . . manure is not typically applied from November to February to the crops grown in dairy production in Yakima, WA." This is simply untrue. Year round application is one of the main reasons that citizens requested a ban on manure spreading during inversions.

Dr. Embertson states, "Ammonia volatilization is significantly reduced during cold weather due to thermal reduction in biological and chemical processes in manure and the soil." However, Hristov (2011, p. 3133) states, "In the cooler months, the formation of ammonium nitrate is favorable, and hence the presence of ammonia can significantly increase PM 2.5 concentrations." His graphs show that around 19% of particulate matter in the northwest can be attributed to agricultural animals. May we suggest

that this may be even higher in the lower Yakima Valley where we have a winter nitrate problem and an overabundance of ammonia from concentrated animal feeding operations?

Emissions from Manure Application

Ammonia and PM 2.5

Dr. Embertson states, “Ammonia is produced from applied manure when conditions such as temperature, pH, and oxygenation allow hydrolysis of urea (in urine) and urease (in feces and soil) to form ammonia gas. For land applied manure, this reaction is catalyzed by the increased surface area and exposure of manure to aerobic conditions on the soil surface. Ammonia volatilization typically peaks within hours to days of application depending on manure type (solid versus liquid), application technology, and meteorological conditions (i.e. wind speed, temperature, precipitation, etc.) (Amon et al, 2006; Hristov et al, 2009; Leytem and Dungan, 2009)”. The referenced study by Hristov et al does not address manure type, application technology or meteorological conditions. Their study was a laboratory testing of a new way to estimate ammonia losses using various chemical markers. Leytem and Dungan (2009) did not address land applied manure, manure type, application technologies or meteorological conditions. They measured ammonia concentrations during different seasons at open lots, compost yards and lagoons on a 10,000 cow dairy in southern Idaho.

It is important to note that Amon et al state in their abstract, “Ammonia emissions mainly occurred after field application.”

Hristov (2009) states "Ammonia emitted from animal feeding operations is an air pollutant contributing to the formation of fine particulate matter (PM2.5), considered a major environmental risk to human health."

Dust (PM 10)

Dr. Embertson states, “However, while biologically derived aerosols (bioaerosols), such as fecal and bacterial origin dust may be present in manure applied to fields, survivability of pathogens through the manure storage period, treatment, and application process is low (McGarvey et al, 2004; Ravva et al 2006; Grewal et al, 2006). It would help to define “low”.

When they used aerobic plate counts McGarvey et al found bacterial counts of 2,100,000,000 CFU/g in manure, 1,900,000CFU/ml in separator pit water and 280,000 CFU/ml in lagoon water. When they used anaerobic plate counts they found bacterial counts of 6,900,000,000 CFU/g in manure, 5,500,000 CFU/ml in separator pit water and 670,000 CFU/ml in lagoon water.

Ravva et al (2006) only studied the ability of E coli 0157:H7 to survive in dairy wastewater with or without aerators. They found low survival rates, possible due to competition from other organisms.

Grewal et al, (2006) studied *Escherichia coli* O157:H7, *Listeria monocytogenes*, *Salmonella* spp., and *Mycobacterium avium* subsp. *paratuberculosis* (*Mycobacterium paratuberculosis*) under different

manure treatments. In liquid manure and pack treatments, some of these microorganisms were detectable up to 28 days. *M. paratuberculosis* DNA was detectable through day 56 in all treatments and up to day 175 in liquid storage treatments.

Dr. Embertson did not address components of dust that have a greater impact on human health than bacteria. These include: the particles themselves, feed materials, endotoxins, fungi and viruses.

Manure Application and Health Effects

Dr. Embertson states, "In fact a comprehensive review of scientific studies conducted by O'Conner et al (2010) looked at the associations between animal feeding operations and measures of health of individuals living near animal feeding operations and found that there were very few applicable studies (0.2%) and no compelling evidence for a consistent, strong association between the clinical measures of disease and proximity to animal feeding operations."

The truth is that O'Conner et al (2010) performed a literature review for the United Soybean Board and the National Pork Board looking for an association between animal feeding operations (AFOs) and health effects in neighbors. The found 4,908 pieces of research and rejected 4,899 before completing their analysis, using just nine pieces of research.

The petitioners referenced 106 pieces of research that describe adverse health effects from confined animal feeding operations. Dr. Embertson simply chose to ignore most of these studies when she considered manure application and health effects.

Dr. Embertson states, "Additionally a study surveying quality of life characteristics of residents living near and far from animal feeding operations concluded that emotional considerations, not physiological ones played a large part in perception of the impact of those facilities on health. (Schmalzreid and Fallon, 2007)."

Let us put this study in context. It was published in the Journal of Dairy Science and represents an attempt to understand concerns of neighbors. The study is based on a thirteen question survey that assessed public perceptions of property values, water quality, flies, odor and demographics. There were no questions regarding physiological symptoms experienced by neighbors or their emotional responses to a nearby CAFO. In addition, this study analyzed neighbors' response to two 700 cow dairies. We can state with confidence that people in the Yakima Valley would not be complaining about one or two isolated 700 cow dairies. The number of dairy cows in the Lower Yakima Valley (120,000) is almost 100 times greater than the 1,400 cows in the survey by Schmalzreid and Fallon.

Dr. Embertson states, "Of the few relevant studies available, most are largely inconclusive and/or found no direct, replicable connection between farm exposure and health effects (Merchant et al, 2004; Heedrick et al, 2007; Muryama et al, 2010)"

In fact, Merchant et al (2004) studied four asthma outcomes in children who live in rural Iowa. The outcomes are doctor-diagnosed asthma, asthma/medication for wheeze, current wheeze and cough with exercise. They found a significant association between living on a hog CAFO and these four symptoms. The association was even stronger for hog CAFOs that fed antibiotics to the swine:

- Do not live on farm/do not raise swine – 33.6% have asthma symptoms
- Live on farm/do not raise swine – 26.2% have asthma symptoms
- Live on farm raising swine, 1–499 head – 42.9% have asthma symptoms
- Live on farm raising swine, 500+ head – 46% have asthma symptoms
- Live on farm raising swine and adding antibiotics to feed – 55.8% have asthma symptoms

The reference to Heedrick et al (2007) is difficult to address because this is another literature review that happens to come from Europe where CAFOs are more stringently regulated. There are abundant references to European studies that document adverse health effects related to animal feeding operations. They state, "This working group, which was part of the Conference on Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards—Searching for Solutions, concluded that there is a great need to evaluate health effects from exposures to the toxic gases, vapors, and particles emitted into the general environment by CAFOs. Research should focus not only on nuisance and odors but also on potential health effects from microbial exposures, concentrating on susceptible subgroups, especially asthmatic children and the elderly, since these exposures have been shown to be related to respiratory health effects among workers in CAFOs."

Muryama et al (2010) did not study farm exposure and health effects. Theirs was a laboratory analysis of air "immediately adjacent to the agricultural spreading of bovine slurry". They found 16 bacterial genera in the air. "Only a few" were found to cause illness in humans and none were "previously described" as being passed by inhalation. For these reasons the authors concluded that none of the bacteria in the applied manure "pose a significant health and safety threat."

Pollutant Exposure Limits

Ammonia

Dr. Embertson documents exposure limits for ammonia of 300 parts per billion for chronic exposure based on the 2003 work of Merchant et al. In 2012 the Agency for Toxic Substances and Disease Registry established minimum risk levels of 1.7 parts per million (ppm) for acute exposure and 100 parts per billion (ppb) for chronic exposure. (ATSDR, 2012)

Dr. Embertson states, "Downwind measures of ammonia from applied manure rarely exceed concentrations in parts per billion (ppb) (Williams et al, 2011)". The referenced study had nothing to do with wind direction or manure application. It did not even mention these parameters. Dr. Williams states, "This does not represent my work." (Personal conversation, Sept. 2013)

Dust (PM10)

Dr. Embertson cites the research of McGarvey et al, 2004; Ravva et al, 2006; Grewal et al, 2006, Hutchison et al, 2008; and Dungan, 2010. All of these studies addressed bacteria in agricultural wastes and dust. None of them looked at the physiological impact of particulate matter per se.

The Environmental Protection Agency (EPA) states, "Major concerns for human health from exposure to PM-10 include: effects on breathing and respiratory systems, damage to lung tissue, cancer, and premature death. The elderly, children, and people with chronic lung disease, influenza, or asthma, are especially sensitive to the effects of particulate matter. Acidic PM-10 can also damage human-made materials and is a major cause of reduced visibility in many parts of the U.S. New scientific studies suggest that fine particles (smaller than 2.5 micrometers in diameter) may cause serious adverse health effects. As a result, EPA is considering setting a new standard for PM-2.5. In addition, EPA is reviewing whether revisions to the current PM-10 standards are warranted." A list of the extensive research that has been done in this area is available from the Environmental Protection Agency at http://www.epa.gov/ncer/publications/workshop/11-30-2005/pmcentersabstract.pdf

Conclusion

Dr. Embertson's conclusion is not supported by the data she provided in her literature review. There is substantial evidence to support the hypothesis that adding more contaminants to air that is already dangerous for vulnerable people increases health risks to the community. She simply chose to ignore it.

Dr. Embertson has omitted research on several relevant factors that impact this discussion. She has not discussed the work that the Washington State Department of Ecology is doing in the Yakima Valley regarding surprisingly high levels of nitrates in the winter air (Van Recken et al, 2013). She has ignored research performed by the University of Washington that found high levels of ammonia in homes near CAFOS in the Yakima Valley (Turcios et al, 2004). She has ignored the fact that Yakima County has a higher rate of pre-term births than Washington State as a whole and that pre-term delivery has been associated with elevated PM 2.5 in the ambient air (Washington State Dept. of Health, 2013b). She has ignored the recent finding of a high incidence of anencephaly in this region which has not yet been explained. She has ignored the higher rates of certain infectious diseases in the Yakima Valley (Washington State Dept. of Health, 2013c). She has omitted the fact that Yakima County has one of the highest rates for asthma hospitalization in Washington State (Washington State Department of Health, 2013a). She did not cite research linking inversions to impaired health in spite of the fact that a recent, well-known study in Utah shows a strong connection between prolonged inversions and hospitalization for asthma. (Beard et al, 2011). She ignored the 106 pieces of research provided by the petitioners to support their request. She did not address sulfur dioxide, hydrogen sulfide, endotoxins or volatile organic compounds.

Thank you for reading and considering this material

Jean Mendoza

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