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Dear Catharine:

In follow-up to the DNR's workgroup this year for implementation of $PM_{2.5}$ standards, I submit this letter as public follow-up to the Iowa Environmental Council's participation on the On-the-Books/Precursors/Transport Subcommittee. Most of what follows consists of research on the role of ammonia emissions from agricultural sources, and there are recommendations herein for the Air Quality Bureau's consideration as it compiles its reports for the Iowa Legislative Assembly and the Governor's Office.

The stakeholder process that was implemented under House File 2418 proved worthwhile, in the Council's opinion, in bringing together disparate interests to talk about the various issues in atmospheric chemistry, emissions inventory, interstate transport, modeling and monitoring, and source sector applicability. We look forward to development of permitting programs and other forms of implementation that bear in mind the environmental and health costs of $PM_{2.5}$ pollution and the benefits from reducing concentrations of this pollutant, along with the needs of regulated industries.

The comments below largely concern agricultural sources. This should not be read by the DNR or any other entity to mean that the Council has an anti-farming agenda. Indeed, we believe that agriculture is central to the state's economy. The Council is concerned that farming practices reflect good scientific conclusions, that they account for the needs of Iowans whose health, recreational, and other lifestyle opportunities are impacted, and that agricultural pollutants receive greater attention and more efficacious solutions than they do at present.

Prioritization of $PM_{2.5}$ precursor compounds

As regulated industries face even more exacting NAAQS and permitting limits for direct $PM_{2.5}$ and precursors such as sulfur dioxide and NOx, the relatively unregulated sources of ammonia (NH_3) are increasing in importance as chemical precursors of ammonium nitrate (NH_4NO_3) and ammonium sulfate ((NH_4)2SO_4S particles. Several agency reports have drawn attention to this issue (Iowa DNR 2004, 2006, 2008; NADP 2000), and EPA has coordinated with commodity groups and university researchers to further develop the understanding of ammonia's impact in the National Air Emissions Monitoring Study (NAEMS; see https://engineering.purdue.edu/~odor/NAEMS/). The United Nations Food & Agriculture Organization (2006) concluded that "Major reductions in [the impact of livestock on environment] could be achieved at reasonable cost." The National Academy of Sciences reported data that show animals and agricultural land as the leading global and US sources of ammonia, in descending order (Ad Hoc Committee 2003).

This finding is well supported by National Emissions Inventory data that were included in a DNR presentation (Page 2010). Dr. Charles Stanier's work with the Lake Michigan Air Directors' Consortium (LADCO) data on wintertime episodes of high ammonium nitrate concentrations (Baek et al. 2010, Stanier 2009) quite clearly shows that (1) agricultural sources need to join currently permitted NAAQS facilities in some proportioned response, whether through regulation or stepped-up voluntary efforts; and (2) adoption of ammonia air emissions controls are likely to have some effect on downwind concentrations. Earlier, Erisman and Schaap (2004) had indicated the need to reduce ammonia releases in relation to European secondary $PM_{2.5}$ formation, a conclusion based on findings that are strikingly aligned with the results from Stanier and colleagues.

At present NH_3 is given very low priority as a $PM_{2.5}$ precursor and pollutant, largely for fear that any attempt to control it will impose financial hardships on Iowa's agricultural and rural economies. It is the opinion of the Council that the DNR should explore whether it should be a "presumed precursor," given its importance in the formation of ammonium nitrate and ammonium sulfate, and given that the other two components in these aerosols already are "presumed precursors." The results of the Stanier Group's work with the LADCO winter nitrate study, cited above, strongly indicate the need to consider ammonia as a key variable in these episodes of high $PM_{2.5}$.

Ammonia emissions modeling & monitoring

A substantial literature that provides rationales for monitoring and modeling of ammonia currently exists. This area is not within the technical expertise of the Iowa Environmental Council. However, we recognize that there are complex factors in estimating emissions. The current IMPROVE monitor network, intended largely for regional haze, provides a relatively good sense of ammonia concentrations over the Upper Midwest. In addition several projects that were conducted by the Iowa DNR have assisted in understanding emissions, dispersion, and models.

Of note are these selected literature sources:

- A CENRAP ammonia emissions report (Coe & Reid 2003) that includes a wide variety of sources from crop fertilizers and livestock species.
- Modeling techniques to distinguish natural landscapes and fertilized soils (Battye & Barrows 2004)
- Emissions from livestock facilities (Pedersen et al. 2004), including broiler housing (Gates et al. 2008), waste storage and treatment (Aneja, Chauhan & Walker 2000), and liquid dairy manure application (Leytem et al. 2009)

Emissions controls of NH_3

The need for better control of NH_3 as a $PM_{2.5}$ precursor is supported by the general literature on $PM_{2.5}$ as a health hazard, as well as specific analyses (for example, ATSDR 2004, Osterberg and Wallinga 2004, Sigurdarson & Kline 2006, Wing & Wolf 2000). In addition, ammonia and co-pollutants have direct and indirect health and environmental consequences. While conversion of NH_3 to the ammonium nitrate aerosol form occurs at unknown flux rates, that such conversion takes place is undisputed. European researchers estimate that 50% or more of secondary $PM_{2.5}$ comes from the chemical reaction of NH_3 with NOx (after its conversion to nitric acid, itself problematic) and SO_2 (Oenema et al. 2007). Further, NH_4NO_3 deposits to the surface in currently unestablished amounts, exacerbating nutrient loading in surface waters of the state (see Stensland, Bowersox & Claybrooke n.d.). Thus there are two points in this process that warrant additional research: atmospheric chemical conversion of emitted ammonia to NH_4NO_3, and deposition of NH_4NO_3 to the surface. Also this speaks to a likely need for the DNR's Environmental Services bureaus, researchers, and others to coordinate efforts because of the air-to-water links.

Despite views expressed in the On-the-Books Subcommittee to the contrary, there are several agricultural best practices that are known to reduce ammonia and other pollutants significantly, and studies of their effectiveness and costs have been done (Burns 2007; ISU Extension 2004; Joint CAFO Study Group 2002; McCubbin et al. 2002; LADCO 2007; Pinder, Adams, & Pandis 2007;Reynolds n.d.). Research on manure incorporation in soil has shown that several techniques are effective, including two techniques that were studied at the USDA's Agricultural Research Service station in Kimberly, ID (cited in the *Iowa Farm Bureau Spokesman*, Oct. 27, 2010, p. 12). Several single-pollutant and multi-pollutant biofiltration systems are known to cut air emissions of direct $PM_{2.5}$ and NH_3 from swine housing (Burns & Xin 2009, ISU Extension 2004), and entrepreneurs in Illinois are taking advantage of this research as an economic opportunity to market filtration systems. Better control of swine feed inputs will reduce overall N levels in manure, with lessened impacts for air and water (Sutton 2008). Methods for reducing NH_3 emissions from poultry litter have been studied (Moore 2010).

Research and analysis for the European Commission (Oenema et al. 2007; see also sources cited by Sutton 2008) indicates that closer attention to the nutrient balance of crop fertilizers (i.e., manure and anhydrous ammonia) possibly is the single most effective means of reducing atmospheric ammonia, nitrous oxide (N_2O, a greenhouse gas), and nitrate (NO_3) in surface waters. The last result may not apply directly to the agricultural scenario of the Upper Midwest, but its results are telling: the emissions inventory for ammonia in Iowa places livestock (building ventilation, open feedlots, manure management) as the higher source of NH_3, with croplands (manure & anhydrous fertilizers, plus smaller fractions of emissions from crop residues) as a near second.

<u>Policy considerations</u>

A conclusion is that the DNR needs to work diligently to apply appropriate pressures, based on the state of research on atmospheric chemistry and transport, emissions, and public health, on the agricultural sector in order to step up controls of NH_3. Of note is the European Commission report's finding that direct ammonia controls have mixed results, as at least some actually increase surface water nitrate and N_2O air emissions. It would seem that the better option for control of NH_3 precursor emissions may be the control of NO_3 and <u>its</u> formative compounds, in relation to both manure and ammonia fertilizers. However this conclusion is tentative and direct controls of emissions are known to be effective, as cited above.

Several attempts at regulation have failed for one reason or another, such as the attempt to establish H_2S and ammonia standards in 2003. There has been no effort on the part of the Iowa Legislature to revisit this, except in the form of the odor study bill, passed in 2008. While research evidence suggests that strategies to control odors do result in reduced release of criteria pollutants and air toxics, it is worthwhile to note that several malodorous components of manure, namely indoles and phenols, are not recognized as air toxics. Questions need to be asked and answered about whether control of odors as such is more protective of environment and health than an approach that directly addresses specific pollutants. In addition the 2008 legislation violates the principle of "polluter pays" by placing a share of costs on taxpayers. One result is that this law has not been implemented; the study it provides for has not taken place, because of budgetary constraints and a political unwillingness to raise taxes for most any purpose.

Out of a sense of equity, we would like to see Iowa's agricultural interests to step forward as a regulated or self-regulated industry sector, at least to assure the wider installation and maintenance of ammonia emissions control practices that can make badly needed improvements in air and water quality. The cost of good air emissions practices and regulations should be spread across the entire agricultural sector, from the large corporations that write contracts for small producers and control distribution and consumption patterns, to consumers who seem to want large amounts of disposable income and very cheap necessities such as food. This avoids the commonly cited problem of placing an undue burden on small farms, farm families, and family businesses.

Shih et al. (2006) point to an "integrated process model" by which all costs of production, including health and environmental costs or benefits, are included in economic analyses. This discussion paper specifically outlines $PM_{2.5}$ reduction from control of NH_3 precursor emissions, and it describes how "farm operators [can] internalize social benefits" as well as costs.

In conclusion, the research literature from Iowa, the US, and Europe indicates numerous directions that might be taken in regard to ammonia as a secondary $PM_{2.5}$ precursor and as a contributor to poor air quality and exceedance days in some locations in Iowa. The Council has indicated above several steps that the DNR might take in addressing these. We believe that these are best for all Iowans, for regulated businesses and industry sectors, and, when all is considered, for agriculture and the farming economy in Iowa.

Thank you for this opportunity to submit these additional comments.

Sincerely,

Leland M. Searles, PhD
Air Quality Program Director

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