

**Preliminary Comments from Members of the Chartered SAB on the SAB
Draft Original Report *Reactive Nitrogen in the United States: an Analysis of
Inputs, Flows, Consequences, and Management Options: (January 20, 2011
Draft)***

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Comments from lead reviewers

Comments from Dr. Ingrid Burke

Note: Since I was not part of the original review, it is a bit difficult to know how much the document was improved over the former version. Rather, I am evaluating whether the report, as it stands, meets the original study objectives, as though it were just released. I read and enjoyed the report through fresh eyes

1. Does the report meet the study objectives?

The study is attractive, well-organized, and thorough in most respects. The study objectives provided an important template, and one that is a bit uneven in its challenges. That is, some of the study objectives were relatively tractable, and others much less so. Specifically, the first and last objectives, reviewing the N problems and their linkages, and suggesting research to reduce risks, were pretty achievable. The committee did a really nice job with these.

Chapter 2 is an excellent review of N sources, transformations, and Chapter 3 also good at reviewing impacts of N. The big picture, and the content covered, I think, is fine (I do have some comments below though).

The review of risk reduction strategies (Chapter 5) was very interesting. Among the interesting components of this section is that there is only one finding, and one recommendation, and they don't relate much to a good deal of the chapter. Is this one finding and recommendation sufficient to meet the study objectives? Isn't this where the rubber was supposed to meet the road, with recommendations?

2. Are there technical errors or omissions in the report, or issues not adequately dealt with? And
3. Is the draft report clear and logical?

The large scale estimates of N storage using C:N have gigantic error associated with them (section 2.3.2 "Storage of N within Terrestrial Environmental Systems (why "environmental", by the way?), for two reasons. First, the carbon stock estimates alone have large uncertainty, and second, the C:N estimates are highly variable. Finally, after taking us through all the calculations, the report notes on page 38 that the estimates are probably +/- 50%. I remain unconvinced that this is an important section, but it's ok, as long as the main message is not that we know how much N is absorbed, nor that a lot of N is absorbed by terrestrial ecosystems. What is the main message, though? I am not sure that Finding #9 quite expresses it; N release as a proportion of input likely shows as high in grasslands and forests because input is so low. Those systems are not where the N source is, and the Finding and Recommendation are not well substantiated.

Literature citations are a bit sparse and focused in an odd way on case studies. For instance, the Danish example is useful but seems a bit of a stretch (and does Figure 9 have the correct y axis label, by the way? The Figure is titled "total cereal grain production" but the y axis says "Fertilizer N Used".). The outcome of the Danish study is that with reduced N application, yields were still high, but protein contents decreased. The following two paragraphs then make an assumption that yields go down (which does not follow the case study), and suggest that CRP

lands would have to come out of production to balance reduced yields. What? And Finding 2, just following this section, states that “Nr inputs are critical to sustain crop productivity and soil quality”. A little more pithy use of case studies with clear results will be easier to follow. (And I might disagree with the finding here, because it remains unclear to me that yields will go down, necessarily, if N fertilization is reduced. And further, later in the report the issue of U.S. protein in diets does not compel concern).

4. Are the recommendations supported by the body....?

The report recommends (#6) a policy, regulatory, and incentive framework for manure, management but not for N fertilization, in general, nor N fertilization for biofuel production. *I think this is my major comment. Why is nothing like this recommended?* The authors are the best people on the planet to do this report, so there must be a reason, but I’d like to hear it.

The report also suggests that EPA study “how biofuel expansion will affect ...Nr”. Alternative recommendations might: a) this study could project how biofuels expansion will affect Nr, and recommend policy approaches (there are an awful lot of studies by EPA, DOE, and NRC right now that provide sufficient information); b) recommend monitoring to assess ongoing changes in biofuel impacts on Nr.

Finally, most of the recommendations for research are fine; they are well connected to the findings. Again, I found that there was a bit of a gap in terms of findings, conclusions, and recommendations related to integrated risk reduction (Chapter 5).

Comments from Dr. Terry Daniel

General comments

This report continues to be an important report of impressive scope and exhibits high technical quality. The report could provide a great service to EPA and to environmental management more generally.

The changes since the September 2009 draft have improved the report very substantially, but there are several key aspects of the report that seem not yet fully resolved:

1. The report is not consistent in the apparent intended audience. Some sections present very detailed technical discussions of data collection/monitoring systems, chemical processes, and even research methodologies that are clearly “too much information” for the public or even for sophisticated non-N scientists and policy makers. Other sections present “tutorials” on basic (textbook) ecological, agricultural and chemical (atmospheric, terrestrial and aquatic) topics that seem inappropriate for an expert science audience and reviews (and critiques) of the historical development and current status of EPA (and other) relevant regulations and policies that should already be familiar to involved regulators (who may or may not agree with the Committee’s assessment of their efficacy). The strongest parts of the report seem to better hit a “middle ground” where the focus is more clearly on integrating science and technology across multiple fields to address the identified policy issue—excess Nr in the environment.
2. Related to the audience question is achieving an appropriate balance between “science” and “policy” for an SAB report/advisory. This issue was much more problematic in the earlier draft and is much better handled in the current draft, but there are still many places (including the letter to the Administrator-see below) where the balance still seems tilted too far toward the policy advice side. The terminology of “target goals” magnifies the impression that policy (rather than science) advice is intended. A better terminology is used on page 9 where the Committee refers to “actions that could be taken by EPA or other management authorities” to reduce excess Nr in the environment. Following this model, the 25% reduction “goal” could be translated into a science-based estimate of how much Nr reduction could be achieved if the identified integrated management actions (mostly based on existing (or at least “realistic”) science, technology, BMP and other available policy tools) were implemented.
3. The presentation of “Findings/Recommendations” boxes throughout the report is a very effective “summary and conclusion” device, but the format for these F/R statements is not always consistent. The strongest examples have a clear “finding X, therefore recommendation Y” format, where the foundation for the finding is clear in the immediate preceding text, the finding is stated succinctly and the recommendation clearly follows from the finding (see some specific good and bad examples below).
4. The paper is quite long and complex and needs a succinct “summary and conclusion” at the end. Chapter 6 is too long, presents too much new (and repeated) information and too detailed information to serve this purpose.

Quality Review Questions

1. YES: The original 4 objectives stated by the IN Committee are appropriate and adequately addressed, though some are more effectively addressed than others and some presented material is not strongly related to any of the stated objectives;
2. NO: There do not appear to be any technical errors or omissions or issues that are inadequately dealt with in the panel's report;
3. YES: the panel's report is for the most part clear and logical;
4. YES: The conclusions drawn and the recommendations provided are supported by the body of the panel's report, but they could be presented.

Specific/editorial comments

Letter to Administrator

P1

use of reactive nitrogen in a way to achieve its benefits **as a fertilizer**

["Fertilizer" does not seem to capture all of the important benefits, especially the positive contributions of Nr to ecological health and function.]

- Identify and analyze from a scientific perspective the problems reactive nitrogen presents in the environment and the links among them;

[Consider instead, • **Identify and analyze from a scientific perspective the threats to human health and the environment posed by excess reactive nitrogen;**]

- Evaluate the contribution an integrated nitrogen management strategy could make to environmental protection

[**Define and evaluate an integrated nitrogen management strategy to protect the environment and human health;**]

- Identify additional risk management options for EPA's consideration;

[**Identify and assess the efficacy of alternative Nr risk management options for EPA's consideration;**]

In general, the Committee finds that:

- The introduction of human created **excess** Nr into the environment degrades air and water quality, which can cause harmful algae blooms, hypoxia, fish kills, loss of drinking water potability, loss of biodiversity, forest declines, and human health problems resulting in losses of billions of dollars per year.

- In the U.S., human activities across multiple sources currently introduce more than five times the reactive nitrogen (Nr) into the environment than natural processes. The largest U.S. sources of new reactive nitrogen entering the U.S. environment include: the creation and use of synthetic fertilizers, Nr created by **cultured** legumes, and the combustion of fossil fuels.

- Much of the Nr used to ensure a plentiful supply of food, fiber and biofuel is released to the environment, as is **all** of the Nr formed during fossil fuel combustion.

- **Multiple new strategies and actions exist to more effectively maximize nitrogen use efficiency while minimizing the inputs of harmful excess Nr to the environment.**

P2

The framing of the nitrogen cascade (the movement of nitrogen among various environmental reservoirs) provides a means for tracking nitrogen as it changes form and passes through multiple ecosystems and media. This complexity requires the use of innovative management systems and regulatory structures to address the environmental and human health implications of the significant damage caused by excess Nr. New institutional structures and relationships that

reflect the multi-media and multi-form character of Nr and its flows and transformations through the environment will have to be created for effective control and management.

The Committee provides the following overarching recommendations to improve the management of Nr.

- An integrated approach is needed for the effective management of Nr. This approach must use a combination of implementation mechanisms appropriate to the specific environmental and policy contexts and supported by critical research on the specific risks of Nr in each context. The approach must recognize the complexity and trade-offs associated with the nitrogen cascade and capitalize on intervention points that maximize efficiency and cost effectiveness.
- ...

In the context of addressing the specific study objectives, the Committee explored how an integrated strategy of management actions based on existing technology could realistically be implemented over the coming 10 to 20 years, resulting in an estimated 25 percent reduction in Nr introduced into the environment.

Executive Summary

P xviii (Impacts of ...)

It seems clear here and elsewhere in the report that the “direct” human health effects of Nr are considerably less diverse and (perhaps) less important than the adverse environmental/ecological effects. In this context, it might be useful to introduce the ecosystems services concept (referred to later in the report) to emphasize that the “environmental effects” are of concern precisely because of their likely significant (indirect) effects on human health and wellbeing.

P xx

Thus, between 1900 and 2002, the amount of anthropogenic (?) Nr introduced to the U.S. has increased by approximately 10-fold.

Figure 1

Is the “Industry” contribution properly labeled as Haber Bosch N Fertilizer?

P xxi (Fig. 1 Explanatory notes)

These notes could more efficiently be replaced by a few minor edits/additions to the text relevant to figure 1.

development and standard setting; total maximum daily load (TMDL) development; National Pollution Discharge

P xx11

Footnote 2 seems unnecessary as this is perhaps the main point of the whole report, and it could better be articulated as part of the main text of this section.

P xxiii

The Committee addressed four objectives: ~~in the following manner.~~

Counting the preceding statement of the charge objectives, the objectives are restated verbatim three times in the executive summary. Ideally, each objective would be stated once. For example, the “Objectives of the SAB ...” section could be re-titled as and reconstructed as:

Objectives of the INC report

To assist EPA in its understanding and management of nitrogen-related air, land, and water pollution issues, and to respond directly to the specific charges of the SAB, the Integrated Nitrogen Committee addressed four objectives, as briefly summarized below:

Objective #1: Identify and analyze, from a scientific perspective, the problems Nr presents in the environment and the links among them.

To address this objective, the Committee used the nitrogen cascade framework to determine the major sources of newly created Nr in the U.S. (Figure 2). The flows of Nr within the food, fiber, feed and bioenergy ...

Etc for the four objectives. Within each of the “objective” summaries, incorporate as “bullets” the “specific findings/recommendations” currently presented beginning on page xxiv. The summaries under each objective, and especially the “specific recommendations” should be further tightened to only present key points and to reduce their length as much as possible.

“Major findings” and “Over arching recommendations” should be combined/integrated into one section.

Page xxv

Four recommended management ~~options~~ actions

Consistent with the overarching and specific recommendations noted above, the Committee identified four management actions that could be undertaken in the near term by applying existing proven science and technology and determined how those actions could contribute to the reduction of excess Nr in the environment.

1. Emissions from many point sources are currently controlled with low-NO_x burners or NO_x reduction, and NO_x controls for modern on-road vehicles are effective. If NO_x equipment were installed on currently uncontrolled industrial boilers and power plants, and technologies currently applied to on-road vehicles were applied to off-road vehicles, locomotives, ships and other devices with internal combustion engines, the Committee estimates that a **2.0 Tg N/yr** decrease in the generation of Nr could be achieved.

Each of the 3 remaining actions should be described in a similar format—translating the Nr reductions from a “target” or goal to a result (estimate) of taking recommended (doable) actions.

Implementing these suggestions will decrease the amount of Nr introduced into the United States by a total of about 25%, which will similarly decrease the amount of Nr lost to the atmosphere, soils and waters. The Committee believes that these represent realistic and attainable near-term ~~targets~~ **outcomes**, however further reductions are undoubtedly needed for many N-sensitive ecosystems and to ensure that health-related standards are maintained.

Page 3-9 (Chapter 1)

This is an excellent chapter that seems to hit just about the right level of detail and technical sophistication and, with some minor editing (below) achieves about the right balance on the science to policy advice dimension. Suggested changes include:

P 8

The footnote describing the nitrogen cascade should not be needed here—this main contribution of the report should be made completely clear by the preceding main text in Chapter 1.

4. The Committee identified actions that could be taken based on available science and management practices to improve the integrative management of N. The Committee suggested ways in which each of these actions could be accomplished and estimated that together they could decrease Nr losses to the environment by about 25%.

5. The Committee identified research needed to improve the scientific foundation to support specific Nr risk reduction activities.

The purpose of the workshop was to receive public input on several subjects: the Committee's preliminary assessment of Nr problems, consequences, and remedies, with emphasis on risk reduction; the Committee's quantitative ~~suggestions for estimates of~~ attainable Nr reductions ~~targets~~; and mechanisms whereby the Nr strategy might be enacted.

Structure of the report

This report contains six chapters. This introductory chapter provides an overview of problems caused by excess reactive nitrogen and describes the study objectives and approach. Chapters 2-6 discuss how the Committee has addressed the four study objectives and present specific findings and recommendations. Specifically:

- Chapters 2 and 3 address study objective 1, identification and analysis of the problems nitrogen presents in the environment and linkages among these problems. Chapter 2 focuses on the sources, transfer, and transformation of reactive nitrogen in environmental systems and Chapter 3 describes the impacts of reactive nitrogen on aquatic, atmospheric, and terrestrial ecosystems.
- Chapters 4 and 5 address study objective 2, evaluation of the contribution an integrated nitrogen management strategy could make to environmental protection. Chapter 4 describes EPA's current activities to manage reactive nitrogen and Chapter 5 discusses integrated risk reduction strategies.
- Chapters 5 and 6 address study objective 3, identification of additional risk management options for EPA's consideration. In Chapter 6, the Committee identifies conservation measures, additional regulation, and applications of modern technologies that could reduce the loss of reactive nitrogen to the environment. The Committee believes that the estimated Nr reductions are realistic and could be attained in the near term using current technology. However, the Committee emphasizes that

further reduction beyond these targets will be needed to protect many N-sensitive ecosystems and to ensure that health-related standards are maintained.

■ Study objective 4 (recommendation of improvements in reactive nitrogen research to support risk reduction) is addressed in all of the report chapters and Chapter 6 contains a section describing the need for a comprehensive program to monitor Nr in the environment.

Throughout this report there are boxes containing summary statements labeled “Findings and Recommendations” for actions that could be taken by EPA or other management authorities. The findings and recommendations corresponding to each of the study objectives are consolidated in Chapter 6.

Chapter 2

This is an important chapter that covers a lot of material. In several places, depending upon what audience is being assumed for the report, it extends the discussion into the “too much information” realm. For example, the section starting on p 16 that purports to be about “Nitrogen fertilizer use” does cover that information, but also includes a lot of rather detailed information and discussion of data needs, data systems, and the sufficiency/insufficiency of both. The “finding/recommendation” at the end of the section makes it clear that it is really about data, not about “use.”

Finding 1/Recommendation 1

Irrespective of the importance or timeliness of the discussion of fertilizer data, this box is a good example of a well structured F/R box. It follows directly from the preceding text, it states the finding succinctly (though perhaps including a bit too much detail about the TgN, given the point is about data sufficiency) and the recommendation clearly is the right “therefore” based on the finding.

Figure 7 is interesting and informative, but the associated text discusses details of the year to year changes in NFUE that are too fine for the reader to see on the figure (e.g., 1974-76, 2002-05). The introduction of specific costs (\$ per pound/kg or per acre/hectare per year) adds to an already complex text without doing much to strengthen the main point—that changes in NFUE have important effects on N input/Nr escape. This and much of the detail about farmer decision making pushes this section into the TMI category as well.

Figure 9 cries out for some explanation for the high variability before about 1995.

Figure 10 and the associated text raise the question of whether NFUE should be measured in terms of “protein production” rather than “grain production.” This difference seems to be important (especially assuming that it also affects meat production ability of the grain), but it is ignored (unless I missed it) in the later sections of the report where it seems to be relevant.

F/R 2

The finding, which is mostly about the need for achieving higher NFUE, is well stated and well founded in the preceding text. However, the recommendation responds only indirectly to this need, and is phrased as “obtaining better information.” The last sentence of the finding (about inadequate research, extension and conservation programs) provides some transition to the information/data recommendation, but it is not clear how the recommendation is a logical “therefore” given the stated finding.

F/R 3 is better stated, but F/R 4 again presents findings about substantive problems with fertilizer use and animal diet changes which does not seem directly addressed by the recommendations for more research and models. The material in the R part about “current models and understanding are not adequate” should be moved up to the finding to provide the needed bridge to the R.

P 28

The section on ammonia-ammonium chemistry seems TMI for the point that needs to be made. Is it safe to assume that those who will be able to understand this already learned it in school (while it is likely too late for those of us who did not)?

P 31

Chapter 2 already covers a lot of ground and the “source” part seems to come to a natural end here. The Committee should consider whether 2.3 on could better be separated into a new chapter that is focused on the very important issues of N transfer and transformation. It would seem that such a new chapter might well lead off with a quick review with a repeat or a modified graphic (e.g., a Millennium Assessment picture-gram) of the N cascade model, and then organize the material around the model.

P 36

SOC is the same as SOM-C?

Chapter 3

Another very substantial chapter that begins to get the report more and more into “policy” territory. Changes to this section will depend upon where the SAB and Committee come down on the desired location along the science-policy dimension (aka, I have no time and I am too tired to offer any really useful detailed suggestions for this chapter just now). I note that the “target/goal” language tends to come back in more strongly again here, but it seems that minor editing could translate this into “doable actions and estimated effects on Nr.”

P 42

According to the USGS (Barber, 2009) *Summary of Estimated Water Use in the U.S. in 2005*, total water withdrawals in the U.S., excluding thermoelectric power usage, were 210 billion gallons per day, of which 44,200 million gallons per day (MGD) were for public water supply.

[So, where does the rest of the water go? I am just asking.]

Text box 2—TMI

Figure 20—TMI

Figure 21—WOW, something like this would have worked swell earlier in the report, and it might even be broken up into pieces and used to illustrate sections of the report.

Text box 5—The figure and the text do not seem to connect—how would one find the data for 1993 and 1998 on the figure?

Chapter 5

The section on tradable permits, as a management/policy option seems very long and detailed relative to other options covered. Does this imply a stronger recommendation of this approach than the Committee (or the SAB) intend?

Several parts of the biophysical/technical controls section get into the TMI range.

Chapter 6

A key concern in this chapter is the return to the target/goal terminology, which again can be (and should be) fixed rather readily, consistent with prior suggestions. “Target goals” should be labeled (and presented as) management actions that have estimated effects on Nr.

Figure 27 is (by now) unreadable and does not seem to offer any useful information above the statements in the text.

P 90 (Summary of specific findings ...)

This section seems to go back to a level of detail that is not helpful in getting the “main points” of the report across. Breaking up the findings and recommendations under each objective (previously presented as F/R boxes) does not help. I have already suggested that this chapter, as presented, does not serve the much needed purpose of a “summary and conclusions.” It might be transformed into a shorter more integrative conclusion, or a separate summary/conclusion might be added. Either way, the many findings and recommendations need to be distilled and prioritized in some way—repeating them all in the order of the initiating objectives does not work well to bring the report to an effective close.

Some FINAL comments/suggestions regarding the Integrated N Report

In addition to the enormous contributions on understanding of N, Nr effects, and Nr management the report could more explicitly be a model for (and an additional inducement for) the “transformation” of EPA research (and regulation/management) toward a multi-media/multi-stressor approach. This

should be explicitly noted in the letter to the Administrator, as well as within the body of the report.

It was not clear at the end of the conference call whether the IR Committee intends to completely shift away from the “target goal” terminology and strategy for presenting the potential Nr reductions that can be achieved by the various integrated actions that are addressed. It seems relatively easy, and very appropriate for a science advisory report, to edit the current text so as to clearly present the individual “targets” as estimates of the N reductions that could be achieved by implementing identified management actions that could be taken based on current science, technology and best management practices (but not based on any formal cost/benefit, political, legal analysis, etc). In this way the potential reductions achieved are presented as estimated results of the actions, and the sum of the actions is found to amount to approximately a 25% overall reduction. The current text already shows that there is a good scientific basis for expecting that the actions identified could be taken and the estimated reductions achieved. This approach avoids the need to justify what appears to be an arbitrary 25% “target” (and sub-targets).

Regarding the inclusion of the N Cascade diagram in the Executive summary, the authors might consider whether a pictogram, similar in form to Figure 21, might provide the needed illustration of the N Cascade in a form better suited to the Executive summary.

Comments from Dr. David Dzombak

The report is a very impressive synthesis and evaluation of the state of understanding of the influence of anthropogenic inputs of nitrogen on the nitrogen cycle, and the resulting impacts on land and water ecosystems. It will be an important reference for researchers, land and water system managers, and regulators. I congratulate the committee for their devoted efforts to the development of this comprehensive report, and their diligence in revising and improving it in response to the extensive SAB comments on the first version (September 2009) of the report. The revised report is very much improved and in my view is will be ready for publication after some additional, relatively minor revision.

1. Comment on whether the report meets the study objectives.

The four study objectives are stated clearly in the letter to the Administrator, the Executive Summary, the introduction in Chapter 1 of the report, and the summary of findings and recommendations in Chapter 6 of the report. In my view the study objectives have been met.

2. Comment on whether there are any technical errors or omissions in the report or issues that are not adequately dealt with in the draft report.

The report examines many issues in great depth, and I have not conducted a close review of all of the specific technical information presented in the report. However, for the technical portions of the report I examined carefully I did not find any technical errors.

Considering the broad scope of the report, the committee made judgments about topics to include and topics to omit. There are other topics that could have been included, such as the potential for reformulation of fertilizer chemistries. However, the scope and focus areas chosen by the committee were broad and comprehensive, and I found the treatments thorough. In my view the chosen scope is comprehensive, adequate, and defensible. I support the scope limits for topics selected by the committee.

I do have some suggestions for specific items not mentioned in the report which the committee may wish to include:

- (a) The National Academy of Engineering has identified management of the nitrogen cycle as one of 14 grand challenges for engineering in the 21st Century (<http://www.engineeringchallenges.org/cms/challenges.aspx>). This speaks to the importance of the topic addressed in the SAB report. I recommend that the identification of nitrogen management as a grand challenge by NAE be included in the Executive Summary and Introduction to the report.
- (b) The National Research Council has conducted several recent studies (NRC 2008b and NRC 2009 as cited in the SAB report) examining water quality challenges in the Mississippi River, with particular focus on the nutrient loading challenge, and the ability of the Clean Water Act to address these challenges. In regard to nutrient control, the NRC reports makes a series of recommendations regarding command and control

options, market based instruments, and biophysical and technical controls which can be implemented for nitrogen control. The NRC findings and recommendations are not cited and discussed in Chapter 5, but should be to help strengthen the chapter. In particular, the NRC findings and recommendations in both reports regarding the need for establishment of numerical water quality criteria for nutrients would be useful to discuss in Section 5.3.1; and the findings and recommendations in NRC (2009) regarding how implementation of nonpoint source nitrogen control best management practices could be promoted would be useful to discuss in Section 5.3.4.

3. Comment on whether the draft report is clear and logical.

By subdividing the material in the report into more chapters, moving some of the material to technical appendices, and more clearly identifying findings and recommendations, the committee has significantly improved the logic flow and clarity of the report. There are some specific, relatively minor steps that can be taken to improve the clarity of the report further, and these are listed below.

- (a) Letter to the Administrator, line 1: need to define what is meant by “reactive nitrogen” and distinguish from plain “nitrogen”
- (b) Letter to the Administrator and throughout the report: I am not a fan of “Nr” for reactive nitrogen. I think this will be confused as an element by some lay readers of the report. I think that N_{reactive} or reactive-N would be better to use. I am not insistent on a change, but I wanted to state my view on this.
- (c) Executive Summary: The ES includes no references, apparently by design, which I guess is acceptable but there are important statements of fact within the ES (e.g., the numbers given for sources, transfer and transformation of Nr in column 1 of page xx, and the related Figure 1) which stand out as needing supporting references. I am not insistent on addition of critical references to the ES, but the committee should consider it.
- (d) Executive Summary, page xviii, col.1, para. 2: Before the last sentence, it would be useful to add a statement about the extent to which N mass fluxes have been increased in the natural N cycle due to anthropogenic inputs. This is discussed in the body of the report.
- (e) Executive Summary, page xx, and throughout report: Convention in scientific publications is to place figure captions below graphics (and table titles above tables, as is done in the report). For Figure 1, and for all figures in the report, the caption is placed above the graphic. This was repeatedly a problem for me as I read the report and looked below the graphic for a caption only to find none, or only a partial caption (sources are cited below some figures; source information is usually included as part of a caption). I recommend that figure captions be moved to be below the graphics for consistency with convention in scientific publications.
- (f) Executive Summary, page xxi, col. 1: It is very strange to put a subsection in the report text entitled “Figure 1 explanatory notes”. These notes should be placed in the figure caption, which is undoubtedly where they were originally before a copy editor moved them into the text in this awkward, confusing, and non-conventional manner.
- (g) Chapter 2, pages 12-13: The continuation of Table 2 on page 12 should have the table title repeated above the table. The presentation of the footnotes for Table 2 in a column of the report text on a page separate from the table is not conventional and doesn't work

well, in my view. I recommend removing the panel of three photographs on the top of page 12 and placing the table notes below the table in the usual manner.

- (h) Chapter 1, page 4; Chapter 2, page 12; Chapter 3, page 42; Chapter 4, page 54; Chapter 5, page 70; Chapter 6, page 84: The inclusion of panels of three photographs across the top of one page in each chapter presents some interesting graphics in the report, but all of these graphics are presented without numbering and without explanation. For some it is apparent what they are and how they relate to the discussion in the chapter, for others it is not so clear. I am not a fan of including unexplained, un-numbered, and un-captioned graphics in the body of the report. If they are to be included in this manner, perhaps they could be used in a separate cover page for each chapter, rather than embedding them in the text of the chapter.
 - (i) Chapter 2, page 35; Chapter 3, page 44.; Chapter 3, page 49; Chapter 4, page 56; Chapter 4, page 67: The word “Text” should be removed from the titles of the boxes for consistency with convention and with box titles used elsewhere in the report (page 72).
 - (j) Chapter 4, page 67, Figure 23: The size of the figure makes it difficult to interpret and almost illegible. Please increase the figure size.
 - (k) Chapter 6 title: The chapter includes a summary of key findings and recommendations, not just recommendations. I suggest that “Findings and” be inserted before “Recommendations” in the title. If changed here, the table of contents must be changed also.
 - (l) Chapter 6, pages 84-85: For consistency with the format used elsewhere in the report, the overarching recommendations should be numbered (rather than lettered), which will facilitate reference to them.
 - (m) Chapter 6, pages 90-96: Inclusion of this summary of specific findings and recommendations corresponding to the four study objectives is effective and well organized. With the new and effective approach of highlighting and numbering key findings and recommendations throughout the report, I was expecting to see a numerical identification for all of the key findings and recommendations presented here but grouped according to study objectives. For a majority of the specific findings and recommendations presented here, a parenthetical note is included at the end giving the specific finding or recommendation number. However, there are many findings and recommendations presented without such a mapping to a specific number. Since this is a summary chapter, in my view only findings and recommendations developed previously in the report should be included here. This is not the place for introduction of new findings and recommendations. I believe that specific finding and recommendation numbers from previous chapters can be identified for most of the statements missing such numbers in parenthetical notes, and I recommend that the numbers and parenthetical notes be included for all findings and recommendations given here.
4. Comment on whether the conclusions drawn or recommendations provided are supported by the body of the draft report.

The conclusions and recommendations are adequately supported by detailed discussion in the body of the report.

I do have suggestions for linking some specific findings and recommendations more directly to the body of the report.

- (a) Figure 1 on page xx in the Executive Summary is presented without citation of any source for the data used to formulate the figure. Further, the figure is not presented in the body of the report. Normally, figures and tables included in executive summaries are taken directly from the body of the report. I recommend that Figure 1 be included in Chapter 2 of the report, where the sources of data used to construct it should be made clear.
- (b) The summary of specific findings and recommendations related to each of the four study objectives which is presented in Chapter 6 of the report should have identification numbers included with each specific finding and recommendation presented to map all of them clearly to specific findings and recommendations developed in the body of the report (see also Comment 3m).

Comments from Dr. Madhu Khanna

The purpose of the study is to identify the environmental problems caused by reactive nitrogen, evaluate the potential for an integrated nitrogen management strategy to protect the environment, identify risk management options and make recommendations to EPA on areas for additional research to reduce risks from reactive nitrogen. The revised report is well organized and makes clear recommendations for EPA's consideration. In response to the comments from the SAB Chair, the report has been substantively revised to improve clarity and linkages between objectives and recommendations. The actions taken by the committee to respond to the comments on the previous report have resulted in a report that is readable, comprehensive and clear in its assessment of the sources of reactive nitrogen to the environment, the potential for reducing it, the challenges of doing so and the need for an integrated multi-media and multi-agency strategy to effectively reduce the reactive nitrogen being discharged into the environment.

My main comment is regarding the need for more support for the assessment that the various management options identified in the report will decrease the Nr introduced in the US by 25%. In general, the revisions in the report do make it clear now that the 25% reduction is being described as an opportunity for reduction in Nr and not a target but the need for a justification for arriving at that percentage instead of some other percentage has not been addressed. However, the issues raised in Consensus Comments 9 and 13 (pages 4 and 5 of the Summary of Revisions) have not been fully addressed. Numerical estimates of potential reductions in Nr that could be achieved through various strategies are provided in the Executive Summary. However, the methods and rationale used to arrive at these estimates is not clear from Section 6.3. As a specific example, the Executive Summary states that "Crop output can be increased while decreasing Nr by 20% amounting to 2.4Tg N/yr." Section 6.3 (page 78) on the other hand discusses this issue in very general terms and does not provide support for concluding that a 20% reduction is possible on a large scale and whether this percentage is being considered to be technically or economically (or both) viable. The discussion on NFUE on page 17 is extremely clear and comprehensive in describing the current knowledge about the NFUE and the possible ways to improve it, but it also does not show how it can be concluded that a 20% reduction in Nr is feasible. Moreover, it is not clear that some of the benefits of the same strategies are not being double counted. For eg on page xxv, the report states that improvements in fertilizer application methods could reduce NH₃ emissions by 20%. Are these improvements also likely to affect NFUE and lead to additional reduction in Nr? Furthermore, Section 6.3 discusses several strategies for Nr reduction, such as removing cropland from production, changing dietary patterns, adopting BMPs etc. The recommended management options on page xxv provide numerical estimates for reductions possible with a few of these strategies. It would be helpful to clarify if the other strategies are not considered viable or if their benefits cannot be quantified and to provide a brief rationale for selecting the management options discussed in the executive summary.

To add greater clarity to the potential reductions that could be achieved, the Committee might also consider revising Table 2 to include a column that shows their assessment of reductions possible for each of the sources of Nr to the environment and is consistent with the estimates provided in the Executive Summary (page xxv).

It would also be helpful to discuss the current state of knowledge about the extent to which the reduction potentials identified in this report are technically feasible vs. economically

viable. For eg. what kinds of economic incentives would be effective in increasing the NFUE to levels discussed in the report.

There are a few other areas where the discussion could be clarified and made more consistent across the report. The potential for soil testing and site specific fertilizer management in reducing N use and increasing crop yields could be discussed some more. Specifically, most of the discussion on pages 20-21 is about low input systems, to lower N use, and the costs it will impose on farmers, livestock and the economy because it is likely to reduce crop yields. The potential for reducing N use without reducing yields through the adoption of innovative technologies like precision farming and the current state of knowledge on that potential is not discussed here. The potential for new technology options that improve crop and soil management is mentioned briefly on page 78. Since improved technologies are being described as a major source for improving NFUE, it could be supported with more evidence from the current literature.

The report finds that the expansion of corn ethanol and use of its co-products (DDGS) has the potential to increase N use and that expansion of cellulosic biofuels could also lead to similar outcomes. Here it should be clarified that the impact of cellulosic biofuels on N depends on the type of cellulosic feedstocks being considered. The removal of crop residues like corn stover will require additional application of nitrogen to replace the nitrogen removed with the biomass; moreover, excessive rates of removal of corn stover could increase erosion and run-off and worsen nitrogen discharges. On the other hand, energy crops like miscanthus require much lower applications of nitrogen than corn and increase N fixation and soil carbon sequestration. [Sarah C. Davis, S.C. et al. "Comparative Biogeochemical Cycles of Bioenergy Crops Reveal Nitrogen-Fixation and Low Greenhouse Gas Emissions in a Miscanthus x giganteus Agro-Ecosystem," *Ecosystems* (2010) 13: 144–156, DOI: 10.1007/s10021-009-9306-9]. Recent research also suggests that low input energy crops can lower N run-off compared to corn production. Thus cellulosic biofuel feedstocks need to be distinguished based on their N requirements and implications for discharging N to the atmosphere and sequestering soil carbon.

The report makes an important point in Findings 11 and 12 that the nitrogen load reductions required to meet TMDLs are often above attainment potential; to achieve these goals substantial changes in regulatory approaches, management technologies and economic demands would be needed. Another limitation of existing approaches to meet TMDLs is often the lack of a clear linkage between TMDL goals and strategies to achieve them within the watershed with adequate consideration of whether there are economic incentives to implement those strategies on the part of landowners. The EPA should be encouraged to consider whether the various policy/regulatory incentives that exist in a watershed (based on various EPA and USDA programs) to reduce N use and provide the incentives needed achieve the TMDL in the watershed and if other policies are needed instead. Greater emphasis should be placed on more site-specific policy approaches that target incentives to specific locations in the watershed instead of uniform incentives across participants in a watershed program.

The diagram presented in Table 17 is an interesting way to compactly present various market based strategies and conditions under which they are effective. However, it is very complicated diagram to understand and should be simplified and/or accompanied with more explanation in the text. It would also be helpful if some concrete examples of policies such as auction based contracting, ITQs etc, in the context of water quality, were provided in the text.

Some of the text in the various boxes is also not clear (e.g Pollution is an absolute (?) consequence of the production process). The role of ITQs for nitrogen management should be explained. The diagram mentions insurance for adoption of BMPs but not existing policies which are primarily cost sharing and financial payments for adopting BMPs.

Comments from Dr. Catherine Kling

Overall, the committee has done a nice job of revising the report. The “Summary of Revisions ...” was very helpful and made the review task easier. The committee has put together an outstanding document that I suspect will generate a lot of discussion and visibility for the issues raised.

a) Does the draft report adequately address the original charge questions to the SAB Panel?

Yes, this is a thorough report.

b) Is the draft report clear and logical?

Yes, the revised chapter organization is a definite improvement. The use of boxes for major findings and recommendations

c) Are the conclusions drawn, and/or recommendations made, supported by information in the body of the draft SAB report?

I still have a minor issue with some of the language used in relation to recommendations for management options and the 25% reduction goal. For example, in the Executive Summary (page xxv) and chapter 6 (page 90), the committee calls for increased funding use of Clean Water State Revolving Funds construction grants. It seems clearly outside the SABs purview to point to a specific source of funding: if the engineering, economic, and physical science suggests that removing additional nutrients through sewage treatment infrastructure is a good approach, then that is what the report should say. Stipulating a particular revenue source is beside the point and really cannot be supported by science.

A second example occurs with respect to the recommendations regarding livestock emissions. In recommendation #2 (again in the Exec Summary and chapter 6), the committee “finds that livestock derived NH_3 can be decreased by 30%....” The use of the “can” clearly indicates that the committee has determined that there is the ability to achieve this reduction. However, later in the same paragraph, the committee states: “Additionally, we recommend decreasing NH_3 emissions derived from fertilizer applications by 20%...” The use of the word “recommend” suggests a great deal more than that fertilizer reductions can achieve a 20%, but rather that these should be the approach pursued.

I would like to see someone do one more careful edit through the document with respect to this issue. I don’t see this as a major shortcoming and it shouldn’t be that much work to change.

Comments from Dr. Judith Meyer

1. Were the original charge questions to the SAB Committee adequately addressed?

YES This is a report that the SAB can be proud of! The authors compiled a vast amount of information on reactive N in the environment and presented it in an understandable and well-organized fashion. The revised document is a substantial improvement over the earlier version. I reviewed my criticisms from the earlier document and find that the revision has dealt with them.

2. Are there are any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee's report?

NO. I do have a couple minor comments:

xxi, R, first full paragraph: "a situation found in wetlands and oxygen-depleted streams and rivers" -- It is also found in reservoirs (sediments and hypolimnion), and that can be a major sink in river basins.

p. 7, R, 3rd paragraph: estuaries (e.g., Gulf of Mexico) can also exhibit co-limitation. This was emphasized in the SAB hypoxia report.

p. 30, L, para1 and Table 10: Where do these numbers come from? Some citations as to source of the numbers are needed.

p. 47, L, para.2: Many wastewater treatment plants have been designed to remove P so it is not correct to say most have not been designed to remove nutrients. It is correct to say that many have not been designed to remove N.

3. Is the Committee's report clear and logical?

YES – Additional editorial comments for clarification are listed at the end of this review.

pp. 11-12: The table would be clearer if it were all on one page. If the photos on the top of p. 12 were moved to p. 11, there would be room for the part of the table on p. 11.

Figures 5, 23 and 25: The key is impossible to read (even with my reading glasses!); I can't read the print or decipher the colors. This part of the figure needs to be enlarged! The axis labels and numbers are also hard to read, so if that could be enlarged, it would also help.

Figure 17: What do the colored areas (red, green, yellow, brown, blue) – not the dots but the shaded areas -- of the map indicate?

p. 48, R, last going over to next page: I'm confused by this paragraph. It sounds as though it is saying that the committee's targets are less stringent than the targets being proposed for specific estuaries. So are they implying that their recommendations are therefore more achievable? I guess I just don't understand what point they are trying to make in this paragraph.

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

YES with a couple minor clarifications needed.

19, L, last para.: Is the observation that university recommendations for nutrient application are old and likely outdated reflected in a finding and recommendation? I didn't find it (but could have missed it). I think it warrants highlighting.

Recommendation 2b (also appears in Chapter 6, p. 95): It seems strange to only recommend this for “land-grant universities”. All the other recommendations involving university research is just “universities.”

- p. 32, R, para 1: The first part of this paragraph seems to be arguing that regulating NO₂ is not the best way to regulate Nr, but it doesn’t ever state that clearly. Could a sentence to that effect be added just before the sentence that starts with “The references listed above also” and then start a new paragraph (which is about the accuracy of monitors) with the phrase I put in quotes. This seems like such an important conclusion, but it gets lost here. Also when talking about the monitors here, no detection limits are mentioned. They are on p. 60 (R) – 0.1 ppb – so it seems they should also be mentioned here.
- p. 33, L, #5: I could have missed it, but I don’t recall reading anything about “poorly constrained estimates of convective venting of the planetary boundary layer”; yet it is here in the conclusions (and in Chapter 6, p. 96). Some explanation is needed.
- p. 57, box 4, last paragraph: “if one is interested in reducing water impact of Nr, the total reduction of damage may rely nearly as much on stricter enforcement of the Clean Air Act as the Clean Water Act.” This seems to be an important point; yet I do not find it clearly stated in Finding 15 and its resulting recommendations. I think it should be.
- p. 85, R, last sentence in Enhancing ecosystem services: Where did “enlarging the surface area of streams and ditches to enhance their potential for denitrification” come from? I recall reading this in the previous version of the report, took strong exception to it there, and did not find it in earlier sections of this report. It is a recommendation that should not be in the report! Maybe “alter ditch design to enhance denitrification” but certainly not streams! But if that suggestion about ditches is included as a recommendation, some support is needed in the text.
- p. 86, R, last sentence of para. 1: “NO_x emissions control should be implemented year round.” This seems like an important recommendation (one also made in the SAB Gulf hypoxia report), yet it is not incorporated into any of the specific (italicized) recommendations (unless I missed it). It should be.

Editorial suggestions:

Page, column (L or R), paragraph

1. xviii, R, last: “biological nitrogen fixation (BNF)” – BNF needs to be defined either here or in the legend for Figure 1.
2. xxi, R, 6 lines from bottom: “load”, not “oad”
3. 3, R, para3: citation needed for source of the values shown (e.g., 23 Tg N/yr).
4. 6, L, last: citation needed for residence times shown.
5. 7, L, second set of bullets: “Cap and trade approaches” should be a separate bullet.
6. Text box 1 should also refer the reader to chapter 5 where this is discussed in much greater detail.
7. Figure 23: The text box mentions a data point for 1993 – I couldn’t find it in the figure.
8. 69, L, 2: Point could be strengthened by adding something like the following sentence: “terrestrial systems. This regulatory structure does not take the N cascade into account.”
9. 75, L, 5 lines from bottom: here they are called “choke points” but elsewhere “control points” – if they are the same, call them one thing. Also p. 80, L, last paragraph.

10. 88, L, 2: Do SAB committees “endorse” aspects of federal legislation (i.e. EISA)? I don’t think so. Maybe “supports”.
11. 90, R, 3 under 6.4: This paragraph is repeated verbatim on p. 91 (L, first bullet under specific recommendations). It belongs on p. 91, not on p. 90.

Comments from other SAB Members

Comments from Dr. David Allen

I have a comment with respect to Consensus comment 6 and the action (reproduced below)

Consensus Comment 6. The report recommends a change in the NO_x NAAQS to NO_y. Members indicated that justification for this recommendation was needed.

Action: Additional text and numerous references were added to section 2.3.1 to further support the recommendation to consider using NO_y as a supplement or replacement for the current NO₂ standard.

While I believe that the revised report makes the case for the use of NO_y as a supplement to the NO₂ NAAQS and the NO_x measurement used in demonstrating attainment of the NAAQS, I do not believe that the report has made the case for replacement.

While it is clear that the existing NO_x measurements have artifacts and biases, it is also the case that NO_y measurements have their own artifacts.

I recommend that the report make the case for supplementing (not replacing) existing NO_x measurements.

Comments from Dr. George Daston

1. Were the original charge questions adequately addressed?

I found the original charge questions to be adequately addressed. Given the large number of programs and program offices that already regulate N from various sources and in various media, it was important for the report to clearly state whether an integrated approach to risk management would add value. The report provides good information on how value would be added, and provides actionable recommendations.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee's report?

I did not note any technical errors or omissions.

3. Is the Committee's report logical and clear?

I found the report to be logically presented and easy to follow. This is a technically complex subject. For that reason, the Committee has chosen to provide some fairly basic background material in the Introduction and Executive Summary. As a reader who is not intimately familiar with all aspects of nitrogen sources, discharges, effects and interconnections, I found this background to be helpful. However, it does make the report a little long. I am concerned that inclusion of basic material in the Executive Summary could decrease the Summary's impact. I suggest that the Committee consider whether the Summary can stand without it.

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

I believe that the Committee's report is extremely thorough and that its conclusions and recommendations are supported by the text.

Comments from Dr. Costel Denson

A General Comment

This report addresses a critically important question. It is a masterful tutorial on the issue of concern, reactive Nitrogen.

Does the report meet the study objectives?

Four study objectives were presented for consideration by the committee. The committee met all of the objectives. It reported three findings and four recommendations. All were adequately supported and discussed in considerable detail.

Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the draft report?

None that was obvious to this reviewer.

Is the draft report clear and logical?

The draft report is laid out in a clear and logical way. Each of the objectives is presented and discussed. The findings are unambiguous. The recommendations, which relate to the management of reactive Nitrogen, are insightful.

Are the conclusions drawn or recommendations provided supported by the body of the draft report?

The findings that are presented and the recommendations that are provided are judged to be supported by the body of the report.

Comments from Dr. Bernd Kahn

Concerning the four quality review questions, the respective answers are yes, no, yes, and yes.

It is an excellent and interesting report. Minor suggestions are:

p. viii: 4.3: 'Regulation' (spelling).

p. viii-ix: Consistently use 'reactive nitrogen' or 'Nr', not both.

p. xiv: The sulfate ion should have '4' as subscript and '2-' as superscript.

p. xv: Should 'ECU' be 'EGU'?

p. xvi: 'Mj' definition is 'Megajoule' (one line below).

'Mmt' definition is missing.

p. xviii, col.1, para.3, 2nd sentence: Delete; it repeats last sentence of 1st paragraph.

p. xxi: Under "Distribution of reactive.." section, lines 10-14, replace double negative with 'All ecosystems.. receive'... In column 2, 6th line from bottom: 'load' (spelling)

p. xxii, col. 2, under 'Objective' section: Delete the four objectives, which are repeated in bold on the next page.

p. xxiii, col.1, line 10: Insert 'in Introduction' behind 'Figure 2'.

p.5, Figure 2: Should there be a line with arrow between 'crops' and 'animals' and between 'people' and 'landscape'?

p.7, col.1, line 25: Delete 'Resources' after "Office of Air'.

p.8: Footnote 8 is the same as footnote 2.

p.9: Somewhere in the Introduction, the following two items should be briefly addressed:

1. What about Alaska and Hawaii? Is their omission merely a matter of convenience or are they not at risk?

2. What changes are expected from 2002 to 2011? Some more recent information is scattered throughout, but a comment on expected trend would be of interest.

p. 17, col.1. 2nd full para.: Delete 2 or 3 sentences without changing point of paragraph.

p. 17, col. 2, l. 13 from bottom: Delete 'increase' after '(PE)'.

p. 18, col.1, l.2-3 from bottom: Replace 'leveled off' with 'increased more slowly'.

p. 31, col. 2, para. 1:Delete; this repeats information in the previous paragraph.

p. 35, Box, end of para. 1: Should '2008' be '2007'?

p. 38: Should the initial portion of Section 2.3.3 be in the format of Findings and Recommendations as elsewhere in this Report?

p. 67, Box: Clarify what the red numbers (historical data) represent.

p. 78, Figure 26: Delete; without numerical values for abscissa and ordinate, the figure tells the reader only what is stated in the text.

p. 83: Delete Col. 1 and most of col. 2; all this is repeated in Section 6.4.

p. 97, Figure A-1: In line 1 of Title, delete 'change in relative'.

p. 113, col. 1,l. 1: Print 'Production of ..' in bold type.

l. 17: '-13' should be an exponent.

l. 28: Should '>>'be '<<'?

Comments from Dr. Nancy Kim

1. Does the report meet the study objectives?

Yes.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the draft report?

None that I noticed although my expertise is not in this area.

3. Is the draft report clear and logical?

Yes. The report is well done and the use of graphs, figures, box inserts, etc., helps the reader without much background on the issue become familiar with its significance, sources of the problems and possible solutions. It is still fairly dense and technical, but the presentation helps. One minor comment is that some of the graphs/tables may need some editing for readability. For example, Table 2 in Chapter 2 is split and both pages 11 and 12 have some of the same content. Figure 5 in the same chapter has an insert to display what the different colors represent and I can't read the insert with or without my glasses.

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes although my review is limited by my expertise.

Minor comments.

Page xviii, under The Nitrogen Cascade, the 9th line from the bottom. In outlining the human health impacts, the text mentions respiratory disease and cancer. Cancer is not mentioned in Table 1, but cardiovascular disease is mentioned along with respiratory disease. Is cancer accurate? Should it be replaced with cardiovascular disease?

Comments from Dr. Cecil Lue Hing

In a charge to its members, the SAB requested that they review the draft report with attention directed to 11 Action Items prepared by the SAB Chair. These Action Items resulted from the earlier review of the report. The INC in response implemented 26 major changes to the report which is the subject of this current review.

General Comments

The INC has done an excellent job of responding to the many thoughtful comments, suggestions and recommendations receive on this report. This report certainly improves our understanding of the inputs, distribution and fate of Nr in the environment.

While the report is an excellent document, this reviewer offers a few minor edits aimed at further improving its content

.Quality Review Questions

1-Does the report meet the study objectives?

Yes

2-Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the draft report?

None of which I am aware.

3-Is the draft report clear and logical?

Yes, but a few minor edits are offered.

4-Are the conclusions drawn and recommendations provided supported by the body of the draft report.

Yes. The conclusions and recommendations flow from the body of the report.

Specific Comments

Transmittal Letter – page 2, third to last paragraph; Goal v. Prescription v. Target v. Recognized Opportunities.

The INC has done a remarkable job of retooling the text language, to establish the distinction between goal and prescription. One of the consequences of this effort for example, is to characterize goal(s) as “recognized opportunities.” Unfortunately this retooling major effort did not carry over completely into the Transmittal Letter to the Administrator, as is required by the SAB Chair’s Action Item #9 – particularly to the word **throughout**.

At page 2, third to last paragraph line 1, we have ----- the Committee explored how a 25 percent reduction in Nr etc.

Opinion – If the word “goal” or the expression “recognized opportunities” belong anywhere in the report, it is in the Transmittal Letter to the Administrator, and the Executive Summary, the two sections that the EPA senior executives are most likely to read.

I propose as follows: a) --- the Committee explored how a **goal** of 25 percent reduction in Nr introduced into the environment might be achieved etc-
 or b) --- the Committee explored how **recognized opportunities** for a 25 percent reduction in Nr etc.

Executive Summary – Goal v. Prescription v. Target v. Recognized Opportunities

Under Summary of Changes in the INC Report in Response to the SAB Chair’s Action Items at page 4, we have:

Action: In Section 6.3 and the Executive Summary, clarifications have been incorporated to characterize the overall 25% reduction as recognized opportunities for reduced loading rather than prescriptive targets.

In a search of the Executive Summary, these clarifications were not readily apparent.

In the Executive Summary at page XXV last paragraph, we have – Implementing these suggestions will decrease the amount of Nr introduced into the United States by about 25%, which ---- . The Committee believes that these represent realistic and attainable near-term **targets**, however ----

To be compliant with the SAB Chair’s Action Item #9, I believe that either the word “goal” or its newly characterized form “recognized opportunities” rather than **targets** need to appear in this last paragraph of the Executive Summary.

Comments from Dr. James Mihelcic

Written Responses of J.R. Mihelcic

Draft report for quality review: *Reactive Nitrogen in the United States; an Analysis of Inputs, Flows, Consequences, and Management Options: A Report of the EPA Science Advisory Board* (January 20, 2011 Draft).

1. Were the original charge questions to SAB Standing or Ad Hoc Committees adequately addressed?

Yes, the original charge questions were addressed.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee's report?

This is the first review of this document I have been involved in. A major omission of the report is that it ignores several stressors that may drive Nr losses to the environment over this century. For example, the increasing stressors of population, land use, and urbanization seem to not play a prominent role in the document. This is especially important since natural processes introduce 6.4 Tg of Nr per year and anthropogenic processes introduce 28.5 Tg of Nr per year (5 times larger than natural processes).

The IPAT equation states that Environmental Impact (I) is equal to Population (P) multiplied by Affluence (A) (or some measure of consumption) multiplied by Technology (T). Related to the Draft Report, Objective 3 is to identify additional risk management options for EPA's consideration. This included identifying four major target goals for management actions that would collectively reduce Nr losses to the environment of about 25 percent. However, if we develop target goals to reduce Nr losses by 25% with a focus on technological solutions (reducing T in the equation), but the stressors of population, land use, and urbanization continue to increase, the environmental impact will not be reduced by 25%, and in fact, might increase. In addition, affluence (as measured by increases in calorie and meat intake) that is occurring in the U.S. and around the world will greatly influence the overall impact. And addition of 3 billion more people to the planet could impact nitrogen losses to the environment if the U.S. were to serve a major provider of calories intake for this population. Accordingly, I thought that in Chapter 2, there should be some discussion of future scenarios of not just economic use of nitrogen and its flows through the environment, but also provide information on future prediction of nitrogen use along with future prediction of other stressors that can impact nitrogen releases. It seems that any risk management options should consider this.

Also, Consensus Comment 11 was that "Reactive nitrogen calls out for a public education effort to show the complexities involved in managing a pollutant that is common to several environmental media and which has multitude impacts." The response (page 5 of Summary of Revision document) was that the importance of the public education effort was addressed in the report and was stated in the letter to the Administrator. However, I felt the report is very weak on issues of education and in fact and the risk management options are overly dependent on

technological solutions. I would suggest that solving the problem discussed in the draft report will include a lot more than advances in (or implementation of) technology, and will include education as well as behavioral changes within businesses, households, and communities. The four recommended management options are overly dependent on technology, where education, behavioral changes, and policy will most likely have similar roles to play in the solution.

In addition, the report might benefit from addition of some of the literature from the ecological sanitation area that has attempted to quantify material flows of nitrogen and phosphorus from human wastes, and relate this information to inputs of agricultural fertilizers. There has been a tremendous amount of literature in this area in just the past 10 years. As just one example, it has been reported that ecological sanitation systems could replace close to 20% of chemical fertilizer demand (on a nitrogen basis) in developing world settings and 100% of current chemical fertilizer usage (on a nitrogen basis) in Sub Saharan Africa (Sustainable Pathways to Attain the Millennium Development Goals: Assessing the Key Role of Water, Energy and Sanitation. Stockholm Environment Institute, 103pg.).

Lastly, recommendation D on page xxiv of Draft Report states successes Nr management will require changes in how EPA interacts with other agencies. However, it ignores listing agencies involved in issues surrounding the built environment who are important players in destruction of urban wetlands that have a large impact on reducing nitrogen loads to aquatic systems. I suggest we include these agencies, e.g., Department of Transportation, Housing & Urban Redevelopment, etc.

3. Is the Committee's report is clear and logical?

Yes, however, in my opinion, is just too focused on technological based management decisions.

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

To a large extent, yes. See my earlier comments.

Comments from Dr. Jana Milford

Integrated Nitrogen Committee Quality Review Comments

Jana Milford

January 14, 2011

1. Were the original charge questions adequately addressed?

I examined the report in light of the study objectives listed on p. 8. In my view, these objectives were addressed well. The report represents a terrific effort and provides a very important comprehensive look at the problem of reactive nitrogen in the US. However, as raised in the previous review, I'm concerned that some of the statements in the report could be perceived as going beyond the objectives to make policy recommendations, which in turn are not adequately justified. An example of this is the "Near-term Target Goals" section beginning on p. 86. The concern that these look too much like regulatory policy recommendations might be relatively simply addressed by changing the wording to avoid using the "Target Goal" terminology and instead labeling the sections as "Nr reduction opportunities"

2. Are there any technical errors or omissions or issues that are not dealt with adequately?

This is not a "technical" issue per se, but I think the report is often unclear or incomplete in its discussion of statutory provisions and regulatory programs that currently address or could address Nr. One fundamental point that seems to be missing is that EPA requires statutory authority to take regulatory action – it's not clear what the authority would be for EPA to pursue some of the management strategies discussed in the report. I don't think it's necessary for the committee to identify existing statutory authorities for every case, but at least the report should recognize that this may be an issue. The report also seems dated in its descriptions of EPA's regulatory programs and estimates Nr emissions and discharges. For example, the report points out that "few" areas currently violate the annual air quality standard for NO₂ (p. 60, also see p. 32), but gives short shrift to the new 1-hr NO₂ standard adopted in January 2010, and the near-roadway monitoring EPA plans to require as part of the program to implement this new standard. On p. xxv and p. 32 the report recommends EPA consider replacing NO₂ as the criteria pollutant indicator species with Nr, using NH_x and NO_y as the indicators. I wonder if the committee fully considered the implications of doing so, given that NO₂ has been used historically and specifically as the "indicator" for many health studies, and that it is regulated in part because of studies that directly link it to respiratory effects. A better recommendation might be to retain NO₂ but add the other indicator species to help address other impacts. The discussion on p. 32, which currently focuses on the inadequacy of NO₂ as indicator for the environmental effects of Nr, should at least mention there is or may be justification for retaining NO₂ as an indicator with respect to health effects.

3. Is the report clear and logical?

These items are fairly minor, but I had the following questions as I read through the report (focusing especially on air quality issues):

- p. xviii What's the link between Nr and cancer?

- p. xviii and repeatedly in the executive summary and throughout the report, the committee refers to NO_x emissions from “fossil fuel” combustion. Actually, NO_x is formed in high temperature combustion of biomass or biofuels, as well, so the problem is not limited to fossil fuel combustion.
- p. xxi , p. 6 I was surprised to see ORD characterized as one of the parts of EPA “most directly concerned with management of Nr.” Is it useful to maintain the distinction between ORD and other offices like OAR and Water that have regulatory authority?
- p. 13 Note b for Table 2 indicates the deposition estimate from CMAQ was scaled up to reflect missing organo-nitrogen. What’s the justification for this?
- p. 15 This table shows up to 6 significant digits for emissions estimates from 2001. Emissions are never known to this degree of precision, and given that a decade has elapsed, the numbers are certainly no longer meaningful to this degree of precision.
- p. 24 The discussion of biofuels and Nr should mention that biofuels production and combustion also result in NO_x emissions to the atmosphere.
- p. 27 I wish the discussion of monitoring networks for agricultural emissions would mention the role and prospects for satellite observations to contribute to such efforts.
- p. 50 I don’t think the heading “Impacts of Reactive Nitrogen on Atmospheric Systems” captures what’s discussed in this subsection. Aren’t these impacts of airborne or deposited Nr on human health and ecosystems, not just impacts on atmospheric systems? Should direct impacts of NO₂ on respiratory health also be mentioned?
- The description of the Clean Air Act and Air Quality Regulation and Management on pp. 60- 61 needs work. For example, PM and ozone standards were changed in 1997 (and several other times) through regulation, not “revision of the CAA.” PM is not strictly a secondary pollutant, as described – there are also substantial primary emissions of PM. I believe the 1990 Clean Air Act Amendments set up an Ozone Transport Region in the Northeast and authorized EPA to establish Ozone Transport Commissions, but the Act itself did not establish OTAG, as the report states.
- On p. 61, the report argues the NO₂ standard is inadequate because (in essence) it hasn’t taken care of the contributions of NO_x emissions to PM and O₃. This argument seems questionable since the latter two pollutants have separate standards, and NO_x emissions are regulated as part of efforts to meet them.
- On p. 61, the report says “The Committee is recommending that NO_x emissions be decreased by 2 Tg N/yr.” What’s the justification for that particular number?
- On p. 63, the report recommends EPA revise its policy on controlling NH₃ as a PM_{2.5} precursor (which the Agency currently does not encourage). I think this recommendation warrants further consideration and better justification. In many places, NH₃ is not thought to be a limiting precursor for PM_{2.5}, so substantial reductions might not reduce PM_{2.5} concentrations. It may be that NH₃ should be controlled for other reasons (e.g., concern about N deposition to ecosystems) but in that case the justification would not be “as a harmful PM_{2.5} precursor”.

4. Are the conclusions and recommendations supported by the body of the Committee's report?

See comments above.

Comments from Dr. H. Keith Moo-Young

Reactive Nitrogen

1. Were the original charge questions to SAB Standing or Ad Hoc Committees adequately addressed?

Yes, the charge questions were adequately addressed.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee's report?

No technical errors were seen.

3. Is the Committee's report clear and logical?

Yes. The report is clear and logical.

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

Yes.

Comments from Dr. Duncan Patton

1. Does the report meet the study objectives?

The report is very comprehensive tracking Nr sources and fates from most areas. The Objectives of the Report include the areas that need to be covered to present this comprehensive overview, including not only sources, etc. but management and "control" suggestions.

2. Are there any technical errors or omissions in the report?

Without studying all the aspects and details of the report, it seems to be without any serious omissions.

3. Is the draft report clear and logical?

In its new format the report much more clear and logical as the earlier draft and the flow of ideas and presentation makes sense. However, the report appears to go way beyond addressing its four basic objectives, but the comprehensive discussion of sources, fates, management options, etc. all are foundations to responses to the objectives. I have no real problem with including the large amount of information as that is essential to our understanding of Nr dynamics, however, it seems as though the four basic objectives may not be "sufficient" for a response of the purpose of this report. The objectives seem to crop their head up in Chapter 6 summary. These summary statements are different from the "summaries" in the Exec. Summary.

Some suggestions:

Because the Executive Summary may eventually become a "stand alone" document, I suggest putting Figure 2 in the Executive Summary where it is cited in the text. That Figure along with Figure 1 (which is cited and included in the Exec. Summary) offers a very broad overview of the sources and flows of Nr.

Because Figure 2 and discussion of source and fate of Nr includes "soil" as a medium in which Nr flows, I suggest wherever the text refers to "atmosphere, hydrosphere, and biosphere" processes that the word "geosphere" be included in the lists.

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report.

Yes.... the body of text appears to be more comprehensive than the original objectives call for but that is for the better.

Comments from Dr. Amanda Rodewald

1. Were the original charge questions to SAB Standing or Ad Hoc Committees adequately addressed?

Yes. I thought that the committee did an excellent job preparing the report and responding to both the original charge questions and review from the Chartered Board.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee's report?

No. The report was very comprehensive.

Minor editorial comment: I noticed that at least one reference was to a numbered Appendix, but the Appendices had since been changed to letters.

3. Is the Committee's report clear and logical?

Yes.

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

Yes.

Comments from Dr. James Sanders

1. Does the report meet the study objectives?

Yes. The revised report has taken the largely successful but somewhat confusing first draft to a higher level of completion. All four objectives have been met and are clearly discussed.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the draft report?

No. The report is complete as it stands. The committee is to be commended for their careful attention to the issues and concerns voiced about the first draft. All of the concerns raised by this reviewer in September 2009, and in my opinion all those raised by others, have been addressed.

3. Is the draft report clear and logical?

Yes. This draft has carefully addressed the concerns voiced about the first draft. The committee has extensively revised the report, yielding a clear and well developed final product.

4. Are the conclusions drawn and the recommendations provided supported by the body of the draft report?

Yes. Again, I commend the committee for a job well done.

Comments from Dr. Stephen Roberts

Review of Reactive Nitrogen in the United States: A Report of the EPA Science Advisory Board.

1. Does the report meet the study objectives?

Four study objectives are articulated, and detailed findings and recommendations are given for each. It appears to me that all of the study objectives were met.

2. Are there any technical errors or omissions in the draft report?

This is not my field, so I am unable to comment on this question.

3. Is the draft report clear and concise?

Overall, the draft report is very well written. The letter to the Administrator is at the right level of detail, I think, but the Executive Summary may need a little work. Creating an Executive Summary for a report of this size and detail is challenging no doubt. This one reads to me more like an introduction to the report than a “stand alone” read capturing the essential points. In a number of places, the reader is simply referred to the body of the report for the relevant information. The body of the report reads well, but the myriad of findings, specific findings, recommendations, specific recommendations, overarching recommendations, gets a little confusing, in my opinion. This is not a criticism of the findings and recommendations themselves, just the organization of their presentation.

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Describing findings, followed by recommendations, helps make the basis for the recommendations clear. For the most part, the recommendations appear to follow from the findings and are supported by the body of the report.

Comments from Dr. John Vena

1. Does the report meet the study objectives?

I read the report of the EPA science advisory Board entitled “Reactive Nitrogen in the United States “. I also carefully read the summary revisions to the integrated nitrogen committee's report in response to quality review comments from the chartered Science Advisory Board. My conclusion after careful assessment was that the changes to the report were well orchestrated and responsive to the consensus comments of the SAB. Therefore, in my opinion the report is easy to read and follow and it is clear how the study objectives were met.

2. Are there are any technical errors or omissions in the report or issues that are not adequately dealt with in the draft report?

To my knowledge there are no technical errors or omissions.

3. Is the draft report clear and logical?

The reorganization into six chapters has resulted in a well-organized report responsive to the four objectives. In my opinion the report is logical and clear how the findings of the review relate to the specific recommendations. The addition of boxes to highlight findings and recommendations was a nice touch.

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report?

It is clear to me that the revisions to the committee's report in response to the previous comments have resulted in a report that clearly articulates conclusions and recommendations that are carefully supported and referenced.